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ПОСТРОЕНИЕ ОБЛАСТИ ПРИТЯЖЕНИЯ НА ОСНОВЕ ФУНКЦИЙ ЛЯПУНОВА ДЛЯ НЕЛИНЕЙНЫХ СИСТЕМ ОБЩЕГО ВИДА

CONSTRUCTION OF THE DOMAIN OF ATTRACTION BASED ON LYAPUNOV FUNCTIONS FOR GENERAL NONLINEAR SYSTEMS

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Аннотация

В работе предложен алгоритм для построения нейросетевых функций-кандидатов Ляпунова с целью максимизации оценки области притяжения положения равновесия. Для этого необходимо, чтобы инвариантное подмножество, задаваемое множеством уровня, занимало как можно большую долю полученной симуляцией эмпирической оценки области притяжения. Реализация данной цели осуществляется путём введения дополнительного слагаемого в функцию потерь. Алгоритм позволяет строить функции-кандидаты для систем с нелинейностями достаточно общего вида. Работа алгоритма проиллюстрирована на примере.

Ключевые слова: функция Ляпунова, область притяжения, искусственная нейронная сеть.

Abstract

The paper proposes an algorithm for constructing Lyapunov candidate neural network functions in order to maximize the estimate of the area of attraction of the equilibrium position. To do this, it is necessary that the invariant subset, given by the level set, occupy the largest possible share of the empirical estimate of the attraction region obtained by the simulation. The implementation of this goal is carried out by introducing an additional term in the loss function. The algorithm makes it possible to construct candidate functions for systems with non-linearities of a rather general form. The operation of the algorithm is illustrated by an example.

Keywords: Lyapunov function, attraction domain, artificial neural network.

Introduction

One of the most important problems in the analysis of control systems is to determine the stability of the equilibrium position of a closed system. As a rule, in applied problems it should be asymptotically or exponentially stable. However, there are cases when the area of attraction of a stable equilibrium position is smaller than the area of operation that is of interest in practice. Thus, for the target equilibrium position, it is desirable to be able to determine not only stability, but also the area of attraction.

In engineering applications, stability is often determined by the first Lyapunov method for a linearized system, but this method is not applicable to non-hyperbolic equilibria, that is, equilibria with zero real part of at least one of the eigenvalues of a linearized system.

There are various methods for determining the area of attraction, but perhaps one of the simplest and most common methods in practice is numerical simulation from the assigned area at the current step. In addition, based on the simulation results, one can also judge the stability of the

equilibrium position, even in the non-hyperbolic case. However, this method relies on the reliability of numerical methods for solving the Cauchy problem, that is, it does not prove the stability of the fact that the resulting region is a subset of the true attraction region.

These two problems can also be solved jointly using the second (direct) Lyapunov method. If it is possible to construct a Lyapunov function that satisfies certain properties, then the stability of the equilibrium position is proved. In addition, the resulting Lyapunov function can be used to estimate the invariant subset of the attraction domain, which is defined by the level set.

The difficulty of applying the second Lyapunov method in practice lies in the absence of algorithms for constructing Lyapunov functions. Such algorithms exist for linear and polynomial systems [1], but it is known that there is no rigorous formal algorithm for systems of general form, since the problem of checking the positivity of functions of general form is unsolvable [2

In recent years, methods have been developed for constructing Lyapunov functions represented as a neural network [3; 4; 5]. This approach has a number of advantages. First, neural networks are universal approximators , that is, they are potentially capable of approximating a suitable Lyapunov function for arbitrary systems. Secondly, methods, software and hardware for their training are currently well developed. Thirdly, in recent years, methods and software tools for verifying neural networks have been developed, that is, checking the fulfillment of certain properties for given input values, for example, positivity in a certain area [6].

In most works in this area, the Lyapunov function is sought to prove stability, without the requirement to obtain a maximum estimate of the attraction domain. In this work, a step is taken to eliminate this shortcoming - an algorithm for constructing Lyapunov candidate functions is proposed in order to maximize the estimate of the attraction domain for general nonlinear systems.

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1. Methods for constructing Lyapunov functions for general systems

The paper considers nonlinear dynamical systems defined by differential

$$\dot{\mathbf{x}} = f(\mathbf{x}), \qquad (1)$$

or difference equations

$$\mathbf{x}_{k+1} = f(\mathbf{x}_k), \qquad (2)$$

where $\mathbf{x} \in \mathbb{R}^n$ is the state vector, $f\colon \mathbb{R}^n \to \mathbb{R}^n$ is an arbitrary differentiable function. We will assume that the equilibrium position of interest to us exists and is zero: $f(0) = 0$, which can always be achieved by changing the coordinates.

Solution of systems (1)and (2)with the initial condition $\mathbf{x}_0 \in \mathbb{R}^n$ as $\mathbf{x}(\mathbf{t};\ \mathbf{x}_k)$ and $\mathbf{x}(\mathbf{k};\ \mathbf{x}_k)$ respectively, where $\mathbf{t} \in \mathbb{R}$ is continuous and $\mathbf{k} \in \mathbb{Z}$ is discrete time. We will assume that the conditions for the existence and uniqueness of the solution are satisfied.

Since the conditions of the second Lyapunov method [7] are used below, we briefly recall its formulation.

Theorem 1. Consider system (1), where $\mathbf{x} \in \mathcal{D} \subseteq \mathbb{R}^n$ and the zero equilibrium position is stable. If there exists a continuously differentiable function $V\colon \mathcal{D} \to \mathbb{R}$ such that

$V(0) = 0$,

$V(\mathbf{x}) > 0$ for everyone $\mathbf{x} \in \mathcal{D} / \{0\}$,

$\dot{V}(\mathbf{x}) \le 0$ for everyone $\mathbf{x} \in \mathcal{D}$,

then the zero equilibrium position is Lyapunov stable. If, moreover, $\dot{V}(\mathbf{x}) < 0$ for all $\mathbf{x} \in \mathcal{D} / \{0\}$, then the zero equilibrium is asymptotically stable.

Similar theorems are also valid for discrete systems (2). In this case , the first difference is used $\Delta V = V(f(\mathbf{x}_k)) - V(\mathbf{x}_k)$instead of the derivative $\dot{V} = \nabla V(\mathbf{x}) f(\mathbf{x})$, and it is enough for the function $V$to be continuous.

Knowing the Lyapunov function, one can try to find an invariant subset of the attraction domain. Namely, the set:

$$\Omega_c = \{\mathbf{x} \in \mathbb{R}^n \mid V(\mathbf{x}) \leq c\} \quad (3)$$

is an invariant subset of the attraction domain for all $c > 0$such that $\Omega_c \subseteq \{\mathbf{x} \in \mathbb{R}^n \mid \dot{V}(\mathbf{x}) < 0\}$in the continuous case or $\Omega_c \subseteq \{\mathbf{x} \in \mathbb{R}^n \mid \Delta V < 0\}$in the discrete case.

Thus, in order to maximize the estimate of the attraction domain, it is necessary to be able to construct Lyapunov functions and find such $c$that the set $\Omega_c$has the maximum volume.

The main disadvantage of this approach is the need to search for the Lyapunov function. For general non-linear systems, the most promising is the construction of candidate functions based on machine learning methods, which allow solving problems of large dimensions, but may not give any formal guarantees.

The idea of using machine learning methods to solve the problem of constructing the Lyapunov function is not new. In particular, works [6; 9; 10]. Later works differ in the type of representation of the Lyapunov function in the form of a neural network , the architecture of the neural network , and the loss function used, which formalizes the Lyapunov conditions. Thus, in [11], the Lyapunov function is sought in the form of a multilayer neural network $V_{\boldsymbol{\theta}}(\mathbf{x})$with the number of inputs equal to the dimension of the system and with one output. The region of interest is set D, and the points on which the network is trained are generated in it.

In [12], a linear controller and a Lyapunov function of a closed system are simultaneously synthesized in a similar way. The loss function has the form (without taking into account the control for the article [12])

$$L(\boldsymbol{\theta}) = \frac{1}{N}\sum_{i=1}^{N}\left(\max(0, -V_{\boldsymbol{\theta}}(\mathbf{x}_i)) + \max\left(0, \dot{V}_{\boldsymbol{\theta}}(\mathbf{x})\right)\right) + V_{\boldsymbol{\theta}}^2(0) \quad (4)$$

In [13], the construction of Lyapunov functions for high-dimensional systems is considered. The neural network has the form $\varphi_{\boldsymbol{\theta}} : \mathbb{R}^n \to \mathbb{R}^m$, where m is the adjustable parameter. The Lyapunov function is sought in the form $V_{\boldsymbol{\theta}}(x) = ||\varphi_{\boldsymbol{\theta}}(x) - \varphi_{\boldsymbol{\theta}}(0)||_2^2 + \delta \log(1 + ||x||^2)$. Here $\delta \log(1 + ||x||^2)$it can be replaced by another increasing function. Obviously, $V_{\boldsymbol{\theta}}(0) = 0$for $V_{\boldsymbol{\theta}}(x) > \delta \log(1 + ||x||^2) > 0$everyone $x \neq 0$. Hence, only one term is sufficient in the loss function:

$$L(\boldsymbol{\theta}) = \frac{1}{N}\sum_{i=1}^{N}\max(0, \dot{V}_{\boldsymbol{\theta}}(\mathbf{x}))^2 \quad (5)$$

It is shown that for any $\varepsilon \in (0, 1)$and $s \in \mathbb{N}$there exists a neural network of the $V_{\boldsymbol{\theta}}(\mathbf{x})$above type with the ReLU activation function and size $O(\varepsilon^{-\frac{n}{s}})$such that for any Lyapunov function of $V \in C^s$the corresponding function $f$with zero equilibrium position

$$||V_{\boldsymbol{\theta}} - V||_{L^\infty} := \max_{\mathbf{x}} |V_{\boldsymbol{\theta}}(\mathbf{x}) - V(\mathbf{x})| \leq \varepsilon \quad (6)$$

for the right parameters $\boldsymbol{\theta}$.

The work [4] is also devoted to the construction of Lyapunov functions for high-dimensional systems. It is assumed that the system admits the presence of a composite Lyapunov function, that is, there are functions $V_i$such that $V(\mathbf{x}) = \sum_{i=1}^{s} V_i(\mathbf{z}_i)$, where $\mathbf{z}_i$is some subvector of the vector $\mathbf{x}$that defines the i - th subsystem. The upper estimate for the number of subsystems is given as a parameter of the algorithm.

The work uses a single-layer network, divided into blocks, where each block is used for its subsystem. Let be $d_{\max}$the maximum degree of the subsystem. It is shown that for single-layer networks with nonpolynomial infinitely differentiable activation functions, the (4)

$$N = O(n^{d_{\max}+1}\varepsilon^{-d_{\max}}), \qquad (7)$$

that is, it grows exponentially not from the dimension of the system, but from the maximum dimension of the subsystem $d_{\max}$.

The loss function is given as:

$$L(\boldsymbol{\theta}) = \left([\dot{V}_{\boldsymbol{\theta}}(\mathbf{x}) + ||\mathbf{x}||^2]_+\right)^2 + \upsilon\left(([V_{\boldsymbol{\theta}}(\mathbf{x}) + \alpha_1||\mathbf{x}||^2]_-)^2 + {}^2 + ([V_{\boldsymbol{\theta}}(\mathbf{x}) + \alpha_2||\mathbf{x}||^2]_+)^2\right) \qquad (8)$$

and implements the requirements $\dot{V}_{\boldsymbol{\theta}}(\mathbf{x}) \le -||\mathbf{x}||^2$and $\alpha_1(||\mathbf{x}||) \le V_{\boldsymbol{\theta}}(\mathbf{x}) \le \alpha_2(||\mathbf{x}||)$, where $\alpha_i(r) = c_i r^2$, $[\alpha]_- = \min(0,\alpha)$, $[\alpha]_+ = \max(0,\alpha)$.

These papers are devoted to the problem of constructing the Lyapunov function, but do not aim at maximizing the attraction domain. Thus, even if the loss function is zero for the entire region D, then it is not guaranteed that D is an attraction region, since the inclusion is not guaranteed $\Omega_c = \{\mathbf{x} \in \mathbb{R}^n \mid \dot{V}(\mathbf{x}) < 0\}$.

An exception is the work [5]. It uses the following idea. Let's assume that we know exactly the area of attraction S. Then, one can try to find such parameters $\theta$of the Lyapunov function so that the area $\{\mathbf{x} \mid V_{\theta}(\mathbf{x}) \le c\}$coincides with S, that is, the level lines $V_{\boldsymbol{\theta}}(\mathbf{x}) = c$coincide with the boundary of the stability region. That is, you can set the decision rule

$$\hat{y}_{\boldsymbol{\theta}}(\mathbf{x}) = \operatorname{sign}(c - V_{\boldsymbol{\theta}}(\mathbf{x})) \qquad (9)$$

and get the classification problem: for any , $\mathbf{x}$the label is defined as $y = 1$if $\mathbf{x} \in S$and -1 otherwise. The condition for the negative of the derivative must also be satisfied:

$y = +1 \implies \dot{V}_{\boldsymbol{\theta}}(\mathbf{x}) < 0$

In this paper, the Lyapunov function is searched for in the form $V_{\boldsymbol{\theta}}(\mathbf{x}) = \varphi_{\boldsymbol{\theta}}(\mathbf{x})^{\mathrm{T}}\varphi_{\boldsymbol{\theta}}(\mathbf{x})$, where $\varphi_{\boldsymbol{\theta}}(\mathbf{x})$is the neural network . It is obvious that $V_{\boldsymbol{\theta}}(\mathbf{x}) \ge 0$. The loss function has the form:

$$l(\mathbf{y},\mathbf{x},\boldsymbol{\theta}) = \max\left(0, -\mathbf{y}\left(c - V_{\boldsymbol{\theta}}(\mathbf{x})\right)\right) + \lambda\left(\frac{\mathbf{y}+1}{2}\right)\max(0,\Delta V_{\boldsymbol{\theta}}(\mathbf{x})) \qquad (10)$$

The definition of labels $\mathbf{y}$is carried out through simulation. The quadratic Lyapunov function obtained from the linearized system is taken as the first approximation. For it, the maximum $c_k$and area are found S_k. Then, to increase the area through simulation, labels are obtained in the

area with a radius $\alpha c_k$where $\alpha > 1$. In general, the algorithm does not guarantee convergence to the true area of attraction and its increase with each iteration, but always gives some internal estimate of it.

Thus, the problem can be formulated as follows: finding an algorithm for constructing a candidate function $V_{\theta}(\mathbf{x})$and a constant $c$such that the region $\Omega_c$is an invariant subset of the attraction region of as large a volume as possible. Provided that the found algorithm works for general systems.

2. Main result

The work [5] considers an online statement of the problem of increasing the attraction area, so the simulation is carried out at each iteration to assign labels to points. At the same time, using simulation, one can directly estimate the area of attraction, for example, by simulating in reverse time from some neighborhood of the equilibrium position or from points distributed inside the area of interest to us.

Let us set the desired domain D, in which we will evaluate the invariant subset of the attraction domain. Let us generate Npoints in the given area $D_N$that serve as initial conditions. By simulation, we obtain a division $D_N$into a set of Sconverging and Unon-converging initial conditions. The set Scan be interpreted as an empirical estimate of the area of attraction.
However, this method relies on methods for solving differential equations and does not prove that the obtained points really belong to the attraction region. In addition, for systems of order greater than four, the question arises of characterizing the attraction domain. For example, belonging to some point not in the $D_N$area of attraction without using simulation.

The paper proposes to obtain a set of points Bbelonging to the boundary of the obtained estimate of the attraction domain S. For example, the vertices of the convex hull of the points can act as such points S. Since the attraction domain does not have to be convex, a more accurate boundary can be obtained using -forms [14]. However, in this case, it is required to select the parameter α, which is difficult if the system dimension is higher than three.

To maximize the attraction region, we will look for such a candidate function $V_{\theta}(\mathbf{x})$that, in addition to the Lyapunov conditions, the level lines $V_{\theta}(\mathbf{x}) = c$coincide with the boundary of the stability region, that is, $V_{\theta}(\mathbf{x}_b) = c$for all $\mathbf{x}_b \in B$. To do this, it is proposed to introduce an additional term into the loss function:

$$\frac{1}{N_B}\sum_{i-1}^{N_B}(c - V_{\theta}(\mathbf{y}_i))^2,$$

where $\mathbf{y}_i \in B, N_B = |B|$.

Since the number of boundary points in the general case is much less than the number of points from S, then during training it is proposed to form a batch from the union of two subbatches : from the set $S$and from the set B. Thus, at each training iteration, both internal and boundary points will be present.

The constant $c$is set during training, let's denote it c_t, for example, you can always put $c_t = 1$. However, after the completion of training, switching on $\Omega_{c_t} \subseteq \{\mathbf{x} \in \mathbb{R}^n \mid \dot{V}(\mathbf{x}) < 0\}$(or its discrete analog) is guaranteed only when the loss function reaches zero. Otherwise, the problem arises of finding the maximum value of the constant $c$for which the specified inclusion is performed. In addition, in both cases, it is necessary to verify the obtained candidate function V_{θ}.

The obvious way is to jointly solve both problems, that is, to find the maximum value c for which it is possible to verify the Lyapunov conditions. However, since verification generally takes a long time, this approach seems inappropriate.

It seems more productive to test on a large validation set, also generated in the domain D. In this case, points are sought $\mathbf{x}_i$ from the set of initial conditions $S_V \cup S$ converging to zero for which at least one of the Lyapunov conditions is violated. The set of such points will be denoted as P. If it is non- empty , then the constant c can be taken equal to the minimum value of the candidate function on it:

$$c = \min_{\mathbf{x}_i \in P} V_{\boldsymbol{\theta}}(\mathbf{x}_i) - \varepsilon \qquad (11)$$

where ε is some small constant. If the set is P empty, then points are generated from some extension of the area D, for which the minimum value is also searched. This procedure is especially simple if D is a hypercube. Then $P = 1.01 \cdot D \setminus D$ the search for a constant c is carried out according to the formula above.

Note that the set P of points for which at least one of the Lyapunov conditions is violated can be added to the training set and further training of the neural network can be carried out.

Thus, the algorithm for constructing a candidate function V_θ and evaluating a constant c is as follows:

Set the area of interest D. We generate in it evenly distributed points for training D_T.

We run the simulation for all points from D_T., we get a set of S_T. convergent to zero initial conditions.

We find the set of boundary points B_T.

We train a neural network $V_{\boldsymbol{\theta}}: \mathbb{R}^n \to \mathbb{R}$ with a loss function:

$$L(\boldsymbol{\theta}) = \frac{1}{N_s}\sum_{i=1}^{N_s}\left(\max\left(0, -V_{\boldsymbol{\theta}}(\mathbf{x}_i)\right) + \max\left(0, \dot{V}_{\boldsymbol{\theta}}(\mathbf{x}_i)\right)\right) +$$
$$+\alpha_1 \frac{1}{N_B}\sum_{i=1}^{N_B}(c_t - V_{\boldsymbol{\theta}}(\mathbf{y}_i))^2 + \alpha_2 V_{\boldsymbol{\theta}}^2(0),$$

where $N_S = |S_T|$, $N_B = |B_T|$, $\alpha_1, \alpha_2 > 0$ are positive weights, c_t is a constant during training.

We generate D evenly distributed points in the area for validation D_V and find the set S_V of initial conditions converging to zero.

We obtain a set P of points from $S_T \cup S_V$ for which at least one of the Lyapunov conditions is not satisfied.

If the set is P empty, then we generate points in the neighborhood and $D: P = D_{new} \setminus D$ find a constant c:

$$c = \min_{\mathbf{x}_i \in P} V_{\boldsymbol{\theta}}(\mathbf{x}_i) - \varepsilon \qquad (12)$$

and complete the algorithm.

If the number of iterations is less than the specified one, then we add the set P to the training sample S_T and go to step 4. Otherwise, we find the constant c using formula (12)and complete the algorithm.

Example

To illustrate the method, let us estimate the area of attraction of the zero equilibrium position of system (12):

$$\begin{cases} \dot{x}_1 = -\frac{1}{4}x_1 + \log(1 + x_2); \\ \dot{x}_2 = -\frac{3}{8}x_1 - \frac{1}{5}x_1x_2 + \left(\frac{1}{8}x_1 - x_2\right)\cos x_1 \end{cases} \quad (13)$$

generate $N = 16000$ points in the range $x_1 \in [-7;\ 4],\ x_2 \in [-1{,}2;\ 11{,}5]$. The estimate of the area of attraction obtained using the simulation is shown in Figure 1 by a solid line, the boundary points obtained by constructing the convex hull are shown by filled circles.

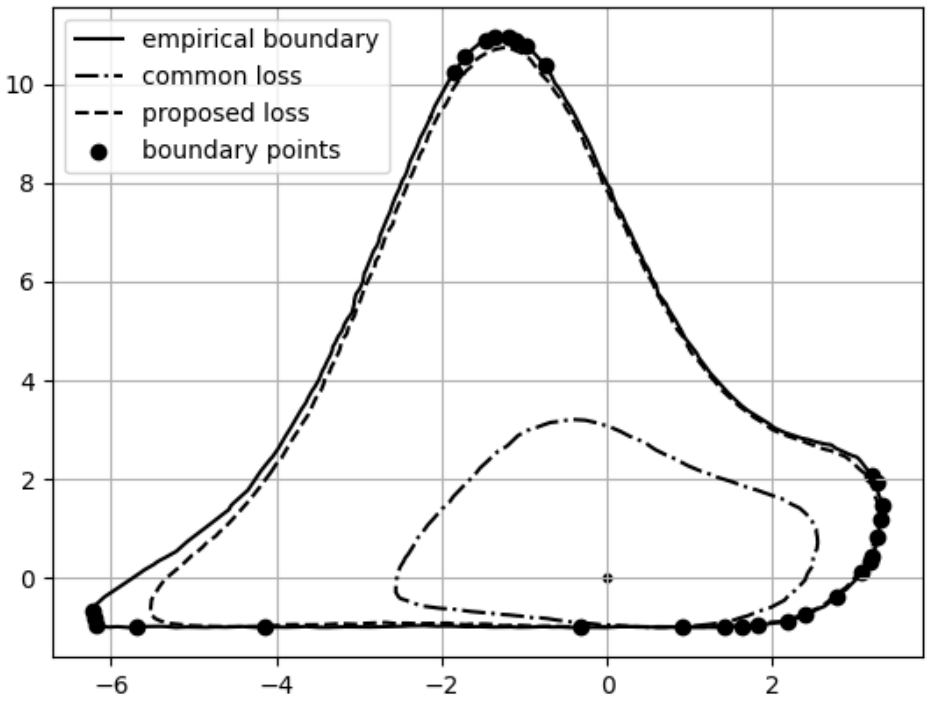

Figure 1 - Evaluation of the area of attraction

Let 's define $\alpha_1 = 1,\ \alpha_2 = 0.1,\ c_t = 1,$ and train a neural network with 3 hidden layers of 128 neurons with the softplus activation function . For validation , we will generate 128000 points and we will carry out the training- validation procedure 10 times. The resulting area of attraction for the loss function of the form (4)is shown in Figure 1 by a dash-dotted line, for the proposed loss function it is a dashed line.

Note that in [15] the area of attraction proved for this system is a circle with a radius of 0.51, and the learning process with the loss function from [5] diverges.

Conclusion

In this paper, an algorithm is obtained for constructing Lyapunov candidate functions in order to maximize the attraction domain. Although the proposed algorithm can be used for general nonlinear systems, it only allows one to construct candidate functions for which the Lyapunov conditions are satisfied at some finite set of points. Thus, in the future, it is necessary to carry out verification, that is, to prove that these conditions are met for all points from the estimated area. In the current work, verification issues are not considered, it is proposed to use the dReal solver . These issues will be the subject of further research.

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ОЦЕНКА ЭФФЕКТИВНОСТИ ЭТАЛОННЫХ МОДЕЛЕЙ МАШИННОГО ОБУЧЕНИЯ ДЛЯ ПРЕДСКАЗАНИЯ ОБЪЕМА БУФЕРНОЙ ПАМЯТИ ПРИ ПРЕОБРАЗОВАНИИ САМОПОДОБНОГО ВХОДНОГО ПОТОКА ПАКЕТОВ В ПОТОК, ИМЕЮЩИЙ ЭКСПОНЕНЦИАЛЬНОЕ РАСПРЕДЕЛЕНИЕ ПРИ УСЛОВИИ РАВЕНСТВА МАТЕМАТИЧЕСКИХ ОЖИДАНИЙ И МЕДИАН ПОТОКОВ

EVALUATION OF THE EFFICIENCY OF REFERENCE MACHINE LEARNING MODELS FOR BUFFER MEMORY PREDICTION WHEN TRANSFORMING A SELF-SIMILAR INPUT STREAM OF PACKETS INTO A STREAM HAVING EXPONENTIAL DISTRIBUTION UNDER THE CONDITION OF EQUALITY OF MATHEMATICAL EXPECTATIONS AND MEDIAN FLOWS

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Аннотация

С использованием методов машинного обучения разработаны модели для предсказания размера очереди в зависимости от показателя Херста на основании данных, полученных при выполнении преобразования входного самоподобного потока, распределенного по закону Парето в поток, имеющий экспоненциальное распределение при равенстве математического ожидания и при равенстве медиан. Выполнен сравнительный анализ полученных моделей. Каждая модель исследована с использованием следующих метрик качества: коэффициента детерминации, среднеквадратичной ошибки регрессии, средней абсолютной ошибки, величины штрафа, предполагаемая величина потерь. Лучшими по выбранным метрикам качества для способов преобразования входного и выходного потока пакетов при равенстве математического ожидания являются модели, которые используют методы изотонической регрессии и опорных векторов. Для способов преобразования входного и выходного потока пакетов при равенстве медиан лучшими являются линейные модели.

Ключевые слова: Телекоммуникационная сеть, самоподобный трафик, показатель Херста, производительность, распределение Парето, потери пакетов, регрессионноый анализ, метрики качества, функция штрафа, машинное обучение.

Abstract

Using machine learning methods, models have been developed to predict the size of the queue depending on the Hurst exponent based on the data obtained when performing the transformation of an input self-similar stream distributed according to the Pareto law into a stream having an exponential distribution with equal mathematical expectation and equal medians. A comparative analysis of the obtained models is carried out. Each model was examined using the following quality metrics: coefficient of determination, rms regression error, mean absolute error, penalty value, estimated loss. Models that use isotonic regression and support vector methods are the best in terms of the selected quality metrics for methods of transforming the input and output packet streams when the mathematical expectation is equal. For methods of transforming the input and output packet stream with equal medians, linear models are the best.

Keywords
Telecommunication network, self-similar traffic, Hurst exponent, Pareto distribution, packet loss, regression analysis, quality metrics, penalty score, machine learning

Introduction. In network traffic, packets at a high speed of their movement through the network arrive at the node not individually, but as a whole bundle. Traffic in such networks has a pronounced peak character, which increases the likelihood of congestion in network nodes, which lead to buffer overflows and cause losses and / or delays [1]. To eliminate the self-similarity of network traffic, various models and traffic conversion devices are used [2], one of which is the asynchronous simulation model described in [2], for which there is a software implementation [3]. In the proposed model, the input and output flows were compared with each other in terms of the value of the mathematical expectation. In other studies [4], the transformation of the input stream of packets with a self-similar law of distribution of time intervals between packets into the Poisson law is carried out when the median of the input and output streams is equal.

Formulation of the problem. Using machine learning methods, it is necessary to develop models for predicting the queue size depending on the Hurst exponent based on the data obtained by converting an input self-similar stream distributed according to the Pareto law into a stream having an exponential distribution with equal mathematical expectation and equal medians. Perform a comparative analysis of the obtained models and choose the best one.

Since machine learning includes many methods, at the initial stage, for further comparison with more complex models built, in particular, using deep learning methods, it is advisable to consider only the methods of paired regression analysis, isotonic regression and support vector machines.

As a quality metric (penalty), we will use a complex indicator [5], which takes into account both packet losses in the process of traffic conversion and inefficient use of buffer space.

Let's carry out a comparative analysis of the obtained models to predict the queue size, depending on the Hurst exponent of the input stream according to the following quality metrics:

determination coefficient;

rms regression error;

mean absolute error;

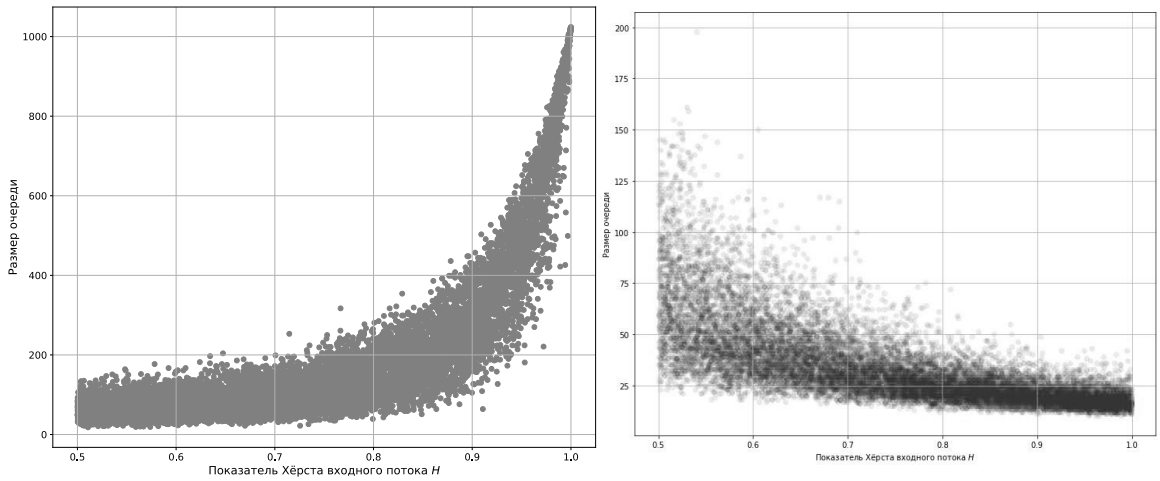
the amount of the fine;

estimated loss;

performance.

The solution of the problem. The computer program presented in [6] provides the transformation of the input stream of packets, which is obviously self-similar, into a given distribution law, in particular, into an exponential one. The object of the transformation is the one-dimensional density of the distribution of time intervals between packets of the input stream. Using the developed model, 11,000 tests were carried out and data were obtained for statistical analysis.

Initial data analysis. Figure 2 shows the scatterplots of the dependence of the queue size on the Hurst exponent for the cases of equal mathematical expectation and equal median input and output packet streams. The figure clearly shows that there is a certain correlation between the Hurst exponent and the amount of buffer memory. The level of significance in statistics is an important indicator that reflects the degree of confidence in the accuracy and truth of the received (predicted) data. A large volume of tests allows not to calculate p - the significance level, because, as practice shows, in this case p - the value is much less than 0.05 [7].



a) b)

Figure 2. Scatterplot of the dependence of the queue size on the Hurst exponent

Let us preliminarily group the tests according to the value of the Hurst exponent. Let's single out 30 groups to estimate the spread of the queue size.

Linear machine learning model. The relationship between the Hurst exponent *H* and the queue size is $\hat{y}$ determined according to the linear equation:

$$\hat{y} = b_0 + b_1 H.$$

Using the least squares method, we obtain the regression equations for the input and output flows compared by the median (1), for the flows compared by the mathematical expectation (2):

$$\hat{y} = 107{,}79236 - 97{,}874061 \cdot \mathrm{H} \quad (1)$$

$$\hat{y} = -611{,}182635 + 1077{,}442810 \cdot H \quad (2)$$

Table 1 shows the quality metrics of the obtained linear models for the methods of converting the input and output stream of packets when the medians and mathematical expectations are equal.

Table 1. Linear regression model quality metrics

Quality Metrics	mathematical expectation is equal	if the medians are equal
Determination coefficient R2	0.584792	0.49081
RMSE Regression Root Mean Square Error	130.908538	14.42016
Mean absolute error MAE	96.808209	9.95253
Estimated amount of the fine	55.710275	4.97626
Estimated loss	48.404104	4.976265

The obtained value of the coefficient of determination for flows matched by mathematical expectation suggests that 58% of the cases of changes in the Hurst exponent lead to a change in the queue size within the linear model.

The obtained value of the determination coefficient for flows compared by the median suggests that only about 49% of cases of changes in the Hurst exponent lead to a change in the queue size within the linear model.

Transforming a packet stream using median equality is less well described than transforming using expectation. This is due to the fact that the spread of buffer memory values when using the equality of medians is greater than when using mathematical expectations. However, the implied penalty and implied loss of the equal median method are much lower than those of the equal mean method.

Linear machine learning model in rectifying space. In general, the results obtained are unsatisfactory for practice, therefore, in the simplest case, it makes sense to consider other methods using the methods of linearization of nonlinear dependencies. As a result, the nonlinear dependence can be reduced to a linear one, and then the least squares method can be used.

Machine learning model based on hyperbolic regression. For hyperbolic regression, the relationship between H and $\hat{y}$ can be described as follows:

$$\hat{y} = b_0 + \frac{b_1}{H}.$$

Linearization of the hyperbolic equation is achieved by replacing $\frac{1}{H}$ it with a new variable, which we denote by z [7, 8]. Then the hyperbolic regression equation will take the form $\hat{y} = b_0 + b_1 z$.

Using the least squares method, we obtain the regression equations for the input and output flows compared by the median (3), for the flows compared by the mathematical expectation (4):

$$\hat{y} = 875{,}438 - \frac{489{,}379}{H} \quad (3)$$

$$\hat{y} = -38{,}443 + \frac{52{,}524}{H} \quad (4)$$

Table 2 shows the quality metrics of the obtained hyperbolic regression models for the methods of converting the input and output stream of packets when the medians and mathematical expectation are equal in relation to the initial data .

Table 2. Metrics of the quality of the hyperbolic regression model

Quality Metrics	if the mathematical expectation is equal	if the medians are equal
Determination coefficient R2	0.453263	0.53129
RMSE Regression Root Mean Square Error	150.218740	13.83514
Mean absolute error MAE	110.511548	9.29888
Estimated amount of the fine	63.841249	4.64944
Estimated loss	55.25577	4.649444

The obtained value of the coefficient of determination for flows matched by mathematical expectation suggests that about 45% of the cases of changes in the Hurst exponent lead to a change in the queue size. This is much worse than the value of the coefficient of determination of the linear model.

The obtained value of the coefficient of determination for flows compared by the median suggests that about 53% of the cases of changes in the Hurst exponent lead to a change in the queue size. This is better than the value of the coefficient of determination of the linear model.

The transformation of a stream of packets using the equality of the median for this model is described better than the transformation using the mathematical expectation.

The estimated penalty and the estimated loss of the equal median method are also significantly better than the equal mean method.

In general , the results obtained are unsatisfactory for practice, and for this reason it makes sense to consider another hyperbolic regression model:

$$\hat{y} = \frac{1}{b_0 + b_1 H}.$$

Using the least squares method, we obtain for this model the regression equations for the input and output flows compared by the median (5), for the flows compared by the mathematical expectation (6):

$$\hat{y} = \frac{1}{(-0{,}029806 + 0{,}0894069 \cdot \mathrm{H})} \tag{5}$$

$$\hat{y} = \frac{1}{0{,}039996 - 0{,}039720 \cdot H}. \tag{6}$$

Table 3 shows the quality metrics of the modified hyperbolic regression model for the methods of transforming the input and output packet streams with the equality of medians and mathematical expectation in relation to the original data.

Table 3. Quality metrics of the modified hyperbolic model

Quality Metrics	if the mathematical expectation is equal	if the medians are equal
Determination coefficient R2	0.591293	0.60839
RMSE Regression Root Mean Square Error	223.798030	14.24760
Mean absolute error MAE	77.543626	8.97085
Estimated amount of the fine	39.537133	6.14195
Estimated loss	28.189645	6.141958

The obtained value of the coefficient of determination for flows matched by mathematical expectation is about 59%, which is somewhat better than the linear model.

The obtained value of the coefficient of determination for flows compared by the median is about 61%, which is better than the linear model.

The transformation of the packet stream using the median equality for this model is described slightly better than the transformation using the mathematical expectation.

The estimated penalty and the estimated loss of the equal median method are also significantly better than the equal mean method.

Power regression. In the case of power regression, the relationship between H and $\hat{y}$ looks like:

$$\hat{y} = b_0 H^{b_1}.$$

This equation is non-linear in coefficient b_1 and belongs to the class of regression models that can be brought to a linear form with the help of transformations [7]

$$\ln y = \ln b_0 + b_1 \ln H.$$

The exponential function is intrinsically linear, so estimates of the unknown parameters of its linearized form can be calculated using the classical least squares method. The regression equations for the input and output flows compared by the median (7), for the flows compared by the mathematical expectation (8) have the form:

$$\hat{y} = 16{,}37597 * \mathrm{H}^{-1{,}97664} \quad (7)$$

$$\hat{y} = 401{,}143661 \cdot H^{3{,}596636} \quad (8)$$

Table 4 shows the quality metrics of the obtained power regression models for the methods of converting the input and output packet streams when the medians and the mathematical expectation are equal in relation to the initial data.

Table 4. Quality metrics of the power regression model

Quality metrics	if the mathematical expectation is equal	if the medians are equal
Determination coefficient R2	0.699138	0.61908
RMSE Regression Root Mean Square Error	128.675573	13.94731
Mean absolute error MAE	72.823850	8.94776
Estimated amount of the fine	53.042530	5.418426
Estimated loss	51.394345	5.418426

The obtained value of the coefficient of determination for flows matched by mathematical expectation is 70%, which is much better than the coefficient of determination of the linear model.

The obtained value of the coefficient of determination for flows compared by the median is 61%, which is much better than the coefficient of determination of the linear model.

The transformation of the packet stream using the equality of the median for this model is described worse than the transformation using the mathematical expectation. However, the estimated penalty and the estimated loss of the equal median method are also significantly better than the equal mean method.

Exponential regression. For exponential regression, the relationship between H and $\hat{y}$ has the form:

$$\hat{y} = b_0 e^{b_1 H}.$$

This equation is non-linear in coefficient b_1 and belongs to the class of regression models, which are reduced to a linear form with the help of transformations [7, 8]:

$$\ln \hat{y} = \ln b_0 + H \ln b_1.$$

The exponential function is intrinsically linear, so estimates of the unknown parameters of its linearized form can be calculated using the classical least squares method. The regression equations for the input and output flows compared by the median (9), for the flows compared by the mathematical expectation has the form (10):

$$\hat{y} = 225{,}66610 \cdot \mathrm{e}^{-2{,}68865\,\mathrm{H}} \quad (9)$$

$$\hat{y} = 2{,}926343 \cdot e^{5.089127 \cdot H} \quad (10)$$

Table 5 shows the quality metrics of the obtained exponential regression models for the methods of transforming the input and output packet streams when the medians and the mathematical expectation are equal in relation to the initial data.

Table 5. Quality metrics of the exponential regression model

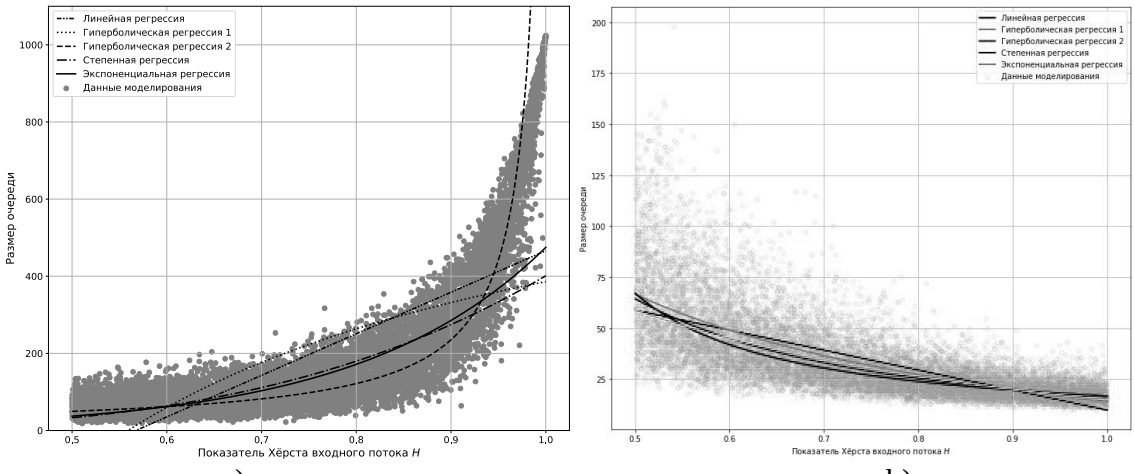
Quality Metrics	if the mathematical expectation is equal	if the medians are equal
Determination coefficient R2	0.745779	0.60997
RMSE Regression Root Mean Square Error	112.443773	14.18827
Mean absolute error MAE	65.199678	9.04531
Estimated amount of the fine	46.768626	5.52332
Estimated loss	45.25324	5.5233289

The obtained value of the coefficient of determination for flows matched by mathematical expectation suggests that about 74% of cases of changes in the Hurst exponent lead to a change in the queue size within the framework of the exponential model, which is the best result when using the methods of paired regression analysis.

The obtained value of the determination coefficient for flows compared by the median suggests that about 61% of the cases of changes in the Hurst exponent lead to a change in the queue size within the framework of the exponential model .

Let's carry out a comparative analysis of the results obtained for the methods of converting the input and output stream of packets when the medians and the mathematical expectation are equal . Let's build graphs of regression equations (Figure 4). Obviously, for flows matched by mathematical expectation , exponential regression and power regression most closely describe the relationship between the Hurst exponents and the buffer volume.

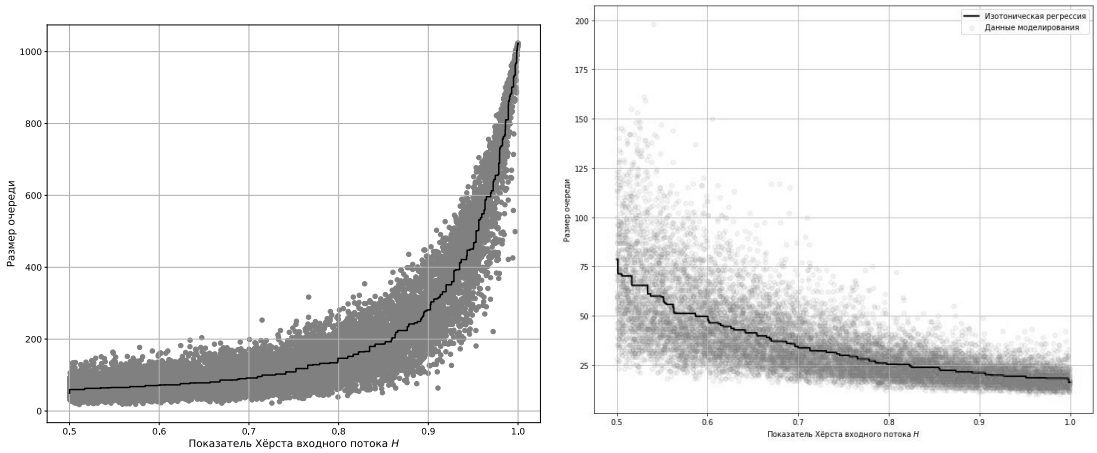
For streams matched by median, exponential regression is also used, power regression most closely describes the relationship between Hurst exponents and buffer volume



a) b)

Figure 4. Comparative analysis of the results of paired regression analysis
a) when the mathematical expectation of the input and output flows is equal b) when the medians of the input and output flows are equal

Isotonic regression. Let's train the isotonic regression model using the scikit - learn package of the Python 3 programming language [9-11]. Let's build graphs corresponding to the model built using isotonic regression for the methods of converting the input and output stream of packets when the medians and the mathematical expectation are equal (Fig. 5)



a) b)

Figure 5. Construction of an isotonic curve in relation to a data set

Table 6 shows the quality metrics of the obtained regression models for the methods of converting the input and output packet streams when the medians and the mathematical expectation are equal in relation to the initial data.

Table 6. Isotonic regression quality metrics

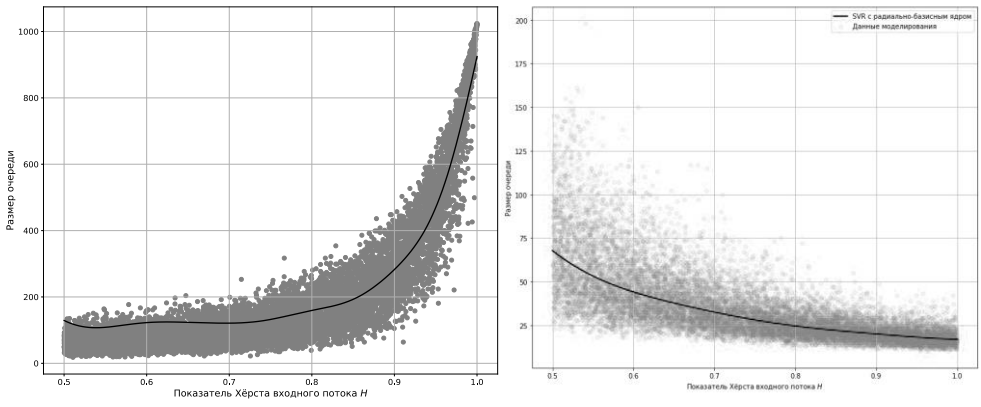
Quality metrics	f the mathematical expectation is equal	if the medians are equal
Determination coefficient R2	0.928199	0.54490
RMSE Regression Root Mean Square Error	54.437567	13.63279
Mean absolute error MAE	39.500659	9.06566
Estimated amount of the fine	21.269167	4.53284
Estimated loss	19.75032	4.5328338

The obtained value of the determination coefficient for flows compared by mathematical expectation suggests that about 92% of the cases of changes in the Hurst exponent lead to a change in the queue size within this model, which is much better than models built on the basis of pair regression methods. At the same time, the penalty value for isotonic regression is two times less than the corresponding value for pairwise regression.

The obtained value of the determination coefficient for flows compared by the median suggests that about 54% of the cases of changes in the Hurst exponent lead to a change in the queue size within this model, which is much worse than models built on the basis of paired regression methods. At the same time, the amount of the fine and the expected amount of losses for isotonic regression is slightly less than the corresponding value for pairwise regression.

Support vector machine. Let's train the model based on SVR . The non-linear nature of the relationship between the Hurst exponent and the queue size indicates the need to choose a radial basis kernel for the SVR model . This model was trained using the scikit - learn package of the Python 3 programming language [9, 12]. On fig. 6 shows the graphs of the relationship between the queue size and the Hurst exponent corresponding to the trained SVR model for methods of con-

verting the input and output stream of packets when the medians and the mathematical expectation are equal



a) b)

Figure 6. Graph corresponding to the trained model by the support vector machine method

Table 7 shows the quality metrics of the obtained models using SVR for the methods of converting the input and output packet streams when the medians and the mathematical expectation are equal .

Table 7. Quality metrics of the support vector model

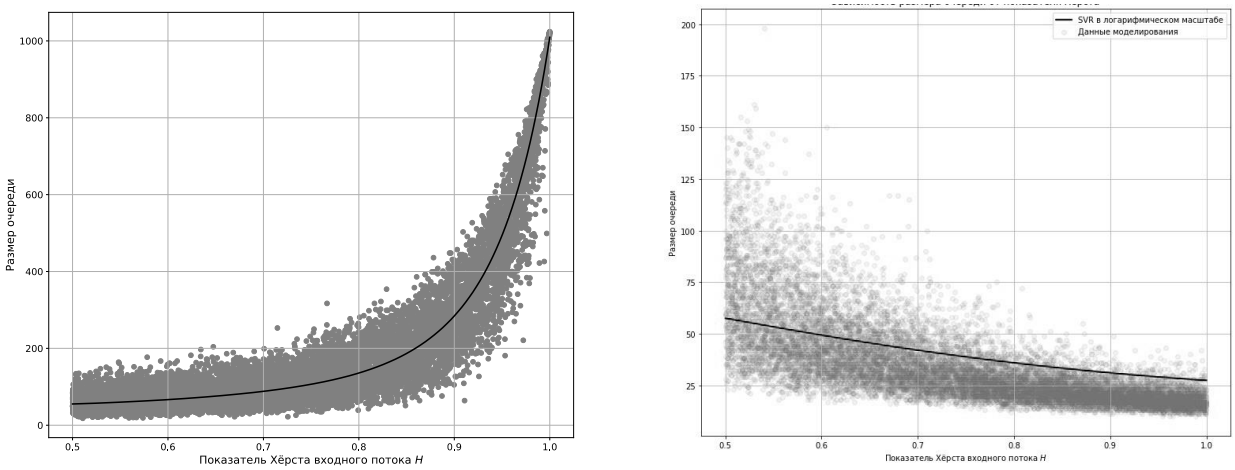
Quality Metrics	if the mathematical expectation is equal	if the medians are equal
Determination coefficient R2	0.901167	0.52283
RMSE Regression Root Mean Square Error	63.868307	13.95936
Mean absolute error MAE	52.506259	8.91937
Estimated amount of the fine	18.374489	5.59611
Estimated loss	15.43061	5.5961137

The obtained value of the coefficient of determination for flows matched by mathematical expectation is about 90%, which is slightly worse than that of the method using isotonic regression. However, the penalty for this method is less than in the case of isotonic regression.

The obtained value of the coefficient of determination for flows matched by median is about 52%, which is slightly worse than that of the method using isotonic regression and worse than that of models built on the basis of paired regression methods. The penalty for this method is greater than for isotonic regression.

Based on the nature of the relationship between the queue size *QS* and the Hurst exponent *H* , it is advisable when using SVR to evaluate not the value of *QS* , but the value of $\ln(QS+1)$, thus passing to the rectifying space.

Let's train the model based on SVR using the scikit-learn package of the Python 3 programming language [9, 12]. On fig. Figure 7 shows the dependency graphs of the queue size and the Hurst exponent corresponding to the trained support vector model with the transition to the rectifier space for the methods of transforming the input and output packet stream with the equality of medians and mathematical expectation.



a) b)

Figure 7. Graph corresponding to the trained model by the support vector machine method in relation to the data set

Table 8 shows the quality metrics of the resulting model using SVR on a logarithmic scale for the methods of transforming the input and output packet streams with equal medians and mathematical expectation in relation to the original data.

Table 8. Quality metrics of the support vector machine model on a logarithmic scale

Quality Metrics	if the mathematical expectation is equal	if the medians are equal
Determination coefficient R2	0.923960	0.36051
RMS error RMSE regressions	56.021631	16.16018
Mean absolute error MAE	39.583393	12.87457
Estimated amount of the fine	21.724137	3.58006
Estimated loss	19.950616	3.580060

The obtained value of the coefficient of determination for the flows compared according to the mathematical expectation is about 92%, which practically coincides with the isotonic regression method. However, the value of the penalty in this case is less than for the SVR method , so the transition to the direct space did not lead to an improvement in the quality of training based on the values of the introduced quality metric, which is the penalty.

The obtained value of the coefficient of determination for flows matched by median is about 36%, which is much lower compared to the isotonic regression method and much worse than the models built on the basis of pair regression methods. However, the amount of the fine and the estimated amount of losses in this case, less than for the SVR method .

Comparative analysis of models. The results of the study are presented in a comparative table. 9 to evaluate and select the best method for predicting the queue size by the value of the Hurst exponent for the methods of converting the input and output packet streams when the medians and the mathematical expectation are equal .

Based on the data of the pivot table, it can be concluded that the best predictive ability based on the introduced quality metric for the method of converting the input and output packet streams when the mathematical expectation is equal is the model built using the support vector machine.

For the method of converting the input and output stream of packets with equal medians, the best results were obtained using power regression.

Within the framework of this study, we can conclude that the method of transformation using the median is better described by linear laws, and the method of transformation using the mathematical expectation by nonlinear laws.

Table 9. Comparative characteristics of regression methods at $0.5 < H < 1$

	Estimated amount of the fine		Estimated loss		Performance	
	mat. expected	median	mat. expected	median	mat. expected	median
Linear Regression	55.710275	4.976265	48.404104	4.976265	0.952730	0.995140
Hyperbolic regression 1	63.841249	4.649445	55.25577	4.649444	0.946039	0.995459
Hyperbolic regression 2	39.537133	6.141958	28.189645	6.141958	0.972471	0.994001
Power Regression	53.042530	5.418427	51.394345	5.418426	0.949810	0.994708
Exponential Regression	46.768626	5.523329	45.25324	5.5233289	0.95580	0.994606
Isotonic regression	21.269167	4.532848	19.75032	4.5328338	0.980712	0.995573
SVR	18.374489	5.596114	15.43061	5.5961137	0.984931	0.994535
SVR on a logarithmic scale	21.724137	3.580060	19.950616	3.580060	0.980516	0.996503

Conclusions. Thus, eight models have been studied that allow predicting the queue size when converting an input stream with a Pareto distribution to an output stream with an exponential distribution, depending on the Hurst exponent of the input stream, based on machine learning methods for converting the input and output stream of packets with equality medians and mathematical expectation .

Since the value of losses in the general case does not give any information about the efficiency of using the queue in the process of traffic conversion, a penalty is introduced to assess the quality of the resulting model, which takes into account not only the value of losses, but also the irrational use of buffer memory.

Each model was studied using the following quality metrics: coefficient of determination, regression mean square error, mean absolute error, penalty value, expected loss value.

The best in terms of the selected quality metrics for the methods of converting the input and output stream of packets when the mathematical expectation is equal are the models that use the methods of isotonic regression and support vectors.

For methods of transforming the input and output stream of packets with equal medians, linear models are the best.

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ОЧИСТКА ИЗОБРАЖЕНИЙ ОТ ИМПУЛЬСНЫХ ПОМЕХ В ДВОИЧНОМ СИММЕТРИЧНОМ КАНАЛЕ СВЯЗИ

CLEANING IMAGES FROM IMPULSE NOISE IN A BINARY SYMMETRICAL CHANNEL

Региональный научно-образовательный математический центр «Северо-Кавказский центр математических исследований» / Regional Scientific and Educational Mathematical Center "North Caucasus Center for Mathematical Research

Аннотация

В работе предложен новый метод очистки незакодированных изображений от импульсных помех в двоичном симметричном канале связи, где при возникновении ошибки, бит информации повреждается и пиксели изображения принимают искаженные значения. Характеристика такого шума соответствует импульсному шуму, где импульсные помехи принимают случайные значения и распределены по изображению случайно. Пиксели определяются как искаженные при помощи оценки разницы между пикселями внутри локального окна. При этой оценке учитывается значение яркостей и удаленность пикселей внутри локального окна. Восстановление изображений выполняется с помощью адаптивной медианной фильтрации.

Ключевые слова: импульсный шум, двоичный симметричный канал связи, медианный фильтр, цифровая обработка изображений, адаптивная фильтрация.

Abstract

The paper proposes a new method for cleaning uncoded images from impulse noise in a binary symmetric channel, where, when an error occurs, the information bit is distorted and the image pixels take incorrect values. The characteristic of such noise cnuorresponds to impulse noise, where impulse noise takes on random values and is randomly distributed over the image. Pixels are determined to be distorted by evaluating the difference between pixels within the local window. This estimate takes into account the brightness value and the distance of pixels within the local window. Image recovery is performed using adaptive median filtering.

Keywords: impulse noise, binary symmetric channel, median filter, digital image processing, adaptive filtering.

Introduction

Images, as one of the forms of information presentation, which are transmitted as messages over communication channels, are subject to interference [1]. When transmitting uncoded images over a communication channel, for example, represented as a model of a binary symmetric communication channel, each bit can be distorted with a certain probability [2]. If at least one bit of the image is distorted, interference occurs that distorts the pixel values. Pixel distortion with a certain probability in a binary symmetric communication channel is similar to impulse noise. Noisy images can negatively affect the operation of various digital image processing algorithms, for example, real-time object recognition, as well as incorrectly display data received from medical or seismological sensors [3].

The problem of restoring an image from impulse noise consists of the problem of finding impulse noise and the problem of restoring a distorted pixel. One of the simple and effective methods for removing impulse noise from images is median filters. But the standard median filter leads to blurring of the image, so modifications of the median filter have been proposed by various authors. One of the modifications that greatly reduced the negative effect of blurring is adaptive median filtering. In adaptive median filters, pixels that are not impulsive noise remain untouched, changes are made only for pixels that have been identified as noisy [4].

The complexity of the pixel detection task depends on the impulse noise model. In the “salt and pepper” impulse noise model, where the distorted pixels take two values: an impulse with minimum and maximum brightness, the detection task is usually not worth it at all. To date, a number of methods for cleaning and detecting impulse noise are known. In [5], a method was developed to clean the image from impulse and Gaussian noise, which is a modification of the bilateral filter for determining distorted impulses. The work [6] describes a method that offers an improvement to the method of [5] and uses a logarithmic function and threshold transformations for this. The paper [7] also describes a comparison of methods [5] and [6] and proposes a method that is another modification of the method [5]. The method introduces a new statistic of the local consensus index, which is calculated by summing up all the similarity values of pixels in its vicinity and finding the value of the central element.

In this paper, we will consider a model for transmitting images through a binary symmetric communication channel (BSC). It will be shown that the characteristics of the noise that occurs in the DSC correspond to the random -valued impulse noise model. The detector of distorted pixels in the image is based on the estimation of the difference between the pixels. Image distortion in a binary symmetric communication channel / distortion of images in a binary symmetrical channel . A channel with a binary input and a binary output, where the probabilities of error and correct transmission are equal, is called a binary symmetric channel. Since each output binary symbol of a channel depends only on the corresponding input binary symbol, we say that this channel is memoryless. Signals can be transmitted via dsk , for example, 0 or 1. Transmission in such a communication channel is not ideal, because of this, the receiving signal with a certain probability p may receive an error, which consists in replacing the sign of 1 with 0 or 0 with 1.

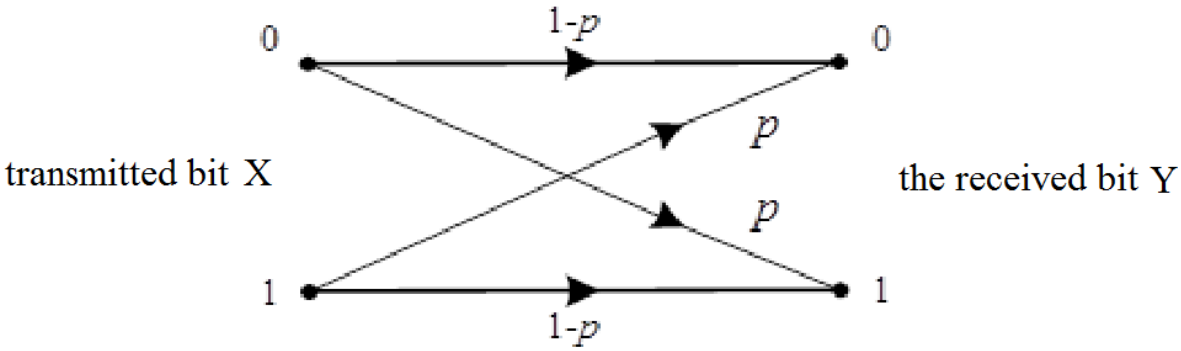


Figure 1. Diagram of a binary symmetrical channel

Figure 1. Shows the DSC scheme p - the probability of error, $1-p$ - the probability of correct transmission.

DSC has input and output signal $X \in \{0,1\}$ and $Y \in \{0,1\}$, hence

$$p(X \mid Y) = \begin{cases} 1-p, & \text{if } X = Y \\ p, & \text{if } X \neq Y \end{cases} \quad (1)$$

Distorted signals in DSC arise as a result of noise. Interference is understood as any random effect on the signal in the communication channel that prevents the correct reception of signals. In communication channels, there are both additive interference, i.e., random processes superimposed on the transmitted signals, and multiplicative interference, expressed in random changes in the channel characteristics.

Additive interference contains three components: concentrated in frequency (harmonic), concentrated in time (impulse) and fluctuation . Impulse interference is a sequence of short-term pulses separated by intervals exceeding the time of transients in the channel. The causes of impulse interference are: the influence of lightning discharges on communication lines; influence of power lines on communication lines; poor contacts in transmission and power equipment; short-

comings in the development and manufacture of equipment; operational reasons, etc. Shortcomings in the development and manufacture of equipment lead to the fact that impulse noise occurs during voltage surges in the supply network or switching from the main elements to the backup ones. Digital data is often transmitted as a sequence of binary numbers (bits of information). During transmission, noise can distort the original message. The model consists of a transmitter capable of sending a binary signal and a receiver.

Data transmission in DSC can be described by the Bernoulli scheme. Let Δ be a random variable that counts the number of failures. Then, according to the Bernoulli scheme, the probability of k errors in the transmission of n bits through the BSC is equal to

$$p(\Delta = k) = \binom{n}{k} p^{n-k} q^k \tag{2}$$

where n is the bit depth of the image pixel, p is the probability of distortion of one bit in the DSC. Based on (2), the density of impulse noise in the image in accordance with the bit depth of the image and the probability of bit distortion is

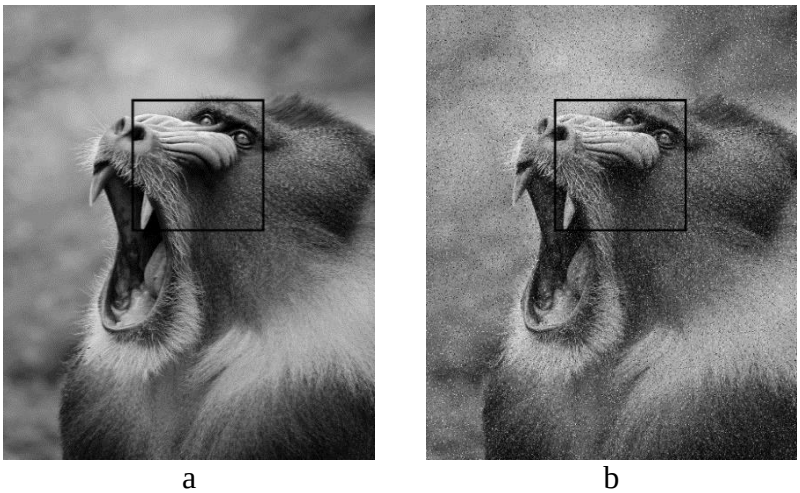
$$\rho = 1 - p^{n-k} \tag{3}$$

Table 1 shows the density of impulse noise ρ in the image in accordance with the probability of bit distortion p .

Table 1. Impulse noise density ρ in the image

Bit distortion probability , p	Pixel bit depth, n			
	eight	12	16	24
0,01	0,077	0,114	0,148	0,214
0,05	0,337	0,4 60	0,560	0,708
0,10	0,570	0,718	0,815	0,920

Consider an image in which errors occurred during transmission through a binary symmetric communication channel. Figure 2 shows a grayscale image where $p = 0.01, 0.05, 0.1$ every bit of the image is likely to be corrupted. The paper presents 8-bit images. The frame highlights the fragments that are considered in the approximation.



a b

Figure 2. Image used in simulation: a) original image; b) distorted image $p = 0,5$;

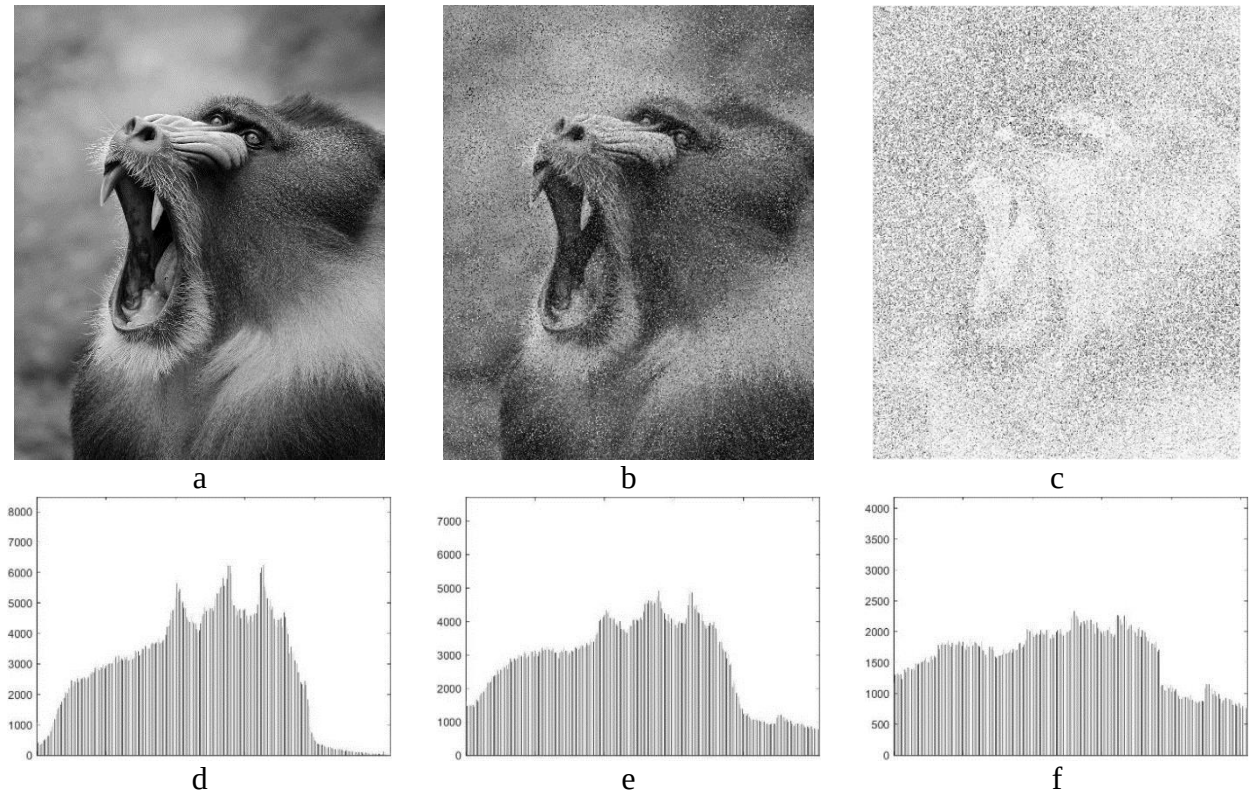


Figure 3. An example of image distortion transmitted via DSC:
a) the original undistorted image; b) image distorted by impulse noise; c) the location of impulse noise in the image; d) the distribution of pixel brightness in the undistorted image; e) distribution of pixel brightness in a distorted image; f) the distribution of the brightness of impulse noise in the image.

Figure 3 shows the distribution of pixels in an uncoded image transmitted via DSC. The figure shows that the distribution of distorted pixels and their brightness is close to uniform. Random in value and location in the image noise that is uniformly distributed corresponds to the characteristics of random -valued impulse noise. If the least significant digits of a bit are damaged, the distorted pixels take on values close to the original ones. Therefore, *in* Figure 3c , where only distorted noise values are presented, the silhouette of the original image is visible. To eliminate this type of noise impact, cleaning methods based on median filtering are suitable.

Method for detecting and cleaning random -valued impulse noise / Method for detection and cleaning random - valued impulse noise

Let digital images be represented by a set of pixels with intensity values $x_{i,j}$ whose coordinates (i, j) vary over some subset Z^2, where Z is the set of integers.

In the proposed method, on a noisy image, it is necessary to determine whether a pixel bit has been distorted. To do this, we introduce an estimate of the difference between pixels in the local window. The score is based on two parameters:

1) Parameter difference brightness pixels , which we offer count on formula

2)

$$V(i,j) = 1 + \{\log_2 \left| x_{i,j} - x_{a,b} \right| - 8, -8\},\ x_{a,b} \in \Omega_{x_{i,j}}. \qquad (4)$$

Next, sort U and sum the first $m/2$ elements, where m is the number of elements in the local window Ω:

$$A_m(x_{i,j}) = \sum_{l=1}^{m} V_l(x_{i,j}). \qquad (5)$$

3) Parameter geometric distance based _ on the Euclidean metric , which defines difference between pixels in local window Ω

$$B(x_{i,j}, x_{a,b}) = \exp\left(-\left\|x_{i,j} - x_{a,b}\right\|^2 / (2\alpha_B^2)\right), \quad (6)$$

where *(i , j)* and *(a , b)* denote pixel coordinates. The parameter α controls $B(x_{i,j}, x_{a,b})$ relative to the geometric distance.

As a result, the similarity parameters between two pixels are obtained, based on the geometric distance and the difference in brightness of the pixels in the detector window, with which you can get an estimate of the difference between the pixels C:

$$C(x_{i,j}, x_{a,b}) = A(x_{i,j}, x_{a,b}) \cdot B(x_{i,j}, x_{a,b}). \quad (7)$$

The similarity score under formula (7) forms an array of values, where, using a certain threshold T, it is possible to determine whether a pixel is an impulse. In the proposed method, the optimal threshold value for $T = 20$. Therefore, if the C value in the array is greater than the threshold value, then the image pixel is an impulse.

We propose to use the filter mask of the following form, which is shown in Figure 4. The distance between pixels in the local window is proposed to be determined by the Euclidean metric (L_2) [8]. The distance $R\left(x_{ij}, x_{ab}\right)$ between pixels x_{ij} and x_{ab} in the metric L_2 is determined by the formula

$$R\left(x_{ij}, x_{ab}\right) = \sqrt{(i-a)^2 + (j-b)^2}.$$

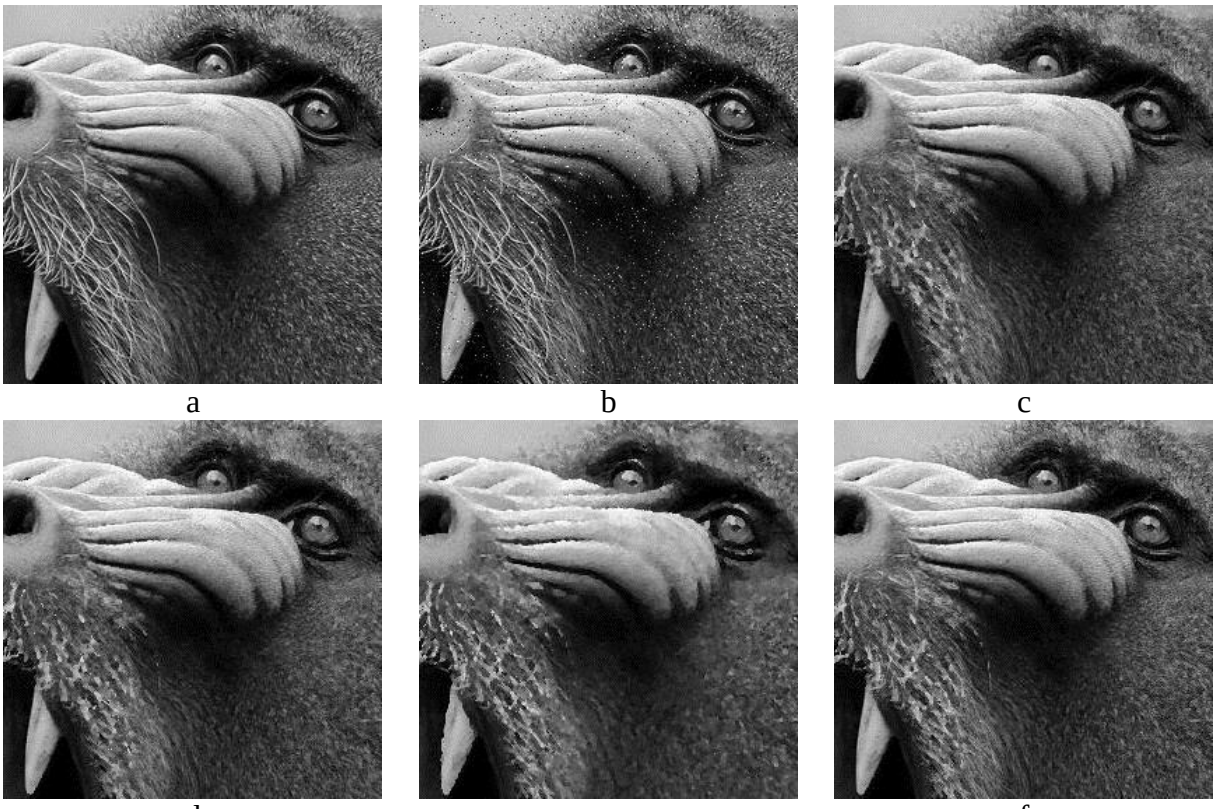
2	1	2
1		1
2	1	2

Figure 4. Local window Ω. The squares of distances defined by the Euclidean metric are inscribed in the pixel cells L_2.

For pixels defined as distorted in the local area Ω, an array of undistorted pixels is formed, in which the median is calculated. The resulting median value is assigned to the distorted pixel.

Results

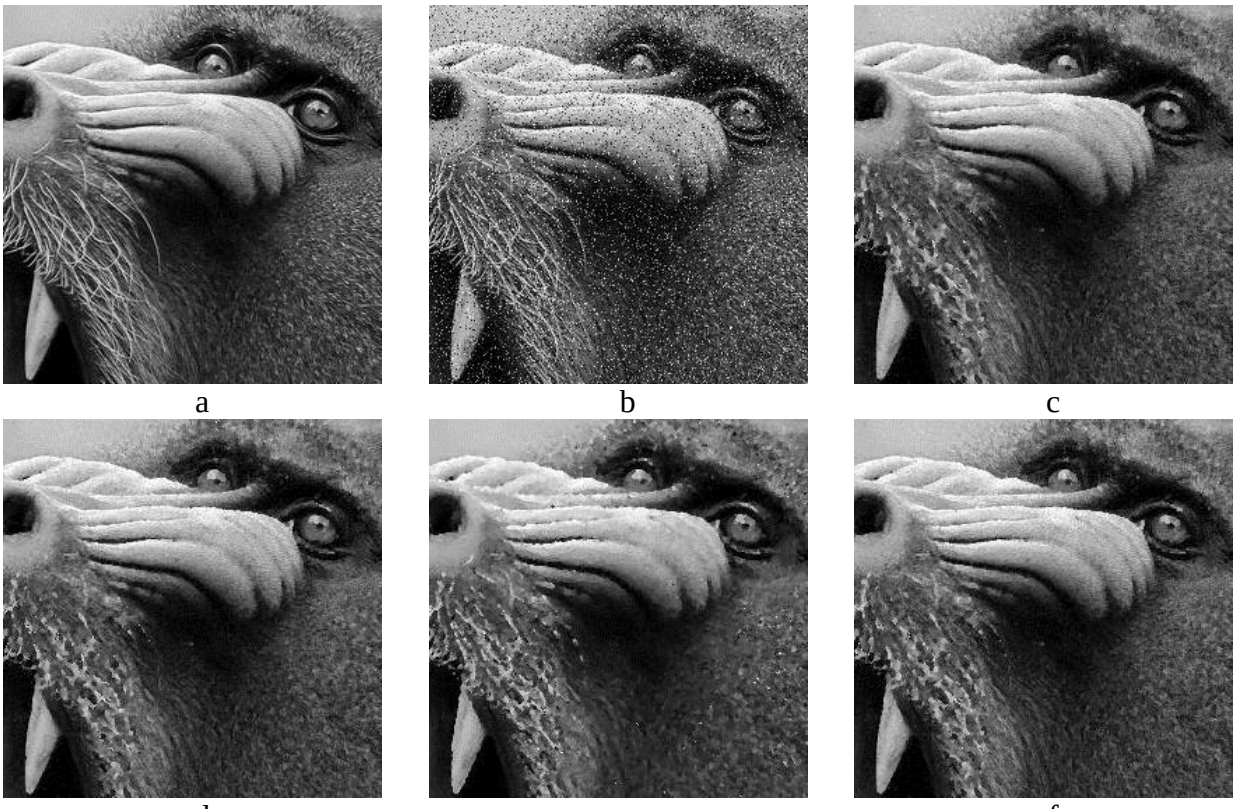
For modeling, an 8-bit grayscale image was used, which is shown in Figure 2. Image resolution is 944 by 768 pixels. In the image, each bit c is distorted with probabilities $p = 0.01, 0.05, 0.1$. The peak signal-to-noise ratio (PSNR) [9] and structural similarity index (SSIM) [10] were used to determine the quality of image processing. The results of the experiment are presented in tables 1 and 2. In fig. 5-7 for clarity of the quality of processing, the original, distorted and restored images are shown.



a b c

d e f

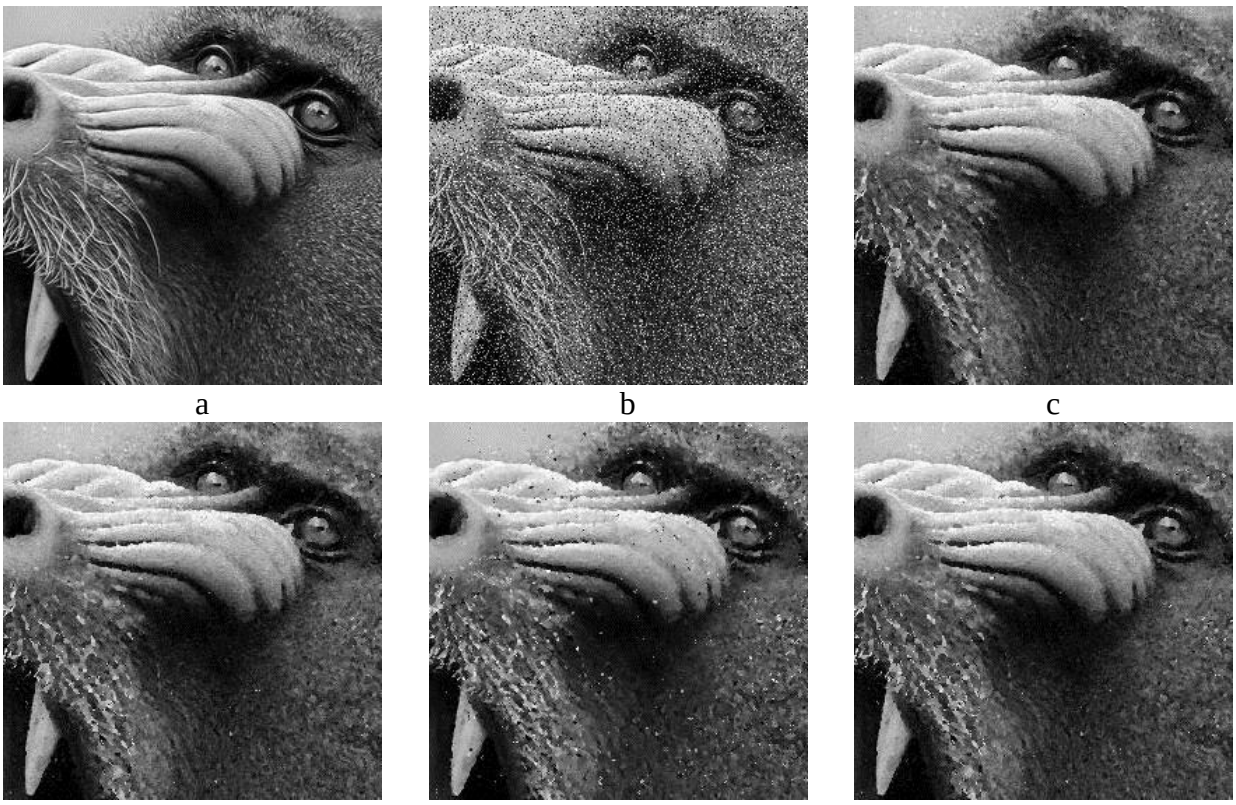
Figure 5. a) Fragment of the original image; b) a fragment of the image transmitted via DSC (p=0.01); c) the result of restoration by the method [5]; d) the result of restoration by the method [6]; e) the result of restoration by the method [7]; f) the result of recovery by the proposed method;



a b c

d e f

Figure 6. Fragment of the original image; b) a fragment of the image transmitted via DSC (p=0.05); c) the result of restoration by the method [5]; d) the result of restoration by the method [6]; e) the result of restoration by the method [7]; f) the result of recovery by the proposed method;



a b c

d e f

Figure 7. Fragment of the original image; b) a fragment of the image transmitted via DSC (p=0.1); c) the result of restoration by the method [5]; d) the result of restoration by the method [6]; e) the result of restoration by the method [7]; f) the result of recovery by the proposed method;

Tab. Fig . 2. PSNR values for various methods of image cleaning from impulse noise.

Bit corruption probability, p	Known Methods			Suggested method
	[5]	[6]	[7]	
0,01	27, 254	26,866	25,661	**28,06 3**
0,05	25,723	25,601	25,200	**25,770**
0,10	24,146	**24,152**	23,244	24,138

Tab. Fig. 3. SSIM values for various methods of cleaning images from impulse noise.

Bit corruption probability, p	Known Methods			Suggested Method
	[5]	[6]	[7]	
0,01	0,901	0,891	0,795	**0,916**
0,05	0,762	0,776	**0,781**	0,775
0,10	0,609	0,637	**0,671**	0,646

The simulation showed the effectiveness of the proposed method. In tables 2-3, the best results among the considered methods are highlighted in bold. For the probability of bit distortion $p = 0,01$, the superiority of the proposed method can be traced. For the bit distortion probability, $p = 0,05$the proposed method is inferior in performance to SSIM . For the probability of bit distortion $p = 0,1$, the proposed method takes values close to the best.

Conclusion

The paper considers the transmission of images through a binary symmetric communication channel, where, with a certain probability, each bit of the image was distorted. The distribution of distortions in the image showed that the noise, random in value and location in the

image, which is uniformly distributed, corresponds to the characteristics of random -valued impulse noise. A method was proposed for detecting and cleaning distorted pixels in images, which is based on estimating the difference between pixels in terms of brightness and geometric distance of pixels in the local window. The distances in the local window are defined by the Euclidean metric.

In the simulation, using the SSIM and PSNR characteristics, it was shown that the proposed method effectively coped with the task of denoising. The proposed method can be used, for example, in video surveillance systems, in data transmission using digital television technology in data networks using the IP protocol. And also in communication channels where weather conditions distort signals.

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МЕТОД БАЛАНСИРОВКИ НАГРУЗКИ ВЫЧИСЛИТЕЛЬНОГО КЛАСТЕРА ЦЕНТРА ОБРАБОТКИ ДАННЫХ

METHOD OF LOAD BALANCING FOR COMPUTER CLUSTER OF DATA PROCESSING CENTER

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Аннотация

В статье представлено описание метода балансировки нагрузки вычислительного кластера центра обработки данных (ЦОД) в основу которого положен вероятностный подход упреждающего прогнозирования состояний пакетного трафика, сформированный на основе результатов его статистического, нелинейного и спектрального анализа. Фрактальные свойства сетевого трафика являются обоснованием возможности предсказания, позволяют с достаточно большой вероятностью прогнозировать появление на отдельных временных интервалах всплесков и спадов его активности, выявление периодов возможной перегрузки серверов и сетевого оборудования и делают возможным разработку методов эффективного планирования и распределения задач внутри ЦОД, обеспечение статистически равномерной загрузки его функциональных элементов. Спектральный анализ временного ряда проводится по нормированным отклонениям фактических уровней от сглаженных. Отсутствие существенных пиков спектральных оценок говорит об отсутствии периодических колебаний. Показано, что суммирование циклов разного периода динамики временного ряда, основанное на использовании наиболее значимых гармониках спектра, определяет моменты возникновения последующих аномалий его развития. В основу процесса выявления существенных гармоник спектра положено исследование его спектральной плотности мощности с помощью преобразования Фурье. Разработанный метод способен обеспечить решение задачи эффективного планирования и распределения задач вычислительного кластера ЦОД с целью оптимизации использования ресурсов, ускорения времени выполнения задач и сокращения расходов на обработку приложений.

Ключевые слова: пакетный трафик, временные ряды, фракталы, балансировка нагрузки, функция автокорреляции, гармонический анализ, нелинейная динамика.

Abstract

The article presents a description of the load balancing method for a computing cluster of a data processing center (DPC), which is based on a probabilistic approach to proactive forecasting of packet traffic states, formed on the basis of the results of its statistical, nonlinear and spectral analysis. The fractal properties of network traffic are the rationale for the possibility of prediction, allow with a fairly high probability to predict the appearance of bursts and drops in its activity at certain time intervals, identify periods of possible overload of servers and network equipment, and make it possible to develop methods for effective planning and distribution of tasks within the data center, ensuring a statistically uniform loading its functional elements. The spectral analysis of the time series is carried out according to the normalized deviations of the actual levels from the smoothed ones. The absence of significant peaks in the spectral estimates indicates the absence of periodic fluctuations. It is shown that the summation of cycles of different periods of the dynamics of the time series, based on the use of the most significant harmonics of the spectrum, determines the moments of occurrence of subsequent anomalies in its development. The process of identifying significant harmonics of the spectrum is based on the study of its spectral power density using the Fourier transform. The developed method is able to provide a solution to the problem of efficient planning and distribution of tasks in a data center computing cluster in order to optimize the use of resources, speed up task execution time and reduce application processing costs.

Keywords: packet traffic, time series, fractals, load balancing, autocorrelation function, harmonic analysis, non-linear dynamics.

Introduction

The computing resources of the data center of cloud systems are implemented in the form of server clusters and a system for distributing and balancing the load. The task of the load distribution and balancing system is to implement a method that provides an approximately equal computational load on the elements of the data center information system, as well as minimal data transfer costs. The purpose of this study is to improve the efficiency of the functioning of data centers that provide information services through the use of a packet traffic management method based on its fractal and harmonic analysis. The block diagram of the data center information cluster, shown in Figure 1, contains many servers and a load balancing system that distributes requests based on server status monitoring information.

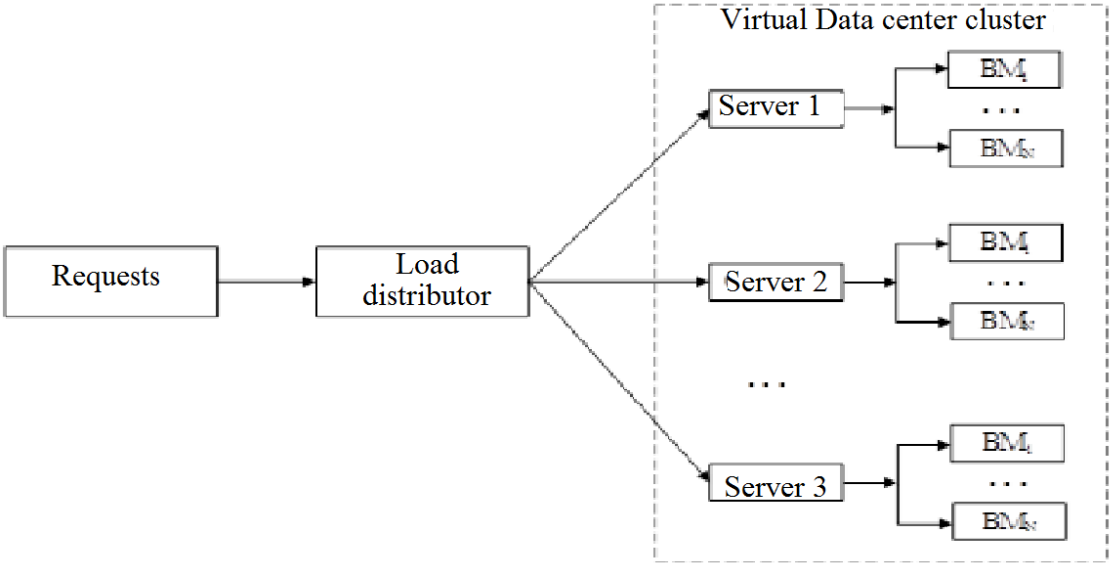

Figure 1. Structural diagram of the data center information cluster

One of the most important factors affecting the efficiency of data centers is network traffic anomalies, which consist in its fractality (self-similarity), frequent bursts and drops in activity, a cyclic component, powerful peak emissions and, as a result, system overload. Detection of such anomalies, timely prediction of the time of their occurrence in the future, in order to take measures to ensure the quality of service, necessitates the creation of more efficient methods for managing a distributed system of data center clusters. It is known [1,3,5] that the properties of the scale invariance of network traffic can provide, by analyzing over a short period of time, a prediction of its behavior over longer intervals, thus ensuring the implementation of effective planning and distribution of tasks within the data center, statistically uniform loading of its functional elements . A measure of the duration of the long-term dependence of a random process, which provides the definition of its fractality (self-similarity), the presence of cycles, long-term memory, and stability, is the Hurst self-similarity parameter N. A short-term forecast of network traffic states is also provided by the Fourier transform and spectral analysis [2,4]. The main advantage of spectral analysis lies in its ability to identify the most significant harmonics of the spectrum of the process under study. Identification of the most significant harmonics of the time series characterizing the dynamics of network traffic is based on estimating the spectral power density of the process using the discrete Fourier transform, obtaining the complex amplitudes of the data series, and then calculating its power spectrum. This decomposition is a spectrum of network traffic dynamics. The points of maximum values of the amplitudes of the spectrum indicate cycles of periodic oscillations of various lengths. If we select these cycles from the general spectrum of network traffic, and then sum them up, then we can determine the further dynamics of the development of traffic anomalies, the time of occurrence of subsequent powerful bursts of its activity, predict the parameters of the most probable peak load and the moments of its occurrence. This study proposes a method for dis-

tributing and balancing the load, which improves the efficiency of the data center by solving the problem of short-term forecasting of network traffic states in time and forming on this basis control decisions aimed at maintaining a uniform load on the data center equipment.

1. Research methodology

Experimental studies [6,9,12] confirm the fractal (self-similar) structure of network traffic. It is known that fractal network processes have a long-term dependence, which is expressed in an almost infinite correlation interval and makes it possible to predict its state in subsequent time intervals [14]. To implement an effective load balancing system, to ensure statistically uniform loading of many servers in data center clusters, it is necessary to take into account the structure and properties of network traffic, and to predict the magnitude of possible load intensity jumps. The solution to this problem is possible by applying a dynamically changing algorithm for distributing and balancing the load, built on the basis of a statistical analysis of the network traffic entering the system, assessing the degree of its fractality, Fourier series and harmonic analysis. The monitoring data of the data center input load used to implement the control action on the load balancing system can be represented as numerical series characterizing changes in its parameters over time. Spectral analysis makes it possible to determine the most significant harmonics of the spectrum of the obtained time series from all *M* harmonics, which are in its various samples and have the largest amplitude. The periods of the most significant harmonics of the spectrum determine the periodicity of the cycle. If we separate these harmonic components of the spectrum from its general dynamics, and then present them as a sum of cycles of different periods, then we can determine the further dynamics of the development of the process, as well as provide the possibility of predicting its further development. The algorithm for solving this problem includes the following steps:

1. Monitoring the input load of the data center, presenting it as a time series, determining the degree of fractality of packet traffic using the Hurst exponent.
2. Determination using the method of least squares of the linear trend of the time series.
3. Removing a trend from the original time series.
4. From the newly formed time series, the selection of harmonics corresponding to the highest coefficient of determination and adding them to the model of the dynamics of the time series.
5. Calculation of Durbin-Watson statistics for the presence and level of autocorrelation. Confirmation of the acceptable quality of the regression model.
6. Definition of cycles, forecast of their development.
7. Based on the analysis of the fractal properties of network traffic, as well as data on server load, the implementation of a new load distribution.

2. Study of the Hurst exponent.

The process of network traffic entering the distribution and load balancing system of the data center is described by the model [7,8,10]

$$Y_t = F_{TP}(t) + \sum_{k=1}^{M} Y_k + \varepsilon_t \quad (1)$$

where $F_{TP}(t)$ is a long-term trend, trend;

Y_k are the harmonics of the Fourier series;

ε_t is a random variable .

The presence of a trend in the aggregation interval of packet traffic, presented as a time series, determines the H -Hurst index, which is a characteristic of the stability of the statistical process, an assessment of the correlation between its elements and is determined by R / S analysis. The proximity of the parameter H to 1 determines the sufficient trend stability of the process and the possibility of predicting the degree of its change over time. The basic formula of R / S analysis is the expression [11]

$$R/S = (a \cdot N)^H , \quad (2)$$

where H is the Hurst exponent;

N is a sample of length N ;

S is the standard deviation of the obtained measurements;

R is the range of relations $R = \max(Z_u) - \min(Z_u)$;

Z_u is the accumulated deviation of the series from the mean $x_{cp.}$;

a is a constant;

$S = \sqrt{N^{-1}} \cdot \sum_{i=1}^{N} (x_i - x)^2$.

Taking the logarithm of the resulting expression, we obtain

$$H = \log(R/S)/\log(N/2).$$

At $0,5 < H < 1$, we have a persistent or trend-stable series. The influence of the present on the future is described by the measure of correlation [13]

$$C = 2^{2H-1} - 1.$$

The Hurst coefficient H is a measure of the duration of the long-term dependence and describes all other fractal parameters of the process under study [15,17]:

- fractal dimension $D = 2 - H$;
- correlation parameter $\beta = 2(1-H)$;
- spectral index $b = 2H + 1$;
- fractal index $a = 3 - 2H$.

For a self-similar process $x(t)$ with the $0,5 < H < 1$ correlation function decays hyperbolically [12]

$$R(K) = \frac{\sigma^2}{2}\left[(K+1)^{2H} - 2K^{2H} + (K-1)^{2H}\right].$$

By definition, the correlation coefficient

$$\tau(K) = R(K)/R(\sigma) = R(K)/\sigma^2 ,$$

hence the autocorrelation function (ACF) will have the form

$$\tau(K) = \frac{1}{2}\left[(K+1)^{2H} - 2K^{2H} + (K-1)^{2H}\right]. \quad (3)$$

The calculation of the ACF must be carried out in order to assess the nature of the decrease in the dependence of the elements of the time series.

The numerical values of the ACF can be obtained from the formula [14]

$$\tau(K) = \frac{\sum_{i=1}^{N-K} (x_i - \bar{x})(x_{i+k} - \bar{x})}{(N-K)\sigma^2(x)}, \quad (4)$$

where $\bar{x}$ is the average value of the *x series* ;

$\sigma^2(x)$ is the variance of the *x series* ;

K - time lag.

A slow decrease in ACF values characterizes a slowly decreasing dependence between traffic elements. A rapid decrease in the ACF values is a sign of the stationarity of the process under study. For fractal processes characterized by the properties of self-similarity and slowly decreasing dependence, the autocorrelation function does not vanish when $t \to \infty$.

For a more accurate description of the measure of the long-term dependence of a self-similar process, inhomogeneous fractal objects, or multifractals, are used [15]. In this case, the original time series $x(t)$ is divided into N segments of length S and for each segment

$$y(t) = \sum_{i=1}^{n} x(t),$$

Function is defined

$$F(s) = \sqrt{\frac{1}{S}\sum_{t=1}^{T}\left(y(t) - y_m(t)\right)^2}.$$

Next, find the dependence $F_q(S)$ on a fixed value q

$$F_q(S) = \left\{\frac{1}{N}\sum_{i=1}^{N}\left[F^2(S)\right]^{\frac{q}{2}}\right\}^{\frac{1}{q}}$$

By changing the length S of the time series, for arbitrary values of q , we find the sequence of values $F_q(S)$. If a $F_q(S)$ seems to depend [16]

$$F_q(S) \square S^{h(q)},$$

then the time series corresponds to the multifractal set and has a long-term dependence on the Hurst exponents $h(q) = H$.

3. Harmonic analysis.

It is known that *R / S* -analysis does not always give correct estimates of the Hurst exponents. A method based on correlation analysis gives greater statistical accuracy. If the expression is true

$$\tau_k = k^{-\beta} L(k) + C,$$

where C – const , $0 < \beta < 1$;

$L(k)$ is a slowly changing function $\lim_{t\to\infty} \frac{L(tx)}{L(t)} = 1,$.

then such a process is described by an ACF decreasing according to a power law [12].

When describing a network process, it is preferable to use a harmonic function of the form

$$Y_t = \overline{Y}_t + \sum_{k=1}^{M} a_k \cdot \cos\frac{2\pi kt}{N} + \sum_{k=1}^{M} b_k \cdot \sin\frac{2\pi kt}{N} \qquad (5)$$

where $a_k = \frac{2}{N}\sum_{k=1}^{M} Y_t \cdot \cos\frac{2\pi kt}{N}$,

$b_k = \frac{2}{N}\sum_{k=1}^{M} Y_t \cdot \sin\frac{2\pi kt}{N}$, are the harmonics of the Fourier series ;

M is the number of harmonics in the series;

N - row length.

To describe the long-term trend of the time series, we use the function [12]

$$\bar{Y}_T = A_1 \sin\left(\frac{2\pi t}{P}\right) + A_2 \cos\left(\frac{2\pi t}{P}\right) + A_3. \quad (6)$$

The period P of the trend cycle is obtained by sequentially dividing its most probable value into equal time intervals P_i and, using regression methods, we determine the coefficients A_1, A_2, A_3. Next, we select the sequence of time intervals in which

$$\frac{1}{T}\sum_{t=1}^{T}\left(Y_T - F_{TP}\left(t, P_i\right)\right)^2 \to \min.$$

The choice of a model that describes the long-term trend of the network process is based on an assessment of its accuracy. Obviously, models that provide a smaller discrepancy between real and calculated values provide greater accuracy. It is most expedient to use the following expressions as indicators of accuracy [17]

a) difference of variances $V_{ar} = \frac{1}{T}\sum_{t=1}^{T}\left(Y_t - F_{TP}\left(t\right)\right)^2$;

b) approximation error $A = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{Y_t - F_{TP}}{Y_t}\right|$;

c) indicator of process determination

$$R^2 = \frac{\sum_{t=1}^{T}\left(F_{TP}\left(t\right) - \bar{Y}\right)^2}{\sum_{t=1}^{T}\left(Y_T - \bar{Y}\right)^2},$$

where $\bar{Y} = \frac{1}{T}\sum_{t=1}^{T} Y_t$ is the average value of the elements of the time series.

The theoretical number of frequencies is chosen equal to N/2 with the length of the series equal to N. In practice, not all N/2 are required, but only some harmonic components that express the main part of the variation of the series. To eliminate random fluctuations and possible errors in the estimated traffic values, the resulting non-stationary time series must be additionally processed. A possible solution in this case is to exclude its trend by smoothing the dynamics, for example, using the centered moving average method, or second-order moving parabolas, i.e. use absolute or normalized deviations of the time series from its long-term trend.

To identify regular periodic cycles that make the greatest contribution to the overall dynamics of the network process, we remove the trend from the time series structure. The forecast of the periods of cycles is built by highlighting the harmonics of the spectrum of the time series with the largest amplitudes, the formation of the corresponding model and its extrapolation. The function by which the Fourier transform of the studied time series is calculated has the form [18]

$$f\left(x\right) = \frac{a_0}{2} + \sum_{m=1}^{M}\left[a_m \cos\left(m\frac{2\pi}{X_{\max}}\right) + b_m \sin\left(m\frac{2\pi}{X_{\max}}\right)\right],$$

where $a_m = \frac{2}{N} + \sum_{n=0}^{N-1} y_n \cos\left(m\frac{2\pi n}{N}\right), 0 \le m \le M;$

$$b_m = \frac{2}{N} + \sum_{n=0}^{N-1} y_n \sin\left(m\frac{2\pi n}{N}\right), 0 \le m \le M;$$

M is the number of harmonics of the studied series;

(x_n, y_n) – array of sample and values of the time series;

$n = 0,..., N$.

It is known [14] that in order to select from all M most significant time series harmonics, Fourier series expansion is used

$$f(x) = \frac{a_0}{2} + \sum_{m=1}^{M}\left[R_m \cos\theta_m \cos\left(m\frac{2\pi}{N}\right) + R_m \sin\theta_m \sin\left(m\frac{2\pi}{N}\right)\right],$$

where $R_m = \sqrt{a_m^2 + b_m^2}$,

$\theta = -arctg\frac{b_m}{a_m}$, $-\pi \le \theta_m \le \pi$;

$a_m = R_m \cos\theta_m$,

$b_m = -R_m \sin\theta_m$.

Denoting the oscillation frequency as $\omega_m = m/N$, we write the Fourier distribution in the form

$$f(x) = \frac{a_0}{2} + \sum_{m=1}^{M} R_m \cos(2\pi\omega_m n + \theta_m),$$

where $T_m = \frac{1}{\omega_m}$ is the cycle period of the time series.

To obtain numerical values of the amplitude and phase of the most probable cycles of the time series, we use the expressions [13]

$$A_n = \frac{1}{n}\sqrt{R_e^{\,2}(S_n) + I_m^{\,2}(S_n)}$$

$$\varphi_n = arctg\frac{I_m(S_n)}{R_e(S_n)},$$

where S_n is the set of frequencies of possible cycles.

Then, the cycle can be described by the expression

$$f_n(t) = A_n \cos(S_n t + \varphi_n).$$

If we represent the dynamics of bursts of network traffic as the sum of a set of cyclic components, then the periodicity of the time series will be equal to

$$V(t) = \sum_{D} f_n(t),$$

where D is the set of possible cycles of the series.

The sequence of stages for selecting cycles of a time series of data:

a) the choice of the initial time series and the determination of its trend using the method of least squares;

b) subtraction of the resulting linear trend from the original time series;

c) from the resulting series, the selection of harmonics that provide the highest coefficient of determination

$$R^2 = 1 - \frac{\sum_{t=0}^{N-1}\left(y_t - Y_t^{garm}\right)^2}{\sum_{t=0}^{N-1}\left(y_t - \bar{Y}\right)}.$$

It is known [17] that for the most accurate models, the coefficient of determination should not be less than 0.8. In this case, the correlation coefficient is close to 1;

d) adding selected harmonics to the time series model;

e) checking for autocorrelation using Durbin-Watson statistics

$$d = \sum_{t=2}^{n}\left(y_t - y_{t-1}\right)^2 \Big/ \sum_{t=1}^{n} y_t^2.$$

The value $1,5 < d < 2,5$ is a confirmation of the acceptable quality of the regression model;

f) definition of short-term cycles.

The obtained dependence Y on the interval $t \in [0,\ N-1]$ makes it possible to determine the values Y on the interval $t \in [N,\ N+m]$.

Using this approach allows you to make a reliable short-term forecast and timely inform the data center balancing system about subsequent significant bursts of network traffic.

4. Nonlinear forecasting.

TCP packet traffic can be described not only as a simple periodic process, but also as a process with more complex behavior and described by methods and models of deterministic chaos. [19]. At the same time, the main method for determining the chaotic nature of this nonlinear process is the spectrum of characteristics, consisting of *n* Lyapunov exponents. The signs of the Lyapunov exponents quite reliably characterize the type of fluctuations in the studied time series. A deterministic chaotic process is determined by positive exponents, a zero exponent determines a quasi-periodic process, a negative exponent is a fixed point of the phase trajectory, called the attractor of the system. Otherwise, all Lyapunov exponents of a deterministic process are negative or equal to zero, while a chaotic process has at least one positive exponent. Using the chaotic properties of the studied fractal process, it is possible to construct a predictive model of its development. The predictive models can be based on the methods of linear, non-linear forecasting, as well as global polynomial approximation [20]. To determine the spectrum of nonlinear parameters of the time series, there is a fairly large set of special software. For example, software packages CDA , Dataplore , RQA , TISEAN . The set of analysis tools implemented on the TISEAN platform provides the determination of a fairly complete range of nonlinear characteristics of a deterministic chaotic process. In this case, the chaotic nature of the process dynamics is determined by the value of the maximum Lyapunov exponent, which characterizes the rate of divergence of its phase trajectories. To determine the Lyapunov exponent, we use the lyap program of the TISEAN package . As a result, we obtain the dependence of the coefficient of $S(\varepsilon, m, \Delta n)$ divergence of trajectories on time [17]

$$S(\varepsilon, m, \Delta n) = \frac{1}{N}\sum_{n_0}^{N} \ln\left(\frac{1}{\left|U\left(S_{n_0}\right)\right|} \times \sum_{S_n \subset U\left(S_{n_0}\right)} \left|S_{n_0+\Delta n} - S_{n+\Delta n}\right|\right),$$

where ε is the neighborhood of the point S_{n_0};

m is the fractal dimension of the phase space;

Δn – time interval;

$U\left(S_{n_0}\right)$ is the neighborhood of the point S_{n_0} with radius ε.

The obtained values $S\left(\varepsilon, m, \Delta n\right)$, for various Δn, characterize the required values of the Lyapunov exponents.

The general model of nonlinear prediction has the form [19]

$$x\left(t+T\right)=\frac{1}{\left|U_m\right|}\sum_{x(t')\in U_m} x\left(t'+T\right),$$

where U_m is the neighborhood of the point $x\left(t\right)$.

This algorithm is implemented by the programs lzo-run, lzo-test, false-nearest of the TISEAN platform.

When using linear prediction, the algorithm [20] is used

$$x\left(t+T\right)=a_n x\left(t\right)+b_n,$$

$$\sum_{x(t')\in U_m}\left(x\left(t'+T\right)-a_n x\left(t'\right)-b_n\right)^2\to\min.$$

The predictive method of global approximation is implemented by the expression [20]

$$\sum_t\left(x\left(t'+T\right)-f_T\left(x\left(t'\right)\right)\right)^2\to\min$$

using the FNN program of the TISEAN platform .

Automation of the process of implementing the predictive model can be carried out using the methodology described in [19], using programs for determining the value of the autocor lag . exe , Tayler's window size selection mutual . exe , calculation of correlation dimension d 2. exe .

5. The structure of the load balancing system.

The computing resources of the data center are represented by a set of server clusters and load balancing tools. The structure of the data center load balancing system is shown in Figure 2. At the request of users, the balancing system generates virtual machines (VMs) with certain system indicators. The local manager analyzes the load of the servers and places the incoming requests on them. The data center monitoring system transmits the received information to the global manager, which performs the formation of VMs, manages the load balancing of data center server clusters, and adjusts the system throughput according to the traffic profile. In this case, the following tasks are sequentially implemented:

- receiving requests from subscribers for the implementation of services;
- calculation of network statistics, implementation of the forecasting algorithm;
- distribution of requests across cluster servers;
- selection of a server in the cluster capable of fulfilling user requests;
- sending requests to the selected cluster server;
- distribution of implemented software applications across cluster servers;
- formation of a set of virtual machines that implement applications;
- receiving the results of solving problems.

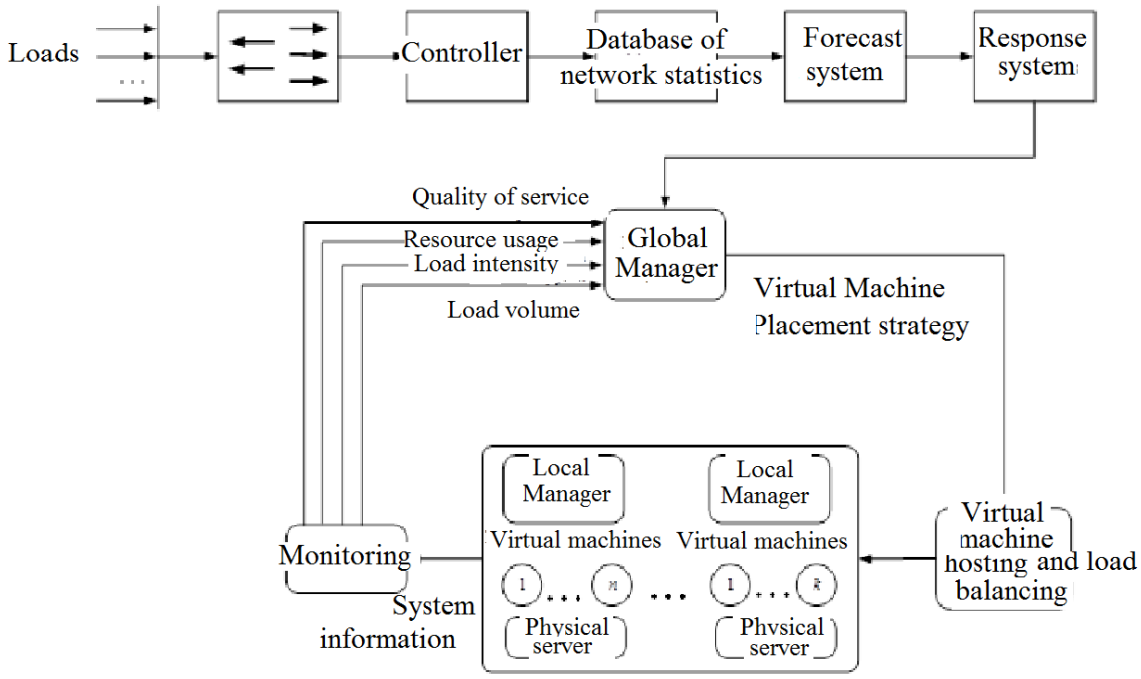

Figure 2. The structure of the load balancing system

To implement the algorithm for predicting anomalies in the network load of the data center, the information structure of the balancing system additionally includes a switch connected via the Gigabit protocol An Ethernet network statistics database with a WireShark sniffer program based on, for example, the WinPcap library , as well as a high-performance controller that implements a prediction algorithm. The sniffer program captures traffic, processes it, aggregates it, forms the required time intervals, and also captures sudden changes in the input load. The resulting level of bursts of traffic intensity, as well as their duration, inform the forecasting system about the need to turn on the aggregation of the response system and redistribute the data center hardware and software at this interval. At the same time, it is obvious that the delay in the control action associated with the process of monitoring network traffic can lead to a decrease in the efficiency of the load distribution and balancing system. Therefore, it is necessary to carry out the formation of a preventive control action, which is directly related to the implementation of the method for predicting the possible peak load and the time of its occurrence.

Conclusion

Experimental studies of the statistical characteristics of packet traffic in modern computer networks indicate its fractal structure, the presence of frequent bursts and drops in activity, powerful peak emissions, and a deterministic component. Such properties of traffic confirm the possibility of using fractal models for predicting bursts of its intensity, determining the volume of incoming traffic with the required accuracy and solving, on this basis, the problems of dynamic control of the distribution system and load balancing of data center cluster servers. The use of classical Markov (without aftereffect) models and Erlang formulas oriented to the simplest flows to calculate the parameters of the load balancing system, as a rule, leads to incorrect results that are inefficient for fractal (self similar) flows. The article presents a description of the load balancing method, which is based on a reliable, probabilistic approach to proactive forecasting of network traffic states, formed on the basis of the results of its statistical and spectral analysis, fractality level, distribution density. The problem of short-term forecasting of packet traffic is reduced to the problem of forecasting a discrete time series. The developed method is able to provide a solution to the

problem of efficient planning and distribution of tasks in a data center computing cluster in order to optimize the use of resources, speed up task execution time and reduce application processing costs. The direction of further research related to improving the operation of cloud data centers is to represent them in the form of dynamic systems, the use of nonlinear dynamics methods that allow identifying phase space attractors and providing deeper research on the impact of self-similar traffic on performance.

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МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ ГИДРОЛИТОСФЕРНЫХ ПРОЦЕССОВ С УЧЕТОМ ПРОЦЕССОВ В «КОЛОДЦАХ»

MATHEMATICAL MODELING OF HYDROLITHOSPHERE PROCESSES TAKING INTO ACCOUNT THE PROCESSES IN "WELLS"

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Аннотация

В работе рассмотрена математическая модель гидролитосферного процесса с учетом «колодца» сформированного добывающей скважиной. Приводится описание математической модели взаимодействия гидролитосферных процессов в «колодце» с водоносными горизонтами. Результаты численного моделирования гидролитосферных процессов показывают существенное влияние радиуса «колодца» на понижение уровня в водоносном горизонте.

Ключевые слова: гидролитосферные процессы, описание гидролитосферных процессов в «колодцах», математические модели гидравлического взаимодействия.

Abstract.

The paper considers a mathematical model of the hydrolithospheric process, taking into account the "well" formed by a production well. A description of the mathematical model of the interaction of hydrolithospheric processes in the "well" with aquifers is given. The results of numerical modeling of hydrolithospheric processes show a significant influence of the "well" radius on the level decrease in the aquifer.

Keywords: hydrolithospheric processes, description of hydrolithospheric processes in "wells", mathematical models of hydraulic interaction.

Введение. Проблема рационального природопользования при эксплуатации гидролитосферных ресурсов, имеет важное значение для региона КМВ [1-3]. В направлении решения этой проблемы, на сегодняшний день, получены следующие результаты: разработаны математические модели гидролитосферных процессов в водоносных горизонтах [4,5];

Разработаны методы верификации математических моделей гидролитосферных процессов[6-8], а также методика формирования целевых функций [9] и методика синтеза алгоритмов управления рассматриваемыми процессами [10,11]. Разработка математических моделей рассматриваемых процессов, с учетом гидравлической взаимосвязи «процессов колодца» и водоносных горизонтов позволяет синтезировать более качественные системы управления и построить более точные модели прогнозирования развития гидролитосферных процессов на ближнюю и дальнюю перспективы.

Известно, что при эксплуатации добывающих скважин, мелкие фракции породы в эксплуатируемых (водоносных) горизонтах, окрестности добывающей скважины, постепенно вымываются. Это приводит к формированию «колодца» вокруг добывающей скважины (см. рис.1). Понижение уровня в таких колодцах, по всему объему, можно постоянным (в заданный момент времени).

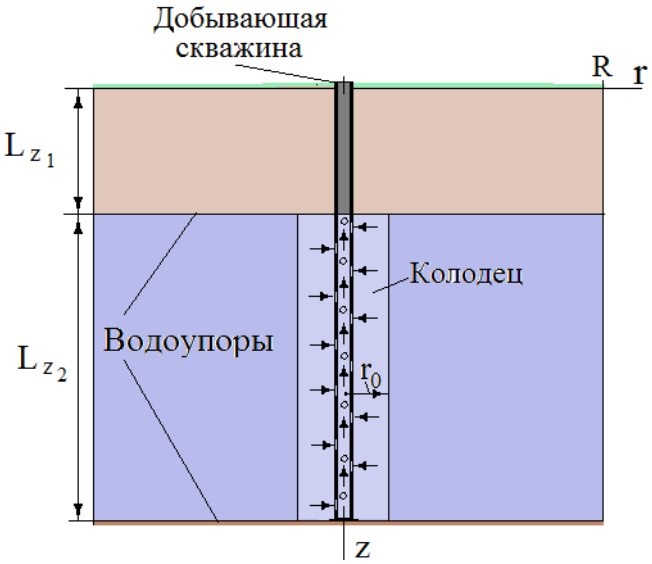

Рисунок 1. Схема гидролитосферного процесса

Схема гидролитосферного процесса, при совершенном водозаборе, показана на рис. 1. Опишем влияние параметров колодца на гидролитосферные процессы в водоносном горизонте.

Математическая модель гидролитосферного процесса. При описании математической модели полагаем, что состояние напора внутри «колодца» ($r < r_0$), в стационарном режиме, не зависит от r.

Известно, что водоотдача (μ) определяется из следующего соотношения:

$$\mu = V_c / V,$$

где: V_c – объем свободно-стекающей воды; V– объем породы.

Данные по водоотдаче приведены в соответствующих справочниках.

Для колодца, показанного на рис.1, рис.2 (в виде цилиндра, радиуса r_0)

при заданном отборе воды (ΔQ м^3/с), за время (Δτ), понижение уровня в колодце (ΔH_k) показанном (см.рис.2) , определяется из следующего соотношения:

$$V_c = V \cdot \mu = -Q \cdot \Delta\tau \rightarrow (\pi \cdot r_0^2 \cdot \Delta H_k) \cdot \mu = -Q \cdot \Delta\tau$$

Или

$$\Delta H_k = -Q \cdot \Delta\tau / (\pi \cdot r_0^2 \cdot \mu).$$

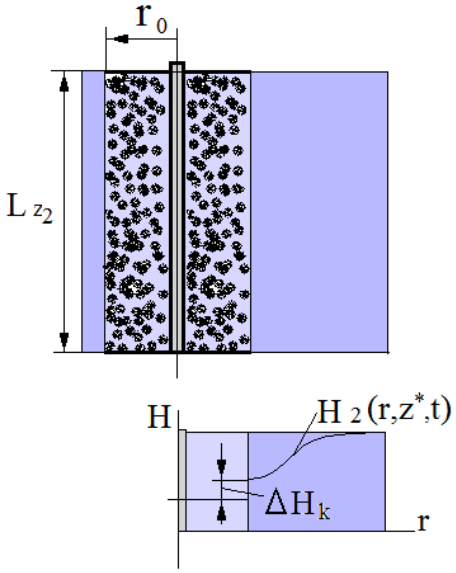

Рисунок 2. Колодец

Определим площадь боковой поверхности колодца:

$$S_k = 2\pi \cdot r_0 \cdot L_{z_2} .$$

Положим, что толщина боковой поверхности ($\Delta L_{z2} \to dz$) , тогда

$$ds_k = 2\pi \cdot r_0 \cdot dz$$

Используя уравнение Дарси, определим объем гидроминерального сырья, поступающего в колодец, за время $\Delta\tau$ (полагая что уровень в колодце равен H_{2k}):

$$\Delta V_k = 2\pi \cdot r_0 \cdot \int_0^{L_{z_2}} \left(k_{2r} \cdot (H_2(r_0, z, \tau) - H_{2k})\right) \cdot dz \quad (1)$$

Повышение уровня в колодце, при притоке ΔV (за время $\Delta\tau$, составит):

$$\Delta H_k^* = (\Delta V_k / \mu)/(\pi \cdot r_0^2)).$$

Изменение уровня в колодце может быть определено из следующего соотношения:

$$\Delta H_{2,k} = \Delta H_{2k} + \Delta H_k^* . \quad (2)$$

Общий приток гидроминерального сырья в колодец, за время $\Delta\tau$, составит:

$V_p = -Q \cdot \Delta\tau + \Delta V_k \cdot \Delta\tau$.

Запишем приращение уровня в колодце за время $\Delta\tau$:

$$\Delta H_{2k} = (V_p / \mu)/(\pi \cdot r_0^2) .$$

Математическая модель рассматриваемого процесса (см. рис. 1, рис. 2) в цилиндрических координатах:

Описание процесса в грунтовых водах

$$\frac{\partial h_1(r, z, \tau)}{\partial \tau} = k_1 \frac{\partial^2 h_1(r, z, \tau)}{\partial r^2} + \frac{k_{1,}}{r} \cdot \frac{\partial h_1(r, z, \tau)}{\partial r} + k_{1,z} \frac{\partial^2 h_1(r, z, \tau)}{\partial z_1^2}; \quad (3)$$

$$0 < r < R; 0 < z < L_{z_1} .$$

Описание процесса в водоносном горизонте.

«Колодец»

$$\Delta V_k = 2\pi \cdot r_0 \cdot \int_0^{L_{z_2}} \left(k_{2z} \cdot (H_2(r_0, z, \tau) - H_{2k})\right) \cdot dz , \quad (4)$$

$$\frac{\partial H_{2k}(\tau)}{\partial \tau} = 1/\mu \cdot (Q + \Delta V_k)/(\pi \cdot r_0^2 \cdot) \cdot,$$

$$0 < r < r_0; L_{z_1} < z < L_{z_2} .$$ Водоносный горизонт

$$\frac{\partial H_2(r, z, \tau)}{\partial \tau} = \frac{1}{\eta_2}(k_2 \frac{\partial^2 H_2(r, z, \tau)}{\partial r^2} + \frac{k_{2,}}{r} \cdot \frac{\partial H_2(r, z, \tau)}{\partial r} + k_{2,z} \frac{\partial^2 H_2(r, z, \tau)}{\partial z_1^2}), \quad (5)$$

$$r_0 < r < R; \quad L_{z_1} < z < L_{z_2},$$

Граничные условия задаются в виде

(условия Дарси)

Грунтовые воды - «Колодец»

$$h_1(\mathrm{r}, L_{z_1}, \tau) = h_1(r, L_{z_1}, \tau) + b_1 \cdot (H_{2k}(r,0,\tau) - h_1(r, L_{z_1}, \tau)) \cdot \partial\tau,$$
$$H_{2k}(r,0,\tau) = H_{2k}(r,0,\tau) - b_1 \cdot (H_{2k}(r,0,\tau) - h_1(r, L_{z_1}, \tau)) \cdot \partial\tau, \quad (6)$$
$$0 < r < r_0,$$

«Колодец» - боковая поверхность

$$\mathrm{H}_{2,\mathrm{k}}(\mathrm{r}_0, \mathrm{z}, \tau) = H_{2k}(r_0, z, \tau) + k_{2\mathrm{z}} \cdot (H_2(r_0, z, \tau) - H_{2k}(r_0, z, \tau)) \cdot \partial\tau,$$
$$\mathrm{H}_2(\mathrm{r}_0, z, \tau) = H_2(r_0, z, \tau) - k_{2z} \cdot (H_2(r_0, z, \tau) - H_{2k}(r_0, z, \tau)) \cdot \partial\tau,$$
$$\partial \mathrm{H}_{2\mathrm{k}}(0, z, \tau) / \partial r = 0, \quad (7)$$
$$0 < z < L_{z_2}.$$

«Колодец» - нижняя граница

$$\partial H_{2\mathrm{k}}(\mathrm{r}, L_{z_2}, \tau) / \partial \mathrm{z} = 0, \quad 0 < r < r_0 \quad (8)$$

Водоносные горизонты

$$h_1(\mathrm{r}, L_{z_1}, \tau) = h_1(r, L_{z_1}, \tau) + b_1 \cdot (H_2(r,0,\tau) - h_1(r, L_{z_1}, \tau)) \cdot \partial\tau,$$
$$H_2(r,0,\tau) = H_2(r,0,\tau) - b_1 \cdot (H_2(r,0,\tau) - h_1(r, L_{z_1}, \tau)) \cdot \partial\tau, \quad (9)$$
$$r_0 < r < R.$$

Нижняя граница водоносного горизонта

$$\partial H_2(\mathrm{r}, L_{z_2}, \tau) / \partial \mathrm{z} = 0, \quad r_0 < r < R, \quad (10)$$

Боковая грань.

$$h_1(R, z, \tau) = h_{1,0}; \quad 0 < z < L_{z_1}, \quad H_2(R, z, \tau) = H_{2,0}; \quad 0 < z < L_{z_2}. \quad (11)$$

Где: b_1–параметр перетекания; h_1 – напор в горизонте грунтовых вод;

H_2 , H_{2k} – напор в изучаемом водоносном горизонте;

$k_1, k_{1,z}\ k_2, k_{2,z}$ – коэффициенты фильтрации в соответствующих горизонтах, по координатам r,z ;

η_2 – упругоемкость; μ–коэффициент водоотдачи; r,z– пространственные координаты; L_{z1}, L_{z2}, R – заданные значения; τ–время; $h_{1,0}$, $H_{2,0}$ – начальные состояния (τ=0) водоносных горизонтов.

Математическая модель (3)-(11) аналитического решения не имеет. Для анализа рассматриваемых процессов, была составлена численная модель и программа численного моделирования рассматриваемых гидролитосферных процессов. При моделировании гидролитосферных процессов были использованы параметры, приведенные в табл.1 и табл.2

Табл.1. Геометрические параметры

R м.	L_{z1} м.	L_{z2} м.	N_1 (число шагов дискретизации по координате r)	N_2 (число шагов дискретизации по координате z)
100	30	60	100	32

Шаги дискретизации по пространственным координатам соответственно равны:

Δ_{z1}=30/(16 -1); Δ_{z2}=60/(16 -1); Δ_r=100/(100 -1).

Табл. 2. Физические параметры гидролитосферного процесса

k_1 м/сут.	$k_{1,z}$ м/сут.	k_2 м/сут.	k_{2z} м/сут.	η_2 1/м	b_1 1/сут.	μ
0.23	0.23	0.28	0.22	0.0005	0.00007	0.04

Начальные условия были заданы в виде: $h_{1,0}$=30 м, $H_{2,0}$=60 м. Дебит скважины: Q=100м^3/сут.

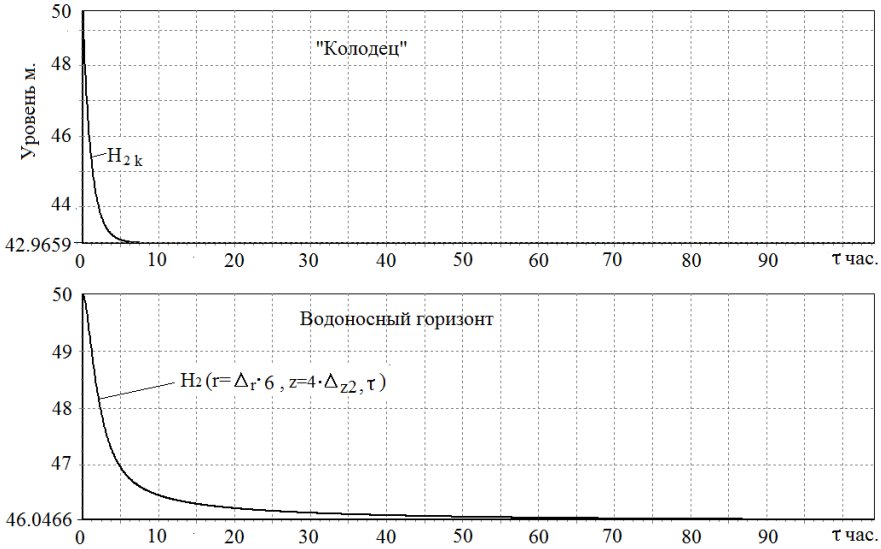

Рис. 3. Графики переходных процессов в колодце и заданной точке водоносного горизонта

Используя результаты моделирования, построены графики переходных процессов изменения уровня в «колодце» и в заданной точке водоносного горизонта (см. рис.3).

Используя результаты моделирования, построены графики (см. рис.4) изменения уровня в «колодце» и в заданной точке водоносного горизонта, в стационарном режиме (при заданном дебите), в зависимости от изменения радиуса колодца:

рис.4 а) - изменение уровня при $r_0=2\cdot\Delta r$, Q=100м^3/сут.;

рис.4 б) - изменения уровня при $r_0=6\cdot\Delta r$, Q=100м^3/сут.;

рис.4 в) - изменения уровня при $r_0=9\cdot\Delta r$, Q=100м^3/сут.,

Δ_r=100/(100 -1)=1.0101 м.

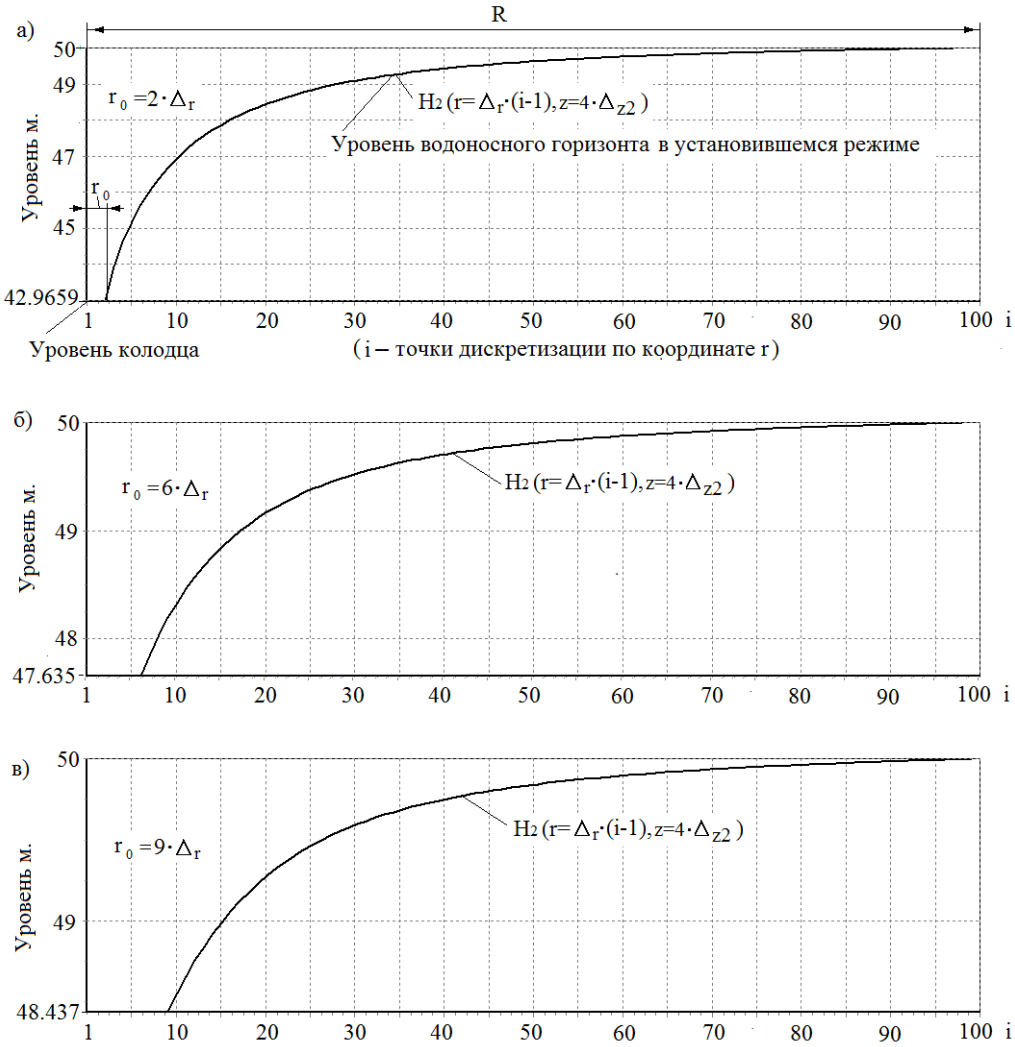

Рис.4. График изменения уровня в установившемся режиме

Заключение. В работе получена математическая модель, описывающая гидролитосферный процесс в «колодце», так же приводится описание математической модели взаимодействия гидролитосферных процессов в «колодце» с водоносным горизонтом и горизонтом грунтовых вод.

Приводятся результаты численного моделирования рассмотренных выше гидролитосферных процессов при заданном дебите добывающей скважины. Результаты моделирования гидролитосферных процессов показывают существенное влияние радиуса «колодца» на понижение уровня в водоносном горизонте.

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МЕТОД ПРИОРИТЕТНОЙ МУЛЬТИПОТОКОВОЙ ПЕРЕДАЧИ МНОГОМОДАЛЬНЫХ СООБЩЕНИЙ

METHOD OF PRIORITY MULTIPATH MULTIMODAL MESSAGES TRANSMISSION

Южный федеральный университет/ Southern Federal University

Аннотация

В статье представлен метод, позволяющий распределять протокольные блоки данных многомодальных сообщений на транспортном уровне модели OSI, учитывая их приоритет. Рассмотрена его реализация в имитационной среде AnyLogic, получены результаты имитационного моделирования с применением разработанного метода и без него.

Ключевые слова: мультипотоковая передача данных, многомодальное сообщение, модальность, имитационное моделирование

Abstract

The paper presents a method that allows to allocate protocol data units of multimodal messages at the transport layer of the OSI model, considering their priority. Its implementation in the AnyLogic simulation environment is developed, the results of simulation modeling are obtained with the developed method and without it.

Keywords: multipath data transmission, multimodal message, modality, simulation modelling

Introduction

With the widespread use of personal means of communication, such as tablets, smartphones, questions of their individualization arise. This means that the user device must adapt to the characteristics and needs of the user in order to provide maximum comfort. In such a scenario, the use of traditional user interfaces becomes inappropriate, they are replaced by multimodal interfaces - interfaces that provide a choice of modalities for transmitting various types of information and their sharing [1].

Modality should be understood as a physically recorded element of communication (human-machine and / or interpersonal), including both the information itself transmitted (message) and information about the individual himself (his state; attitude to the message, to the interlocutor, to communication, etc.) [2]

On the other hand, modern personal communication media of users are equipped with multiple communication interfaces and use wireless communication for data transmission. Although wireless network throughput is predicted to increase significantly in the coming years [3], the amount of transmitted traffic will also increase. This is due, on the one hand, to the growth of the Internet of Things (IoT) technology, on the other hand, the role of telecommunications in professional activities, training and public relations is significantly increasing. Thus, in the structure of information flows, the share of services that consume significant amounts of the data transmission resource increases [4]. Thus, the trend of data transmission over wireless communication channels is also relevant for multimodal information systems.

In addition, one should take into account the fact that the wireless user device does not have a permanent connection to any access point (base station) that would guarantee the required level of quality, since it has a large spatial dynamics. In this case, the user can move to areas with a critically weak network signal or no network signal at all, or to areas with a large number of users sharing the channel capacity.

Investigation of the problem and its current state

The analysis of the subject area showed that the issues of multimodal information transmission in communication networks have not yet been worked out: there are no recommendations and a unified approach to the transmission of various modalities. Moreover, the issue of using a multistream scheme for transmitting multimodal information has never been considered.

One of the solutions to these problems can be the development of models, as well as methods and algorithms for transmitting multimodal information by using a multistream data transmission scheme. In this case, protocol data units (PDUs) of modalities of the same transport stream of a multimodal message are distributed among several transport substreams, each of which has its own route.

Due to one of the main principles of the architecture of the worldwide network - the "End-To-End" principle [5], it is not desirable to interfere with the work of the flow within the network, this should be done at the ends of the connection. Therefore, the distribution of PDU between communication channels must be carried out on the terminal sides of the interaction.

In addition, we believe that modalities within a multimodal message have different priorities. The ranking of modalities by priority is relevant for various systems of multimodal interaction, for example, for systems of infocommunication interaction of officials of the public administration system with the determination of their psychophysical state [6], or for multimodal authentication systems [7].

To solve this problem, a method was developed for priority multistream transmission of multimodal information, which makes it possible to increase the efficiency of data transmission. In this case, efficiency is understood as a reduction in PDU losses of a multimodal message.

Proposals and prospects for solving the problem

In the study, we assume that the system of multi-stream information transfer has a client-server architecture (consists of a source and a receiver). On the source side, PDUs of multimodal messages are generated, and on the receiver side, service PDUs are generated, which allow to determine the data transfer statistics.

of multi-modal Ndata are: a $\mathrm{L} = \{L_1, L_2, \dots, L_N\}$,multi -modal message consisting of a PDU $K$of modalities of different priority levels with the $X = \{X_1, X_2, \dots, X_K\}$volume

The output parameters are the modalities PDUs distributed to the available transmission substreams.

The initial phase of the method of priority multistream transmission of multimodal information

At the initial moment of time, the data transmission system does not have information about the throughputs and transmission delays of available communication channels if the communication interface was not used before the start of the multimodal subsystem. One solution is to check the availability of the node using the ping command (ICMP protocol) in order to get the first value of the round trip (Round - Trip Time , RTT), however, in this case, the multistream protocol loses the ability to send data on new substreams. Another solution might be to use the Round algorithm Robin and automatically switch to the substream that shows the lowest RTT or the highest throughput. However, in the case of a large heterogeneity in the characteristics of substreams, the problem of blocking the head of the queue (Head - of - line blocking). The most obvious solution is redundant modality messaging. This is due to the lack of data on the indicators of the quality of service of communication channels. The transmission of the same data on all available communication channels increases the probability of data delivery, but does not guarantee optimal use of the channel resource. The recalculation of network service quality indicators occurs after receiving service PDUs on each of the communication channels.

After receiving the first service PDU, according to the priority multistream data transfer method, it is necessary to calculate the available bandwidth of the available communication channels as follows:

$$C_i(t_1 - t_0) = \frac{(X_i(t_1 - t_0) + A_i(t_1 - t_0)) * (1 - \omega_i(t_1 - t_0))}{t_1 - t_0}, \quad (1)$$

where $t_0$is the time of departure of the first group of PDUs along the subflow i, $t_1$is the time of receipt of the first group of PDUs, $X_i(t_1 - t_0)$is the amount of PDUs of a multimodal message sent in the stream $i$over time $t_1 - t_0$, $A_i(t_1 - t_0)$is the amount of PDUs of third-party applications sent in the stream $i$over time $t_1 - t_0$, $\omega_i(t_1 - t_0)$is the number of losses in the stream $i$over time $t_1 - t_0$.

Thus, the method of priority multistream transmission of multimodal information makes it possible to obtain the first portion of statistics. Further, according to the method, it is necessary to initiate the procedure for distributing PDUs of a multimodal message between the available communication channels without retransmitting the same packets to flows, but in accordance with the policy of distributing PDUs of a multimodal message to subflows.

Distribution of PDUs of a multimodal message into substreams

After the initial phase and the definition of the primary set of communication channels for sending data and their characteristics, the method of priority multistreaming of data determines the logic for distributing PDU modalities to the available communication interfaces. Each multimodal message has a lifetime ttlafter which it will not be transmitted. This is due to the fact that these modalities are sensitive to delay and ttlwill be irrelevant after the deadline in multimodal communication. To ensure the transmission of high-priority modalities, the developed method ranks PDUs of modalities of different priority within a multimodal message: $X = \{X_j\}, j = \overline{1,K}$. In this case, we assume that multimodal messages certainly have a higher priority than data from other applications.

The amount of data that can supposedly be transferred (resources) within the lifetime of a multimodal message for each of the substreams is calculated:

$$Y_i = ttl * C_i(\tau) \quad (2)$$

and the total amount of data that can be transmitted across all substreams within ttl:

$$Y = \sum_{i=1}^{L} Y_i \quad (3)$$

The obtained values of the volumes of resources are ranked from the largest to the smallest:$Y = \{Y_i\}, i = \overline{1,L}$

Next, within the framework of the method of priority multi-streaming of multi-modal messages, it is checked whether PDUs of a multi-modal message Xcan be transmitted within its lifetime on any sub-stream. If the condition is achievable, then the multimodal message is completely distributed to one of the substreams. Otherwise, the PBDs of each modality are distributed separately $X_j, j = \overline{1,K}$. In this case, if modality PDUs have already been allocated to one of the substreams, the free amount of resources in this substream is checked to allocate PDUs of the current modality.

If the PDUs of any modality cannot be allocated to any substream (the resources are all busy), then the PDUs of the modality are allocated to the next substream. If modality PDUs cannot be allocated to any substream, then they are distributed in parts, starting with high priority, to all substreams until all modality PDUs have been allocated or all available resources are occupied.

This approach can be illustrated by the following example (Fig. 1): a multimodal message consists of PDUs of three modalities of different priority $X = \{X_1, X_2, X_3\}$, the user device has two communication interfaces $L = \{L_1, L_2\}$. Assume that a multimodal message Xcannot be transmitted in its entirety on one of the substreams. Then, according to the developed method, it must be fragmented into modalities $\{X_1, X_2, X_3\}$, which will be distributed among substreams depending on the amount of data that can be transmitted by them.

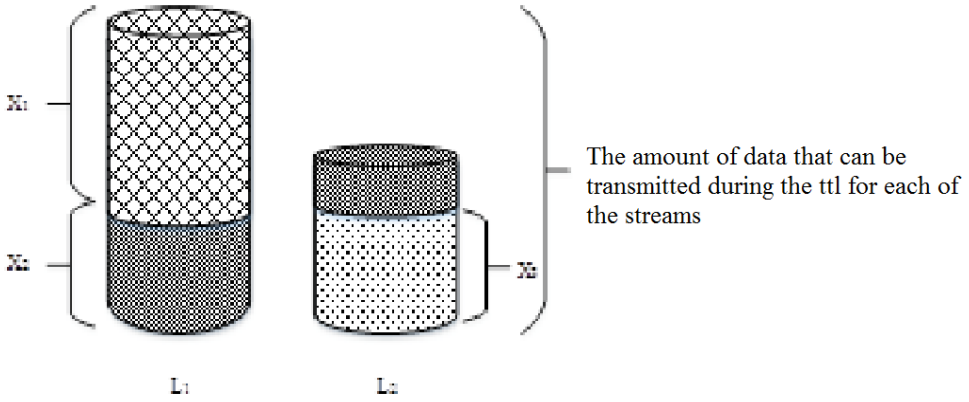

Figure 1. The result of the distribution of PDU modalities according to the method of priority multi-stream transmission of multimodal messages

Within the framework of the proposed method, it is assumed that service PDUs are transmitted from the receiver to the sender, based on the information of which it is possible to calculate the current throughput of all substreams, the number of losses on all substreams, delays and delay variation.

According to the proposed method, each time the sender receives a service PDU, it determines the loss factors $\omega'_i, i = \overline{1,L}$and the values of the current available network throughputs $C'_i, i = \overline{1,L}$for each flow L.

The loss factor $\omega_i, i = \overline{1,L}$is defined as the percentage of multimodal message PDU losses that were sent but not delivered to the receiver.

Throughput per time τfor each of the substreams is defined as [58]:

$$C_i(\tau) = \frac{(\beta_i(\tau) * (1 - \omega_i(\tau))}{\tau}, i = \overline{1,L} \qquad \text{(four)}$$

where $\beta_i(\tau)$is the number of bits sent to the stream in time τ.

The average PDU delivery delay is the time interval required for the delivery of a message PDU from the source to the recipient, plus the delivery time of the service PDU. In other words , $t_1$the $t_2$delivery delay is determined from the $(t_2 - t_1)$relation Moreover $t_2 > t_1$, , (t_2-$t_1 \leq ttl$), where $ttl$is the maximum allowable delay. Exceeding the maximum allowable delay will cause the message PDU to be lost.

At the same time, the issue of calculating the value of the time interval is relevant τ, within which the available bandwidth is calculated. Since the data rate can change significantly over time, it is clear that the throughput is a time function depending on the previous values. However, τit should not be so large that old values do not have a significant effect on its value, and not so small that the throughput calculation is not skewed by short-term changes in the transfer rate. Taking into account all of the above, it can be concluded that the calculation of the average throughput of the sub-data streams can be calculated as a function of the moving average. However, its result will greatly depend on the input load, so it is obvious that it should be considered individually for each transmission system.

Approbation of the method of priority distribution of multimodal information on a data transmission network in the anylogic environment

To test the method of priority transmission of multimodal information, an algorithm was formulated for the priority transmission of multimodal messages in the AnyLogic 8.7.12 simulation environment, which implements the logic of the developed method (Fig. 2).

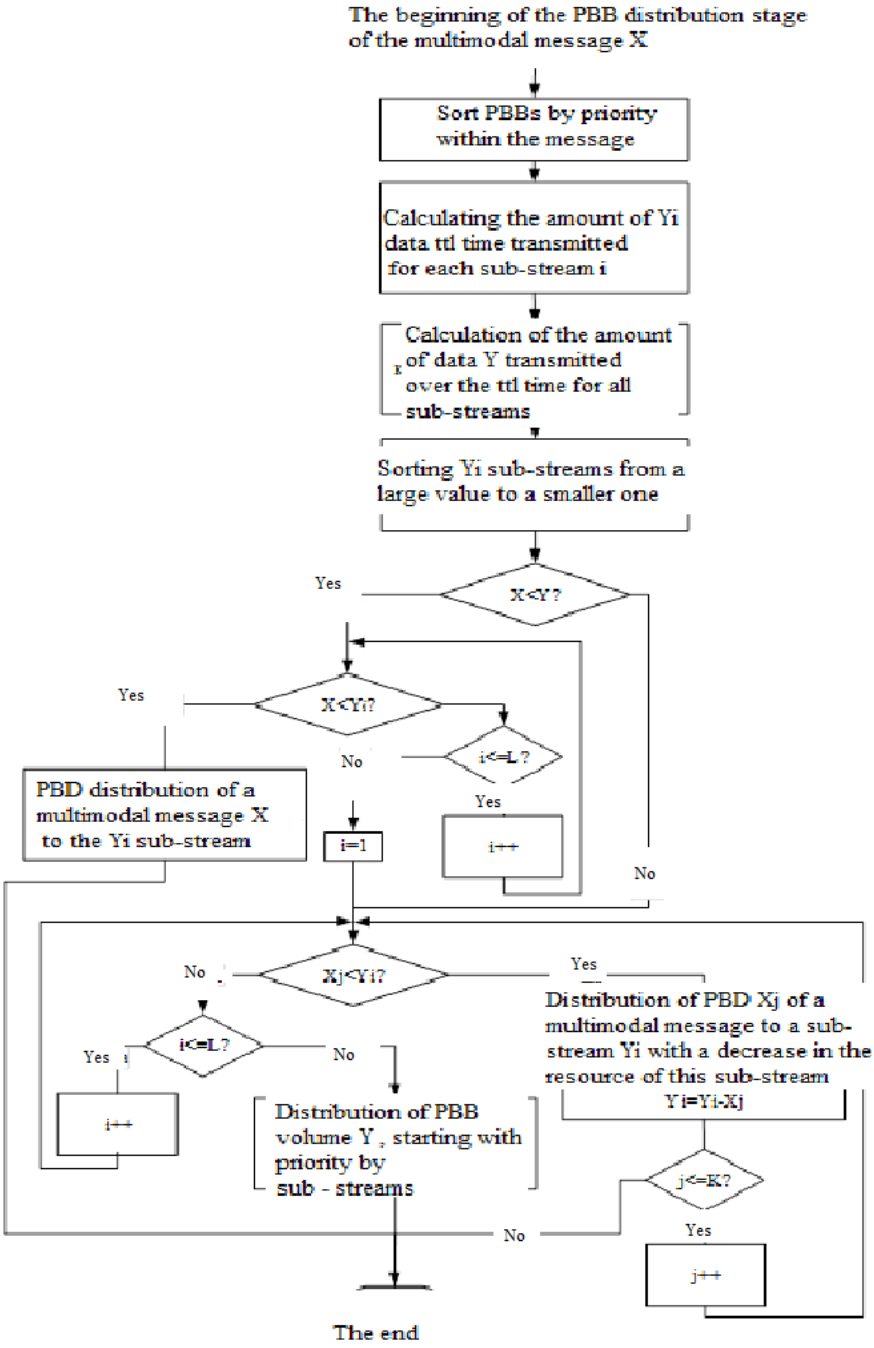

Figure 2. Block diagram of the algorithm for priority multi-streaming transmission of multimodal information for the AnyLogic simulation environment

The Source generates a PDU of a multimodal message of a different priority class according to the Poisson distribution law. Let's assume that the modalities are synchronized in time.

Algorithm execution starts from the Exit block . The logic of work is implemented through the Action Diagram. Defragmentation of a message into parts is implemented using the Split block . Timeout messages are implemented using the Enter 4 block.

As a result of the implementation of the algorithm in the simulation environment, additional restrictions are introduced. Since the value of the number of resources is given in the simulation, it is assumed that the value of the network bandwidth is known. In addition, it is obvious that during simulation there are no service PDUs, and all statistics on the operation of the algorithm are collected inside the model. Then it is obvious that when considering the reception-transmission delays, their end-to-end characteristics are taken.

The structure of the simulation model in the AnyLogic 8 University 8.7.12 environment with the implementation of the developed algorithm is shown in Figure 3.

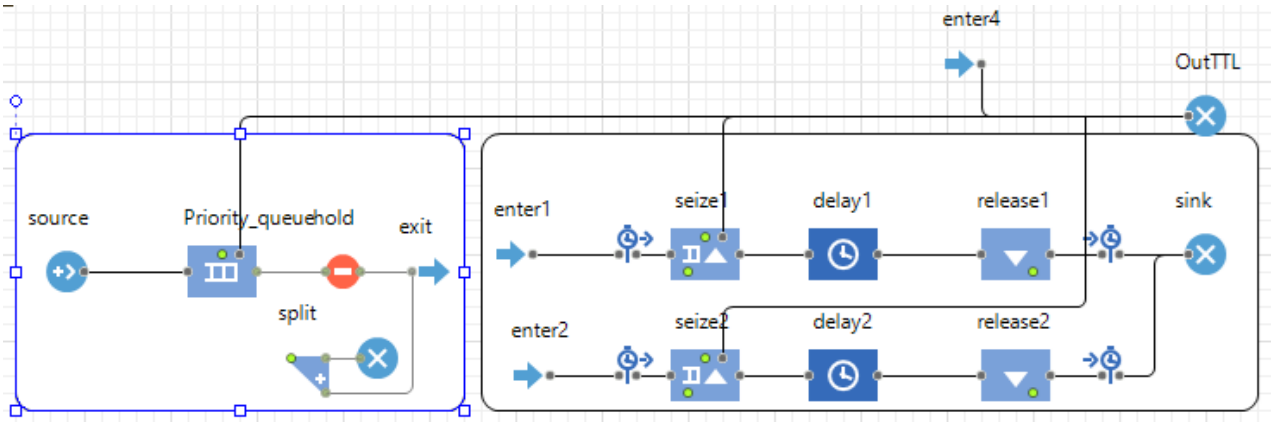

Figure 3. Simulation model of multi-stream transmission of multi-modal information with the implementation of the algorithm for the priority distribution of multi-modal information on the data network in the AnyLogic environment

To analyze the operation of the algorithm, a number of experiments were carried out with the following initial data. Let us assume that a stream of modalities is received at the input: a data stream with an optical resolution of 1280x720 pixels at 30 frames per second and a bit rate of 1536 Kbps [8], an audio stream in mono mode is 128 Kbps. Let's also assume that the upstream bandwidth of one of the available networks is 2048 Kbps, the other network is 3072 Kbps. For ease of modeling, assume that the packet size for all priority levels is the same. Then the formalized record of the initial data using the ECR equal to 128 Kbps will look like: n = 2, u 1 = 12 ECR, u 2 = 1 ECR. The total channel resource in this case is 40 ECR. The packet service time is inversely proportional to the amount of free network resources.

Each experiment lasted 1000 seconds with the random number generator initialized with a random seed to set the number of generated input messages. The results of the experiments are given in table. 1 (average values).

When modeling without using the method of priority multi-stream data transfer, modality PDUs are distributed first to the first sub-stream, if there are resources in it, then to the second sub-stream.

Table 1 - Message passing simulation results

Link	Number of received messages	Number of messages sent	Transmission delay, sec	Channel delay variation, sec	Channel Loss Factor	Timeout care factor
Without applying the algorithm						
Substream 1	2960	2220	0,36	0,08	0,02	0,05
Substream 2		592	0,51	0,03	0,01	
Using the algorithm						
Substream 1	300 0	2400	0,181	0,01	0,01	0,02
Substream 2		540	0,266	0,02	0	

Based on the simulation results, the following conclusions can be drawn. It is obvious that the application of the developed method increases the efficiency of multimodal information transmission in the scenario of multistream data transmission. The number of lost messages in substreams decreased by 2 times. The number of messages sent by timeout has decreased by 3 times.

There has been a significant decrease in delay values and delay variation in both communication channels, which increases the likelihood of using interactive services.

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ТЕХНОЛОГИЯ ПРОДОВОЛЬСТВЕННЫХ ПРОДУКТОВ | TECHNOLOGY OF FOOD PRODUCTS

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ПЕРСПЕКТИВЫ ИСПОЛЬЗОВАНИЯ ПОЛИФЕНОЛОВ В КАЧЕСТВЕ ИСТОЧНИКОВ АНТИОКСИДАНТОВ ДЛЯ ФУНКЦИОНАЛЬНОГО ПИТАНИЯ

УДК 57.044/ 637.049
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PROSPECTS FOR THE USE OF POLYPHENOLS AS SOURCES OF ANTIOXIDANTS FOR FUNCTIONAL NUTRITION

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Аннотация

Согласно данным ВОЗ, наблюдается сниженное потребление фруктов и овощей среди населения. В данный момент, подобный дефицит потребления наблюдается и в России. Сниженное количество в рационе подобных продуктов приводит к росту неинфекционных заболеваний, увеличению оксидативного стресса в организме человека, что в свою очередь приводит и к снижению антиоксидантного статуса. Решить подобную проблему можно добавлением в рацион человека различных функциональных продуктов с различными антиоксидантными компонентами с повышенной антиоксидантной активностью. Подобной активностью обладают полифенолы. Рассматривались 10 групп флавоноидов, а также остальные крупные группы полифенолов. В продуктах питания в основном используются некоторые флавоноиды и антоцианидины. Остальные группы, несмотря на их полезные терапевтические свойства, не используются в пищевой промышленности.

Согласно данным ресурса PubMed наблюдается значительный рост публикативной активности по темам функционального питания и полифенолов за последние 20 лет как за рубежом, так и в России.

Функциональные продукты с полифенолами в большем количестве представлены на зарубежных рынках, нежели на российских. Такие продукты за рубежом представлены в самых различных сегментах рынка – в хлебобулочных изделиях, молочных продуктах, безалкогольных напитках, сухих продуктах и суперфудах. На российском рынке продукты с полифенолами представлены в небольшом количестве в молочных продуктах, безалкогольных напитках и суперфудах, зачастую зарубежными компаниями. В современных условиях такое распределение поднимает проблему импортозамещения и необходимости использования научных пищевых достижений в области молочной продукции и безалкогольных напитков, опережая зарубежные аналоги.

Ключевые слова: полифенолы, антиоксиданты, функциональные продукты, обогащенные продукты, молочные продукты, хлебобулочные изделия, напитки.

Abstract

According to WHO data, there is a reduced consumption of fruits and vegetables among the population. At the moment, a similar consumption deficit is observed in Russia. A reduced amount of such products in the diet leads to an increase in non-communicable diseases, an increase in oxidative stress in the human body, which in turn leads to a decrease in the antioxidant status. This problem can be solved by adding various functional foods with various antioxidant components with increased antioxidant activity to the human diet. Polyphenols have similar activity. 10 groups of flavonoids were considered, as well as other large groups of polyphenols. Some flavonoids and anthocyanidins are mainly used in foods. The remaining groups, despite their useful therapeutic properties, are not used in the food industry.

According to the PubMed resource, there has been a significant increase in publication activity on the topics of functional nutrition and polyphenols over the past 20 years, both abroad and in Russia.

Functional products with polyphenols are presented in greater quantities on foreign markets than on Russian ones. Such products are represented abroad in a variety of market segments - in bakery products, dairy products, soft

drinks, dry foods and superfoods. On the Russian market, products with polyphenols are presented in small quantities in dairy products, soft drinks and superfoods, often by foreign companies. In modern conditions, such a distribution raises the problem of import substitution and the need to use scientific food achievements in the field of dairy products and soft drinks, ahead of foreign analogues.

Keywords: polyphenols, antioxidants, functional foods, enriched foods, dairy products, baked goods, beverages

Introduction

According to the World Health Organization, there is a reduced consumption of fruits and vegetables among the population. Russian researchers have shown that a deficit in the consumption of fruits and vegetables is observed in Russia at the present time [1–3] . Reduced consumption of various plant products is accompanied by an increase in various non-communicable diseases, an increase in oxidative stress in the human body, which also leads to a decrease in antioxidant status [4] .

The solution to this problem can be functional nutrition, which includes various components. To improve the antioxidant status, various dietary supplements with increased antioxidant activity can be used [5] . Substances known as polyphenols possess such strong activity. They are also known as secondary metabolites of plants, whose molecules contain a large number of hydroxyl groups, which cause antioxidant and other effects [6] . The use of such additives will make it possible to enrich the final food products with antioxidant components, correcting the deficit in the consumption of fruits and vegetables by the population, which is an important task for the food industry as a whole.

In the concept of the roadmap of the national project " FoodNet 2.0" it is also proposed to expand certain areas of the market - alternative sources of raw materials and food, personalized and special nutrition, which considers product segments and the invention of new food composites for specialized and functional nutrition [7] . The expansion of these segments and directions of the market fits well into the concept of obtaining a functional product with increased antioxidant activity, achieved through the use of polyphenolic components.

The purpose of this study is to review the types of polyphenols used in food production with an increased antioxidant effect, to consider Russian and foreign food products that currently use polyphenols.

Substances with an antioxidant effect: meaning and classification

The balance between oxidation and reduction is an important element in maintaining a healthy state of any organism. During the life of living organisms, particles are formed that cause a violation of this balance. Such particles are such radicals as hydroxyl, superoxide, nitric oxide and peroxide. Peroxynitrite, hypochlorous acid, hydrogen peroxide, singlet oxygen and ozone, in turn, are not free radicals, but can lead to the formation of free radicals in living organisms [8] . Such compounds are called reactive oxygen species (ROS) - they are produced during the life of cells, in particular, in mitochondria, during the process of oxygen reduction, hydrogen peroxide can be formed from superoxide [9] . One of the main ways to neutralize ROS in the body is provided by enzymes - catalase and superoxide dismutase, but if the enzymatic link of the antioxidant system is weakened, then in this case we observe the phenomenon of an excess of ROS, or oxidative stress [10] .

With the accumulation of ROS, a state is possible when they themselves begin to influence mitochondria and further increase the amount of ROS received [11] . In addition, they can disrupt the usual mechanisms of cell signaling, oxidize proteins and fats, cause cell apoptosis [12] and cause cognitive dysfunction [13] , as well as accelerate the aging of the body, reducing its performance [11] . Protection of cells from such influences is carried out with the help of various substances - antioxidants - both the aforementioned enzymes and low molecular weight substances (vitamin C, uric acid) or high molecular weight compounds such as phenols and polyphenols act in this role [6] .

Antioxidants are substances that inhibit the oxidation reaction. They are usually divided into water-soluble (glutathione, lipoic acid and uric acid) and fat-soluble (carotene and ubiquinol). Water-soluble antioxidants react with oxidants in the cell cytosol and blood plasma, and fat-soluble antioxidants protect cell membranes from peroxidation [14] . According to their function or mechanism of action, antioxidants can be classified into:

1. free radical-reactive (or "terminators"), which inhibit the formation of free radicals in the initiation phase, and "chain-breakers", which interrupt the reaction at the stage of chain development;
2. metal chelators, which convert metal ions into stable forms that cannot be an electron acceptor;
3. singlet oxygen reactive antioxidants that reduce oxygen to its base state;
4. synergists (or "regenerators"), which increase the activity or restore other antioxidants in the mixture;
5. reducing agents that donate an electron to other oxidizable compounds;
6. inhibitors of oxidative enzymes [15] .

Types of polyphenols and their action

Polyphenols are secondary metabolites of plants and are usually involved in defense against ultraviolet radiation or pathogen aggression [16] . They include a wide range of molecules that have polyphenolic structures, i.e. multiple hydroxyl groups in aromatic rings, as well as molecules with a single phenolic ring such as phenolic acids and phenolic alcohols. Depending on the number of phenolic rings they contain and the structural elements that link these rings to each other, polyphenols are classified into various groups, including phenolic acids, flavonoids, stilbenes, and lignans. It is believed that flavonoids and phenolic acids are the main components that exhibit antioxidant activity in medicinal plants [17] .

Flavonoids constitute the most abundant group of plant polyphenols [17] . Their common structural feature is the diphenylpropane moiety, which consists of two aromatic rings linked via three carbon atoms, which together usually form an oxygen-containing heterocycle. Depending on the type of heterocycle involved, flavonoids are divided into six classes: flavones, flavanones, flavonols, isoflavones, anthocyanidins, and flavanols (or catechins) [18] . Flavonols are the most abundant flavonoids, with quercetin and kaempferol being the most commonly used in foods. Phenolic acids can be divided into two classes: benzoic acid derivatives and cinnamic acid derivatives. Hydroxybenzoic acids such as gallic acid and protocatechuic acid are found in a few edible plants (blueberries, blackberries, strawberries, plums, grapes, mangoes, cashews, hazelnuts, walnuts, tea) [19] . Hydroxycinnamic acids are more common than hydroxybenzoic acids and consist mainly of p-coumaric, caffeic, ferulic, and synapic acids. Gallic acid, a precursor of many tannins, is one of the most studied and promising compounds in the group of hydroxybenzoic acids [20] .

Flavonoids are currently the most studied group of polyphenols. They are divided into 10 generally accepted classes based on the degree of oxidation:

1. Catechins

A large number of catechins are known, the most studied being green tea catechins, namely catechin, epicatechin, epicatechin gallate, epigallocatechin, gallocatechin, catechin gallate, gallocatechin gallate and epigallocatechin-3-gallate. The diversity of structures is explained by the ability of open hydroxyl groups in the composition of molecules to interact with other polyphenols [21] . They have studied antiradical, antibacterial, anticarcinogenic properties and the effect of slowing down cell aging [22,23] . However, during storage, catechins tend to darken, and at the same time, their antioxidant activity decreases [24] , which limits their use in the food industry. Epigallo-3-catechin gallate is one of the best known and most widely used catechins. It can be said that it is also the most studied polyphenol in whey protein-polyphenol complexes, as evidenced by many studies [25,26] . This catechin has a diverse set of functional properties. For example, it may cause a slight decrease in low-density lipoprotein (cholesterol) [27] , and also has an anti-inflammatory effect, it can fight cardiovascular, infectious and neurodegenerative diseases [28–31]

. However, it has a rather low bioavailability due to its instability in the gastrointestinal environment [32] , which has led to widespread studies of its interaction with various proteins.

2. Anthocyanins and anthocyanidins

Anthocyanins are one of the most studied groups of polyphenols [33–36] . The main source of anthocyanins are extracts of various berries or their components (the most common extract from the skin of grapes and an extract from blackcurrant berries). Anthocyanins are widely known in the food industry and are used as a food additive with the label E 163. In addition to their antioxidant properties, these compounds are known for their biological properties associated with the elimination of the consequences of neurodegenerative diseases, diabetes, angiocardiopathy, inflammation and anticancer activity [37,38] . Research is also underway on other therapeutic effects [39] . Small amounts of anthocyanins entering the intestine are reported - various researchers have from 40 to 85% of the encapsulated material, depending on the conditions and methods of encapsulation [40,41] .

3. Leukoanthocyanins

Leukoanthocyanins are derivatives of anthocyanidins. In free form, they exist in large quantities in wines, but they are quite easily oxidized, for example, when heated, as a result of which the amount of anthocyanidins increases. They are responsible for the astringency of the wine, but if they are excessive in taste, excess bitterness appears, and when they polymerize, they precipitate, which causes darkening of the wine.

This group of flavonoids has shown to be potentially effective in the study of their effect in non-alcoholic fatty liver disease (excessive deposition of fatty particles in hepatocytes) [42] .

4. Flavanones

They are colorless ketones, often found in plants in the form of glycosides. In total there are 15 compounds of this type [43] . The most common are eriodictyol and hesperetin in plant tissues, naringin in grapefruit peel, and hesperidin in orange and tangerine peel. Hesperetin is a derivative of eriodictyol, and hesperidin is in turn a glycoside of hesperetin [44] . It is these polyphenols that give bitterness to the taste of the considered citrus fruits. These compounds belong to the vitamin P group [45] .

Eriodictyol is found in small amounts in almonds and pistachios [46] , but is also widely distributed in small amounts in a wide variety of plants, such as sorghum [47] .

5. Flavanonols

This is a subclass of flavanoids that contain two or more oxygen atoms, such as 3-hydroxyflavanol or 2,3-dihydroxyflavonol. The most well-known examples of substances in this subclass are dihydroquercetin (taxifolin), dihydrocampferol (aromaderin) and engeletin (dihydrocampferol-3-rhamnoside). Flavanonol glycosides are present in large quantities in plants [48] .

Dihydroquercetin is found in large quantities in the butt of the Siberian and Daurian larches [49] . It is included in the State Register of Medicinal Products as a pharmaceutical substance. Possessing a fairly large number of positive effects [50-52] , it is less toxic than its predecessor quercetin [52] . In the dairy industry, it is used as an antioxidant to increase the shelf life of canned milk and products [53] and may enhance the growth of lactic acid bacteria [54] .

Enegeletin is found in the skin of grapes, is found in wine, and is also found in small amounts in *Hymenaea martiana* [55] . According to the international patent classification, it refers to traditional herbal medicines according to codes A61K 36/00 and A61P 43/00.

6. Flavones and Isoflavones

Flavones and isoflavones are a fairly extensive subclass of polyphenols (the most common are chrysin, apigenin, acacetin, luteolin, diosmetin, chrysoeriol, diuretin and tricine). Of the flavones in human nutrition, rutin (3-rhamnoglucoside quercetin), which has the activity of vitamin P, is of the greatest interest. It should be noted that this group of substances of their flavonoids is limited in use, since reactions of reversible cleavage of the pyran ring during alkalization under mild conditions with further formation of chalcones are possible. It is this reaction mechanism that

also proceeds with amine-containing compounds, including proteins, leading to the destruction of the original flavone molecule (Figure 1).

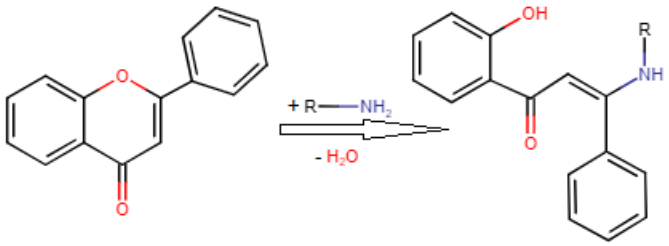

Figure 1. The reaction of flavones with amine-containing compounds

Isoflavones differ in the position of the side phenyl ring, which is in the C-2 position rather than the C-3 position. Compounds of this type can be found in the root of licorice or harrow [56] . Their high content in soybeans is noted with the definition of these substances as phytoestrogens with high biological activity and the ability to inhibit some isoforms of P450 cytochromes, which can affect the metabolism of pharmacological drugs and change the detoxification function.

7. Flavonols

A rather extensive subclass of flavonoids, a characteristic feature is the presence of OH - groups in various positions, which just explains the large number of representatives of the subclass. Kaempferol and quercetin are the best known substances of this series.

Kaempferol is a 3,4',5,7-terahydroxyflavone found in a wide variety of vegetables and fruits: apples, grapes, tomatoes, green tea, green beans, peaches, blackberries, and raspberries [57, 58] . It is used in the manufacture of soft drinks [59] and in sports nutrition [60] .

Quercetin is one of the most studied polyphenols. Contained in a large number of plants, fruits and vegetables - lovage, buckwheat, onions, apples, peppers, garlic, red grapes [61] . It has a fairly large number of positive effects - it activates mitochondrial biogenesis, which leads to an increase in the number of mitochondria in brain cells that have undergone traumatic brain injury [62] . It has an anti-inflammatory effect [63] .

8. Chalkons

A subclass of compounds with an open pyran ring, which is why they are quite reactive compounds, which means they can enter into dimerization, glycosylation and reduction reactions. They show antibacterial, antifungal and antitumor properties [64] , and some members of the class have also shown the ability to block potassium channels [65] . Contained in the bark of the apple tree, grapes [66] and hops [67] .

9. Dihydrochalcones

Dihydrochalcones are derivatives of chalcones, differ from chalcones in the presence of a saturated propane fragment. Depending on the nature of the substituents in the rings, they have a different severity of sweet taste; in the food industry they are used as sweeteners [68] , for example, the food additive E959 - neohesperidin hydrochalcone. It is mainly found in various parts of the apple tree, such as roots, leaves, shoots and seeds [69] .

10. aurons

Aurones are presented as cis- and trans-isomers. The main difference from other flavonoids is the content of the benzofuran fragment associated with benzylidiene. These compounds can be found in various plants, such as snapdragon and cosmea [70] , brown algae [71] . By analogy with other flavonoids, it is assumed that there are similar biological effects [72] , but only the antifungal properties of these compounds have been proven [73] .

Thus, from the classes and subclasses of polyphenols and individual compounds discussed above, one can single out the potential possibility of their use as a functional ingredient in products. So, stilbenes in the face of resveratrol and pterostilbene show themselves as independent substances; all flavonoids have problems with bioavailability, and, basically, the protein acts as a transport molecule. Catechins have been extensively studied, and the best known representative is epigallocatechin-3-gallate (EGCG). This compound is the most studied within the food industry and various pharmaceutical effects. Anthocyanidins are also quite widely studied, but if in the case of catechins the clear leader of the subclass is EGCG , then in the case of anthocyanidins there is no such substance. The raw materials in this case are the most homogeneous - red fruits and berries, mainly red grapes. In the case of working with flavanones and flavanonols, there is a possibility that, in addition to problems in extraction (some substances are found in oak bark, for example), there will be problems with the organoleptic part (they have a pronounced bitter taste), which does not occur in the case of anthocyanins (the most common berry sweet and sour taste). Quercetin and kaempferol are found in a wide variety of fruits and plants. Also, these substances are individual, unlike anthocyanin extracts with a diverse profile of substances. Chalcones, dihydrochalcones and aurones are rather poorly studied.

Analysis of food fortification and functional food market.

People consume a large number of functional foods - various bakery products, dairy products, meat and fish semi-finished products, alcoholic and non-alcoholic drinks, snacks and confectionery. A special category is to highlight baby food, where enrichment with various useful additives has long been practiced. In most of these categories, there is a growing demand for functional and herbal products. Also, according to the PubMed resource , the publication activity on the topic under discussion has been growing over the past 20 years:

Table 1 - the number of scientific publications for the keywords " Functional Foods " and " Functional food POLYPHENOLS " according to PubMed .

Request/year	Functional _ food »	Functional _ food POLYPHENOLS »
2000	205	2
2001	236	2
2002	248	3
2003	262	5
2004	287	7
2005	356	7
2006	369	fourteen
2007	435	four
2008	477	eleven
2009	536	2
2010	655	27
2011	776	3
2012	932	39
2013	1065	61
2014	1266	7
2015	1376	eight
2016	1506	81
2017	1729	108
2018	2042	147
2019	2253	134
2020	2538	157
2021	2631	141

The data shown are also consistent with the position of Russian researchers in this field, who recently presented the FoodNet 2.0 concept as part of the national technology initiative. The concept of " FoodNet " is the systematic development of various segments of the food industry market, as well as the formation of a globally competitive Russian "food industry 4.0" - new production, logistics and marketing solutions based on digitalization, network market models and customization of products and services, biotechnology, resource efficiency . Within the framework of this model, functional foods act as participants in two segments of the food industry market at once - as an alternative source of food or personalized and special nutrition. It is predicted that the capitalization of these segments will double by 2035 [7] . However, when using various new technologies, one should not forget about the issue of security [74] .

The positions of the most famous companies in the market of functional and fortified food products are considered below. The leaders of Russian and foreign ratings in terms of revenue in the specified industry were taken as a basis.

1. Bakery products

The Karavay company (St. Petersburg) has in its assortment milk bread with apple, enriched with zinc, iron and iodine, vitamins B1, B2, B6, C, PP and prebiotic inulin. Also bread "Farmer" hearth with the addition of vitamins E, H and group B, calcium, manganese, iron, chromium, and bread "Starorussky" enriched with vitamins and microelements. Bakery and confectionery holding "Kolomenskoye" has 3 types of bread with various additions of large quantities of pumpkin, flax and sunflower seeds, which provides products with more vitamins and minerals than in ordinary bread. JSC "LIMAK" offers a choice of "Iodized" loaf, enriched with iodized protein. Also, like BKH "Kolomenskoye", they use flour of various origins in their production to enrich their products with various vitamins and macro- and microelements. JSC "First Bakery" has a whole line of bread for a healthy diet - there are breads with a low glycemic index, enriched with various additives of pumpkin and flax flour, as well as bread "Grain with calcium", containing a vitamin and mineral complex with vitamins B1, B2, B6, folic acid, as well as calcium and iron. But the most interesting representative for this study is Champion-Leader bread with a high content of phospholipids and vitamin E (tocopherol). In general, the specified line of breads is shown as products for a healthy diet. The group of companies "Darnitsa" (brand "Aladushkin") also has in its assortment a line of so-called "healthy breads" enriched with various vitamins and minerals. Other companies do not produce such useful products (KBK Cheryomushki, SMAK, Volzhsky Pekar and Khlebzavod No. 28). The products of local producers represented by Stavropol Dairy Plant JSC were also considered. MKS produces Fermersky bread, which contains Jerusalem artichoke flour, which contains various vitamins (A, groups B and C), macro- and microelements.

The company " Nestlé " produces under the brand " Oats & More " a series of various oatmeal for breakfast, containing both additives in the form of raisins or almonds, and enriched with a vitamin-mineral complex (7 vitamins, riboflavin and iron are declared). Large company Mondelez International produces a large number of fortified bakery and confectionery products under various brands. So, under the Belvita brand , various cookies are produced, enriched with vitamins B2, B6, as well as thiamine, niacin, riboflavin and iron. Brand " Enjoy " life Food " also produces various cookies, but they are not enriched, but on the contrary, they are free of various allergens and gluten. " Lu " produce crackers, toasts and crackers, in their assortment they have crackers enriched with iron, magnesium, folic acid and vitamins B1, B2, B6 and E. Bars " Perfect Snacks with added superfoods, and high in calcium, potassium, niacin, magnesium, iron, and vitamin E. Associated british food Plc owns the Burgen brand , which produces a variety of prebiotic-infused breads. Another brand of theirs, Kingsmill , sells breads with vitamin supplements (vitamin D , iron and calcium) and increased fiber content.

Considering Russian and foreign bakery and confectionery products, it should be noted that despite the presence on our market of individual products in the range of the above brands, in the foreign market such niches are immediately entered by large brands and companies whose goal is to produce enriched and functional products. The main additives are B vitamins and minerals in

the form of micro and macro elements. Polyphenols were absent in Russian bakery products; abroad, it is practiced to add small amounts of various berries (for example, raisins in Oats & More cereal), which increases the amount of polyphenols in the final product.

2. Dairy products and drinks.

One of the largest groups of functional foods. Brands " Danone " - "Actual" (whey with the addition of fruit juice and a vitamin complex with vitamin D), a series of baby food "Rastishka" (also with the addition of vitamin D), a series of vegetable-based soft drinks " ALPRO " with the addition of vitamins D and B 12, Actimel fermented milk products (D 3, B 6 and probiotics). Fonterra is practically not represented in Russia , one of its brands is Anchor , which produces various yogurts enriched with vitamins A and D , calcium, and various prebiotics. PepsiCo brands (represented in Russia by Wimm-Bill-Dann) - products of the Mazhitel line (a cocktail of milk, whey and fruit juice), the Immunele line in the form of a fermented milk product with the addition of vitamins D 3 and B6. Enriched with calcium and a complex of 6 vitamins (C, B1, B6, B9, B12, PP) Toptyzhka milk from the Milkom company. "Komos-Group" company - the entire line of products " Fitness time " consists of superfoods (non-alcoholic drink based on whey, fruit juice and matcha tea), protein yogurts (yogurts with the addition of milk protein), fortified milk (vitamin-mineral premix: calcium phosphate, magnesium citrate, zinc sulfate, D 3 and B12) and "albumin curd" (curd mass with the addition of hydrolyzed collagen, whey and albumin). Company « Foodland » - fermented milk product «Elanochka» enriched with vitamins A, C, B1 and B2. The local manufacturer of dairy products, Stavropolsky Dairy Plant, also has products with various additives in its assortment. Pasteurized milk with prebiotic lactulose, thermostatic “Snezhok” with probiotic L. Rhamnosus LGG, “Pure” Bioyogurt with five microorganisms (*Str. thermophilus, L. bulgaricus, Bifidobacterium sp, L. plantarum, L. acidophilus, L. casei, L. rhamnosus LGG*), bioyogurt with the addition *of L.casei* , milkshake enriched with protein, vitamin D3 and calcium "Active Milk", sour-milk bio-ice cream with probiotic (acidophilus bacillus) and prebiotic (lactulose).

In the range of soft drinks, fruit juices are the predominant type of product. A significant market share is occupied by the PepsiCo company with the brands J 7, Lyubimy, Fruktovy Sad, Ya. Together with them, brands of other companies are presented on the shelves, such as Dobry, Sady Pridonya, etc. A distinctive feature of such drinks is the absence of the need to add other functional additives there - fruits and vegetables from which these juices or enriched with various micro and macro elements, vitamins. However, the Nestle company abroad produces a line of nutritional drinks using milk proteins, soy and stevia - " Boost ". This fortification is more appropriate for sports nutrition drinks, which are not the focus of this review. Note that all drinks of this brand are enriched with a large number of vitamins and microelements - vitamins D, A, C, E, K, B6, B12 calcium, iron, potassium, thiamine, riboflavin, niacin, folic acid, biotin, pantothenic acid, phosphorus, iodine, magnesium, zinc, selenium, copper, manganese, chromium, molybdenum, chloride and choline. In Russia, stevia is mainly used as an independent sugar substitute and in various confectionery products.

In this segment, it is not possible to divide companies and brands into Russian and foreign ones, due to their close coexistence. The main functional additive in dairy products is vitamin D and B vitamins . Sometimes vitamins of groups A and C are added, as well as various micro and macro elements or their complexes. Within the production of various yoghurts, there is a tendency to introduce various pre- and probiotics. Polyphenols are present in small quantities both in Russian holdings (Komos Group with a line of superfoods based on whey) and abroad (Mazhitel from PepsiCo).

3. Dry Foods/Superfoods

Abroad, dry products in the form of dietary supplements are widely represented, packaged in the form of bags with a zip - lock fastener for reusable use from 100 to 500 grams. So, for example, in the top 100 most popular products ordered through the amazon platform . com got the following superfoods:

1) Organic Acai Berry Powder, positioning itself as freeze-dried acai (vegetable euterpe), with a high content of vitamins A and C, iron and calcium. It is used as a base for making various juices, smoothies, yoghurts [75] .

2) Laird Superfood Instafuel Matcha, this superfood claims two main components - powdered green tea and original non-dairy creamer powder (includes coconut milk powder, coconut sugar and coconut oil). It contains a large amount of vitamins A, C, as well as calcium [76] .

3) Sweetwell Keto Sugar-Free Meringue Cookies is not a superfood, but it captures the general trend quite accurately. These meringue cookies come in a variety of flavors and are low in carbs to support a keto diet. The manufacturer focuses on the use of stevia as a sweetener. The enrichment of various elements depends on each specific taste. So, cookies with chocolate flavor, due to the large amount of cocoa, have a large amount of magnesium and potassium [77] .

4) Country Farms Super Reds Energizing Polyphenol Superfood is a polyphenol superfood dry blend containing 48 different berries and fruits rich in antioxidants, phytonutrients and fiber [78] .

The rest of the products on this list are dietary supplements or specific compounds.

Also the previously mentioned company Mondelez International owns the Tang brand , which specializes in low-sugar beverage powders fortified with vitamins C and D. Such a product can be classified as a superfood. The Associated Company british food Plc " with its brand " Anthony 's Goods has a fairly large selection of superfoods - and various fruit and vegetable powders, flour, sugar substitutes and more.

Similar products are beginning to appear on the Russian markets, although they have not yet gained such great popularity. The brands " Royal " are engaged in the sale and production of such superfoods. forest " and " SpirulinaFood ". Royal products forest " is mainly made from a cocoa substitute - carob. It is high in fat and protein, high in fiber, low in carbohydrates, and contains gallic acid [79] and SpirulinaFood puts more emphasis on spirulina powders and supplements. However, the products of these companies are not positioned as functional or enriched with any elements.

The main difference between superfoods and other types of products can be called their independence - they are made exclusively from plant components, and sometimes they themselves can act as food additives. All presented positions contain a large amount of vitamins A and C and various micro and macro elements.

Polyphenols in foreign superfoods and dry products are presented much better than in Russia - abroad they produce and buy a very large amount of dry products with a large amount of polyphenols in the composition, in addition to other enriched items. There is no wide range of manufacturers of such products on the Russian market, despite the popularization of this segment.

Conclusion

Polyphenols have been shown in research to be useful components that can be used in different food systems and exhibit different properties. However, market saturation with products with polyphenols is low. The largest number of such products is produced abroad - in particular, superfoods, dry foods and the presence of bakery products with polyphenols in the composition stand out. In Russia, similar products are currently presented in small quantities on the shelves by foreign companies in the dairy segment. Superfoods are represented by Russian companies, but also in small quantities. Thus, the issue of the lack of such products in the segment of bakery products and dry products is raised, as well as the problem of import substitution within the segment of soft drinks and dairy products. In such a situation, it is worth focusing on the need to use scientific nutritional achievements in the field of dairy products and soft drinks, ahead of foreign analogues.

The market for functional products is growing every year, both in Russia and abroad, but the foreign market has long been saturated with functional products, while Russian markets are just beginning to follow the trend of "healthy" nutrition. New companies are emerging, customer

interest is increasing and publishing activity has been growing over the past ten years, new food concepts are being developed.

The following polyphenols and flavonoid classes were not present in foodstuffs: phenolic acids, stilbenes, chalcones, aurones, leukonanthocyanidins and most flavonoids - catechins, flavanones, flavanonols, flavanols (quercetin and kaempferol). Despite this, the demand for such products is growing both among consumers and among manufacturers and researchers, as literature data show us. This suggests that functional products with the above polyphenols may soon appear.

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ГИГРОСКОПИЧЕСКИЕ ПАРАМЕТРЫ САЗАНЬЕЙ ИКРЫ, КАК ИСТОЧНИКА ЛЕЦИТИНА И ОБЪЕКТА СУШКИ, И ТЕРМОДИНАМИЧЕСКИЙ АНАЛИЗ СТАТИЧЕСКИХ ЗАКОНОМЕРНОСТЕЙ ЕЕ ВЗАИМОДЕЙСТВИЯ С ВОДОЙ

HYGROSCOPIC PARAMETERS OF SAZAN CAVIAR AS A SOURCE OF LECITHIN AND A DRYING OBJECT AND THERMODYNAMIC ANALYSIS OF THE STATIC REGULARITIES OF ITS INTERACTION WITH WATER

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Аннотация

Повышение эффективности глубокой переработки сырья товарного рыбоводства, в том числе мало востребованной на российском рынке икры пресноводных рыб семейства карповых, В качестве объекта исследования использована икра из сазана, которая является перспективным источником для выработки природных эмульгаторов высокого качества, к примеру, лецитина. Известно, что самым распространенным способом консервации биополимеров является сушка исходного сырья. Анализ способов обезвоживания продуктов, подобных сазаньей икре, показал, что наиболее рациональным из них для этой цели является конвективный при возможной комбинации с кондуктивным энергоподвод, что предопределяет контакт объекта изучения с паровоздушной средой и обусловливает целесообразность определения его гигроскопических параметров для рациональной организации процесса сушки и хранения высушенного продукта с целью максимального сохранения в продукте комплекса фосфолипидов, состоящих из ненасыщенных и насыщенных жирных кислот, фосфорной кислоты, глицерина и холина, в целом представляющий собой лецитин. Целью исследования послужило определение гигроскопических и термодинамических параметров взаимодействия сазаньей икры с водой для применения при рациональной реализации технологии ее сушки и получения лецитина из сазаньей икры с целью выявления условия максимальной сохранности в ней необходимого целевого компонента. В рамках данного исследования для икорного продукта определялась его гигроскопичность, характеризующая равновесную влажность продукта, посредством тензометрического метода. Полученные функциональные зависимости гигроскопических параметров от влияющих факторов позволяют определить численные значения удельной тепловой энергии испарения для подстановки их в дифференциальное уравнение теплопереноса при моделировании процессов сушки икорного продукта. В результате, можно сделать вывод о том, что полученные гигроскопические и термодинамические параметры икорного продукта могут успешно использоваться при рациональной организации и реализации технологии и техники его сушки.

Ключевые слова: *икра сазана, сушка, внутренний тепломассоперенос, гигроскопические параметры, статика процесса сушки, термодинамический анализ, конечная влажность.*

Abstract

Increasing the efficiency of deep processing of raw materials for commercial fish farming, including caviar of freshwater fish of the carp family, which is little in demand on the Russian market. As an object of study, carp caviar was used, which is a promising source for the production of high quality natural emulsifiers, for example, lecithin. It is known that the most common method of conservation of biopolymers is the drying of raw materials. An analysis of the methods for dehydrating products like carp caviar showed that the most rational of them for this purpose is convective, with a possible combination with conductive energy supply, which predetermines the contact of the object of study with the steam-air medium and determines the expediency of determining its hygroscopic parameters for the

rational organization of the drying and storage process. dried product in order to maximize the preservation of the complex of phospholipids in the product, consisting of unsaturated and saturated fatty acids, phosphoric acid, glycerol and choline, which in general is lecithin. The aim of the study was to determine the hygroscopic and thermodynamic parameters of the interaction of carp caviar with water for use in the rational implementation of the technology for its drying and obtaining lecithin from carp caviar in order to identify the conditions for maximum preservation of the necessary target component in it. Within the framework of this study, for the caviar product, its hygroscopicity, which characterizes the equilibrium moisture content of the product, was determined using the tensometric method. The obtained functional dependences of hygroscopic parameters on the influencing factors make it possible to determine the numerical values of the specific thermal energy of evaporation for their substitution into the differential heat transfer equation when modeling the drying processes of the caviar product. As a result, it can be concluded that the obtained hygroscopic and thermodynamic parameters of the caviar product can be successfully used in the rational organization and implementation of the drying technology and technique.

Keywords: carp caviar, drying, internal heat and mass transfer, hygroscopic parameters, statics of the drying process, thermodynamic analysis, final moisture content.

Introduction

Increasing the efficiency of deep processing of raw materials for commercial fish farming, including caviar of freshwater fish of the carp family , which is little in demand on the Russian market [1, 2], is an important and urgent task.

In modern conditions, the food industry of the Russian Federation needs high quality natural emulsifiers, for example, lecithins. It should be noted that carp caviar, in particular carp caviar, contains a large amount of lecithin [3, 4], about 10,000 mg per 100 g of the product [5]. According to the data of the European Association of Lecithin Manufacturers (ELMA), its world production is currently more than 250 thousand tons per year, and the need is more than 400 thousand tons per year [6]. With the increasing demand for lecithin, the question arises of identifying a new raw material base for its production.

It is known that lecithin parameters are significantly affected by the source of its production [7, 8, 9, 10], in which it is necessary to preserve its target properties as much as possible during its conservation until the moment of direct use in the selected technology, while the most common methods of conservation are drying and freezing of raw materials.

An analysis of the methods for dehydrating products like carp caviar showed that the most rational of them for this purpose is convective, with a possible combination with conductive energy supply, which predetermines the contact of the object of study with the steam-air medium and determines the expediency of determining its hygroscopic parameters for the rational organization of the drying and storage process. dried product in order to maximize the preservation of the complex of phospholipids in the product, consisting of unsaturated and saturated fatty acids, phosphoric acid, glycerol and choline, which in general is lecithin.

Purpose of the study

Determination of hygroscopic and thermodynamic parameters of the interaction of carp caviar with water for use in the rational implementation of the technology of its drying and obtaining lecithin from carp caviar in order to identify the conditions for maximum preservation of the necessary target component in it.

Objects and methods of research

The object of the study was carp caviar,

As part of this study of the hygroscopic characteristics of the caviar product, its hygroscopicity, which characterizes the equilibrium moisture content of the product, was determined using the Van Bamelen tensometric method. According to this static method, samples of the test product with a predetermined moisture content were kept in desiccators with a solution of sulfuric acid of various concentrations. At the same time, a certain partial pressure of water vapor corresponds to a certain concentration of the solution at a given temperature, i.e. a certain value of relative air humidity φ[11, 12]. A certain amount of the test material is weighed on an analytical balance with an accuracy of 0.001 g after reaching a constant mass, at which its moisture content corresponds to equilibrium.

Equilibrium humidity W_p, which was obtained during the experiments, is determined by the formula:

$$W_p = \frac{G_2 - G_1(1 - W_{обр})}{G_2}, \quad (1)$$

where $W_{обр}$is the initial moisture content of the sample, kg/kg; $G_1$is the initial mass of the test sample, kg; $G_2$is the mass of the sample upon reaching hygrothermal equilibrium, kg;

The experimental study of the hygroscopic properties is intended to characterize the dry product under study and give recommendations on the choice of the final moisture content of the material, which is the most appropriate for the storage process. When constructing sorption curves, it was assumed [12] that the numerical values of the water activity indicator $A_w$and the relative air humidity φcoincide, due to the equality of the vapor pressure above the surface of the material under study and its pressure in the desiccator medium.

Research results and discussion

After a series of experiments on a desiccator pilot plant, moisture sorption isotherms of the dehydrated caviar product were obtained at air temperatures of 25°C and 40°C, which are presented below (Fig. 1).

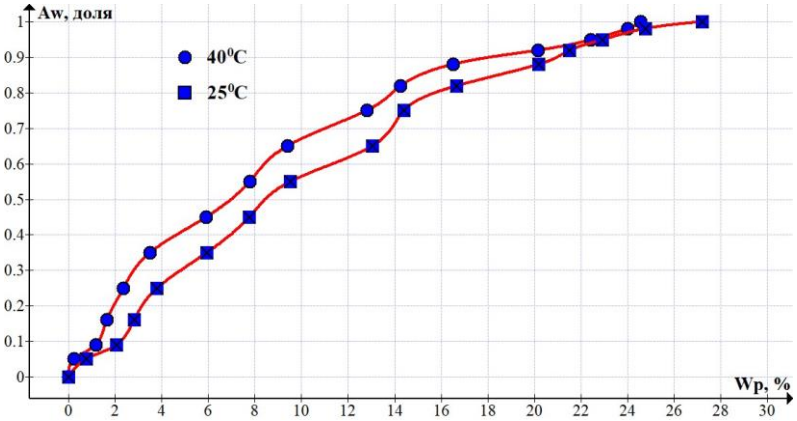

Figure 1. Equilibrium curves for moisture sorption by a dry product

The resulting sorption isotherms can be conditionally divided into three sections, which is especially clearly seen when they are plotted in a semilogarithmic modification (Fig. 2).

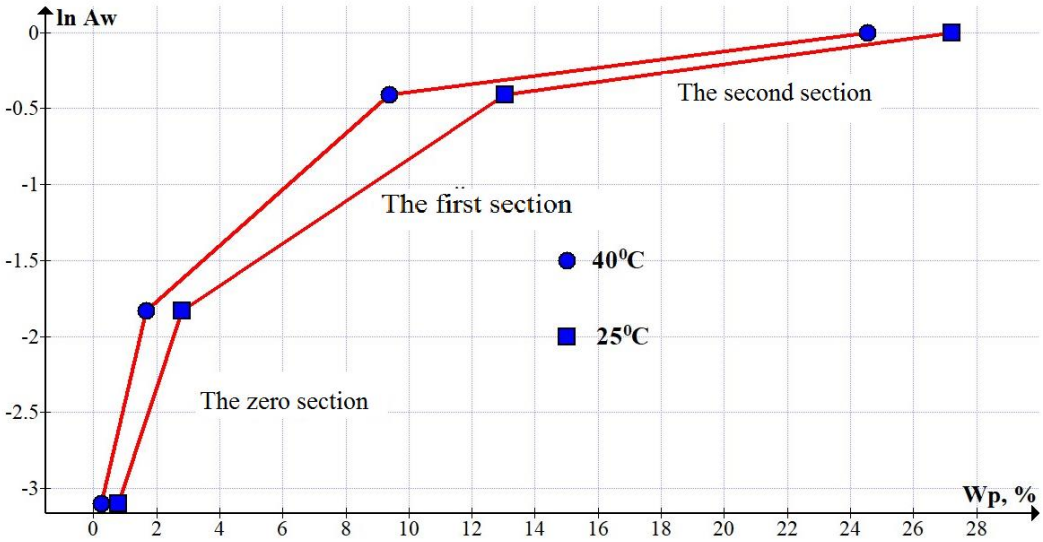

Figure 2. Equilibrium curves plotted in semi-logarithmic coordinates

According to A.V. Lykov [13], all wet materials are divided into several main groups depending on their colloid-physical properties: capillary-porous, colloidal and capillary-porous colloidal, occupying an intermediate position between the first and second. This classification is widely used in generalizing the results obtained. The dry structure of carp caviar is a capillary-mesoporous body with a large number of pores and capillaries through which water vapor can penetrate or be removed. The characterization of the state of moisture in the material and the corresponding parameters of moisture transfer is given on the basis of an analysis of the adsorption phenomena developing on the phase interface (moist air - solid). A generalization of knowledge in this area is currently the theory of polymolecular adsorption developed by S. Brunauer, L. Deming, W. Deming, R. Emmett and B. Teller [12], who proposed a classification based on the identification of five types of isotherms.

The resulting isotherms can be attributed to type I– V , and if the adsorption of gas by a solid body is described by an isotherm of this type, then this indicates that the dry skeleton of dried caviar is characterized as a mesoporous body, i.e. is a porous material, the structure of which is characterized by the presence of cavities or channels with a diameter in the range from 2 to 50 nm [14]. The type IV isotherm also describes physisorption and multilayer processes, resembling the type II isotherm, but now in porous or mesoporous solids, where condensation of gas particles in small volumes of liquid is possible, and therefore, until the pores are “clogged” with liquid, the monolayer is not complete .

Type IV isotherms have a hysteresis loop, the lower branch of which is obtained by measuring adsorption with the sequential addition of gas to the system, and the upper branch is obtained with its sequential decrease (desorption). Effects associated with hysteresis are also possible for other types of isotherms [14].

G.K. Filonenko proposed a mathematical description of isotherms to be carried out by two equations. To do this, you need to divide the curve (Fig. 2) into two sections: the first - from W_0 to W_m; the second - from W_m and above. The point W_0 on the isotherm characterizes the transition from monomolecular to polymolecular adsorption and is obtained by crossing the normal from the first singular point on the isotherm to the abscissa axis. Usually, during actual drying of materials, moisture bound by monomolecular adsorption is not removed, so the isotherm section from 0 to W_0 is not described by the isotherm equation. The point W_m characterizes the transition from moisture bound by polymolecular adsorption to capillary- and osmotically-bound moisture and is obtained by crossing the normal from the second singular point on the isotherm to the abscissa axis. Starting from the values W_m, the isotherm curve sharply goes to the right. Figure 3 below shows a breakdown of the obtained sorption isotherm at 25°C into 2 sections.

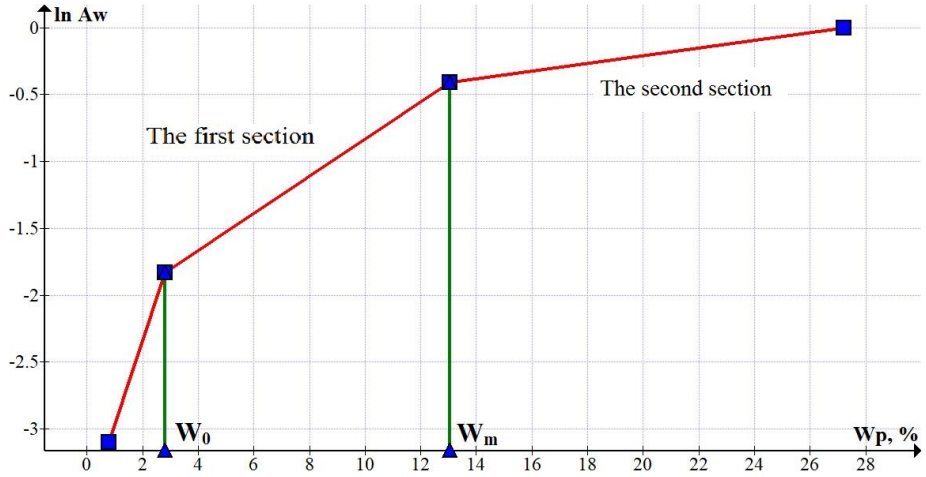

Figure 3. Breakdown into sections with different types of moisture bond with the material: from 0 to W_0 - chemical bond prevails; from W_0 to W_m – adsorption bound moisture prevails; from W_m and above - capillary bound and osmotic moisture

Following the approach described above, on the moisture sorption isotherm of the studied caviar product (Fig. 3), these areas are distinguished: the area from W_0 to W_m characterizes adsorption-bound moisture and the area from W_m and above characterizes capillary-bound and osmotic moisture.

Thus, two sections are distinguished from the empirically obtained sorption isotherms, the reason for the appearance of which is analytically substantiated. It should be noted that the first section starts from the moment where the monomolecular adsorption zone ends, in which moisture is quite strongly bound to the product, therefore, for the dried polymer material, the most appropriate final moisture content is the one that borders on the adsorption-bound interval: $0{,}03 \leq W_p \leq 0{,}13$, i.e. the most rational final moisture for the investigated product is the range from 10 to 12%.

Carrying out the logarithm facilitates the mathematical processing and interpretation of the obtained isotherms (Fig. 2), which, for convenience, are divided into 2 sections (Fig. 3) and approximated by the equations presented below. The calculated error between the approximated and empirically obtained values is no more than 2%.

Approximate Equations 2 and 3 for the sorption isotherm plotted at 40°C.

Plot 1: $0{,}03 \leq W_p \leq 0{,}13$:

$$\ln A_W = 13{,}142W_p - 2{,}141. \quad (2)$$

Plot 2: $0{,}13 \leq W_p \leq 0{,}27$:

$$\ln A_W = 3{,}04W_p - 0{,}828. \quad (3)$$

Approximate Equations 4 and 5 for the sorption isotherm plotted at 25° C .

Plot 1: $0{,}03 \leq W_p \leq 0{,}13$:

$$\ln A_W = 9{,}179W_p - 1{,}47. \quad (4)$$

Plot 2: $0{,}13 \leq W_p \leq 0{,}27$:

$$\ln A_W = 2{,}386W_p - 0{,}587. \quad (5)$$

Due to the fact that the process of drying the caviar product under study proceeds, including in the hygroscopic region, a thermodynamic analysis of the static laws of heat and mass transfer is necessary to identify the influence of the nature of moisture binding with the dry residue on the quality of the resulting dry semi-finished product. In addition, the result obtained must be taken into account when making design decisions for the rational implementation of the processes under study.

On the basis of the obtained equations, graphic dependences of energy changes on the moisture content of the material are constructed, which are shown in Figure 4.

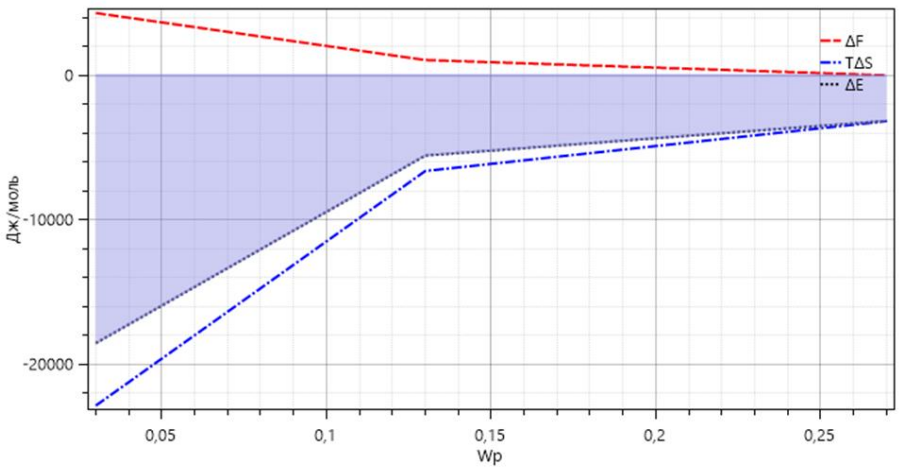

Figure 4. Change in free $\frac{\partial \Delta F}{\partial W_p}$, bound $T\frac{\partial \Delta S}{\partial W_P}$ and internal $\frac{\partial \Delta E}{\partial W_P}$ energy depending on the moisture content of the material

The graphic dependences presented in Figure 4 show that the statics of the processes of interaction with water and the analysis of sorption isotherms allows us to establish and quantify the nature of the change in the thermodynamic components of the Gibbs-Helmholtz equation for an isobaric-isothermal process:

$$\Delta F = \Delta E - T\Delta S, \quad (6)$$

where $\Delta F, \Delta E, \Delta S$are, respectively, changes in free, internal energy (enthalpy) and entropy, according to moisture content $W_p$at $P, T = const$.

Equation 6 in differentiated form looks like this:

$$\left(\frac{\partial \Delta F}{\partial W_P}\right)_{T,P} = \left(\frac{\partial \Delta E}{\partial W_P}\right)_{T,P} - T \cdot \left(\frac{\partial \Delta S}{\partial W_P}\right)_{T,P}, \quad (7)$$

where the entropy component of the free energy $T \cdot \left(\frac{\partial \Delta S}{\partial W_P}\right)_{T,P}$ plays a significant role for most products.

The calculation of differential changes in the bound sorption energy for different temperatures is necessary in order to determine the value of the specific heat of vapor formation r, (J/kg) under different technological conditions of the drying process. Figure 5 graphically shows the dependence of the specific thermal energy of evaporation on the equilibrium humidity in the process of sorption of water vapor by dry caviar product for two sections in the interval: $0{,}03 \leq W_p \leq 0{,}27$.

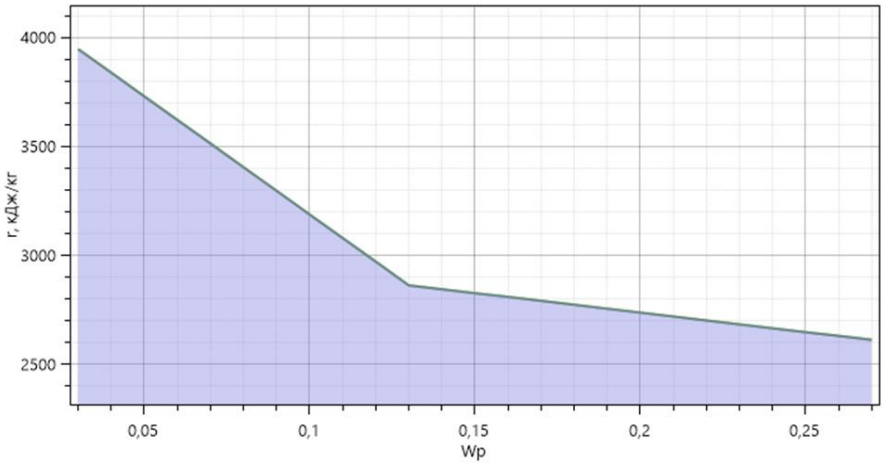

Figure 5 - Graphical dependence of the specific thermal energy of evaporation on the equilibrium humidity in the process of reducing the humidity of the material under study.

It should be noted that the nature of the dependence $r = f(W_p)$for the product under study is typical for most food materials, and is due to various energy forms of the relationship between the moisture in the sample and its dry residue.

Heat of vaporization associated with the material for 1 section:

$$r = 2437230 + |294724 - 1808985W_p| + |9028799W_p - 1541193|. \quad (8)$$

The heat of vaporization associated with the material for section 2:

$$r = 2437230 + |113953 - 418438W_p| + |1371267W_p - 545714|. \quad (9)$$

Functional dependencies (8 and 9) make it possible to determine the numerical values of the specific thermal energy of evaporation for their substitution into the differential heat transfer equation when modeling heat and mass transfer processes of caviar product drying.

Conclusions

As a result, it can be concluded that the obtained hygroscopic and thermodynamic parameters of the caviar product can be successfully used in the rational organization and implementation of the technology and technique for drying it and obtaining lecithin from carp caviar, because make it possible to determine the conditions for the preservation of the necessary target component in it.

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ПРИМЕНЕНИЕ БАРЬЕРНЫХ ТЕХНОЛОГИЙ ДЛЯ ПРОЛОНГИРОВАНИЯ СРОКОВ ХРАНЕНИЯ КОЛБАСНЫХ ИЗДЕЛИЙ

APPLICATION OF BARRIER TECHNOLOGIES TO PROLONG THE SHELF LIFE OF SAUSAGE PRODUCTS

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Аннотация

Изучены закономерности и оптимизированы режимы синтеза концентрата агрегативно-устойчивых наночастиц серебра. Исследовано влияние условий дисперсионной среды на выход наночастиц серебра в составе биологически активной фракции. Теоретически обоснован и экспериментально доказан синергетический антимикробный эффект наночастиц серебра и антимикробной композиции при обработке поверхности колбас.

Ключевые слова: наночастицы серебра, антимикробрый эффект, антимикробная композиция, колбасные изделия

Abstract

Regularities have been studied and modes of synthesis of a concentrate of aggregation-resistant silver nanoparticles have been optimized. The influence of the conditions of the dispersion medium on the yield of silver nanoparticles in the biologically active fraction was studied. Theoretically substantiated and experimentally proven synergistic antimicrobial effect of silver nanoparticles and antimicrobial composition in the surface treatment of sausages.

Keywords: silver nanoparticles, antimicrobial effect, antimicrobial composition, sausages

Introduction. С учетом сложившейся экологической ситуации, современного состояния рабочих мощностей предприятий мясоперерабатывающей промышленности и ряда других факторов, неблагоприятно воздействующих на безопасность продукции, сегмент рынка производства продуктов питания нуждается в современных эффективных средствах защиты колбас от потерь. Задача этих средств защиты – обеспечение гарантированной долговременной гигиенической безопасности и сохранение показателей качества колбасной продукции [1].

Анализ критических контрольных точек на этапах «производство – хранение – реализация» полукопченых, варено-копченых и сырокопченых колбас показывает, что одной из существенных причин снижения срока годности этой продукции является развитие на поверхности изделий нежелательной микрофлоры [2].

Этого результата можно достичь следующими способами:

- применение ионизирующего излучения, однако это приводит к возникновению таких химических изменений, которые могут ухудшить вкус, запах, консистенцию, опасность образования вредных соединений во время облучения и после него, развитию ферментативных процессов во время хранения [3, 4, 5, 6];

- облучение ультрафиолетовыми лучами, при этом точные режимы хранения мясопродуктов в условиях облучения УФЛ еще не достаточно разработаны. Следует отметить, что УФЛ опасны для человека, в особенности их действия на кожу и глаза [7];

- использование электрического тока высокого напряжения для поверхностной обработки пищевых продуктов, но применение электростатического поля ускоряет лишь один

из этапов обработки и поэтому не приводит к существенному сокращению технологического процесса в целом;

- использование консервантов для обработки поверхности колбасных изделий, этот вид барьерных технологий нашел широкое применение в промышленности, в том числе для обработки полукопченых и варено-копченых колбас, изготовленных в натуральных и искусственных оболочках по технологии с использованием душирования [1].

Несмотря на разработанные высокоэффективные антимикробные препараты для обработки поверхности колбас, целесообразным и своевременным является продолжение исследований по разработке новых синергетических добавок к этим составам для повышения эффективности их действия и расширения ассортимента средств защиты колбасных оболочек различной природы. В этой связи заслуживает внимания применение барьерных технологий с использованием высокоэффективных бактерицидных препаратов на основе наночастиц серебра, стабилизированных высокомолекулярными полимерами.

Материалы и методы / Materials and methods.

Молярную массу ПВП определяли вискозиметрическим методом с помощью капельного вискозиметра дающего средневязкостное значение молекулярной массы.

Активную кислотность исследовали потенциометрическим методом, основанным на измерении электродвижущих сил с использованием pH-метра «Эксперт – 101».

Массовую долю серебра в слое фарша непосредственно контактирующем с оболочкой, определяли с помощью высокочувствительной качественной реакции на наличия Ag^+ по образованию дитизоната серебра.

Для определения размера наночастиц серебра методом фотонной корреляционной спектроскопии использовали спектрофотометр динамического рассевания света Photocor Complexx.

Морфология наночастиц серебра в металл-полимерной композиции изучалась методами электронной микроскопии с использованием просвечивающей электронной микроскопии на установке JEM 100B фирмы JEOL.

Активность воды (A_w) в готовых варено-копченых колбасных изделиях определяли криоскопическим методом с помощью прибора АВК-4.

Для определения массовой доли влаги в готовых варено-копченых колбасных изделиях использовали анализатор пищевых продуктов «FoodScan» тип 78800.

Результаты и обсуждение / Results and discussion.

В основу синтеза полимер-стабилизированных высокодисперсных частиц металлического серебра был положен способ получения каталитически активных коллоидальных и субколлоидальных частиц благородных металлов путем восстановления их катионов в среде слабого восстановителя – этанола, в присутствии гидрофильного полимера.

Обнаружено, что необходимым элементом синтеза является пассивация внутренней поверхности реакционного аппарата металлическим серебром путем предварительного проведения в нем реакции восстановления нитрата серебра в сильно разбавленных растворах ПВП (0,005 - 0,01%). В противном случае при высоких концентрациях этилового спирта, а так же концентрациях нитрата серебра в реакционной массе происходит отложение металла на стенках аппарата в виде «серебряного зеркала» или агрегация высокодисперсных частиц серебра.

С учетом этих данных, предложен способ получения таких композиций, которые реализуются взаимодействием нитрата серебра с водно-спиртовым раствором ПВП при следующих концентрациях ингредиентов в реакционной системе (пределы): нитрат серебра 0,1 - 2% (масс.); этиловый спирт 10 - 15% (масс.); ПВП 10 - 30% (масс.); вода – остальное.

Проведение синтеза в однофазных системах, как правило, приводит к образованию наночастиц серебра с различным уровнем полидисперсности, при этом антимикробная активность наночастиц серебра является размернозависимой функцией. С уменьшением размеров наночастиц серебра их антимикробная активность увеличивается и достигает мак-

симума в интервале 1 – 10 нм (так называемая биологически-активная фракция). Таким образом, в диссертационной работе особое внимание было уделено получению агрегативно-устойчивых наночастиц серебра с диаметром ≤ 10 нм.

В соответствии с методологией априорного ранжирования, учитывая литературные данные и результаты предварительных экспериментов, был проведен отбор основных переменных параметров, оказывающих значимое влияние на размеры наночастиц серебра и выход биологически активной фракции наночастиц серебра (не более 10 нм).

В качестве переменных параметров были выбраны факторы, представленные в таблице 1.

Таблица 1 – Параметры плана

Наименование параметров, обозначения	Уровни варьирования переменных			
Массовая доля $AgNO_3$, %, **(a)**	1	1,5	2	2,5
Массовая доля ПВП, %, **(b)**	5	10	15	20
Температура, ^oC, **(c)**	50	60	70	80
Массовая доля этилового спирта,%, **(d)**	2	3	4	5

В результате обработки экспериментальных данных выведены регрессионные зависимости для исследуемых показателей отражающие влияние факторов, скорости их изменения и межфакторных взаимодействий. Выведенные уравнения адекватно описывают процесс. Полученные уравнения регрессии приведены в приложениях.

Кроме этого, полученные результаты были обработаны с использованием пакета прикладных программ Statistica Neural Networks v.4.0e.

На начальном этапе анализа полученных экспериментальных данных была создана нейронная сеть, т.е. многослойный персептрон с четырьмя входными переменными и одной выходной переменной – функцией (рисунок 1).

Установлено, что оптимальными условиями получения агрегативно устойчивых наночастиц серебра с размерами не более 10 нм являются следующие:

Массовая доля нитрата серебра 0,75±0,05%
Массовая доля ПВП 25±1%
Температура 50±5^{o}C
Массовая доля спирта 7,5±0,2%

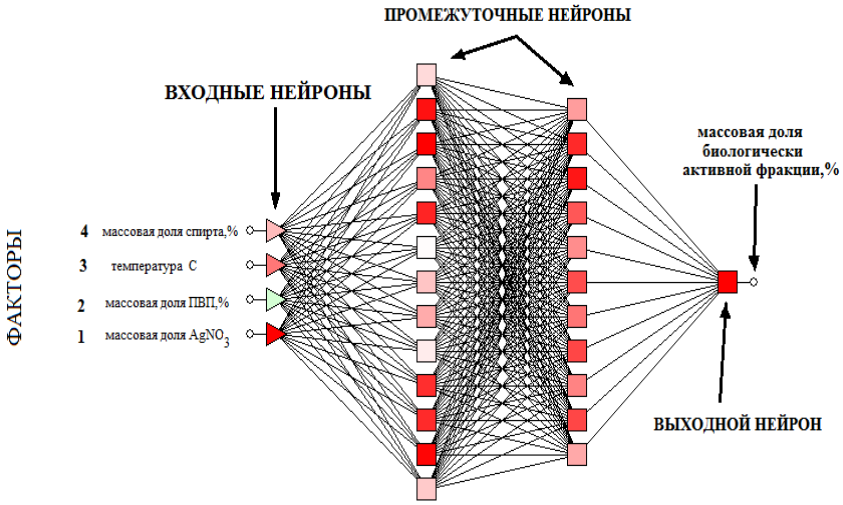

Рисунок 1. Многослойный персептрон, адаптированный к модели процесса получения низкоразмерных агрегативно устойчивых наночастиц серебра

Выход биологически активной фракции наночастиц серебра составляет 22 ± 2% Апробация оптимальных параметров, проведенная в лабораторных условиях, показала

практически полную адекватность расчетным данным, воспроизводимость результатов, а также возможность получения концентрата агрегативно-устойчивых наночастиц серебра.

Фотокорреляционная спектрофотометрия полученного концентрата (рисунок 2, таблица 2) свидетельствует не только об эффективности разработанного процесса синтеза агрегативно устойчивых наночастиц серебра, но и о его достаточно хорошей агрегативной устойчивости, т.к. скорость укрупнения наночастиц серебра в течение срока наблюдения была пренебрежимо мала, а содержание биологически активной фракции наночастиц серебра составляла не менее 20%.

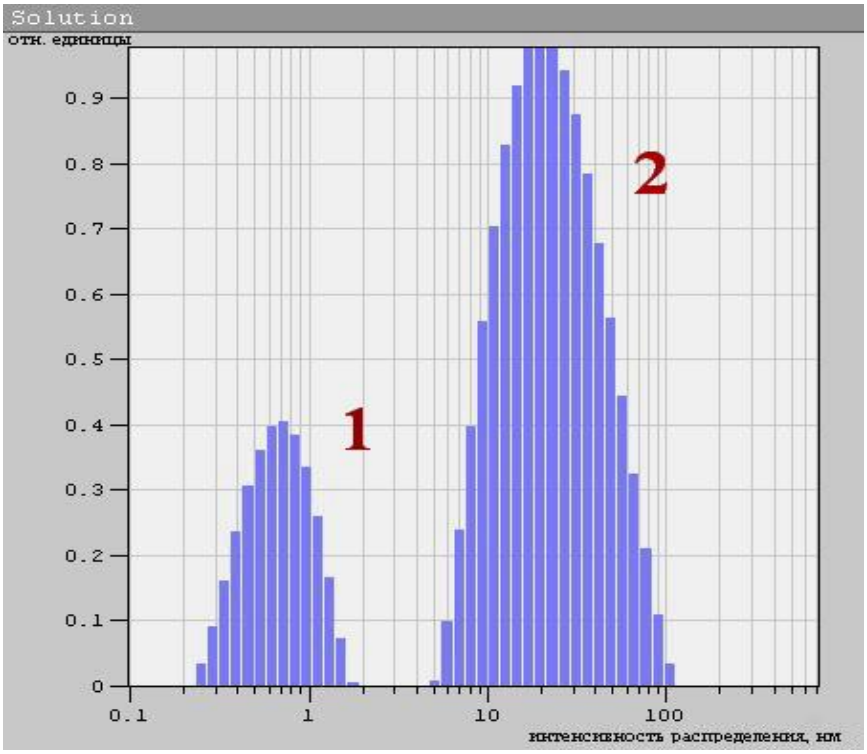

Рисунок 2. Гистограмма распределения наночастиц серебра по размерам в концентрате

Таблица 2 – Анализ распределения наночастиц серебра

Фракция	Массовая доля, %	$r_{ср}$, нм
1	21,8	0,703
2	78,2	26,50

Спектр поглощения водного раствора полученного образца наночастиц серебра (рисунок 3) в УФ и видимой областях с $\lambda_{макс}$ = 440 нм свидетельствует о том, что в системе присутствуют ультрадисперсные частицы серебра с размерами менее 10 нм.

Дополнительно, размеры кластеров серебра, стабилизированных водорастворимым полимером, были определены методом фотонной корреляционной спектроскопии на спектрометре динамического рассеяния света Photocor Complex. На стадии микроэлектронных исследований установлено, что наночастицы серебра имеют форму сфер, треугольников, а также стержней, при этом антимикробные и антивирусные свойства наночастиц серебра проявляются в первую очередь за счет наличия их в сферической форме.

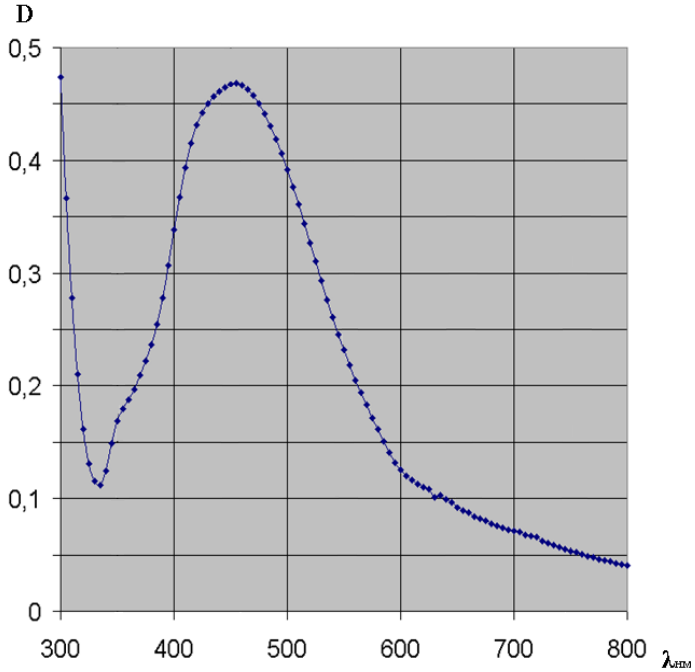

Рисунок 3. Спектр оптического поглощения водной системы нано-частицы серебра – поливинилпирролидон

Анализ микрофотографий полученных с помощью просвечивающего электронного микроскопа, подтверждает данные полученные спектрофотометрическими методами и позволяет говорить о наличии в коллоидном растворе биологически-активной фракции наночастиц серебра с размерами от 1 до 10 нм.

Исследования зоны подавления роста микроорганизмов показали, что с увеличением концентрации раствора нано размерного серебра с 0,001 до 0,010%-ной к 7 суткам экспозиции наблюдается увеличение диаметров зоны подавления роста микроорганизмов Escherichia coli, микроскопических грибов Aspergillus niger, Penicillium expansum и молочной плесени Endomyces lactis.

При 0,001%-ной концентрации раствора наночастиц серебра наблюдается подавление только микроорганизмов группы кишечной палочки (21 мм), в то время как на уровень роста микроскопических грибов Aspergillus niger, Penicillium expansum и молочной плесени Endomyces lactis данный препарат не оказывает направленного воздействия. Увеличение концентрации данного раствора до 0,003%-ной привело к подавлению развития исследуемых микроорганизмов – Aspergillus niger – 14 мм, Penicillium expansum – 6 мм, Endomyces lactis – 17 мм, зона подавления Escherichia coli увеличилась на 14% по сравнению с 0,002%-ной концентрацией раствора. При 0,005%-ной концентрации раствора наночастиц серебра также отмечается увеличение зон подавления роста изучаемых микроорганизмов. Так, наибольшее подавление микроорганизмов, по сравнению с предыдущей концентрацией раствора, наблюдается в отношении Penicillium expansum – в 2,78 раза и Aspergillus niger – в 1,5 раза. Степень подавления таких микроорганизмов, как Escherichia coli и Endomyces lactis находилось на одном уровне и увеличилось в 1,1 раз. Дальнейшее увеличение концентрации раствора наночастиц серебра до 0,007%-ной показало более интенсивную степень подавления роста всех видов изучаемых микроорганизмов. Причем наибольшая степень подавления наблюдалась для Endomyces lactis – на 49% и Aspergillus niger – на 38%, в отношении Penicillium expansum и Escherichia coli площадь зоны подавления была идентична и составила 28% по отношению к предыдущей концентрации раствора нано размерных частиц серебра.

На основании анализа отечественных и зарубежных публикаций, посвященных взаимодействию ионов серебра, которые генерируются с поверхности наночастиц серебра, с клетками про- и эукариотных микроорганизмов следует, что токсический эффект ионов серебра обусловлен его связыванием с мембранно-ассоциированными белками и липидной стромой мембран, вследствие чего происходит изменение трансмембранного потенциала и, в некоторых случаях, пробой клетки.

Таким образом, по результатам проведенных исследований можно сделать вывод о том, что все исследуемые препараты обладают антимикробными свойствами, причем по эффективности данных препаратов на изучаемые группы микроорганизмов, их можно расположить в следующей последовательности: раствор препарата «Аллюзин-Нео» ⟶ раствор НЧ серебра ⟶ комплексный препарат «Аллюзин+Ag». Повышенное антимикробное действие комплексного препарата «Аллюзин+Ag», по всей видимости, является результатом синергетического эффекта данных препаратов в отношении микроорганизмов.

Полученные результаты исследований антимикробной активности препарата «Аллюзин-Нео» в целом коррелируют с ранее изученными антимикробными свойствами, которые были получены специалистами МГУПБ [8, 9, 10].

В результате обработки поверхности варено-копченых колбас антимикробными препаратами установлено ингибирующее влияние на развитие плесеней (рисунок 4).

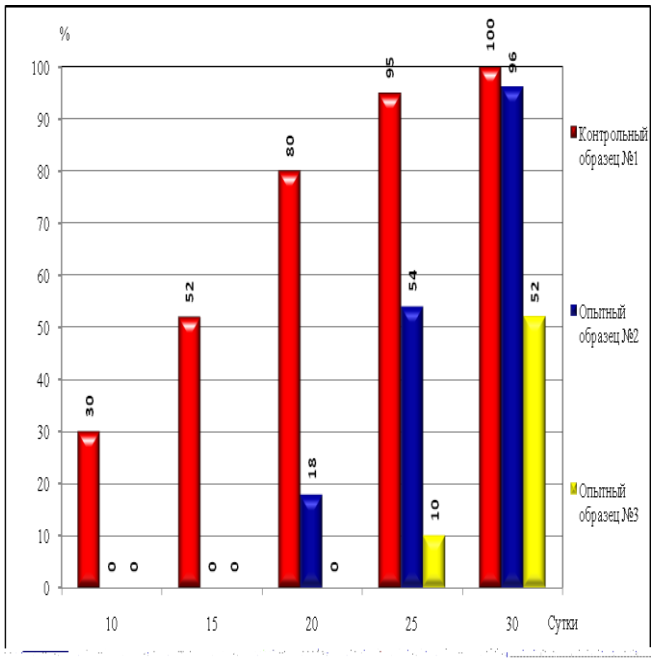

Рисунок 4. Площадь плесневения контрольного и опытных образцов варено-копченых колбас на 10-30 сутки хранения, % (□ – контроль; □ - «Аллюзин-Нео»; □ - «Аллюзин+Ag»)

Заключение / Conclusion.

Изучены закономерности и оптимизированы режимы синтеза концентрата агрегативно-устойчивых наночастиц серебра в присутствии поливинилпирролидона (ПВП) т.е ω (ПВП) - 25%;. ω ($AgNO_3$) - 0,75%; ω (C_2H_5OH) - 7,5%; температура 50^0C.

Исследовано влияние условий дисперсионной среды (ω (ПВП), %;. ω ($AgNO_3$), %; ω (C_2H_5OH), %; температура ^{0}C) на выход наночастиц серебра (≤10 нм) в составе биологически активной фракции.

Изучены физико-химические свойства и морфология наночастиц серебра в составе биологически активной фракции.

Теоретически обоснован и экспериментально доказан синергетический антимикробный эффект наночастиц серебра и антимикробной композиции «Аллюзин-Нео» в составе комплексного антимикробного препарата «Аллюзин+Ag».

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КУРКУМИНОИДЫ: ПОЛУЧЕНИЕ, СВОЙСТВА И ПРИМЕНЕНИЕ СООБЩЕНИЕ 2. АНТИОКСИДАНТНАЯ И АНТИМУТАГЕННАЯ АКТИВНОСТЬ КУРКУМИНОИДОВ.

CURCUMINOIDS: PRODUCTION, PROPERTIES AND APPLICATION REPORT 2. ANTIOXIDANT AND ANTIMUTAGENIC ACTIVITY OF CURCUMINOIDS.

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Аннотация
Показано, что антиоксидантная активность в ряду куркумин, бис-деметоксикуркумин, деметоксикуркумин снижается. Определена величина TEAC для куркумина, бис-деметоксикуркумина, деметоксикуркумина, которая составляет 0,41, 0,32 и 0,21 соответственно. Суммарный препарат куркуминоидов обладает антимутагенной активностью при концентрации 8,3 мг/л в тест системе штамма S. typhimurium TA100 и S. typhimurium TA98.

Ключевые слова: куркуминоиды, куркумин, деметоксикуркумин, бис-деметоксиксикуркумин, антиоксидант, антимутаген, АБТС-радикал, тролокс.

Abstract
As a result of studies, it has been shown that the antioxidant activity in the series curcumin, bis-demethoxycurcumin, demethoxycurcumin decreases. The TEAC value was determined for curcumin, bis-demethoxycurcumin, demethoxycurcumin, which is 0.41, 0.32 and 0.21, respectively. The total preparation of curcuminoids has antimutagenic activity at a concentration of 8.3 mg / l in the test system of S. typhimurium TA100 and S. typhimurium TA98 strains.

Keywords: curcuminoids, curcumin, demethoxycurcumin, bis-demethoxycurcumin, antioxidant, antimutagen, ABTS radical, trolox.

Introduction.

Turmeric Rhizome *Curcuma longa* L. _ serve as a source of highly active compounds that are widely used in the food industry [1, 2]. Chemical analysis of the composition of turmeric rhizome extracts showed that the plant material contains carbohydrates (69.4%), water (13.1%), proteins (6.3%), fats (5.1%) and minerals (3.5%). %), essential oil (5.8%), and curcumin (3–6%) [3]

The active components of turmeric extracts are curcuminoids [4]. Curcuminoids are a mixture of curcumin (K) and two of its derivatives, demethoxycurcumin (DMC) and bis-demethoxycurcumin (BDMC) [5]. The ratio of curcuminoids in the composition of curcumin is 52–63% for K, 19–27% for DMC, and 18–28% for BDMC. Due to the presence in their structure of two benzenemethoxy rings connected by an unsaturated chain, these compounds exhibit keto-enol tautomerism. Aromatic groups in the structure of molecules provide the hydrophobicity of curcuminoids, and the presence of an isoprenoid linker causes flexibility, tautomeric transitions of

the structure, and also affects their hydrophobicity and polarity [5]. Due to the peculiarities of the chemical structure, curcuminos are poorly soluble in water at acidic and neutral pH values, but soluble in methanol, ethanol, dimethyl sulfoxide and acetone.

Curcuminoids and their derivatives have a wide spectrum of biological activity, including antioxidant, anti-inflammatory, antitumor, bactericidal, neuro-, cardio- and radioprotective [6, 7].

A number of studies have shown that the administration of curcuminoids to laboratory animals at a dose of 300 mg/kg has a neuroprotective activity under conditions of hypoxia of the nervous tissue and significantly reduces the percentage of neuron and neuroglia death, and reduces the risk of cerebral infarction [8]. The introduction of the drug at a dosage of 5–100 mg/kg led to a decrease in the symptoms of ketamine-induced syndrome in laboratory animals [9], the preservation of the functional activity of GABAergic receptors and the normalization of GABA metabolism in the nervous tissue, reducing the toxic effects caused by the administration of streptozotocin to rats [10]. The introduction of the curcuminoids drug led to inhibition of peroxidation reactions of microglia cell membranes and a decrease in the production of nitrogen monoxide. Moreover, the inhibitory activity decreased in the series demethoxycurcumin, bis-demethoxycurcumin, and curcumin [11].

The study of the antioxidant effect of the total preparation of curcuminoids and its individual components showed the presence of pronounced activity in various test systems. Thus, the administration of curcuminoids to laboratory rats at a dosage of 50–250 mg/kg led to the induction of synthesis and an increase in the activity of enzymes of the antioxidant system: serum and erythrocyte glutathione peroxidase, superoxide dismutase, and catalase [12, 13]. In the urine of the examined animals, a decrease in the level of biomarkers of oxidative stress, allantoin, m-tyrosine, 3-nitrotyrosine, and 8-hydroxy-2-deoxyguanosine, was observed [14]. Similar studies were obtained in the study of the oxidative status of the tissues of the heart, kidneys, and liver of laboratory animals [13]. In the phosphomolybdenum and DPPH model systems, the studied preparations showed pronounced antioxidant activity [15, 16].

Curcumin preparations showed pronounced anticancer and antiproliferative activity against a number of cell lines: MCF-7 human breast tumor cells [17], K 562 human leukemia cells [18], HeLa cells [19], H22 mouse hepatoma cells [20] , HT1080 human fibrosarcoma cells [21], rectal cancer cells [22, 23], A549 human lung adenocarcinoma cells and A549 cisplatin-resistant cells [24], HMEC1 dermal capillary endothelial cells [25].

On a model object, a histidine auxotrophic mutant strain of Salmonella typhimurium TA97, the presence of mutagenic activity of curcuminoids was shown when exposed to the cultivation medium at concentrations of 10–50%, which is expressed in an increase in the amount of revertants [26].

The cardioprotective activity of curcuminoids has been shown when the drug is administered to laboratory animals at a dosage of 75 mg/kg. Oral administration of curcuminoids led to significant improvements in the physiological and functional parameters of the heart, a decrease in necrotic zones, and a decrease in the level of serum markers in an experiment on an induced myocardial infarction model [27].

Along with antioxidant activity, the presence of radioprotective activity was shown for the curcuminoids preparation. Oral administration of curcuminoids at a dose of 50 mg/kg to laboratory rats caused a significant decrease in the number of necrotizing cells and a significant decrease in the number of chromosomal mutations [28, 29].

The antifungal and antiviral activities of the curcuminoids preparation have been shown against strains of the pathogenic fungus Candida albicans [30] and influenza virus [31].

A number of authors have shown that curcuminoids have a pronounced anti-inflammatory effect. Experiments on cell lines and when administered to laboratory animals showed a decrease in the activity of calmodulin-dependent protein kinase II and, as a result, inhibition of NO synthase activity [32]. Along with a decrease in the immunoreactive status of the organism and activation of

enzymatic systems of xenobiotic metabolism, there was a decrease in the migration of neutrophils from the bloodstream to tissues and an increase in the barrier function of the endothelium [33].

In recent years, intensive studies have been carried out on the bioavailability, safety and efficacy of curcuminoids, which are used in complex therapy or as an independent drug in the treatment of various diseases. Due to the pronounced biological activity and low toxicity of curcuminoids, they can be used as part of functional foods [34–36].

The aim of the work was to study the antioxidant and gene-protective properties of curcuminoids.

Materials and methods.

The object of the study were curcuminoids: curcumin, demethoxycurcumin, bisdemethoxycurcumin, obtained from the rhizome of turmeric (*Curcuma longa* L.).

Determination of antioxidant activity.

The antiradical activity of curcuminoids was evaluated in the model system for the reduction of the radical cation ABTS˙+ [37, 38]. The generation of radical cations ABTS˙+ was carried out in the presence of ammonium persulfate. Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid), a water-soluble analog of vitamin E, was used as a standard antioxidant. under the action of the test compound) and calculated by the formula:

$$\% \text{ inhibition} = 100*(1-A2/A1),$$

where A1 is the optical density of the ABTS˙+ solution at a wavelength of 734 nm without adding the test sample; A2 is the optical density of the ABTS˙+ solution 6 min after the addition of the test sample.

The results were plotted as percent inhibition versus test substance concentration. To calculate the IC50 and TEAC values, a calibration curve was constructed for Trolox as a standard antioxidant. According to the calibration curve, a linear regression equation of the form y=ax+b was calculated, which was used for further calculations.

Determination of antimutagenic activity

The antimutagenic effect of purified curcuminoids was studied in a series of in vitro experiments using one of the variants of the Ames bacterial test, the FAT plate test (High Throughput Fluctuation Ames Test) [39, 40]. Histidine auxotrophic strains of *Salmonella typhimurium* TA100 and TA98 were used as test objects . 2-nitrofluorene was used as a standard mutogen causing frameshift mutations in the *S. typhimurium* TA98 strain. Sodium azide was used for base pair substitution mutations in the *S. typhimurium* TA100 strain. These substances caused a reverse mutation in test strains, as a result of which they acquired the ability to develop in an environment deficient in histidine and return to prototrophy. An increase in the number of revertants in this test indicates that the test compound induces gene mutations. When standard mutagens and curcuminoids under study are introduced into the incubation medium of *Salmonella typhimurium strains* , a decrease in the amount of revertants indicates that the tested compounds have antimutagenic activity [41, 42]. For analysis, the total preparation of curcuminoids was dissolved in 96% ethanol. Studies were carried out at 2 concentrations of the total preparation of curcuminoids, the final concentration of which in the test systems was 1.7 and 8.3 mg/l. To exclude the influence of the solvent, 96% ethanol was used as a negative control. To prevent contamination of the culture medium by microorganisms, the initial solutions were filtered through a sterile filter tank with a pore size of 0.2 μm.

Results and Discussion

Traditionally, turmeric is used as an active component in the composition of herbal remedies, in everyday nutrition as an independent seasoning (turmeric) or as part of spices [1, 2]. As a result of clinical trials, curcumin was recognized as safe and classified as a hazard class 5 (is not hazardous). According to the decision of the US Food and Drug Administration (FDA US), turmeric is included in the group of "generally recognized as safe" compounds [1]. Curcumin has a

wide spectrum of biological activity, which makes it possible to use it in functional foods. In this regard, it is important to determine its antioxidant and gene protective properties.

Antioxidant activity of curcuminoids. Studies have been carried out on the antioxidant activity of the total preparation of curcuminoids and individual compounds included in its composition: curcumin, demethoxycurcumin and bisdemethoxycurcumin. The antioxidant activity of curcuminoids was studied in the model system for the reduction of the radical cation $ABTS^{\cdot}+$. Trolox was used as a standard antioxidant. Antioxidant activity was expressed as a percentage decrease in the concentration of the radical cation $ABTS^{\cdot}+$ in the reaction system as a result of its reduction by the molecules of the test compound.

Based on the obtained results, graphs of the dependence of the percentage of inhibition of the $ABTS^{\cdot +}$ radical on the concentration of Trolox and the curcuminoids preparation were plotted (Figure 1).

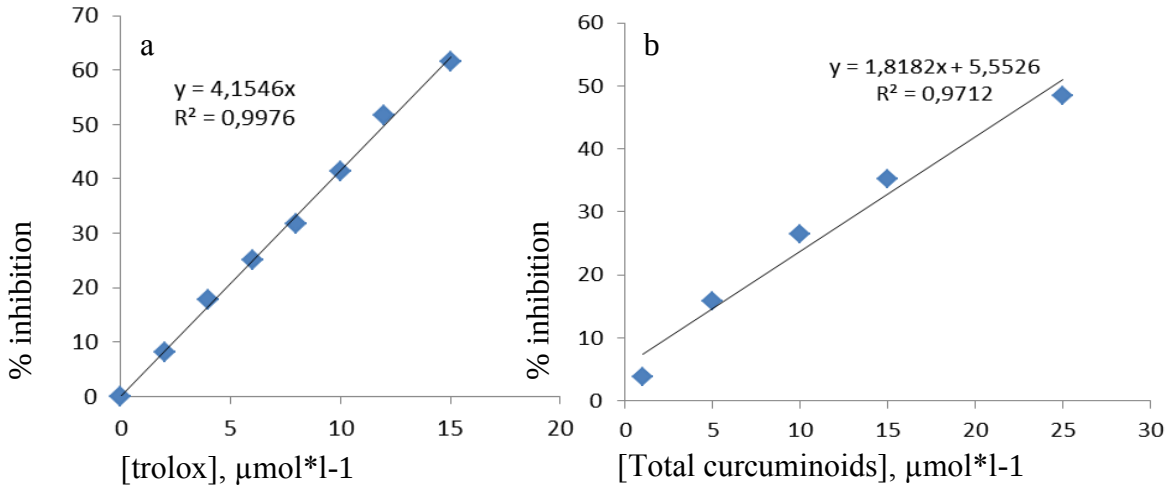


Figure 1. Dependence of the inhibition of the radical cation $ABTS^{\cdot +}$ on the concentration of trolox (a) and curcuminoids preparation (b)

For the resulting plots, linear regression equations were calculated and used for further calculations of Trolox equivalent (TEAS) and IC_{50}.

For Trolox, the $IC_{50\ value}$ was 12.04 µmol/L, and for the total preparation of curcuminoids it was 24.45 µmol/L. The TEAC value of the total preparation of curcuminoids, calculated as the ratio of the tangents of the slope of the curves presented in Figures 1a and 1b, was 0.44. This indicates that the studied preparation of curcuminoids has a 2.3 times lower antioxidant activity compared to Trolox.

The antioxidant activity of individual curcuminoids was studied using a series of standard solutions with different concentrations of curcumin, demethoxycurcumin, and bisdemethoxycurcumin in 96% ethanol. To calculate the IC_{50} and TEAC values, the corresponding graphs were constructed and linear regression equations were calculated for curcumin (Figure 2a), demethoxycurcumin (Figure 2b) and bisdemethoxycurcumin (Figure 2c).

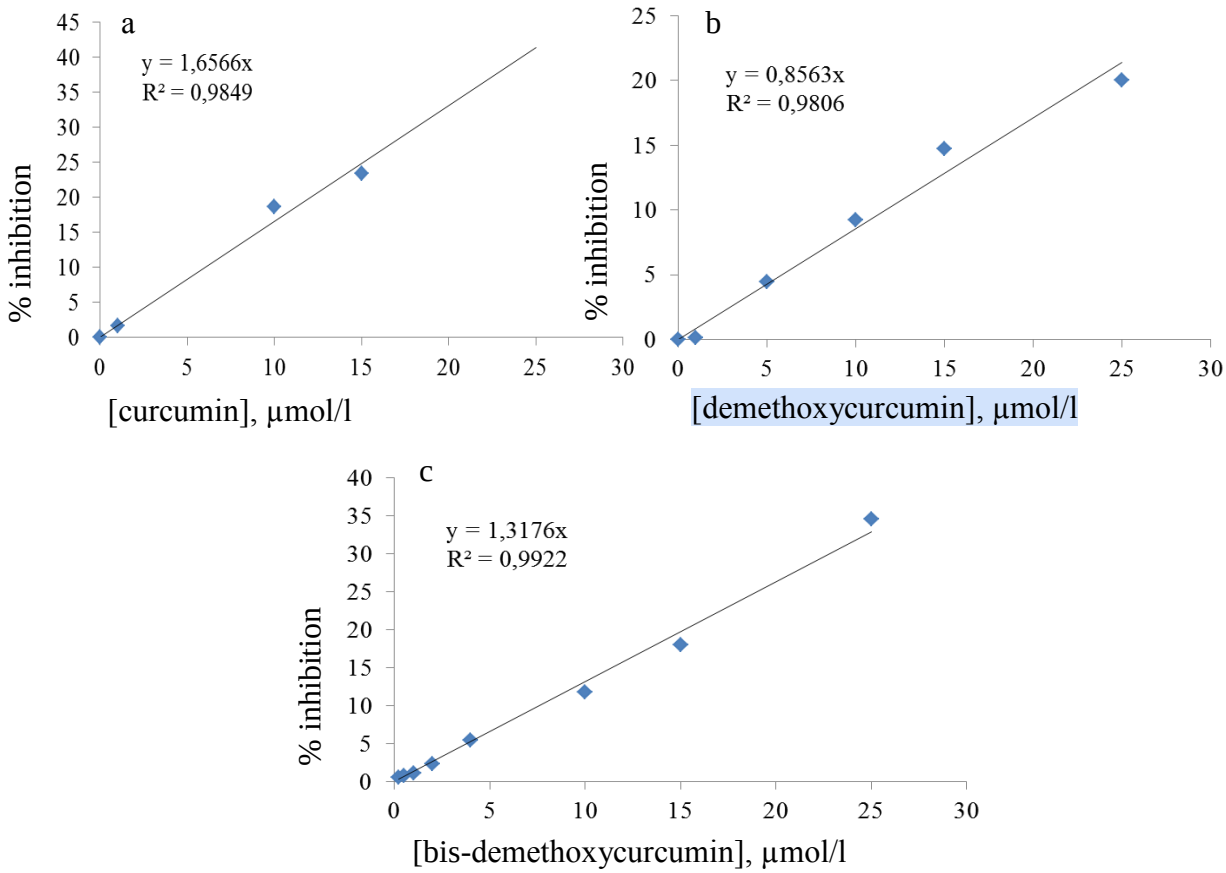
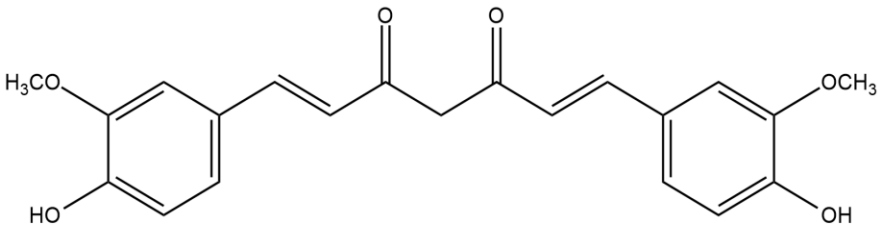


Figure 2. Dependence of ABTS˙+ inhibition on the concentration of curcumin (a), demethoxycurcumin (b) and bis-demethoxycurcumin (c)

The antioxidant activity of individual curcuminoids with respect to the ABTS $^{+\bullet}$ radicals formed in the aqueous phase depends on the amount of methoxy and OH groups in the aromatic rings of their structure (Figure 3). The efficiency of reduction of ABTS $^{+\bullet}$ radicals is also associated with the presence of a –C=C –bond conjugated to the aromatic ring.

For Trolox, the $IC_{50\ value}$ was 12.04 µmol/L (3.13 a), and for curcumin, demethoxycurcumin, and bisdemethoxycurcumin, it was 30.19 µmol/L, 58.41 µmol/L, and 37.97 µmol/L, respectively. The calculated TEAC values for these compounds were 0.41, 0.21 and 0.32, respectively. The data obtained indicate that in the series curcumin, bisdemethoxycurcumin, demethoxycurcumin, the anti-radical activity is reduced compared to trolox by 2.4, 3.1, and 4.7 times, respectively [43]. The curcuminoids preparation exhibits antioxidant activity mainly due to curcumin and bis-demethoxycurcumin, and to a lesser extent, demethoxycurcumin.

1



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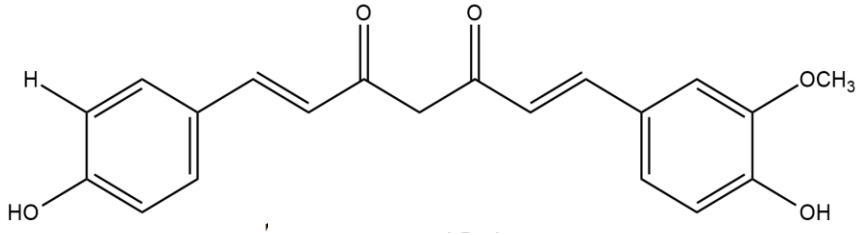

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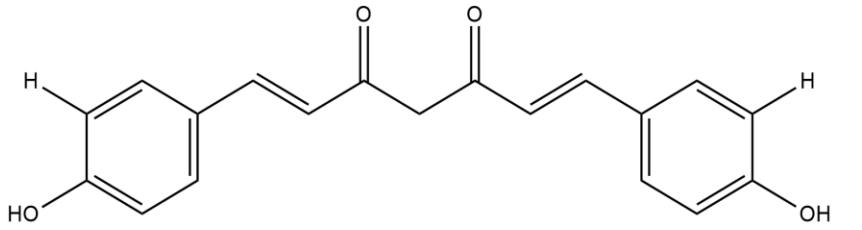

Figure 3. Structural formulas of curcumin (1), demethoxycurcumin (2) and bis-demethoxycurcumin (3)

Thus, the antioxidant activity of curcuminoids, as a rule, is maximal in the presence of a pyrocatechin group, which increases the stability of the phenoxy radical. A significant contribution is made by the presence in the structure of the molecule of two double –C=C –bonds conjugated with aromatic rings. Such a structure ensures the delocalization of the spin density of the phenoxy radical [44]. In the absence of one of these structural fragments, the antioxidant activity of curcuminoids, as a rule, decreases.

Antimutagenic activity of curcuminoids preparation. An analysis of the literature data showed that curcuminoids are characterized by antioxidant and anticarcinogenic activity [41, 42]. To evaluate the antimutagenic activity of the obtained total preparation of curcuminoids, a series of experiments was carried out using the Ames test. Histidine auxotrophic strains of *Salmonella typhimurium* TA100 and TA98 were used as test objects . Due to the difference in genotype, the parallel use of these strains makes it possible to fairly fully assess the nature of the DNA-damaging effect of mutagenic substances - base pair replacement for the *S. typhimurium* TA100 strain or frame shift for *S. typhimurium* TA98 [39, 40].

To assess the antimutagenic effect of curcuminoids, a standard mutagen, 2-nitrofluorene, was introduced into the *S. typhimurium TA 98 test system, which caused the formation of a large amount of prototrophic revertants.* In the presence of antimutagenic activity in curcuminoid compounds, their introduction into the incubation medium caused a decrease in the amount of formed revertants, due to their inhibition of frameshift mutations. caused by 2-nitrofluorene. For the *S. typhimurium* TA100 strain, a standard mutagen, sodium azite, was used. The presence of the antimutagenic effect of the total preparation of curcuminoids was taken into account by reducing the frequency of induction of reverse mutations from histidine auxotrophy to prototrophy.

The final concentration of the total preparation of curcuminoids after adding the working solution to the test system of strains *S. typhimurium* TA98 and *S. typhimurium* TA100 was 1.7 and 8.3 mg/l.

The results of the study of the antimutagenic activity of the total preparation of curcuminoids in the test system with the *S. typhimurium* TA98 strain are shown in Table 1.

Table 1 - The results of the antimutagenic effect of the total preparation of curcuminoids with the mutagenic effect of 2-nitrofluorene in the test system with the *S. typhimurium* TA98 strain

Sample	concentration of curcuminoids, 1.7 mg/l		concentration of curcuminoids, 8.3 mg/l	
	Share of positive wells, %	Share of negative wells, %	Share of positive wells, %	Share of negative wells, %
Standard mutagen (2-nitrofluorene)	14,58	85,42	50,00	50,00
Negative control (96% ethyl alcohol)	8,33	91,67	8,33	91,67
Total preparation of curcuminoids	8,33	91,67	25,00	75,00

When the total preparation of curcuminoids at a final concentration of 1.7 mg/l was introduced into the test system of the *S. typhimurium* TA98 strain containing 2-nitrofluorene in the culture medium, the level of induced mutagenesis did not decrease. An increase in the final concentration of the total preparation of curcuminoids in the cultivation medium of the test object *S. typhimurium* TA98 to 8.3 μg/ml leads to an increase in gene protective activity. There is a decrease in the proportion of positive wells by 42.87% when an alcohol solution of the total preparation of curcuminoids is added.

Table 2 shows the results of a study of the antimutagenic activity of the total preparation of curcuminoids in a test system with the *S. typhimurium* TA100 strain.

Table 2 - The results of the antimutagenic effect of the total preparation of curcuminoids with the mutagenic effect of sodium azide in the test system with the *S. typhimurium* TA100 strain

Sample	concentration of curcuminoids, 1.7 mg/l		concentration of curcuminoids, 8.3 mg/l	
	Share of positive wells, %	Share of negative wells, %	Share of positive wells, %	Share of negative wells, %
Standard mutagen (sodium azide)	83,33	16,67	100	0,00
Negative control (96% ethyl alcohol)	12,50	87.50	16,67	83,33
Total preparation of curcuminoids	75,00	25,00	14,58	85,42

According to the results of the test, the presence of a total preparation of curcuminoids at a concentration of 1.7 mg/l in the cultivation medium of the *S. typhimurium* TA100 strain did not lead to a significant antimutagenic effect. With an increase in the final concentration of the total preparation of curcuminoids in the test system of the *S. typhimurium* TA100 strain to 8.3 mg/l, there is a decrease in the frequency of induced mutations in the *S. typhimurium* TA100 strain by more than 6 times ($p<0.01$) to a level comparable to spontaneous mutagenesis.

The conducted studies allow us to conclude that at low concentrations, the total preparation of curcuminoids does not show a pronounced antimutagenic effect in the considered test systems. With an increase in the final concentration of the total preparation of curcuminoids to 8.3 mg/l, a pronounced antimutagenic effect is observed, preventing 50% of the frameshift mutations for the *S. typhimurium* TA98 strain under the action of 2-nitrofluorene. At this concentration, the curcu-

minoids preparation prevented base pair substitution mutations for the *S. typhimurium* TA100 strain under the action of sodium azide to a spontaneous level.

Conclusion.

A study was made of the antioxidant and gene-protective activity of the total preparation of curcuminoids and individual compounds included in its composition: curcumin, demethoxycurcumin and bisdemethoxycurcumin. The antioxidant activity of curcuminoids was studied in the model system for the reduction of the radical cation $ABTS^{\cdot+}$. For Trolox, the $IC_{50\ value}$ was 12.04 μmol/l, and for the total preparation of curcuminoids - 24.45 μmol/l, and for curcumin, demethoxycurcumin and bisdemethoxycurcumin - 30.19 μmol/l, 58.41 μmol/l and 37. 97 μmol/l, respectively. The calculated TEAC values for these compounds were 0.41, 0.21 and 0.32, respectively.

The TEAC value of the total curcuminoids preparation was 0.44. This indicates that the total preparation of curcuminoids has a 2.3 times lower antioxidant activity compared to Trolox.

The data obtained indicate that in the series curcumin, bisdemethoxycurcumin, demethoxycurcumin, the antiradical activity is reduced compared to trolox by 2.4, 3.1 and 4.7 times, respectively. The antioxidant activity of individual curcuminoids depends on the number of methoxy and OH groups in the aromatic rings of their structure, as well as on the presence of a –C=C –bond conjugated with the aromatic ring.

To assess the antimutagenic activity of the total preparation of curcuminoids, the Ames test was used on histidine-auxotrophic strains of *Salmonella typhimurium* TA100 and TA98. Studies have shown that at a concentration of curcuminoids of 1.7 mg/l, the antimutagenic effect on both strains is not manifested. At a concentration of the total preparation of curcuminoids of 8.3 mg/l, a pronounced antimutagenic effect is observed, preventing 50% of the frameshift mutations caused by the action of 2-nitrofluorene for *S. typhimurium* TA98. At this concentration, the curcuminoids preparation prevented base pair substitution mutations for the *S. typhimurium* TA100 strain under the action of sodium azide to a spontaneous level.

Thus, the conducted studies showed that the total preparation of curcuminoids and individual compounds curcumin, demethoxycurcumin and bis-demethoxycurcumin, due to their antioxidant and gene-protective properties, can be recommended for use in the food industry to create functional foods.

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РАЗРАБОТКА НОВЫХ ВИДОВ ФУНКЦИОНАЛЬНЫХ МЯСОРАСТИТЕЛЬНЫХ ПОЛУФАБРИКАТОВ С ПРЕБИОТИЧЕСКИМ ДЕЙСТВИЕМ

DEVELOPMENT OF NEW TYPES OF FUNCTIONAL MEAT AND VEGETABLE SEMI-FINISHED PRODUCTS WITH PREBIOTIC EFFECT

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Аннотация

В настоящее время особую актуальность приобретает разработка функциональных пищевых продуктов профилактической направленности, в том числе для персонализированного питания, адекватно обеспечивающих организм человека основными источниками эссенциальных веществ – незаменимыми аминокислотами, жирными кислотами, витаминами, микро-, макроэлементами и пищевыми волокнами.

В статье представлены результаты разработки рецептур функциональных мясорастительных полуфабрикатов со сбалансированным нутриентным составом, пребиотическим действием, высокими органолептическими свойства и повышенным выходом. Высокий уровень пищевой и биологической ценности разработанных полуфабрикатов, профилактическая направленность и пониженная себестоимость достигнуты за счет комбинации сырья животного и растительного происхождения, включения в состав рецептур инновационного пищевого ингредиента – мелассы молочной с лактулозой и использования современных инструментов компьютерного моделирования.

Ключевые слова: функциональные пищевые продукты, пребиотики, лактулоза, нутриентная сбалансированность, меласса молочная, персонализированное питание

Abstract

Currently, the development of functional food products of a preventive orientation, including for personalized nutrition, adequately providing the human body with the main sources of essential substances – essential amino acids, fatty acids, vitamins, micro-, macroelements and dietary fibers, is of particular relevance. The article presents the results of the development of formulations of functional meat-vegetable semi-finished products with a balanced nutrient composition, prebiotic effect, high organoleptic properties and increased yield. The high level of nutritional and biological value of the developed semi–finished products, preventive orientation and reduced cost are achieved through a combination of raw materials of animal and vegetable origin, the inclusion of an innovative food ingredient in the formulations - milk molasses with lactulose and the use of modern computer modeling tools.

Keywords: functional foods, prebiotics, lactulose, nutrient balance, milk molasses, personalized nutrition

Introduction

Malnutrition is a major social problem worldwide. The change in the lifestyle of a modern person and the associated decrease in the physiological need for energy consumption, insufficient intake of vitamins, minerals and other essential substances in the body, led to the development of the functional food industry and the formation of the FoodNet market [8]. Considering the growing number of nutritionally dependent diseases, stress factors and natural disasters, expanding the range and providing the population with high-quality functional food products is one of the most important national tasks [8].

Personalized nutrition in the context of a healthy lifestyle today is becoming one of the new directions in the development of a range of functional food products [9]. Along with dietary and preventive nutrition, it is called upon to play an important role in the prevention of non-communicable alimentary- dependent diseases [11]. In accordance with the recommendations of nutritionists, the development of new functional food products should be aimed at improving the health of target consumer groups, include technological solutions to reduce the content of beet sugar, salt, cholesterol in formulations, enrich products with high-grade animal and vegetable proteins, vitamins, dietary fiber, micro- , macronutrients and prebiotics. When creating functional food products, an important role is given to such issues as biomedical requirements for raw materials and products, prescription base and additional components, biologically active substances, giving them a preventive focus, taking into account the balance, compatibility and cost of the components [1].

Materials and methods of research

The aim of the research was to develop meat and vegetable semi-finished products with a functional orientation with a prebiotic effect, expanding the range of products for healthy, including personalized nutrition, with a balanced amino acid composition, consistently high consumer properties, nutritional and biological value, organoleptic characteristics and yield due to specially selected components, in including reducing the cost of the product.

The meat of chickens and ducks was used as the main raw material for functional semi-finished products. To ensure the nutritional balance of finished products, their preventive orientation and prebiotic effect, when modeling recipes, raw meat was combined in optimal proportions with various vegetables and functional ingredients.

Recipe modeling and calculation of the nutrient composition of meat and vegetable semi-finished products were carried out using the Etalon software package [2, 3] (registration certificate No. 2005610751). The yield of finished semi-finished products was determined according to GOST 31988-2012 as the ratio of the mass of the finished product after heat treatment and cooling to the mass of the semi-finished product before heat treatment [5]. The organoleptic evaluation of the quality of the finished product was carried out according to a 5-point scale according to GOST 9959-2015 [6].

Results and discussion

The recipes of the developed functional meat and vegetable semi-finished products with prebiotic action contain duck meat and mechanically deboned chicken meat in an optimally selected ratio of 6: 1, beef protein, carrots, white cabbage, sweet pepper, milk molasses with lactulose, semolina, egg powder, soybean oil, wheat bran, breadcrumbs and spices.

The combination of duck meat with mechanically deboned chicken meat in a prescribed ratio made it possible to obtain minced meat with optimal nutritional value at a reduced cost. It is known that duck meat is one of the most balanced in terms of nutrient composition , contains a large number of various vitamins and minerals (vitamins A, PP, E, almost all B vitamins), its fat includes a large amount of omega-3 unsaturated fatty acids, beneficially affecting the cardiovascular system and improving brain function [4]. An important advantage of mechanically deboned poultry meat is the absence of a deficiency of essential amino acids, a rather low content of phenylalanine relative to other types of meat raw materials [4], as well as an increased calcium con-

tent, which makes it possible to bring the “calcium -phosphorus” indicator in the finished product closer to the recommended medical and biological norm.

Beef protein (for example, fibrillar collagen "VT-PRO", manufacturer JSC "Verkhnevolzhsky tannery") is used in the formulation of semi-finished products as a structure-forming and functional protein ingredient. The established advantages of its use include: increasing the amino acid balance of the prescription composition; increase in the output of products by reducing thermal losses; improving the organoleptic properties of finished products and improving their quality, including by improving the consistency of minced meat and the structure of the finished product by creating a protein matrix; cost reduction due to partial replacement of the main raw material with a relatively inexpensive protein of animal origin; decrease in adhesion (sticking of stuffing to the forming parts of the equipment), which improves the process of mechanized molding of the product.

The use of dry milk molasses with lactulose (LaktuVet-1, produced by Stavropolsky Dairy Plant JSC) in the formulation of semi-finished products made it possible to reduce thermal losses, increase product yield, juiciness of finished products, improve their color characteristics, nutritional value, taste and obtain pronounced health-improving and preventive effect. The obtained results are associated with the presence of lactose and lactulose in LaktuVet-1, as well as a whole complex of micro- and macroelements at its low cost, since it is a by- product of milk processing [7].

An important advantage of using "LaktuVet-1" in the formulations of semi-finished products is that during their heat treatment, lactulose diffuses into the protein molecules of the product, but no chemical reaction occurs. Lactulose retains its structure and bifidogenic activity [10]. Of particular note is the high content of calcium in LaktuVet-1 (at least 3.4%), which forms the basis (together with phosphorus) of human bone tissue, activates the activity of a number of important enzymes, participates in maintaining ionic balance in the body, affects processes occurring in the neuromuscular and cardiovascular systems [12].

Among other macronutrients contained in milk molasses with lactulose, an important role belongs to magnesium and potassium. Magnesium is of interest from the point of view of vasodilating action, as well as stimulating intestinal motility and increasing bile excretion. Magnesium salts help reduce cholesterol with an increase in its content in the blood plasma, participate in the formation of bones, the regulation of the nervous tissue, in the metabolism of carbohydrates and energy metabolism. Potassium stimulates heart contractions, regulates acid-base balance. It is involved in the transmission of nerve impulses, activates the work of enzymes. It is believed that potassium has a protective effect against the undesirable effects of excess sodium and normalizes blood pressure [3].

As a result of the research, recipes for meat and vegetable semi-finished products with a high level of balance in essential amino acids were obtained (Figure 1).

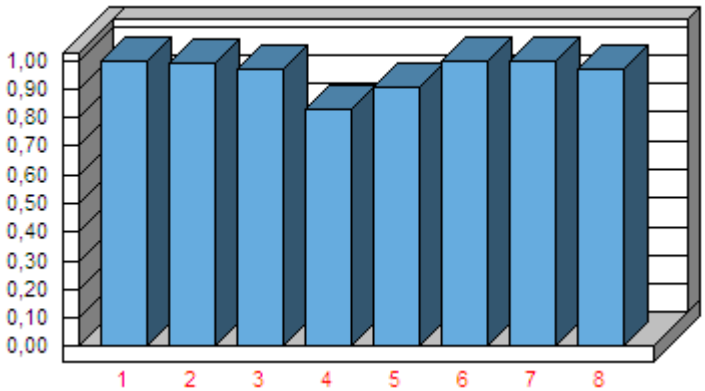

Figure 1. Graphical interpretation of the amino acid balance of meat and vegetable semi-finished products of prebiotic action *(*1- Leucine, 2- Isoleucine, 3 - Lysine, 4 - Methionine + Cystine, 5 - Phenylalanine + Tyrosine, 6 - Threonine, 7 - Tryptophan, 8 – Valine)*

The general and partial indicators of the desirability of the amino acid balance of the developed product are close to the reference values equal to one. The obtained indicators (Figure 1 and Table 1) indicate a high biological value of the developed semi-finished products.

Table 1 - Criteria for nutrient adequacy for essential amino acids

The name of indicators	Meaning
General desirability criterion D (fraction of one)	0.956
Mass fraction of protein, g/100g of product	10.15
Minimum speed (fraction of unit)	0.881
Utility factor (fraction of unit)	0.876
Comparable excess ratio (g/100g protein)	4.498
Essential Amino Acid Index (INAC, fraction of one)	0.995
Difference coefficient AK, KRAS,%	0.313
Biological value of protein in the product,%	99.687

The energy value of the developed semi-finished products is 177.8 kcal, of which 22.8% is provided by protein, which allows them to be classified as food products with a high protein content.

The ratio between saturated and unsaturated fatty acids in the product is equal to that taken as a reference value (Table 2). The product contains at least 28.6% of the recommended daily intake of the prebiotic lactulose.

Table 2 - Indicators of nutrient balance, nutritional and energy value of meat and vegetable semi-finished products

The name of indicators	**Meaning**
Protein, g/100 g product	10.15
Fat, g/100 g product	11.23
SFA, g/100 g lipids	25.05
PUFA, g/100 g lipids	25.66
MUFA, g/100 g lipids	37.08
NFA/UFA	0.4
Dietary fiber, g/100g of product	1.68
Lactose (not less than), g/100 g	1.01
Lactulose (not less than), g/100 g	0.572
Energy value, kJ/kcal	744.4/177.8

The combination of meat, vegetable raw materials and functional ingredients made it possible to most significantly provide the developed food product with protein, PUFAs, vitamins, micro-, macroelements, where the ratio of calcium and phosphorus is close to optimal. The semi-finished product contains all the necessary nutrients, micro-, macro-elements and antioxidants (table 3). This made it possible to solve a set of problems aimed at creating a functionally oriented product with a prebiotic effect, with a balanced amino acid composition, consistently high consumer properties, nutritional and biological value, organoleptic characteristics and yield due to specially selected components, including those that reduce the cost of the product.

Table 3 - The content of micro-, macroelements and vitamins in the developed product

Nutrient	Content in 100 g of finished semi-finished products, taking into account losses during heat treatment	% of RSP*
vitamins		
Vitamin A, ret. equiv., mcg	138.00	15.35/17.26
Vitamin B_1, thiamine, mg	0.065	4.34
Vitamin B_2, riboflavin, mg	0.0947	5.26
Vitamin B_3, niacin, mg	2.089	10.45
Vitamin B_5, pantothenic acid, mg	0.341	6.81

Vitamin B_6, pyridoxine, mg	0.113	5.65
Vitamin B_{12}, cobalamin, mcg	0.072	2.4
Vitamin C, mg	8.297	8.3
Vitamin D, mcg	0.16 _	1.1
Vitamin E, current. equiv., mg	0.6658	4.44
Macronutrients		
Potassium, mg	198.498	5.67
Calcium, mg	153.822	15.38
Magnesium, mg	39.44	9.39
Phosphorus, mg	144.338	18.04
trace elements		
Iron, mg	0.733	7.33/4.07
Zinc, mg	1.012	8.43

* RDA - recommended daily requirement in accordance with MR 2.3.1.0253-21 (for men / for women)

Analysis of the data in Table 3 shows that, in accordance with TR TS 022/2011, the developed product is a source of micro-, macroelements and vitamins, namely, calcium and phosphorus with their recommended ratio and vitamin A, and also contains most B vitamins, vitamin C and fat-soluble vitamins D , E, macronutrients potassium, magnesium and trace elements iron and zinc.

The conducted studies showed that the inclusion of milk molasses with lactulose LaktuVet-1 (experiment) in the recipe of meat and vegetable semi-finished products allows increasing their yield by an average of 3.5% (table 4).

Table 4 - Results of determining losses during heat treatment of meat and vegetable semi-finished products ($m_{av} = \pm 0.5$)

Name of indicator	An experience		Control	
	G	%	G	%
Weight of semi-finished product prepared for heat treatment	133.1	100.0	134.1	100
Weight of finished product after heat treatment	129.7	97.4	125.7	93.7
Losses during heat treatment	3.4	2.6	8.4	6.3
Weight of finished product after cooling	127.1	95.5	123.4	92.0
Losses during heat treatment, taking into account losses when cooling down	6.0	4.5	10.7	8.0
Product yield	-	95.5	-	92.0

Table 5 shows the organoleptic characteristics of the developed meat and vegetable semi-finished products with the inclusion of milk molasses with lactulose (experiment) and without it (control) in the recipe.

Table 5 - Results of organoleptic evaluation of semi-finished products

Samples semi-finished products	Appearance	Taste	Color	Smell	Consistency	juiciness	Overall rating
Control	4.9	4.8	4.8	4.8	4.7	4.7	4.78
An experience	4.9	4.9	4.9	4.8	4.8	5.0	4.88

Organoleptic evaluation was carried out according to a five-point system. Its profilogram is shown in Figure 2.

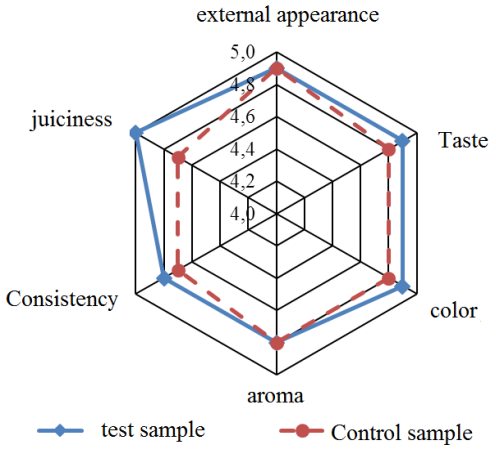

Figure 2. Organoleptic profile of finished semi-finished products

The following indicators were taken into account: appearance, color, smell, texture, taste and juiciness. For almost all of them, the control sample of the semi-finished product has improved performance.

Thus, the developed semi-finished products have the following advantages:

- have a high balance of amino acid composition of proteins, which guarantees a consistently high nutritional and biological value;

magnesium, etc.) easily accessible for assimilation by the body ;

- contain components that provide high quality, consumer characteristics, increased yield and, at the same time, reduce the cost of the finished product.

Conclusion

The formulation and technology of nutritionally balanced meat and vegetable semi-finished products of directed action, which have functional and preventive properties, have been developed to improve the health of wide consumer groups and prevent the most common alimentary-dependent diseases. The use of the proposed semi-finished products in the diet of various categories of the population will contribute to the normalization of the gastrointestinal tract, strengthening the musculoskeletal system, and slowing down the aging process. The presence in finished products of such micro and macro elements as calcium, phosphorus, iron and zinc helps to prevent cardiovascular diseases, osteoporosis, and strengthen teeth. Zinc takes part in the formation of the most important hormones, neurotransmitters, blood cells, creating favorable conditions for the cells of the body for full functioning, and iron, in turn, is involved in the formation of hemoglobin.

The inclusion of milk molasses with lactulose in the recipe of meat and vegetable semi-finished products allows not only to carry out daily prevention of common deficient conditions of the body associated with a lack of prebiotic substances and the most important micro-, macro-elements of milk, but also to reduce thermal losses, increase the yield of products, juiciness of finished products, improve them color and taste characteristics.

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СРАВНИТЕЛЬНАЯ ЭФФЕКТИВНОСТЬ АСПИРАЦИОННОГО ОБОРУДОВАНИЯ ПРИ ПЫЛЕЗАЩИТЕ ЭЛЕВАТОРНЫХ КОМПЛЕКСОВ ВМЕСТИМОСТЬЮ 20000 ТОНН

THE COMPARATIVE EFFICIENCY OF ASPIRATION EQUIPMENT FOR DUST PROTECTION OF ELEVATOR COMPLEXES WITH A CAPACITY OF 20,000 TONS

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Аннотация

Цель работы заключалась в исследовании эффективности использования аспирационного оборудования типа ББЦ и его эффективность использования на сегодняшний день по сравнению с передовыми достижениями техники по аспирации в элеваторной промышленности для процесса создания разряжения воздуха и удаления зерновой пыли при эксплуатации оборудования на примере современного силосного элеватора вместимостью 20000 тонн, при крупяном производстве, включающем в себя приемку и хранение кондиционного зерна.Для достижения цели исследования и ответа на поставленные исследовательские вопросы об эффективности установок батарейных циклонов типа ББЦ был произведен расчет по количеству выбрасываемой зерновой пыли за период в 365 дней эксплуатации элеватора при режиме в 3 смены по «Временной методике расчёта плановых показателей по охране атмосферного воздуха зерноперерабатывающих предприятий и элеваторов», в соответствии с «Методикой расчёта аспирационных установок и взрыворазрядных устройств», серия 14, выпуск 1 «Промышленная безопасность взрывоопасных объектов хранения и переработки зерна».Согласно полученным результатам по произведенному расчету был установлен коэффициент

очистки батарейных установок, который составил 95-96%, количество удаленной зерновой пыли за год работы элеватора составляет 40,16 тонн. Данный показатель положительно влияет на оценку эффективности работы батарейных аспирационных установок типа ББЦ. Выявлены ряд недостатков и преимуществ аспирационных установок типа ББЦ перед современным аспирационным оборудованием на примере точечного локального фильтра.На сегодняшний день батарейные установки типа ББЦ являются эффективным аспирационным оборудованием, несмотря на неоспоримые преимущества инновационных точечных локальных фильтров, существенной проблемой которых является их мало универсальность.

Ключевые слова: элеватор, зерновая пыль,ББЦ, воздух, загрязнение, очистка.

Abstract

The purpose was to study the efficiency of the use of aspiration equipment of the BC type and its efficiency of use today in comparison with the advanced achievements of aspiration technology in the elevator industry for the process of creating air dilution and removing grain dust during the operation of equipment using the example of a modern silo elevator with a capacity of 20,000 tons, in grain production, including acceptance and storage of air-conditioned grains. In order to achieve the purpose of the study and answer the research questions about the effectiveness of the installations of battery cyclones of the BC type, a calculation was made on the amount of grain dust emitted for a period of 365 days of elevator operation in 3 shifts according to the "Temporary method of calculating planned indicators for the protection of atmospheric air of grain processing enterprises and elevators", in accordance with the "Calculation Method aspiration installations and explosion-discharge devices", series 14, issue 1 "Industrial safety of explosive grain storage and processing facilities". According to the results obtained, according to the calculation, the cleaning coefficient of battery installations was established, which amounted to 95-96%, the amount of grain dust removed during the year of operation of the elevator is 40.16 tons. This indicator has a positive effect on the evaluation of the efficiency of battery-operated aspiration units of the BBTS type. A number of disadvantages and advantages of BBC type aspiration units over modern aspiration equipment have been identified on the example of a point local filter. To date, battery installations of the BPC type are effective aspiration equipment, despite the undeniable advantages of innovative point local filters, the essential problem of which is their low versatility.

Keywords: elevator, aspiration equipment, grain dust, BBTS, air, pollution, cleaning.

Введение Сельское хозяйство России – крупная отрасль экономики страны. Россия занимает первое место в мире по экспорту пшеницы. В частности, зерновая промышленность - один из основных источников дохода страны при экспорте сельхозпродукции [1,3] В связи с перспективным развитием сельскохозяйственной промышленности, где экспорт зерна является стратегически важным фактором для экономики государства, возрастает актуальность строительства предприятий по хранению и переработке зерна. По статистическим данным на 2020 год общий объем экспорта сельхоз-сырья и продовольствия достиг 30 млрд долларов [5,7,12].

Столь интенсивный рост развития зерновой промышленности влечет за собой активный спрос на строительство элеваторов. Основным сопутствующим явлением при работе такого предприятия является наличие зерновой пыли, которая содержит вредные вещества, влияющие на здоровье рабочих и населения близь расположенных от территории элеватора [2,6,9]. Одним из жизненно важных элементов окружающей нас природной среды является атмосферный воздух [4,8,11], особую опасность представляет нахождение частиц зерновой пыли в неразряженном воздушном пространстве, что ведет к взрывоопасной ситуации на предприятии. Для этого на элеваторах согласно «Правилам безопасности взрывопожароопасных производственных объектов хранения и переработки растительного сырья», утверждённых Приказом Ростехнадзора от 15 ноября 2016 года № 475, следует использовать специальное аспирационное оборудование.

На сегодняшний день для разряжения воздуха при транспортировке зерна на предприятии и удаления зерновой пыли все чаще используют сравнительно современное оборудование, такое как точечные локальные фильтры, подразумевающие разряжение воздуха каждого оборудования отдельно, не объединяя в общую сеть [10,13]. Однако, параллельно новым техническим открытиям многие предприятия по-прежнему вот уже более полувека активно используют батарейные установки типа ББЦ, входящие в состав аспирационной сети [14]. Такой выбор обоснован значимыми факторами, которые исследованы и представлены в данной статье на примере современного силосного элеватора вместимостью 20000 тонн, при крупяном производстве, включающем в себя приемку и хранение кондиционного зерна.

Материалы и методы исследований.Объектом исследования является аспирационное оборудование типа ББЦ и его эффективность использования на сегодняшний день по сравнению с передовыми достижениями техники по аспирации в элеваторной промышленности и для процесса создания разряжения воздуха и удаления зерновой пыли при эксплуатации оборудования на примере современного силосного элеватора вместимостью 20000 тонн, при крупяном производстве, включающем в себя приемку и хранение кондиционного зерна (рис. 1).

В технологический комплекс входят следующие здания и сооружения:

1. Устройство приема зерна из автотранспорта на два проезда (поз. 1);
2. Блок из двух бункеров для отходов (поз. 2);
3. Устройство отгрузки зерна на автотранспорт ОАТ2хСКД5/7-45 (поз. 3);
4. Пост управления и ПЩ (поз. 4);
5. Емкости для хранения зерна СПД 18/19 — 4 шт, общей вместимостью 20000 тонн (поз. 5...8);
6. Конвейерные надземные эстакады (поз. 9...12)

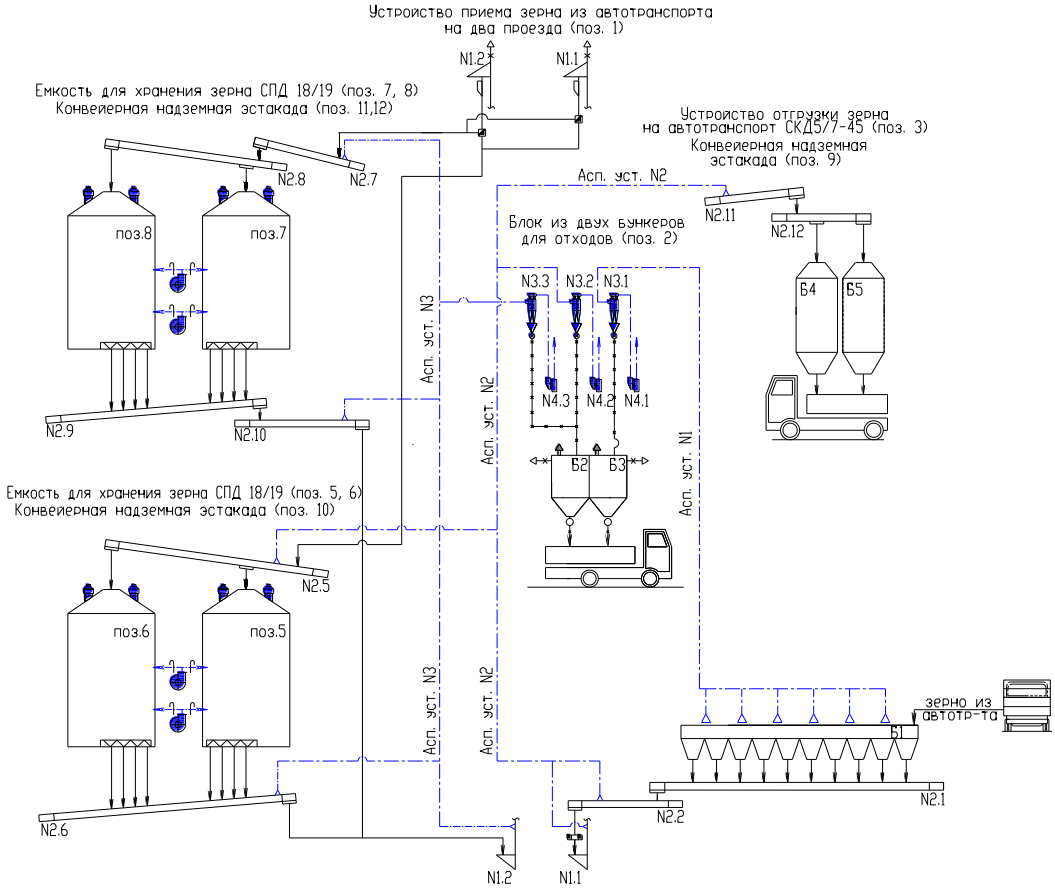

Рисунок 1. Технологическая схема элеватора вместимостью 20000 тонн

Схемой технологического процесса предусмотрено выполнение следующих операций:

- Приём зерна из автотранспорта с подачей в любой ряд емкостей для хранения зерна СПД 18/19;
- Перекачка зерна из емкости в емкость, а также из каждого ряда емкостей в любой ряд емкостей;
- Отгрузка зерна из емкостей для хранения зерна СПД 18/19 на автотранспорт

Управление производством осуществляется автоматической системой управления технологическим процессом (АСУТП) на базе персональных компьютеров с установкой оборудования в помещении поста управления.

Режим работы — 3 смены, 365 дней в году.

Очистка воздуха в аспирационных установках предусмотрена на установках батарейных циклонов ББЦ ООО «Корпорация «СКЭСС» с использованием вентиляторов фирмы «Завод «ВЕНТИЛЯТОР»». Для уменьшения объемов выбросов пыли до нормативных пределов предусмотрена аспирация всех мест пылеобразования. К таким местам относятся: место отгрузки зерна с автотранспорта в приемные бункера; башмаки нории; места загрузки и выгрузки конвейеров надсилосных, подсилосных и транспортирующих по предприятию. Произведена компоновка аспирационных сетей в общую сеть, по принципу согласованности и одновременности работы оборудования в целях более рационального использования энергоресурсов (таблица 1). Расчет и подбор оборудования осуществлен на основе паспортных данных упомянутых выше фирм.

Таблица 1. - Компоновка аспирационных установок

Наименование аспирируемых машин	Отм. установки	Кол. машин	Норма отсоса воздуха от 1 машины $м^3/час$	Всего отсасыв. воздуха $м^3/час$	Пылеотделитель, вентилятор
1	2	3	4	5	6
Устройство приема зерна из автотранспорта на два проезда (поз. 1)					
Аспирационная установка №1					
Бункеры устройства приема зерна из автотранспорта Б1	0,000	1	1300х5	6500	Установка батарейная циклонов ББЦ-500 №3.1 Вентилятор ВЦП 7-40-5 №4.1
Qвент.=6500х1,05+150=6975 $м^3$/час					
Аспирационная установка №2					
Нория II-175 №1.1 Конвейер скребковый №2.2; №2.5; №2.11	0,000 -4,550 +10,500 +30,200	1 3	1540 510х3	3070	Установка батарейная циклонов ББЦ-350 №3.2 Вентилятор ВЦП 5-45-4,25 №4.2
Qвент.=3070х1,05+150=3376 $м^3$/час					
Аспирационная установка №3					
Нория II-175 №1.2 Конвейер скребковый №2.6;№2.7; №2.10	-5,450 0,000 0,000 +30,200	1 3	1540 510х3	3070	Установка батарейная циклонов ББЦ-350 №3.4 Вентилятор ВЦ 5-45-4,25 №4.4
Qвент.=3070х1,05+150=3376 $м^3$/час					

Аспирационное оборудование предназначено для удаления зерновой пыли и газов, которые образуются в ходе работы технологического оборудования на предприятии.

Зерновая пыль – субстанция, состоящая из мелких частиц, возникающих от процесса трения зерен друг о друга и о стенки оборудования при перемещении на производстве. Зерновая пыль многогранна по своему составу. Она содержит минеральную пыль (почва), разрушенное зерно и части растений, семена сорняков, мицелии и споры грибков, микробов, насекомых и клещей. Зерновая пыль и споры грибков опасны для здоровья работающих и населения прилегающих к предприятиям селитебных территорий. Является источником так называемой «зерновой лихорадки», хронических поражений лёгких («лёгкие фермеров») и других системных поражений внутренних органов при воздействии зерновой пыли (таблица 2).

Таблица 2. - Предельно допустимые концентрации (ПДК) зерновой пыли

ПДК максимально концентрация зерновой пыли в атмосферном воздухе		
	разовая	среднесуточная
городское население	0,5 мг/м^3	0,15 мг/м^3
сельское население	0,5 мг/м^3	0,15 мг/м^3
ПДК зерновой пыли в воздухе рабочего пространства		
4 мг/м^3		

Главной опасностью является легкая воспламеняемость этой субстанции в сочетании с созданием пониженного давления при транспортировке зерна. Она относиться к 3-му классу опасности по токсичности и взрывоопасности.

Объектом исследования является аспирационное оборудование типа ББЦ и его эффективность использования на сегодняшний день по сравнению с передовыми достижениями техники по аспирации в элеваторной промышленности. Батарейные установки типа ББЦ предназначены для улавливания среднедисперсной пыли в системах пневмотранспорта и аспирационных установках (рис. 2).

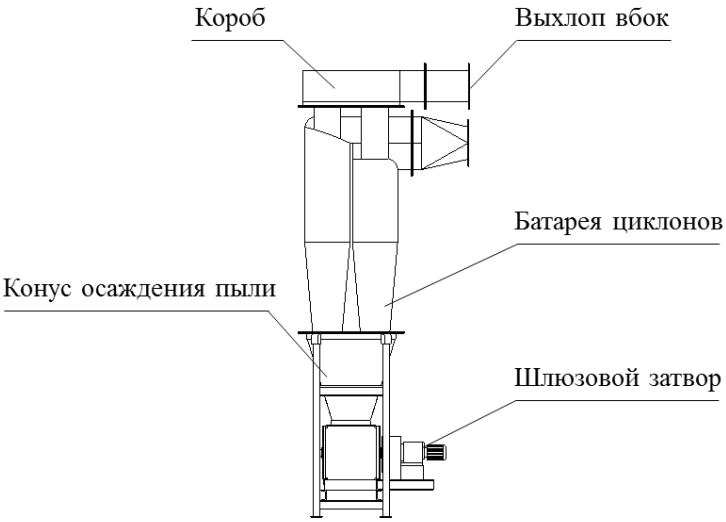

Рисунок 2. Батарейная установка типа ББЦ

Принцип действия заключается в выведении запыленного воздуха, который поступает через входной патрубок поступает в циклоны и получает вращательное винтообразное движение. Под действием центробежной силы частицы пыли прижимаются к стенкам циклонов, теряют скорость и осаждаются вниз в сборный конус. При помощи шлюзовых затворов собранная пыль выводится в пылеотвод, а очищенный воздух через выхлопные трубы циклонов и сборную коробку выводится из циклонов вверх или вбок в воздуховод очищенного воздуха (рис. 3).

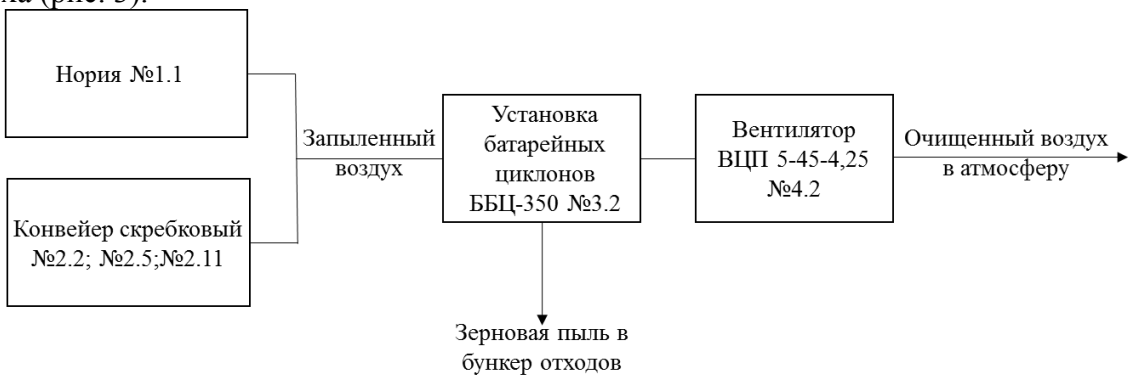

Рисунок 3. Схема движения воздушной массы в аспирационной установке №2 (см. Таблицу 1)

Для достижения цели исследования и ответа на поставленные исследовательские вопросы об эффективности установок батарейных циклонов типа ББЦ был произведен расчет по количеству выбрасываемой зерновой пыли за период в 365 дней эксплуатации элеватора при режиме в 3 смены по «Временной методике расчёта плановых показателей по охране атмосферного воздуха зерноперерабатывающих предприятий и элеваторов», в соответствии с «Методикой расчёта аспирационных установок и взрыворазрядных устройств», серия 14, выпуск 1 «Промышленная безопасность взрывоопасных объектов хранения и переработки зерна».

Организованным источникам выбросов присвоены номера с №1 по №3, соответственно номерам аспирационных установок.

Расчет производится по формуле:

$$m = V \times Z_K, \text{ г/сек, где:}$$

m - выброс пыли, г/сек;

V - объем воздуха, выбрасываемый источником, $м^3$/сек.

Z_K - концентрация пыли в воздухе после очистки, г/$м^3$.

Объём воздуха (V), выбрасываемый источником определяется по формуле:

$$V = \frac{(\Sigma oom. \times 1{,}05) + Qб.y.}{3600}, м^3 / сек,$$

где:

$Q_{б.у.}$ - количество воздуха, подсасываемого в циклонах, $м^3$/час.

Концентрация пыли в воздухе после очистки (Z_K) определяется по таблице 10 (приложение 32) «Методики расчёта аспирационных установок и взрыворазрядных устройств» в зависимости от концентрации пыли и скорости воздуха на входе в пылеотделитель.

Устройство приема зерна из автотранспорта
на два проезда (поз. 1)
Источник № 1
Аспирационная установка № 1

Загрязняющее вещество - пыль зерновая
Объём воздуха - 1,94 $м^3$/сек
Диаметр выхлопного воздуховода - 0,50 м
Высота выброса - 2,5 м от отм. 0,000 сооружения
Время работы - 1450 час/год
Пылеотделитель - установка батарейная циклонов ББЦ-500
Коэффициент очистки фильтра - не менее 95%

Наименование аспирируемого оборудования	Объем отсасываемого воздуха, $м^3$/час	Концентрация пыли в воздухе, отходящем от оборудования, г/$м^3$
Бункера устройства приема зерна из автотранспорта на два проезда	6500	1,3

Средневзвешенная концентрация пыли до очистки - 1,21 г/$м^3$

Количество пыли в воздухе до очистки:

$$m = 1{,}21 \times 1{,}94 = 2{,}35 \text{ г/сек}$$

Концентрация пыли в воздухе после очистки — 0,0625 г/$м^3$

Выброс пыли после очистки составит:

$$m = 0{,}0625 \times 1{,}94 = 0{,}12 \text{ г/сек; } 0{,}63 \text{ т/год}$$

Коэффициент очистки батарейной установки составит - 95 %

Источник № 2

Аспирационная установка № 2

Загрязняющее вещество - пыль зерновая
Объём воздуха - 1,54 м^3/сек
Диаметр выхлопного воздуховода - 0,450 м
Высота выброса - 11,9 м от отм. 0,000 сооружения
Время работы - 1450 час/год
Пылеотделитель - установка батарейная циклонов ББЦ-350
Коэффициент очистки фильтра - не менее 96%

Наименование аспирируемого оборудования	Объем отсасываемого воздуха, м^3/час	Концентрация пыли в воздухе, отходящем от оборудования, г/м^3
Нория II-175 №1.1	1540	2,0
Конвейер скребковый №2.2; №2.5; №2.11	510х3	0,8

Средневзвешенная концентрация пыли до очистки - 1,28 г/м^3.
Количество пыли в воздухе до очистки:

m = 1,28х0,94 = 1,2 г/сек.

Концентрация пыли в воздухе после очистки — 0,0513 г/м^3
Выброс пыли после очистки составит:

m = 0,0513х0,94 = 0,048 г/сек; 0,25 т/год

Коэффициент очистки батарейной установки составит - 96%

Источник № 3

Аспирационная установка № 3

Загрязняющее вещество - пыль зерновая
Объём воздуха - 1,54 м^3/сек
Диаметр выхлопного воздуховода - 0,450 м
Высота выброса - 11,9 м от отм. 0,000 сооружения
Время работы - 1450 час/год
Пылеотделитель - установка батарейная циклонов ББЦ-350
Коэффициент очистки фильтра - не менее 96%

Наименование аспирируемого оборудования	Объем отсасываемого воздуха, м^3/час	Концентрация пыли в воздухе, отходящем от оборудования, г/м^3
Нория II-175 №1.2	1540	2,0
Конвейер скребковый №2.6; №2.7; №2.10	510х3	0,8

Средневзвешенная концентрация пыли до очистки - 1,28 г/м^3.
Количество пыли в воздухе до очистки:

m = 1,28х0,94 = 1,2 г/сек.

Концентрация пыли в воздухе после очистки — 0,0513 г/м^3
Выброс пыли после очистки составит:

m = 0,0513х0,94 = 0,048 г/сек; 0,25 т/год

Коэффициент очистки батарейной установки составит - 96%
В процессе эксплуатации предприятия, кроме загрязняющих веществ, выбрасываемых

в атмосферу, образуются некормовые отходы от аспирационных установок №1...3, которые накапливается в блоке из двух бункеров для отходов (поз. 2). По мере накопления отходы отгружаются на автотранспорт для вывоза на полигон ТБО.

Сводная таблица данных по организованным источникам выбросов аспирационных установок приведена в таблице 3. Количество и характеристика отходов приведена в таблице 4.

Таблица 3 – Сводная таблица данных по организованным источникам выбросов аспирационных установок

№№ источников	Объём воздуха в сети $м^3$/сек	Кол-во выделяемой пыли до очист. г/сек	Количество выделяемой пыли после очистки г/сек	Загрязняющее вещество	Тип пылеотделителя		Диаметр выхлопного воз-да, м	Высота выброса, м	Время работы источника, час/год
					Типа ББЦ	Коэф эффициен очистки %			
1	2	3	4	5	6	7	8	9	10
1	1,94	2,35	0,12	Пыль зерновая	Установка батарейная циклонов ББЦ-500	95,0	0,500	2,5	1450
2	0,94	1,12	0,048	Пыль зерновая	Установка батарейная циклонов ББЦ-350	96,0	0,355	11,9	1450
3	0,94	1,12	0,048	Пыль зерновая	Установка батарейная циклонов ББЦ-350	96,0	0,355	11,9	1450

Таблица 4 – Количество и характеристика отходов

Наим.	Место образования отходов	Класс опасности	Физико-химическая характеристика отходов(состав, содержание элементов, состояние, влажность и т.д)	Периодичность образования отходов	Кол-во отходов, т/год	Использование отходов (т/год)	
						Передано другим организациям	Складирование в накопителях, на полигонах
1	2	3	4	5	6	7	8
Некормовые отходы зернового сырья	Устройство приема зерна из автотранспорта на два проезда (поз. 1)	III	Пыль аспирационная, осаждаемая в установках батарейных циклонов	Постоянно	40,16	-	Вывоз на полигон ТБО

Результаты исследований и их обсуждения. Согласно полученным результатам количество удаленной зерновой пыли за год работы элеватора составляет 40,16 тонн. Данный показатель положительно влияет на оценку эффективности работы батарейных аспирационных установок типа ББЦ. Так как выделенная зерновая пыль не только предотвращает пожаровзрывоопасную обстановку, способствует сохранению здоровья работающих предприятия и ближайшие территориально от элеватора населения, но влияет на качество заготовляемого для хранения зерна при крупяном производстве. Это существенное преимущество данных установок перед точечными локальными фильтрами, принцип работы которых имеет немного другую специфику (рис. 4).

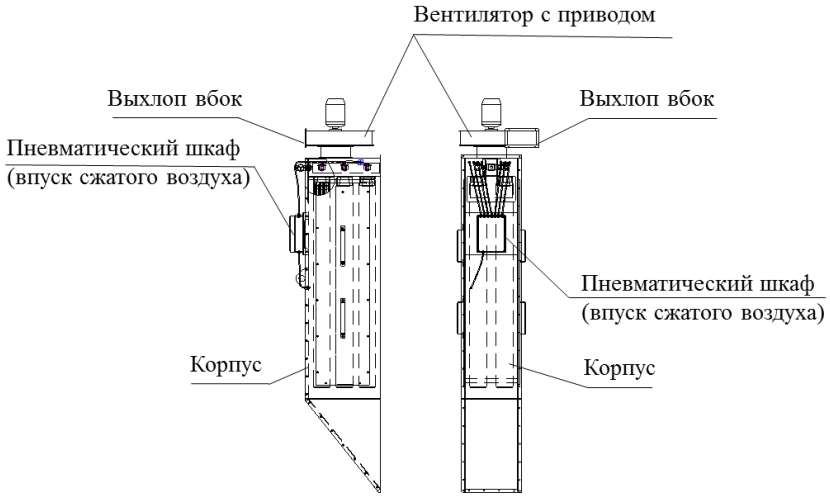

Рисунок 4. Локальный фильтр для вертикального монтажа

Локальный фильтр устанавливается непосредственно на оборудование, которое подлежит аспирации и работает параллельно с ним, то есть, когда транспортируется продукт и происходит образование пыли – запускается и локальный фильтр. Соответственно исчезает необходимость воздуховодов. В момент, когда транспортное оборудование не работает, локальный фильтр также отключен. В каждом месте образующаяся пыль улавливается и возвращается эффективно в процессный поток, при этом поддерживается незначительное отрицательное давление в системе. В результате не происходит утилизация ценного продукта, повышается выход продукта и производительность. В это заключается ряд преимуществ точечного локального фильтра.

Однако, так как принцип работы локального фильтра не предполагает отвода зерновой пыли, а пускают ее обратно в продукт при транспортировке сохраняя выход продукта, но снижается качество заготовляемого сырья, особенно это важно, если заготовляемое сырье идет на переработку в крупяное или мукомольное производство.

Так как локальные фильтры работают, используя сжатый воздух, то обязательным пунктом становится постройка компрессорной. Это проблема сказывается на больших расходах в экономическом плане. Точечные локальные фильтры являются современной, высокоэффективной заменой централизованных систем аспирации. Но проблема заключается в том, что современные фирмы выпускающие данные фильтры, изготавливают их акцентировано под размеры нового технологического оборудования. В связи с этим не каждое предприятие может подобрать фильтр под свой типоразмер и перейти на его использование.

Заключение. В связи с перспективным развитием сельскохозяйственной промышленности страны, где экспорт зерна является стратегически важным фактором для экономики государства, возрастает актуальность строительства предприятий по хранению и переработке зерна.

В данной статье были рассмотрены основные отрицательные факторы, сопутствующие эксплуатации элеватора. Было дано определение зерновой пыли, как субстанции из мелких частиц, заключающих в себе ряд негативных явлений: вред здоровья работнику предприятия и населенным пунктам, входящим в район работы элеватора, провоцирующие заболевания легких; взрывопожароопасность; влияние на качество, заготовляемого продукта.

Для аспирации оборудования предприятия была выбрана батарейная аспирационная установка типа ББЦ. На примере предполагаемого современного силосного элеватора вместимостью 20000 тонн, при крупяном производстве, включающий в себя приемку и хранение кондиционного зерна, была рассмотрена эффективность работы установок типа

ББЦ.

По произведенному расчету был установлен коэффициент очистки батарейных установок, который составил 95-96%. Количество отходов для утилизации составила 40,16 т/год.

Выявлены ряд недостатков и преимуществ аспирационных установок типа ББЦ перед современным аспирационным оборудованием на примере точечного локального фильтра. К недостаткам относится: необходимость в наличии аспирационной сети, включающей в себя различной протяженности воздуховоды, которые со временем стираются от постоянного соприкосновения абразивных частиц зерновой пыли со стенками трубы; осаждение в камерах части продукции совместно с зерновой пылью; обязательность утилизации собранных отходов. К преимуществам относится: высокая степень очистки; универсальность данной аспирационной установки для различного технологического оборудования; экономически выгоднее, так как присутствует только потребление электроэнергии, нет необходимости в компрессорной в отличие от локальных фильтров.

Таким образом можно сделать вывод, что на сегодняшний день батарейные установки типа ББЦ являются эффективным аспирационным оборудованием, несмотря на неоспоримые преимущества инновационных точечных локальных фильтров, существенной проблемой которых является их мало универсальность.

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КОНТРОЛЬ ПОКАЗАТЕЛЕЙ КАЧЕСТВА СОЛОДА ФОТОЛЮМИНЕСЦЕНТНЫМ МЕТОДОМ

QUALITY CONTROL OF MALT BY PHOTOLUMINESCENT METHOD

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Аннотация

Солодоращение – один из самых ответственных этапов при производстве пивоваренной продукции. Он весьма продолжительный и может проходит в течение 7-10 дней, за это время используемые семена превращаются непосредственно в готовое сырье, солод. Этот период характеризуется протеканием сложных биохимических процессов, проходящих в зерне и именно поэтому он особенно требователен к экспрессному и высокоточному контролю показателей качества. Для удовлетворения подобных потребностей необходимо внедрение современных методов оценки качества, например фотолюминесцентного метода анализа. Подобное технологическое решение позволит в кратчайшие сроки производить достаточно точные анализы в условиях производственной лаборатории и оперативно разрешать выявленные проблемы.

Материалы и методы, результаты и обсуждения

Для адаптации фотолюминесцентного метода контроля показателей качества солода были проведены экспериментальные исследования с его зернами. Измерение спектров проводили по ранее разработанной авторами методике на основе аппаратно-программного комплекса, состоящего из многофункционального спектрофлуориметра «Флюорат-02-Панорама» и компьютера с установленным программным обеспечением «PanoramaPro». Измерение биохимических показателей: мучнистости, экстрактивности и кислотности проводили в биохимической лаборатории и с использованием соответствующего оборудования согласно методам контроля, описанным в ГОСТ 29294-2021. Для всех исследуемых образцов получали семейства характеристик возбуждения и люминесценции для зерен различной степени мучнистости, экстрактивности и кислотности.

Заключение

В результате проведенных исследований:

1. Изучены спектральные характеристики возбуждения и люминесценции зерен ячменного и овсяного солода различной степени прорастания.

2. Изучена динамика изменения мучнистости, экстрактивности и кислотности ячменного и овсяного солода в ходе проращивания.

3. Представлены зависимости потока люминесценции от исследованных биохимических характеристик.

4. Выведены уравнения линейной аппроксимации для зерен ячменного и овсяного солода.

5. При помощи аддитивного моделирования выведены уравнения, позволяющие прогнозировать время для достижения нормы показателей солода высшего класса.

6. Разработана технологическая схема процесса экспресс-диагностики мучнистости, экстрактивностии и кислотности солода.

Полученные результаты проведенных спектральных и биохимических исследований являются ценными экспериментальными данными, которые могут стать основой для дальнейших научных изысканий в области изучения зерна и солода. Так же полученные результаты могут лечь в основу прибора люминесцентного контроля параметров качества солода.

Ключевые слова: спектр люминесценции, овес, ячмень, солод, мучнистость, экстрактивность, кислотность, аддитивная модель, линейная аппроксимация.

Abstract

Malting is one of the most important stages in the production of brewing products. It is very long and can take place within 7-10 days, during which time the seeds used are converted directly into finished raw materials, malt. This period is characterized by the course of complex biochemical processes taking place in the grain and that is why it is especially demanding for express and high-precision quality control. To meet such needs, it is necessary to introduce modern methods of quality assessment, for example, the photoluminescent analysis method. Such a technological solution will make it possible to produce sufficiently accurate analyses in a production laboratory in the shortest possible time and promptly resolve the identified problems.

Materials and methods, results and discussions

To adapt the photoluminescent method of malt quality control, experimental studies were conducted with its grains. The spectra were measured according to a technique previously developed by the authors on the basis of a hardware and software complex consisting of a multifunctional spectrofluorimeter "Fluorat-02-Panorama" and a computer with the installed software "PanoramaPro". The measurement of biochemical parameters: powdery content, extractivity and acidity was carried out in a biochemical laboratory and using appropriate equipment according to the control methods described in GOST 29294-2021. For all the samples studied, families of excitation and luminescence characteristics were obtained for grains of varying degrees of powdery content, extractivity and acidity.

Conclusion

As a result of the conducted research:

1. The spectral characteristics of excitation and luminescence of barley and oat malt grains of various degrees of germination have been studied.

2. The dynamics of changes in the powdery content, extractivity and acidity of barley and oat malt during germination has been studied.

3. The dependences of the luminescence flux on the studied biochemical characteristics are presented.

4. Linear approximation equations for barley and oat malt grains are derived.

5. With the help of additive modeling, equations are derived that allow predicting the time to reach the norm of indicators of malt of the highest class.

6. The technological scheme of the process of express diagnostics of powdery content, extractivity and acidity of malt has been developed.

The obtained results of spectral and biochemical studies are valuable experimental data that can become the basis for further scientific research in the field of grain and malt studies. Also, the results obtained can form the basis of the device for luminescent control of malt quality parameters.

Keywords: luminescence spectrum, oats, barley, malt, powdery content, extractivity, acidity, additive model, linear approximation.

Introduction

Food safety and quality are becoming increasingly important, so there is an increasing focus on new control methods. These innovations include near infrared (NIR) spectroscopy, which has gained wide popularity and recognition over the past 15 years due to its ability to be used in research aimed at determining the quality of food products. In particular, the NIR method was used to assess the fuzzy consumer properties of the food environment [3], to identify butter [5], to study vegetable oils and their blends [6], to determine the vitreousness of wheat [10], to detect a high content of deoxynivalenol in barley [13].

Spectrophotometric methods can be applied in the field of food and agriculture, as methods for monitoring and studying the quality of products of plant and animal origin, for example, to control the color of vegetable oils during their refining [8], to study the composition of the pigment complex of rapeseed oil [9], to create spectral portraits of the optimal nutrition menu [7], to classify botanical origin and determine the falsification of raw honey [14], to predict the rheological properties of Tilsit cheese [15] .

Absorption and scattering of optical radiation are two main optical properties for turbid biological materials. To control food spoilage, the initial data for the development of an optoelectronic device were determined [2]. A simplified fiber optic system was also developed to determine the quality of mangoes [16].

In Russia, a large number of determinations are carried out annually to assess the quality of agricultural products according to various indicators, including extractiveness, flouriness and acidity of grain material. The methods used are time-consuming and low-productive. For example, GOST 29294-2021 describes the process for determining extract, flouriness and acidity to estab-

lish the quality of malt. Arbitration methods are carried out in special laboratories with the described equipment, have a relatively low speed of research and a high cost of one analysis.

To solve such problems, various optical research methods are currently used, based on the spectral analysis of the intermediate product and its comparison with the spectrum of the previously studied and obviously true finished product. As shown above, such definitions are successfully used in various countries to conduct express analyzes of a number of indicators of the quality of agricultural products.

The main advantages of all known optical instruments are: reduced analysis time, energy efficiency, the absence of specific consumables and reagents, and simpler requirements for the qualification of maintenance personnel. The issues of creating new methods for studying quality and equipment for their implementation are being dealt with both in our country and abroad.

Developed on the basis of the experiment, the technological process of express diagnostics of flouriness, extractivity and acidity will allow, firstly, to make a decision with high accuracy on the end, continuation or adjustment of the germination conditions (changes in temperature, humidity, conditioning, etc.) and, secondly, to predict the time to reach the norm of high-class malt indicators.

Materials and methods

To find dependencies and, subsequently, to create such a technological process, it is necessary to conduct a laboratory experiment to study flouriness, extractivity, acidity and spectral characteristics of malt on each day of germination. Determination of the percentage of flouriness (P), extractivity (E) and acidity (A) of malt was carried out in accordance with the requirements and in accordance with the recommendations of GOST 29294-2021. The results of experimental biochemical and spectral studies are presented in Table 1.

The spectral characteristics of excitation $\eta_e(\lambda)$ and luminescence $\varphi_l(\lambda)$, as well as their parameters ($\lambda_{in,\,max}$, $\eta_{e,\,max}$, $\lambda_{l,\,max}$, $\varphi_{l,\,max}$) for barley and oat malt were measured according to a previously developed method [11] on a Fluorat-02-Panorama diffraction spectrofluorimeter with the PanoramaPro software. The results of the spectral analysis of barley and oat malt are presented in Figure 1 and Figure 2, respectively. Each curve in the graphs is an average of 20 individual measurement curves.

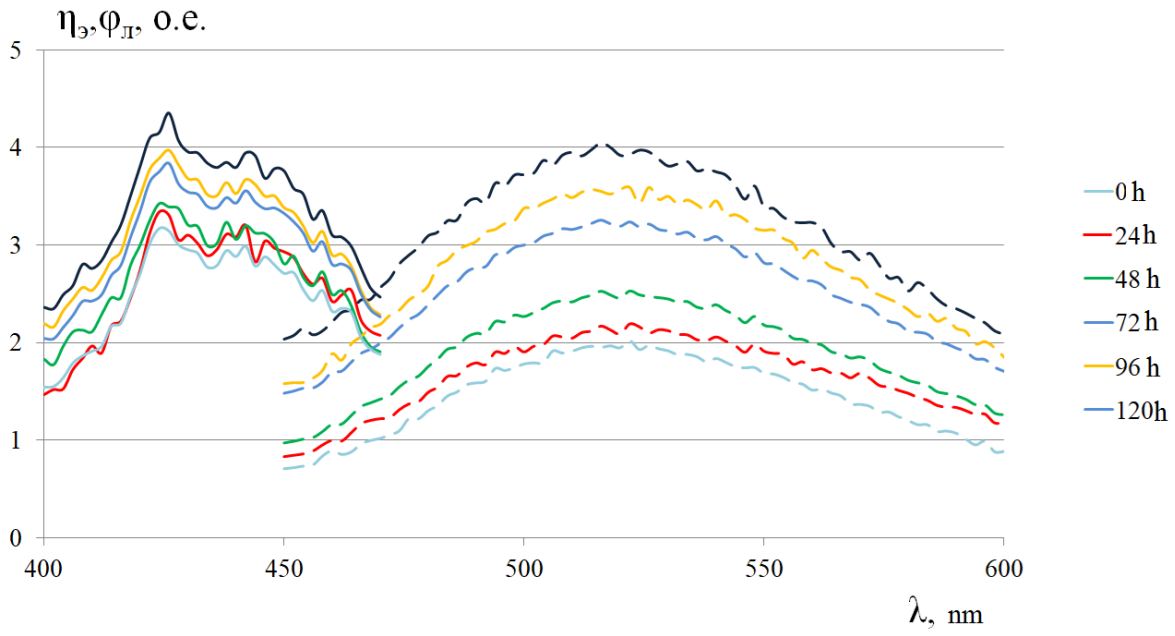


Figure 1. Spectral characteristics of excitation and luminescence of grains of barley malt with different degrees of flouriness, extractivity and acidity

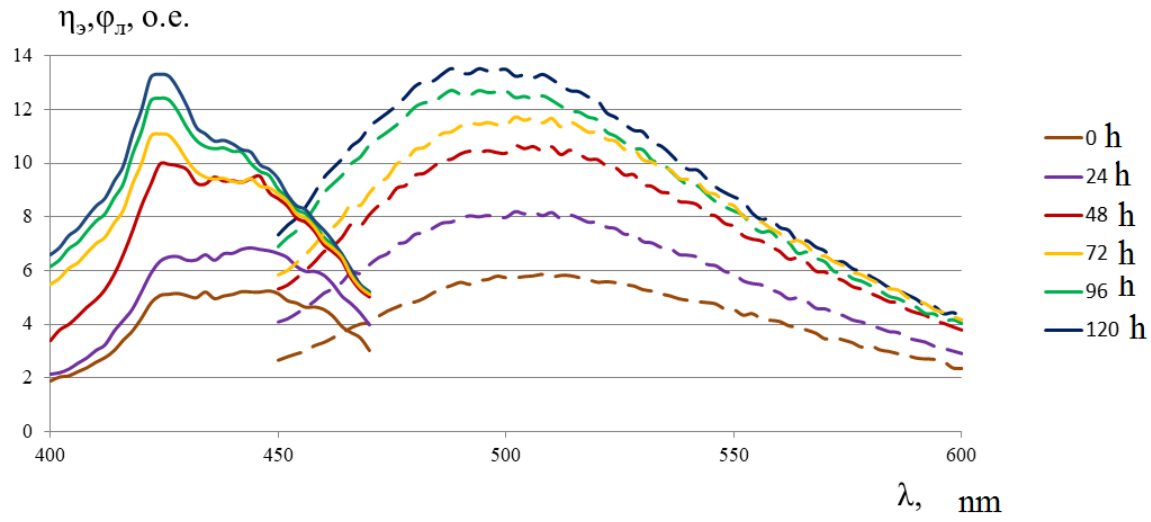


Figure 2. Spectral characteristics of excitation and luminescence of grains of oat malt with different degrees of flouriness, extractivity and acidity

The parameters of this family of characteristics for barley and oat malt are presented in tables 1 and 2, respectively.

Table 1. Parameters of the spectra of barley malt grains of varying degrees of flouriness, extractivity and acidity.

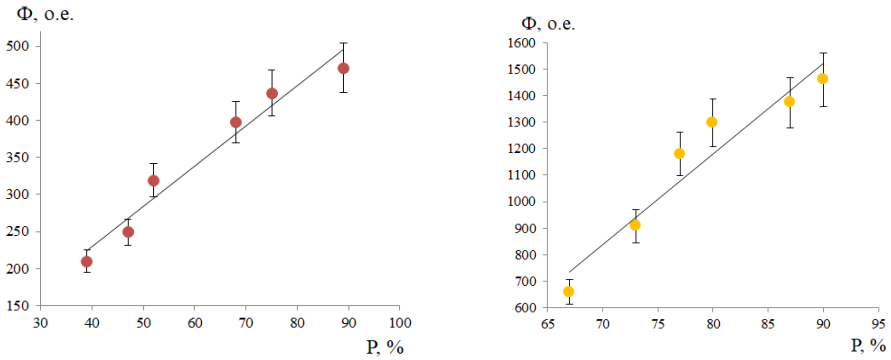
τ, h	A_i, c.ed.	E_i, %	P_i, %	Excitation spectrum			Δλ, nm	Luminescence spectrum		
				N, o.u.	$\lambda_{w.max.}$, nm	$\eta_{e.max}$ p.u.		F, o.u.	$\varphi_{in.max.}$, nm	$\varphi_{l.max.}$, o.u.
0	3.78	37.3	39	173± 10	424	3.2	98	210± 10	522	2.0
24	3.30	45.3 _	47	180 ± 9	424	3.3	98	249 ± 15	522	2, 2
48	2.84	51.4	52	186± 11	424	3.4	98	319 ± 20	522	2.5
72	2.31	62.0	68	202± 10	42 6	3, 8	9 6	398± 19	522	3, 3
96	1.90	68.6 _	75	216± 13	426	4.0	96	437 ± 25	522	3.6
120	1.48	76.6	89	237 ± 16	426	4.3	90	471 ± 30	516	4, 1

Table 2. Parameters of the spectra of oat malt grains of varying degrees of flouriness, extractivity and acidity

τ, h	A_o, c.ed.	E_o, %	R_o, %	Excitation spectrum			Δλ, nm	Luminescence spectrum		
				N, o.u.	$\lambda_{w.max}$, nm	$\eta_{e.max}$, p.u.		F, o.u.	$\varphi_{in.max.}$, nm	$\varphi_{l.max.}$, o.u.
0	2.40	59.7	67	292±13	448	5.2	60	659± 33	508	5.9
24	2.08	66.8	73	370 ±18	444	6.8	58	907 ± 51	502	8.1
48	1.95	67.2	77	527 ±27	424	10.0	78	1179 ±81	5 0 2	10.6
72	1.79	69.4	80	581 ±26	426	11.0	76	1297 ± 84	502	11.8
96	1.54	73.2	87	631 ±36	42 6	12.4	62	1373 ±92	488	12.6
20	.47	4.2	0	6 61±35	4 26	1 3.4	2	14 60±89	4 88	1 3.6

So, on the basis of the data obtained, we derive the equations for the dependence of the luminescence flux on flouriness, extractivity and acidity of malts.

Dependences $P_i(F)$ and $P_o(F)$ for barley and oat malt are shown in Figure 3 (a, b) and linearly approximated by equations (1) and (2).



a) b)

a) barley malt
b) oat malt

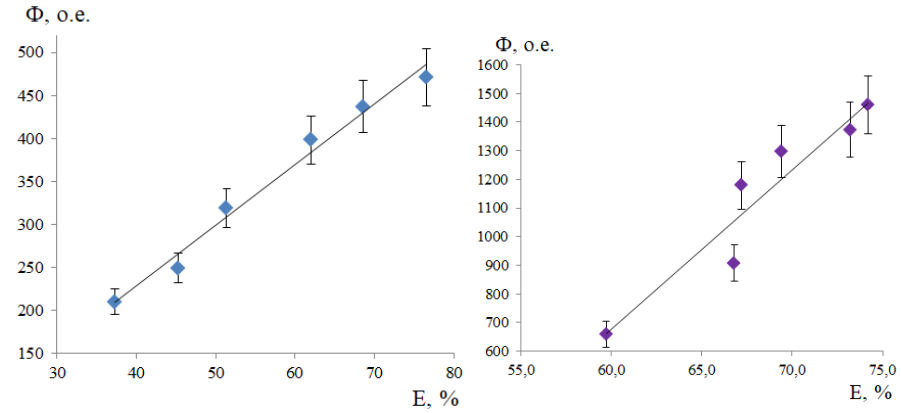
Figure 3. Dependence of the relative luminescence flux on the flouriness of malt grains

$$P_Я = 0{,}184\Phi - 2{,}6245, \quad (1)$$

$$P_О = 0{,}027\Phi + 48{,}09. \quad (2)$$

The coefficients of determination $R^2_{P_Я} = 0{,}971$, $R^2_{P_О} = 0{,}921$, that is, by 97.1% and 92.1%, the total scatter of the results relative to the average flouriness of the grains is explained by the obtained regression equation.

Similar dependences $E_i(F)$ and $E_o(F)$ are shown in Figure 4 (a, b) and linearly approximated by equations (3) and (4).



a) b)

a) barley malt
b) oat malt

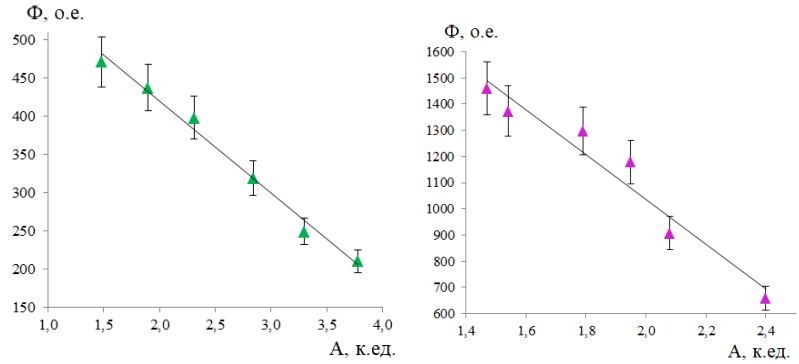
Rice. **Figure 4. Dependence of the relative luminescence flux on the extractivity of malt grains**

$$E_Я = 0{,}1491\Phi - 4{,}6264, \quad \textbf{(3)}$$

$$E_О = 0{,}0163\Phi + 49{,}72. \quad (4)$$

Determination coefficients $R^2_{E_Я} = 0{,}984$, $R^2_{E_О} = 0{,}908$, that is, 98.4% and 90.8% of the total scatter of results relative to the average grain extractivity is explained by the obtained regression equation.

Dependences $A_o(F)$ and $A_o(F)$ are shown in Figure 4 (a, b) and linearly approximated by equations (5) and (6).



a) b)

a) barley malt

b) oat malt

Figure 5. Dependence of the relative luminescence flux on the acidity of malt grains

$$A_{Я} = -0{,}0084\Phi + 5{,}5172, \quad (5)$$

$$A_{О} = -0{,}0011\Phi + 3{,}1397. \quad (6)$$

The coefficient of determination $R^2_{A_Я} = 0{,}992$, $R^2_{A_О} = 0{,}945$, that is, by 99.2% and 94.5%, the total scatter of the results relative to the average acidity of the grains is explained by the obtained regression equation.

Applying the additive modeling method to the obtained experimental data, we derived equations for predicting the time until the standard of barley and oat malt quality indicators is reached:

$$T_{E_Я} = \frac{80 - E}{0{,}334}, \quad (7)$$

$$T_{P_Я} = \frac{85 - P}{0{,}4}, \quad (8)$$

$$T_{A_Я} = \frac{A - 1}{0{,}019}, \quad (9)$$

$$T_{E_О} = \frac{75 - E}{0{,}072}, \quad (10)$$

$$T_{P_О} = \frac{90 - P}{0{,}147}. \quad (11)$$

Results and discussions

Now, having all the desired equations, we can draw up a block diagram of the technological process of express diagnostics of the characteristics under study (Fig. 6).

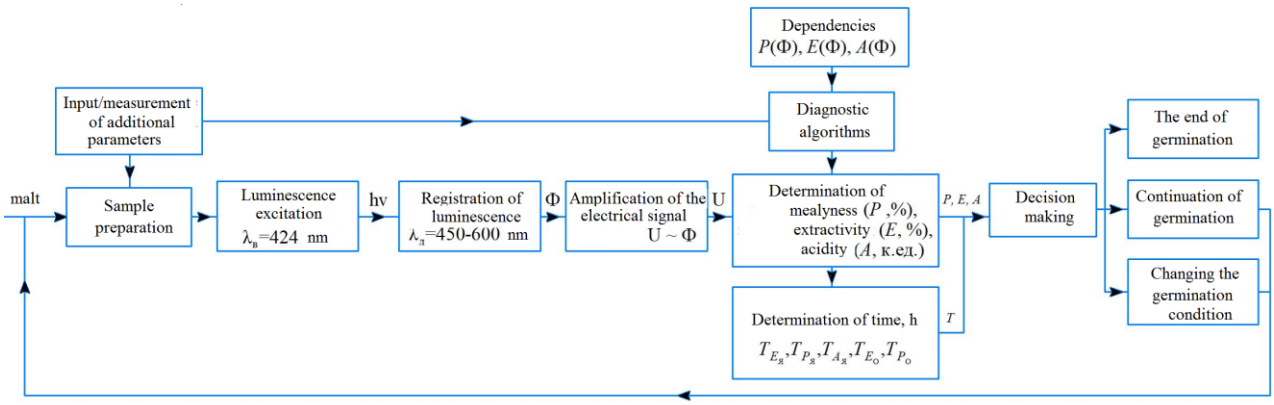


Figure 6. Block diagram of the technological process of express diagnostics of flouriness, extractivity and acidity of malt

Express diagnostics of malt quality indicators with excitation of photoluminescence in the range of about 400-470 nm and its registration in the range of 450-600 nm can be recommended for malt grains from various crops.

The technological process begins with sample preparation. The test samples are placed in one to one and a half layers in a dark, light-tight chamber and aligned horizontally. In parallel with this stage, the type of product is identified and a number of grain parameters can be measured (or established in another way, for example, according to the accompanying documentation), which is necessary to establish the appropriate diagnostic algorithm, for example: type (barley, wheat, rye, etc.), variety, humidity, harvest time. Then, the excitation of the photoluminescence of the grains is carried out by radiation of a narrow spectral range with a maximum of λ=424 nm for 20 μs. A signal is registered proportional to the photoluminescence flux Φ in the spectral range 450-600 nm. The process takes 2-3 seconds to average the result. The received photosignal (photovoltage U, photocurrent I), proportional to the flux Φ, is amplified by the amplifier. Further, the amplified photosignal enters the microprocessor, where it is processed taking into account the a priori information available in its memory - a linear characteristic of the dependence of the luminescence flux on flouriness, extractivity and acidity of malt P(F), E(F), A(F).

Based on the results of determining the powderiness and the mass fraction of the extract in the dry matter of malt, a decision is made on further actions: changing conditions, ending or continuing germination.

The decision to continue germination is made when a correspondence is established between the germination time and the P, E, A indicators identified during express diagnostics. The germination time and the corresponding biochemical characteristics of barley and oat malt are shown in tables 1 and 2, respectively.

The decision to complete the germination is made at P≥85%, E≥80% and A≤1.

A decision to change the germination conditions is required if the sum of the time from the beginning of germination to the control measurement and the time calculated by formulas (7-11) is more than 168 hours by ≥8.4 hours.

It is desirable to carry out measurements several times with averaging of the obtained results. When integrated into other technological processes, continuous (in-line) control of the biochemical characteristics of malt is possible.

Conclusion

The spectral characteristics of excitation and luminescence of products of different powderiness, extractivity and acidity are qualitatively similar, but with an increase in the presented pa-

rameters, the curves reflecting the spectral characteristics shift upwards on the graphs. The dependences of the integral photoluminescence fluxes on flouriness, extractivity, and acidity can be statistically reliably approximated by linear regression models.

The developed photoluminescent method for express diagnostics of flouriness, extractivity and acidity of barley and oat malt serves to improve the technology of malting and can form the basis of an optical device for monitoring grain and malt quality indicators.

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КРАТКИЕ СООБЩЕНИЯ| SHORT REPORTS

В.Ф. Антонов [V.F. Antonov]

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УСТРАНЕНИЕ ДЕФЕКТОВ НА ФОТОГРАФИЯХ С ИСПОЛЬЗОВАНИЕМ НЕЙРОННЫХ СЕТЕЙ

ELIMINATION OF DEFECTS IN PHOTOS USING NEURAL NETWORKS

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Аннотация *Применение математического аппарата нейронных сетей становится весьма важным инструментов при решении различных задач искусственного интеллекта. К числу таких задач можно отнести и задачи распознавания образов. В данной работе приводится пример использования нейронной сети для идентификации дефекта на фотографии, а затем устранения такого дефекта.*

Материалы и методы, результаты и обсуждения. *В предлагаемой статье рассматриваются специальные алгоритмы работы нейронной сети, которые предназначены для распознавания графических образов, а также алгоритмы поиска дефектов на графических изображениях с последующим их устранением.*

Огромное количество фотографий на бумажных носителях со временем хранения подвергаются физическим повреждениям (в отличии от фотографий на электронных носителях). Чтобы решить такую задачу в необходимо разработать алгоритмы поиска и распознавания дефектов на фотографиях, а также алгоритмов по устранению этих дефектов с помощью математического аппарата нейронной сети.

Заключение. *Решения, которые предлагаются по результатам выполненной работы в рамках рассматриваемой статьи, дадут возможность пользователям восстановить старые фотографии с дефектами, которые могут быть бесценными не только для них, но и для всего общества – например, фотографий исторических событий, великих людей нашего государства.*

Ключевые слова*:* алгоритм, нейронная сеть, искусственный интеллект, нейрон, персептрон.

Abstract. *The use of the mathematical apparatus of neural networks is becoming a very important tool in solving various problems of artificial intelligence. Pattern recognition problems can be attributed to the number of such problems. This paper provides an example of using a neural network to identify a defect in a photograph, and then eliminate such a defect.*

Materials and methods, results and discussions. *The proposed article discusses special algorithms for the operation of a neural network that are designed to recognize graphic images, as well as algorithms for finding defects in graphic images with their subsequent elimination.*

A huge number of photographs on paper are subject to physical damage over time (unlike photographs on electronic media). To solve such a problem, it is necessary to develop algorithms for searching and recognizing defects in photographs, as well as algorithms for eliminating these defects using the mathematical apparatus of a neural network.

The article discusses approaches to the development of a neural network for recognizing defects in photographs with their subsequent restoration.

Conclusion*. The solutions that are offered based on the results of the work performed within the framework of this article will enable users to restore old photographs with defects that can be invaluable not only for them, but for the whole society - for example, photographs of historical events, great people of our state.*

Keywords: algorithm, neural network, artificial intelligence, neuron, perceptron.

Introduction. This article discusses approaches to using a neural network to recognize defects in damaged photographs and eliminate these damages.

To date, there are many photographs that have lost their usefulness over time, but are very important for our citizens, in particular photographs of war times. In old wartime photographs, there is no color at all. The durability of photographs, in the form in which we are accustomed to

seeing them, leaves much to be desired, because photographs lose their structure in a relatively short period of time.

To date, a huge number of tools have been developed that allow you to find defects in photographs and restore it. At first glance, it seems that a graphical editor can be used to solve such a problem. Another approach for solving problems of this kind is to use the theory of neural networks.

Figure 1 shows an example of photographs with defects that need to be recognized, and then the background corresponding to these defects should be restored.

Figure 1. Photo defects

Restoring photos using traditional tools consists of the following steps:

– it is necessary to find all the defects in the image: breaks, scuffs, glare, holes, bends;

– you also need to paint over the found defects, using a special technology based on the pixel values around the damage;

– colorize the image with the received data.

Restoring photographs using a neural network makes it possible to determine possible defects as input data, and then, based on the developed neural network, replace areas of photographs with defects with the background of areas where these defects were detected.

Materials and research methods. To implement this task, it was decided to develop a neural network. Based on the mathematical model (1) of a single neuron developed a neural network.

$$y_i(t) = f_2\left(a_{20i} + \sum_{i=1}^{N} a_{2i} f_1\left(\sum_{k=1}^{K} a_{1k} x_k(t) + a_{10k} \right) \right), \qquad (1)$$

where i $= 1, 2, \ldots, N$ - the number of neurons in the second layer;

$k = 1, 2, \ldots, K$ – the number of neurons in the first layer;

f_1, f_2 – activation functions of neurons of the first and second layers;

a_{10k} – initial excitation of the kth neuron of the first layer;

a_{20i} – initial excitation of the i - th neuron of the second layer;

a_{2i}, a_{1k} are the weight coefficients of the i - th neuron of the second layer and kth neuron of the first layer;

$y_i(t)$ – i- th coordinate of the output vector;

$x_k(t)$ is the k-th coordinate of the input vector.

Figure 2 shows a block diagram of a multilayer network, which is used in the development of a neural network:

Enter ***First layer*** ***Second layer*** ***Third layer***

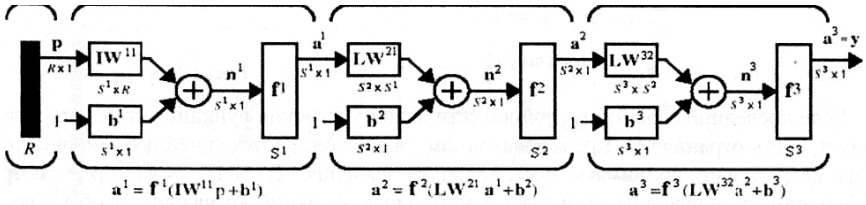

Figure 2. Structural diagram of a three-layer network

In order to build a neural network that would recognize images, while not being difficult from a computational point of view, and also providing invariance to various image distortions, it is necessary to apply in this case convolutional neural networks.

Research results. The developed network architecture implements the main paradigms:

– on the input neuron (output previous neuron) is served not all image , but only her separate part ;

– usage very small set by weight coefficients , for big quantities connections ;

– decrease spatial dimensions photos .

The next stage of work is training the neural network to recognize defects. In order to evaluate the quality of defect recognition in photographs, in the presented work, the root-mean-square error function is used as a criterion, which can be calculated by the following formula:

$$E^p = \frac{1}{2}(\mathrm{D}^p - \mathrm{O}(\mathrm{I}_p, \mathrm{W}))^2 \qquad (2)$$

where E^p is the standard error of defect recognition for the *p* - th training pair, D^p is the desired network output, $\mathrm{O}(\mathrm{I}^p, \mathrm{W})$ is the network output depending on the p *-th* input and the weighting coefficients W.

Using the error function as a criterion for assessing the quality of recognition, while the values of the error function can be applied in order to improve the quality of defect recognition. To do this, the graph of the error function is constructed, and then the search for the minimum of the function is carried out using gradient methods. We expand the resulting analytical error function in a Taylor series, we get:

$$\mathrm{E}(\mathrm{W}) = \mathrm{E}(\mathrm{W}_c) + (\mathrm{W} - \mathrm{W}_c)\frac{d\mathrm{E}(\mathrm{W}_c)}{d\mathrm{W}} + \frac{1}{2}(\mathrm{W} - \mathrm{W}_c)^2 \frac{d^2\mathrm{E}(\mathrm{W}_c)}{(d\mathrm{W}^2)} + \ldots\ldots \qquad (3)$$

For the resulting function (3), we find the derivative, which we equate to zero in order to find the extrema of the error function. After a series of elementary transformations, we obtain the following expression:

$$\mathrm{W}_{\min} = \mathrm{W}_c - \left(\frac{d^2\mathrm{E}(\mathrm{W}_c)}{d\mathrm{W}^2}\right)^{-1} \cdot \frac{d\mathrm{E}(\mathrm{W}_c)}{d\mathrm{W}} \qquad (4)$$

The optimal value of the weight coefficient calculated by formula (4) makes it possible to increase the efficiency of defect recognition in photographs, which ultimately increases the efficiency of the proposed solutions.

In the process of training a neural network, it is necessary to take into account the maximum size of identified defects, so that later such a defect can be eliminated with a certain probability .

To eliminate defects, image sections with defects are segmented, and then they are painted over with a certain color, after which, taking into account the background closest to the defect, color reconstruction is performed. To solve this problem, a special class has been developed that implements a convolutional neural network of arbitrary architecture and apply them to various tasks. A very important result of this work is the development of a neural network training algorithm, which takes some time. The developed algorithm for training a neural network with a teacher, which is shown in Figure 3.

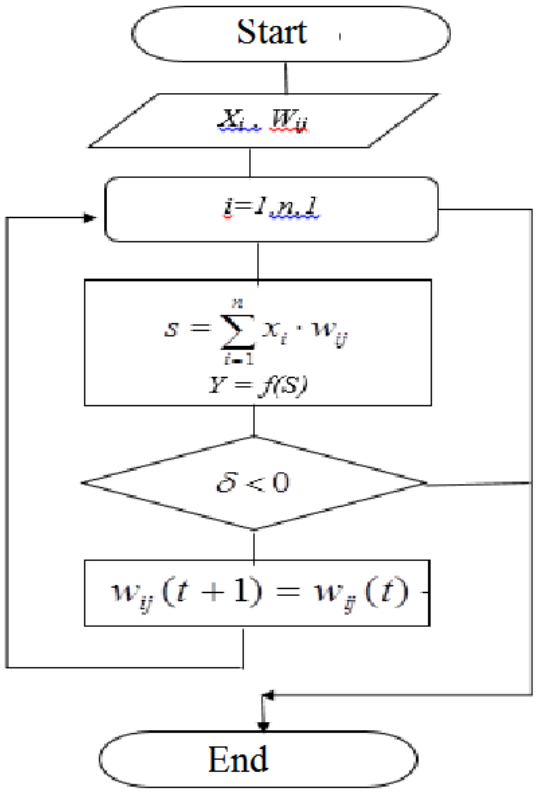

Figure 3. Block diagram of the supervised learning algorithm

Conclusion. An experiment was conducted based on the results of the neural network. The same photo was edited using the Photoshop editor and using the developed neural network, the results are shown in Figure 4.

Figure 4. The results of the neural network

a) in Photoshop b) in the neural network

Thus, the developed neural network, with its normal training, allows, firstly, to recognize defects and its background, and then to restore them. The solutions proposed in this paper can be used to restore a huge number of photographs that are of great value to most people.

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ТЕХНОЛОГИИ УПРАВЛЕНИЯ ПОЛИТИЧЕСКИМИ ПРОЦЕССАМИ В МОЛОДЕЖНОЙ ПОЛИТИКЕ РЕГИОНА

TECHNOLOGIES FOR MANAGING POLITICAL PROCESSES IN THE YOUTH POLICY OF THE REGION

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Аннотация

В статье раскрываются основные направления молодежной политики, определяются стратегии реализации молодежной политики, описываются технологии управления политическими процессами в молодежной политике региона.

Ключевые слова: молодежная политика, стратегия, молодежь, технологии, регион.

Abstract

The article reveals the main directions of youth policy, defines strategies for the implementation of youth policy, describes technologies for managing political processes in the youth policy of the region..

Key words: youth policy, strategy, youth, technology, region.

In modern reality, the study of technologies for managing political processes in the youth policy of the region is relevant. V.V. Putin, in his Address to the Federal Assembly on December 1, 2016, noted that he sees “in the younger generation a reliable, strong support for Russia in the turbulent, complex XXI century” [1]. Eliseev A.L. states that the state implements the state youth policy, the purpose of which is to create all the necessary conditions for the socialization of youth [16]. Merkulov P.A. in his work “Legislative regulation of state youth policy in Russia” says that now there are completely new goals and objectives for youth policy in our country [16]. Samokhvalov N.A. notes that young people can become "the main driving force in Russia in the long term" [19].

A number of researchers were engaged in the research of youth policy, such as Ph.D. N. Shapinsky V.M., Doctor of History, prof. Krivoruchenko V.K., Machulskaya I.G., Ph.D. Chuprov V.I., Doctor of History Ruchkin B.A., Volodina E.P., Academician of the Academy of Medical Sciences Doctor of Medical Sciences, prof. Serdyukovskaya G.I., Doctor of Medical Sciences, prof. Sukhareva L.M., Doctor of Philosophy, prof. Ozhegov Yu.P., Ph.D. n. Inozemtseva G.I., and others [9].

Knyazkova E.A. notes that the methodological and regulatory tools and recommendations on the main areas of youth policy were developed in the works of AA Zelenin, I.M. Ilyinsky, V.K. Krivoruchenko, V.A. Lukova, Yu.I. Masterova, V.E. Panshin [4], [5], [9], [10], [17], [18].

In accordance with the goals of implementing the youth policy, the main strategic directions are defined: value strategy, health saving strategy, strategy for developing socio-economic potential, strategy for the formation of a young family, information strategy.

The value strategy is aimed at "... the formation of a moral and civil system of values, taking into account the multinational basis of our state, the value of cultural, historical, national

heritage ...". The educational strategy contains the development of "... innovative educational, educational and educational technologies ..." [2]. The health saving strategy is aimed at "... the formation of healthy lifestyle values, the creation of conditions for the physical development of young people, the formation of an environmental culture, as well as an increase in the level of safety culture for the life of young people ..." [2]. The strategy for the development of socio-economic potential defines "... creating conditions for realizing the potential of young people in the socio-economic sphere ..." [2]. The strategy for the formation of a young family basically contains "... the creation of favorable conditions for young families aimed at increasing the birth rate, the formation of family culture values and the image of a successful young family, comprehensive support for young families ..."[2].

The information strategy is aimed at "... the formation of an information field favorable for the development of youth, the intensification of feedback mechanisms between government agencies, public associations and youth, as well as increasing the efficiency of using the information infrastructure in the interests of patriotic and civic education of youth ..." [2].

In accordance with the strategies, technologies for the implementation of the state youth policy are determined: value, technology for the formation of a young family, technology for health saving, technology for the development of socio-economic potential, information technology. The use of technology in youth policy is necessary to manage political processes with the help of technological procedures, techniques and methods of activity, which makes it possible to find algorithms for solving problems in the field of youth policy, both at the state level and at the regional level. The description of the results of the theoretical and methodological research consists in the implementation of research technologies for the state youth policy. Each technology has its own implementation algorithm. Let us present a brief description of them [6].

Technological aspects of creating and becoming a young family: positive motivation; family forms of education; Information support. So, for large families, support is provided in the field of medicine, education, and employment at the state level. Technology of formation of national and international values: development of projects and programs aimed at the formation of an active position in all spheres of life; popularization of professionals and their copyright systems of professional activity; development of mechanisms to ensure the availability of youth infrastructure [6].

Educational technology basically contains the following aspects: creation of conditions and a system of motivation that contribute to the education and self-education of young people, including persons with disabilities, in the humanitarian, legal, economic, professional areas; training of specialists in organization of work with youth; development of youth self-government in educational organizations [6].

Health saving technology is based on the following provisions: development of motivation for regular physical education, for a healthy lifestyle: implementation of projects in the field of a healthy lifestyle; c improving infrastructure for a healthy lifestyle. Promoting a healthy lifestyle and education in this direction is an important condition for the physical activity of young people [6]. Physical culture and sports have an impact on the moral and aesthetic development of the individual [20].

The technology of development of socio-economic potential is based on the following positions. Creation of conditions for vocational guidance work. Creation of the mentoring institution in organizations. Support for youth programs and projects at the international, Russian, and regional levels. Creation of conditions for self-realization of youth in the socio-economic spheres [6].

The implementation of information technology is represented by the following algorithm. Development of principles of information support for youth. Development of regulatory and legal mechanisms for informing young people. The study of factors and the creation of conditions that affect the increase in the culture of information security. Formation of youth information systems.

Formation of effective mechanisms for informing young people. Information self-realization of youth: participation in competitions, projects, creation of information systems.

The effectiveness of the technology for the formation of a young family can be determined through the following criteria. Quantitative criterion – the number of created families and born families for a certain period of time. In 2019, 7.1 thousand marriages were concluded in the Lipetsk region, or 6.2 marriages per 1,000 inhabitants. Compared to 2018, their number increased by 5%. 30% of men and 25% of women get married at the age of 20-28 [15].

Changing the marriage structure of the population has a certain impact on demographic indicators. In 2021, compared to the previous year, in the Lipetsk region there is an increase in the number of marriages by 18% (from 5692 to 6739) and an increase in the number of divorces by 7% (from 4828 to 5171) (diagram 1) [11].

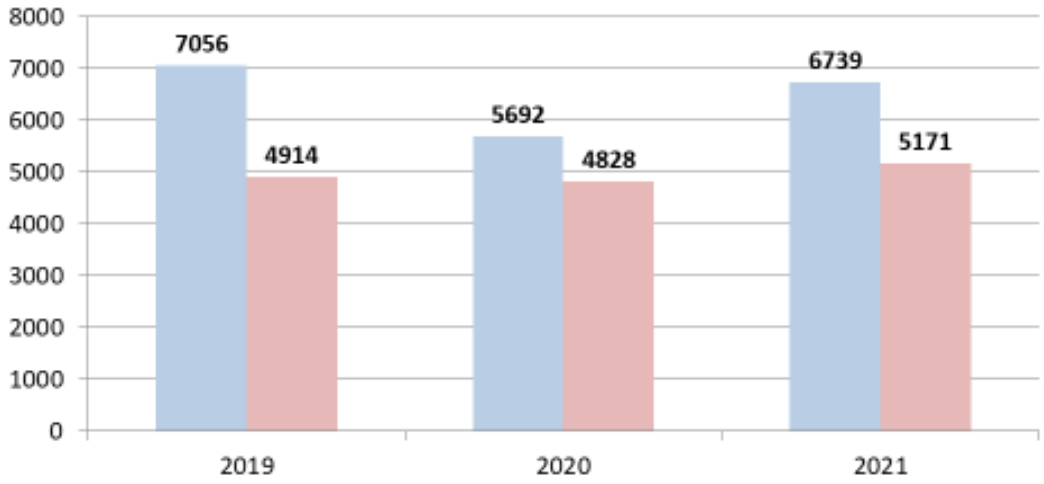

Figure 1. The number of marriages and divorces in the Lipetsk region for 2019-2021 (blue – marriages, pink – divorces)

A qualitative criterion is comprehensive support for creating a young family. Currently, the Lipetsk Region is implementing the subprograms "Mortgage lending", "Own House", "On state support in providing housing for young families" of the state program of the Lipetsk Region "Providing the population of the Lipetsk Region with quality housing, social infrastructure and Sustainable development of rural areas of the Lipetsk Region for 2014 – 2021 and for the period up to 2021" of the state program of the Lipetsk region "Development of agriculture and regulation of agricultural products, raw materials and food markets in the Lipetsk region" [21].

The technology for the formation of national and international values can be determined by its effectiveness through the number of young people involved in the development of society, the number of programs for young people aimed at the formation of national and international values at all levels of educational levels. The formation of value orientations of youth is facilitated by events that are held within the framework of Presidential grants received by young people in areas relevant to the Lipetsk region. Among them: "volunteering", "sports, healthy lifestyle, tourism", "patriotic education", "initiatives of creative youth". In 2019, 354 young people took part in the Presidential Grants Competition. In the first half of 2020 – 154. In the regional competition "Youth Project" in 2019, 82 people took part [3].

Diagram 2 shows the number of personnel who are engaged in research and development (excluding part-time workers and employees under civil law contracts). If in 2015 there were 701 people, then in 2020 – 570 people.

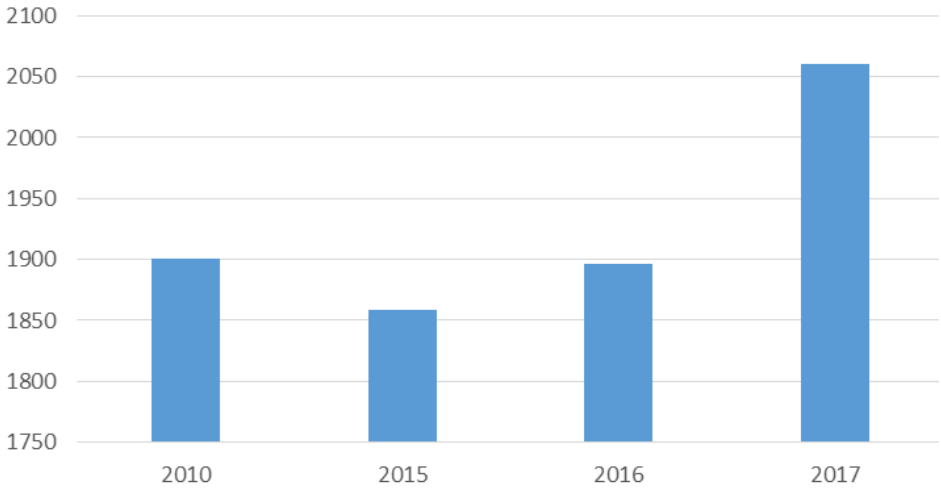

Figure 2. The number of personnel involved in research and development.

Health saving technology is based on the following criteria for evaluating its effectiveness: the availability of projects, infrastructure, the number of young people engaged in regular physical education. In the Lipetsk region, more than 517 thousand people are systematically engaged in physical culture and sports, this is 49.4% (against the planned 47.4%) of the total population (2020 – 45.8%).

In 2021, 407 regional physical culture and sports events were held. There are 3928 sports facilities in the Lipetsk region. The level of provision of the population with sports facilities based on the one-time throughput of sports facilities amounted to 78.7% (in 2020 – 76.2%).

As part of the implementation of the federal project "Creation for all categories and groups of the population of conditions for practicing physical culture and sports, mass sports, including increasing the level of provision of the population with sports facilities, and preparing a sports reserve" ("Sport is the norm of life") with the involvement of funds of the federal budget, TRP grounds (small sports uniforms) were created in Dolgorukovsky and Volovsky districts, an open-type sports and recreation complex in the city of Lipetsk (district MAOU secondary school No. 48). The construction of a sports and recreation complex was completed in the area of MBOU secondary school No. 14, Lipetsk (put into operation on 23.08.2021).

In the Lipetsk region, more than 19 thousand people are engaged in adaptive physical culture and sports, which is 27.9% of the total number of people with disabilities who do not have contraindications for physical education and sports (25.8% in 2020). In 2021, 15 regional sports events and 3 sports events for the disabled were held.

As part of the implementation of the "Accessible Environment" subprogram of the state program "Social Support for Citizens, Implementation of the Family and Demographic Policy of the Lipetsk Region", for 2021, sports and recreational activities for the disabled (swimming) were held, coverage – 40 people.

Piskunova Anna, Borisov Evgeny, Terekhov Evgeny (sports of persons with POD, rowing) took part in the 2020 Summer Paralympic Games in Tokyo. Athletes competed in the same crew and took 7th place in the discipline [14].

Diagram 3 shows the figures for financing the physical culture and sports industry in the Lipetsk region.

Figure 3. Financing of the branch of physical culture and sports in the Lipetsk region. Red – local budgets, million rubles, Orange – regional budget, million rubles, Green – federal budget, million rubles. (Over the past 12 years, about 16.8 billion rubles have been financed, including: from the federal budget, 928 million rubles, from the regional budget 7,593 million rubles, from local budgets 8,604 million rubles)

Subsidies are annually provided to local budgets for the implementation of municipal programs aimed at providing conditions for the development of physical culture and mass sports in the territory of municipal districts and urban districts. 5.4 million rubles were allocated for the implementation of this event in 2019. The funds of the regional budget for the purpose of their effective use are provided to municipalities on the terms of co-financing [21].

The effectiveness of the implementation of the technology for the development of socio-economic potential is based on the following criteria: the number of young people receiving a profession, the presence of a mentoring institution in organizations; availability of youth programs and projects at the international, Russian, regional levels.

More than 2,300 residents of Lipipa will be able to undergo free retraining for new professions or advanced training within the framework of the federal project “Employment Promotion” of the national project “Demography. Now 30% of this number is directed to study. More than 700 residents of the Lipetsk region have already completed vocational training or received additional education. Programs related to the skills of accounting, programming, working with data, and management were in great demand.

Vocational training or retraining can be completed in more than 300 areas: from a welder to an IT specialist. Courses for people without education are available for a range of competencies. The training is provided by federal operators of the Employment Assistance project. These are RANEPA, Tomsk State University and the Agency for the Development of Professional Skills (WorldSkills Russia). Unemployed citizens, citizens over 50 years of age, citizens of pre-retirement age, women on parental leave up to three years old, as well as unemployed women with children of preschool age, certain categories of citizens under the age of 35 can become participants in the free vocational training and retraining program. years; workers at risk of layoffs.

The Lipetsk region also leads in the number of applications for training from citizens 50+ and pre-retirees submitted to the RANEPA for free retraining programs for new professions. In the top 3, the region bypassed the Samara region and St. Petersburg, calculated at the university [12].

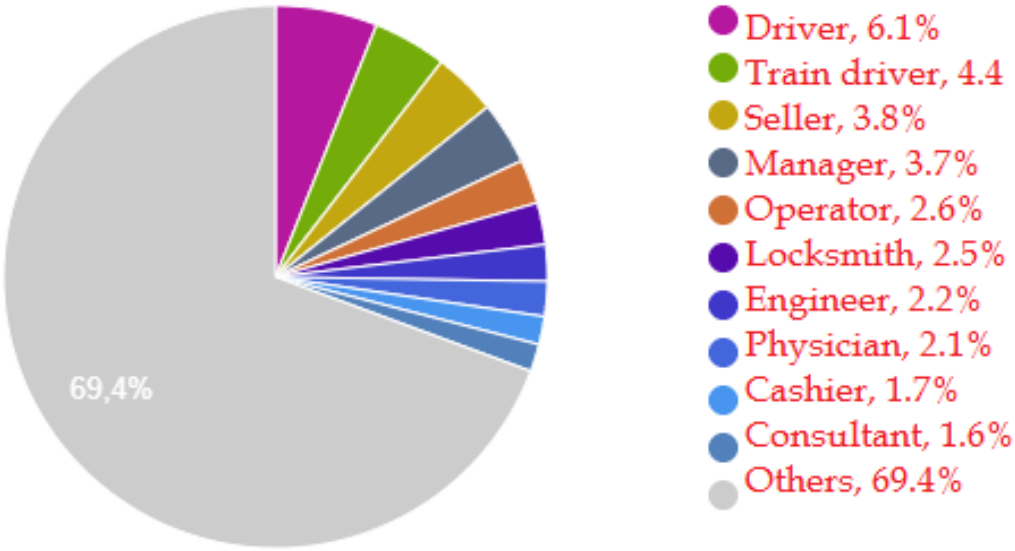

Figure 4. Top 10 professions in demand in the Lipetsk region (January 2022 – July 2022)

In the Lipetsk region, a driver, a machinist, a salesman – are most often required. The most demanded areas of work are working personnel, transport, logistics, and sales.

The implementation of information technology is represented by the following algorithm: information infrastructure, the level of awareness of young people, the existence of regulatory and legal mechanisms for informing young people. Diagram 5 presents the Key indicators of the use of information and communication technologies in organizations in the Lipetsk region. If in 2019 2103 organizations had fixed (wired and wireless) Internet, then in 2020 – 2062, the number of organizations with personal computers in 2019 and 2020 is the same – 2142 organizations.

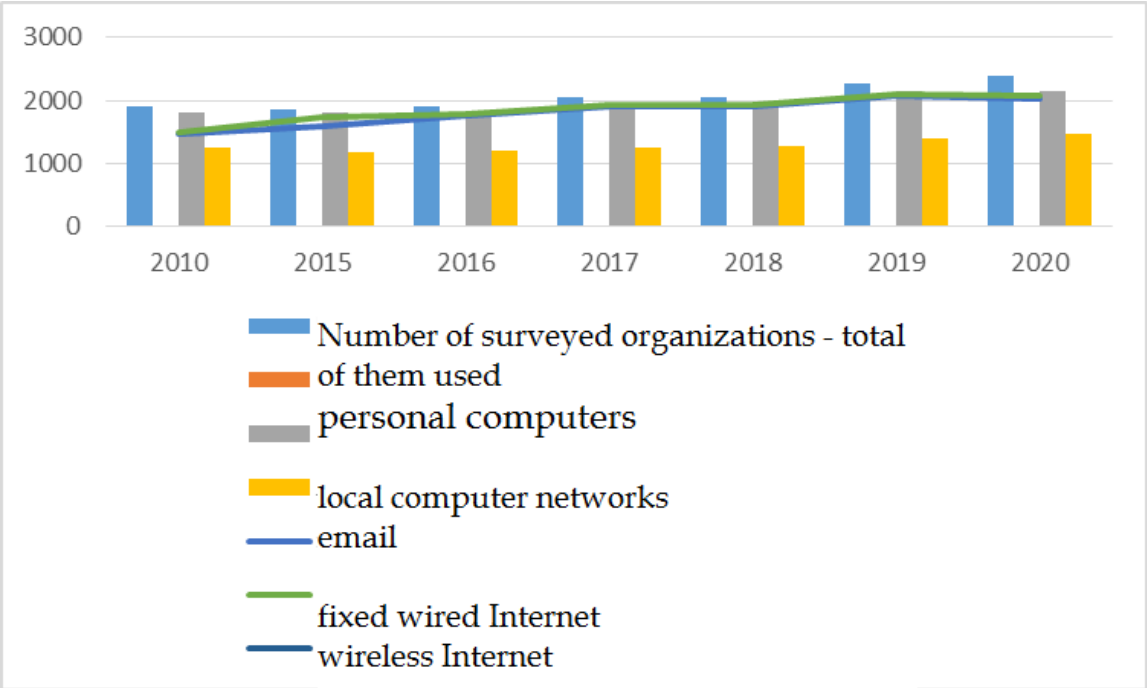

Figure 5. Main indicators of the use of information and communication technologies in organizations (excluding small businesses; units)

The territory for the introduction of new technologies of mobile radiotelephone communication is expanding, providing the possibility of broadband access to the Internet (3G and 4G). In

2020, more than 120 standard cellular communication base stations were put into operation, providing high-speed access to the Internet. The number of cellular subscriber devices per 100 people in the region, according to the Russian Ministry of Communications, is 198.4 devices. In accordance with the Decree of the President of the Russian Federation dated July 21, 2020 No. 474 "On the national development goals of the Russian Federation for the period up to 2030", by 2030 it is necessary for 97 percent of households to provide broadband access to the Internet [13].

Each of the technologies has its own specific criteria for the effectiveness of their implementation. A comprehensive study makes it possible to determine the overall effectiveness of youth policy.

So the purpose of the study of information technology is to identify the level of knowledge among young people about the information support of youth policy. Objective: to identify the level of knowledge about obtaining knowledge from information sources, its role in educating young people, what Internet opportunities are usually used, identifying knowledge about information and documentation centers for young people, how information and communication technologies are used to implement professional tasks. 570 respondents participated. At the age of 17 to 35 years. Diagram 1 shows the assessment of young people's knowledge of the information support of youth policy.

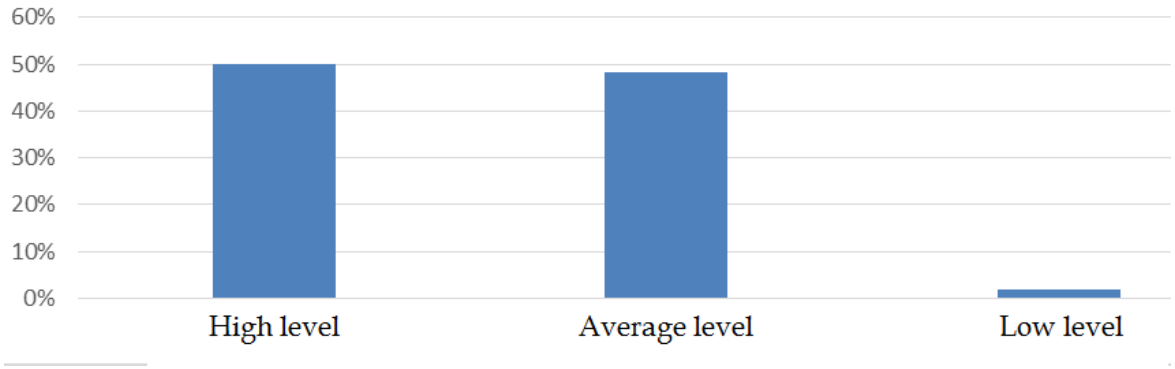

Figure 6. Evaluation of youth knowledge on information support youth policy

Therefore, we can conclude that half of the respondents are aware of the information support of youth policy at a high level, while others – 48.2% – are informed at an average level and only 1.8% – at a low level.

As the survey showed, the majority of young people are well informed in the field of state youth policy. Most people don't know how information support is developed. If you need to get information or solve a problem, they will turn to the Internet. Most respondents are aware of the existence of various programs in the field of state youth policy. A large percentage of young people use the Internet every day. Many people use the following features of the Internet: searching for help information, searching, listening, downloading music, watching, downloading movies, for communication (chat, Skype, social networks, ICQ , forums), online games, ordering and buying goods through the Internet store, etc. / d and air tickets, travel packages, other – search for information, for creativity. Most people download books from the Internet. Most young people have not heard about the Federal Center for Information and Documentation at the Institute of Youth.

The majority of young people believe that the information and documentation centers of the constituent entities of the Russian Federation for young people are collecting information. Also, the majority believe that there are city and regional information centers, information centers of higher and secondary specialized educational institutions, schools, enterprises and organizations in the city of Lipetsk. The youth noted that the main task of the information centers of the third level is to work with consumers.

Currently, youth is considered as a full-fledged subject of youth policy, the main partner of authorities at all levels, therefore, modern youth policy is focused on maximizing the inclusion of young people in social practice, on creating conditions and opportunities for the youth community to independently solve their own problems and the full participation of young people in life of society.

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ВЛИЯНИЕ КОНСТИТУЦИОННОЙ РЕФОРМЫ НА ВНУТРИПОЛИТИЧЕСКИЕ ПРОЦЕССЫ В ГРУЗИИ В НАЧАЛЕ XXI ВЕКА

THE IMPACT OF THE CONSTITUTIONAL REFORM ON THE INTERNAL POLITICAL PROCESSES IN GEORGIA AT THE BEGINNING OF THE XXI CENTURY

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Аннотация

В статье анализируются события, сопровождаемые конституционной реформой, проведенной в республике в 2009-2010 гг. Подчеркивается, что она основательно видоизменила структуру государственной власти, отрегулировала взаимоотношения между законодательной и исполнительной властью. В то же время, соблюдение баланса между этими двумя ветвями власти не представлялось возможным без наличия сильной и независимой судебной системы. Исходя из этого, в новой редакции конституции были учтены рекомендации по реформированию судебной системы, поступающие от Венецианской комиссии. Исходя из опубликованных в 2014 г. материалов по выполнению государственной программы реформирования политической системы в Грузии следовало, что после внесения изменений в конституцию Высший совет юстиции республики приобрел гораздо более транспарантный и демократический вид. В целом, в рамках евро-грузинской ассоциации проблемам реформирования судебной системы в Грузии уделялось особое внимание.

В ходе проведения судебных реформ следовало решить важные задачи, связанные с справедливым судебным разбирательством, проведением независимых следственных мероприятий и т.д. Созданная независимая судебная системы должна была стать индикатором функционирования в республике демократических институтов. Была разработана также концепция военной реформы, которая предусматривала создание института военной службы и принятие регуляторов, способствующих ее освобождению от политического влияния. Наконец, в 2014 г. по представлению правительства парламентом был принят законопроект о ликвидации всех форм дискриминации. В заключении в работе сделан вывод, что конституционная реформа сыграла важную роль, способствуя реформированию политической системы, дальнейшей интеграции республики в европейские структуры.

Ключевые слова: Грузия, Европейский союз, конституционная реформа, реформирование политической системы, евро-грузинское ассоциированное соглашение, интеграционные процессы

Abstract. *The article analyzes the internal political processes in Georgia, accompanied by* the *constitutional reform carried out in the republic in 2009-2010. It is emphasized that she thoroughly modified the structure of state power, regulated the relationship between the legislative and executive authorities. At the same time, maintaining a balance between these two branches of government was not possible without a strong and independent judicial system. Based on this, the new version of the Constitution took into account the recommendations on the reform of the judicial system received from the Venice Commission. Based on the materials published in 2014 on the implementation of the state program for reforming the political system in Georgia, it followed that after the amendments to the Constitution, the Supreme*

Council of Justice of the Republic acquired a much more transparent and democratic appearance. In general, within the framework of the Euro-Georgian Association, special attention was paid to the problems of reforming the judicial system in Georgia. In the course of judicial reforms, it was necessary to solve important tasks related to a fair trial, conducting independent investigative measures, etc. The established independent judicial system was supposed to be an indicator of the functioning of democratic institutions in the republic. The concept of military reform was also developed, which provided for the creation of the institution of military service and the adoption of regulators that would facilitate its liberation from political influence. Finally, in 2014, on the proposal of the Government, the Parliament adopted a bill on the elimination of all forms of discrimination. In conclusion, the paper concludes that the constitutional reform played an important role, contributing to the reform of the political system, further integration of the republic into European structures.

Keywords: Georgia, European Union, constitutional reform, political system reform, Euro-Georgian Association agreement, integration processes.

Introduction. Within the framework of the European Neighborhood Policy (ENP) approved by the European Union (EU) in 2004, Georgia was given a priority place in plans for developing cooperation with the countries of the South Caucasus. The associated agreement between the EU and Georgia, concluded in 2014, was considered by the parties as a specific plan of action towards reforming the political, economic and social life of the republic. Its successful implementation was supposed to make the process of its Europeanization irreversible, which, in principle, is consistent with the US strategic plans for Georgia [6, p.178]. The article analyzes the institutional changes in Georgia in the context of the priorities outlined in the agenda of the Euro-Georgian Association; reforms on decentralization of power structures are traced, the role of constitutional reform in the democratic transformation of institutions in Georgia is revealed. The theoretical basis of the work is the presentation of the essence and specifics of the constitutional reform in Georgia in 2009-2010, the identification of problems that arose during its implementation, and the EU's cooperation with Georgia in reforming its political system.

Materials and methods of research. The empirical basis of the work was political and legal documents reflecting the internal political strategy of the legislative, executive and judicial authorities of Georgia: Opinion of the European Commission on the Constitution of Georgia; Constitution of Georgia (1995); Constitutional Law of Georgia "On Amendments and Additions to the Constitution of Georgia" (2010), etc.

In the course of covering a complex of problems related to the reform of the political system in Georgia, the authors adhered to the principle of objectivity. The study involved methods of institutional and comparative analysis; in addition, a systematic method was used, which made it possible to conduct a comprehensive analysis of the reform of the political system in Georgia.

Research results. The constitutional reform carried out in Georgia in 2009-2010 fundamentally changed the structure of state power in the republic, the relationship between the legislative and executive powers. In expert circles, the new version of the constitution, adopted in February 2004, has often been criticized, believing that it overestimates the power of the president and at the same time weakens the power of parliament – in other words, it contributes to the creation of a "super-presidential" state administration [1]. Operating in 2004-2012. the system of state power largely confirmed this assessment: indeed, the executive power consolidated around the figure of the president played a leading role in governing the country, determined its foreign policy, oriented towards the West, towards rapprochement with the United States and its NATO allies. At the same time, the role of parliament, the judiciary and local self-government in the system of power was relegated to the background: in fact, they were forced to follow the political course of the president on all major issues.

In 2009, a state commission was established in Georgia to develop and amend the current constitution of the country, aimed at creating a balanced system of state power and administration.

Representatives of the parliamentary and extra-parliamentary opposition, experts, public activists took part in its work. The fact of the creation of the constitutional commission testified that there are significant shortcomings in the constitution of the republic, and the development of its new model should be carried out in conditions of broad consultations.

The package of constitutional amendments presented in November 2010 reflected the position that in order to develop democratic processes in Georgia, the system of state power should be modernized by strengthening the powers of parliament and weakening the power of the president. The mood of the majority of the citizens of the republic in favor of strengthening the power of the parliament directly reflected the constitutional trends in international practice. In the political circles of Europe, these changes were positively assessed: for example, in the opinion of the European Commission for Democracy through Law (Venice Commission) on October 15, 2010, it was emphasized that the proposed changes in the constitution of Georgia provide for several important positive improvements [3].

In accordance with the new institutional changes, the relationship between the powers of the president and parliament has changed radically: presidential power has been noticeably reduced, and the prime minister began to lead the government, having independent powers.

Challenges arising from the irresponsible domestic and foreign policy of the Saakashvili regime [2, p. 80-81], as well as increased criticism from international organizations, necessitated a constitutional reform, which resulted in the adoption on October 15, 2010 of a new version of the Georgian constitution. At the same time, the authors of the reform took into account the problems that existed during the period when the previous constitution was in force. In the draft constitutional reform, it was recorded that the measures taken to reform the constitution aim to create a balanced, efficient state system, within which any arbitrariness on the part of the highest authorities is excluded [8].

One of the grounds for the constitutional reform in Georgia was the revision of the constitutional and legal status of the president. In the course of it, sharp discussions flared up concerning the problem of constitutionally fixing the status of the presidential institution in the highest state authorities. Given this circumstance, the main goal of the reform was to rethink the constitutional status and functions of the president in the system of state power: in particular, it was necessary to reduce his powers and redistribute them in favor of other branches of state power [8].

In accordance with the new version of the constitution, the president continued to be the head of state and supreme commander of the armed forces. At the same time, when reading the text of the new edition, it was evident that its authors sought to bring the functions and powers of the president into line with his status enshrined in the constitution.

First of all, this concerned the changes made to Art. 69 of the constitution: in accordance with them, the president distanced himself from the executive branch, concentrating his main efforts on directing the foreign policy of Georgia [4, art. 69]. In accordance with the amendments and additions made to the constitution, the president is the head of state, the guarantor of its unity and independence; he acted as an arbitrator, ensuring the functioning of state bodies within the powers granted by the constitution [5].

In the course of determining the role of the institution of the president in the system of state power and concretizing his powers, the constitutional commission considered that, if necessary (following from the status of the head of state), the president could resort to influencing other branches of power, but he was not authorized to exercise their functions . The new rationale for the constitutional status of the president's functions has narrowed his competence in the system of state power. In this regard, it seems necessary to compare presidential powers in the main areas of state activity, reflected in the previous text of the constitution and modified in its new edition. When introducing constitutional changes to the text, the members of the state commission believed that the president should not be endowed with direct legislative powers. He no longer had the right, on his own initiative and agenda, to convene an extraordinary session of Parliament. In this situation, one of the mechanisms of influence of the head of state on the parliament was the right

to refuse to promulgate the bill, return it with his comments for revision to the parliament, or use the right of veto in the issue of its adoption. Also, the discretionary right of the president to address the citizens of the country and the parliament could be considered a mechanism for influencing the parliament.

As a result of constitutional changes, the leading role of the president in the implementation of the country's foreign policy has also noticeably weakened. First of all, this was expressed in the fact that the president could negotiate with other states or international organizations only after his actions were coordinated with the government. A similar procedure was required for the President to conclude international agreements and treaties.

One of the goals of the constitutional reform was to create a legislative framework to strengthen the role of parliament. In accordance with the constitution adopted on August 24, 1995, the parliament was assigned the status of the highest representative body, endowed with the function of legislative power, determining the main directions of domestic and foreign policy, exercising control over the activities of the government. In the text, these provisions were retained, although the political and legal conditions for maintaining the high status of the parliament and for the implementation of its legislative functions have changed [4, art. 48].

The president was no longer entitled to monopolize the legislative initiative of the parliament, he did not have the imperative rights to demand an extraordinary consideration of his bills by the parliament, the right to convene an extraordinary session or meeting of the parliament. The veto power of the head of state was significantly weakened. In turn, the right of the parliament to remove the president from office by means of impeachment, as well as dismiss other persons holding high positions in the system of state power, has become more effective and efficient. This procedure has become much more efficient, since, in accordance with the new version, the decision on impeachment was made by the constitutional court, while the supreme court had to establish signs of existing offenses.

In accordance with constitutional changes, the government began to be formed from factions that make up the majority in parliament; active participation of the president in this process was allowed only in the absence of a parliamentary majority [4, art. 80]. The number of deputies who took the initiative to create a temporary commission to solve the problem of forming a government was reduced from 1/4 to 1/5 [4, art. 56, item 2]. In the new version of the constitution, a fundamental reform of the status of the government took place: the principles of its formation, competence and responsibility have changed; in connection with a significant strengthening of the status of the government, the president was forced to distance himself from the executive branch [4, art. 78, item 1].

Within the framework of the constitutional reform, the leading functions of the parliament were fixed in determining the main directions of the country's domestic and foreign policy. In accordance with them, parliamentary control over the work of the government was carried out. Parliament had many mechanisms at its disposal to act as a flagship in carrying out reforms aimed at Georgia's European integration. An important means of parliamentary control over the executive power was the procedure for passing a vote of no confidence in the government [4, art. 80, item 4].

The government was a collegial body of executive power, formed on the basis of the confidence expressed by the parliament - the only source of legitimization of the government. It logically followed from this that the parliament was empowered to control possible future changes in the composition of the government. Parliament was entitled to express no confidence in the government. This procedure could be launched with the consent of at least 2/5 of the members of parliament. If, after a vote of no confidence, the government was renewed by 1/3, it again had to gain the confidence of the parliament [4, art. 81, item 1].

A separate chapter in the new edition of the constitution was devoted to the status of local governments. Their powers differed from those vested in the highest authorities. Local self-government had its own powers delegated to it. The basic principles for determining the powers of local self-government bodies were established by an organic law [4, art. 101, p. 1.]: in particular,

the local self-government body (sakrebulo) was elected by citizens on the territory of a self-governing unit in the course of direct, universal and equal elections, by secret ballot [4, art. 101, p. 2].

Maintaining a balance between the legislative and executive powers was not possible without the functioning of a strong and independent judiciary. Based on this, the new edition of the Basic Law took into account the recommendations coming from the Venice Commission in the course of the constitutional reform. The independent status of the judiciary was spelled out in detail in Chapter 5 of the text of the Constitution. In particular, it provided for an increase in the age limit for judges who supervised the work of courts of general jurisdiction; appointment of judges to office for an indefinite period, after they have passed a "probationary" period; increasing the total number of votes in parliament to elect members of the constitutional court; transformation of the Council of Justice into a constitutional body; the growth of the powers of the constitutional court.

In 2014, the results of the implementation of the state program on the constitutional and legal reform of the political system in Georgia were published. It followed from them that the first stage of reforms was generally successfully completed by May 2013. After the introduction of constitutional amendments to the legislation approved by the Venice Commission, the High Council of Justice acquired a much more transparent and democratic appearance. The participation of judges in the election of members of the High Council of Justice has expanded; it was pointed out that instead of various politicians, representatives of public and academic circles should be involved as non-judicial members of the supreme council [9, p . 119-120].

On May 21, 2013, the Georgian parliament adopted the first package of amendments to the legislation on the activities of general courts. They significantly improved many provisions of the legislation in the activities of the courts of general jurisdiction, in terms of the administration of all judicial procedures. The mass media were given the right to attend court hearings, which was previously prohibited by the current legislation. This approach aimed to strengthen the justice system while emphasizing the principle of transparency.

In 2014, the second stage of reforming the justice system was completed. In the course of it, in accordance with constitutional changes, it was decided to appoint the heads of courts of general jurisdiction for an indefinite period, but before that a 3-year "probationary" period was determined for judges. In the same year, Parliament adopted a package of amendments to the organic law developed by the Ministry of Justice. They contained objective criteria and principles for evaluating the professional activities of judges, who were given a "probationary" period. Evaluation of the work of judges was carried out by 6 different members of the High Council of Justice by applying two main criteria – honesty and competence. The last word remained with the High Council of Justice, which, consisting of at least 2/3 of the members, documented the appointment of judges indefinitely, or refused to do so for some of them. During 2014, a package of changes was developed during the third phase of the reform of the justice system, which was then submitted to the Venice Commission for the preparation of an opinion on the reform of the political system in Georgia.

In the course of judicial reforms, such important tasks as a fair trial, the right to defend the accused should be solved; conducting independent investigations. For the purpose of professional training of judges, as early as 1999, a training center was opened at the Ministry of Justice. Subsequently, this training center was singled out as a separate structure, and on December 28, 2005, the Law "On the Higher School of Justice of Georgia" was adopted, which fixed the structure of the educational institution, admission to training courses for judges and issuance of relevant qualification documents to them [10].

One of the priorities in the work of the government was also designated a policy aimed at protecting human rights. In 2014, the Georgian Parliament adopted the "National Strategy for the Protection of Human Rights", based on the sources of constitutional and international law. The

document stated that a prerequisite in the process of protecting human rights is a high level of efficiency in the functioning of state institutions [11].

In order to strengthen the coordination and efficiency of activities in various sectors, the government approved an action plan in this area for the next two years [12]. It presented a long-term vision for solving problems in the field of human rights protection, identified priorities in this direction by strengthening the rule of law, creating democratic institutions, ensuring gender equality, which, among other things, was also necessary for a positive political image of the state in the conditions of formation and development of the global information space [7].

Conclusions.

Thus, the constitutional reform carried out at the beginning of the 21st century in Georgia contributed to the reform of the political system, the spread of European norms and values in the republic. After the amendments were made to the constitution, the political institutions of the republic acquired a much more transparent and democratic appearance.

The European Union played an important role in the constitutional reform in Georgia, which paved the way for the country's further integration into European structures.

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РОЛЬ МОЛОДЁЖНОЙ ПОЛИТИКИ В ПОЛИТИЧЕСКОМ ПРОЦЕССЕ ГОСУДАРСТВ И ОБЕСПЕЧЕНИЕ СТАБИЛЬНОСТИ

THE ROLE OF YOUTH POLICY IN THE POLITICAL PROCESS OF STATES AND ENSURING STABILITY

Аннотация

Молодёжь – значимая поколенческая группа, которая при достаточных ресурсах может принести большую пользу государству и обществу, а они, в свою очередь, несут ответственность за обеспечение надлежащих стартовых условий для развития молодежи, и вместе с тем - будущего человеческого потенциала. Поэтому актуально изучение текущих государственных мер, сравнительный анализ решений разных стран, а также анализ проблематики со стороны молодёжи. Всё это позволит вести эффективную работу сейчас и формировать направления будущих исследований. Описанные методы работы послужили для основной цели статьи – изучения взаимосвязи молодёжной политики и стабильности государства. Результаты теоретического анализа показывают, что для всех стран проведение комплексной молодёжной политики или уже является одной из приоритетных задач, или стремительно набирает обороты развития. Основными целями государств является обеспечение доступного образования и трудоустройства выпускников, работа по популяризации здорового образа жизни, внедрение политических организаций как способа для молодёжи проявлять активность в социальных вопросах. Опросы молодёжи до 18 лет показывают, что проблемы курения и употребления наркотиков, алкоголя – весьма серьёзный пласт для работы. Для молодёжи 18-35 лет ведущими проблемами становятся коммерциализация образования, безработица и низкий уровень жизни. Перспективными являются направления работы по анализу реальных угроз и формированию молодёжной политики на основе полученных данных. Также на фоне глобализации может стать важным элементом анализ успешных зарубежных технологий в области молодёжной политики.

Ключевые слова: молодёжная политика; современное общество; развитие общества; государственная поддержка; экономика.

Abstract*. Youth is a significant generational group, which, with sufficient resources, can bring great benefits to the state and society, and they, in turn, are responsible for providing proper starting conditions for the development of youth, and at the same time – the future of human potential. Therefore, it is important to study the current state measures, a comparative analysis of the decisions of different countries, as well as an analysis of the problems on the part of the youth. All this will allow us to conduct effective work now and form directions for future research. The described methods of work served for the main purpose of the article – to study the relationship between youth policy and the stability of the state. The results of the theoretical analysis show that for all countries the implementation of a comprehensive youth policy is either already one of the priority tasks, or is rapidly gaining momentum in development. The main goals of the states are to provide affordable education and employment of graduates, work to promote a healthy lifestyle, the introduction of political organizations as a way for young people to be active in social issues. Surveys of young people under 18 show that the problems of smoking and the use of drugs and alcohol are a very serious layer for work. For young people aged 18-35, the leading problems are the commercialization of education, unemployment and low living standards. Promising are the areas of work on the analysis of real threats and the formation of youth policy based on the data obtained. Also, against the backdrop of globalization, the analysis of successful foreign technologies in the field of youth policy can become an important element.*

Keywords: *youth policy; modern society; development of society; governmental support; economy.*

Introduction

Political stability is a prerequisite for the development of the country and society, and can be achieved in two ways: dictatorship or the broad development of democracy. Stability, which was achieved through violent and repressive means, does not involve the participation of the masses of the people and is therefore historically short-lived and illusory. Stability, which is based

on democracy, a broad social base and a well-formed civil society, is eternal. Stability determines the attitude of the population to the current political power, the ability of the political regime to take into account the interests of various groups and ensure their coordination.

In modern conditions, young people are one of the most economically and socially and legally vulnerable groups in society, whose well-being does not meet minimum standards. They live in conditions of increased social stress and psychological discomfort. However, only healthy, well-educated, moral, economically secure and prosperous young citizens can bring the greatest benefit to the state and society, and in turn it is they who are responsible for ensuring proper starting conditions for young people, their future development, and at the same time the implementation of future human potential. For this reason, there is an urgent need for analysis and coverage of research in this area. One of the instruments that can help achieve this goal is youth policy. Youth policy contributes to the state's efforts to ensure that young people enjoy the rights that the law recognizes for them as full citizens who contribute to progress and drive development. Policy effectiveness is linked to the ability to develop comprehensive solutions to youth problems in cooperation with young people themselves. At the same time, it should be remembered that when we talk about youth policy, we are talking about mechanisms that can already be created to a large extent by young people. For this reason, the integrative aspect of youth policy is especially important, associated with a model of cooperation, dialogue and partnership, a key element of which is the inclusion of young people in decision-making processes.

Thus, the purpose of this article is to study youth policy as a factor in the stability and development of the state and society.

Results and discussion

Youth representatives are the driving force of progress, a key factor in the development of society, they pass on social experience, spiritual and material values from generation to generation, and therefore the issue of socialization of the young generation is of paramount importance [8]. The socialization of youth, carried out in the course of the implementation of youth policy measures, is a significant process of personality formation, realizing its capabilities for effective and fruitful interaction between itself and society, the state, and social institutions [11]. For the successful realization of the individual for the benefit of society and the state, it is important to provide children and youth with decent conditions for growth and development. Of the estimated 1.9 billion children (0-18 years old) in developing countries, 1 billion live in poverty. Most of these young people live in developing countries. The demographic picture in industrialized countries is somewhat different, but there is also an increase in youth poverty. It is expected that the share of young people in the population of Europe (15-24 years old) will decrease from 12.6% to 9.7% between 2005 and 2050 [10].

Young people manifest themselves as a generational social group with many specific features, such as susceptibility to innovation, avant-garde, ideals of cultural life. On the one hand, young people are focused on empowerment (participation), on the other hand, they expect institutional and social paternalism [4].

Each state understands the importance of youth policy in a different way, taking actions due to the possibilities and plans. Youth policy is implemented in European countries in very different ways, depending on their institutional features.

Government assistance for unemployed young people who have left the education system (also known as "NEETS " – " Not in employment , education or Training ") emerged in France after the economic crisis as a new challenge for government action as part of a broader effort to combat inequality [1]. In many European countries, youth unemployment is twice as high as unemployment among the entire population of a given country. An extremely negative phenomenon for the economy is the problem of NEETs . This is one of the symptoms of progressive social exclusion among young people. It is believed that young people who realize their advantages and opportunities, accept new challenges and actively participate in social, economic and political life can become a way out of this situation [4]. There is a negative correlation between the phenome-

non of NEETs and the extent of public participation among the members of this group [4]. Reducing inequality in the medium term is seen by providing young people with more affordable public (non-commercial) education, which corresponds to "stimulating" citizenship. However, such a paradigm shift can only be achieved at a significant cost to the state budget and the risk of not being used by the most vulnerable young people who require special provisions, which is a significant obstacle [1]. Thus, in Australia, those who have not received at least a 12th year of education (general secondary) qualification or its equivalent or secondary vocational education are most often unemployed or underemployed [5].

Africa has the youngest population in the world with over 400 million young people between the ages of 15 and 35. Here, young people are demanding more investment in economic and social development factors in order to boost the African Development Index. Several continental-level youth development strategies and programs have been developed to ensure that the continent benefits from its demographic dividend. Such strategies include the African Youth Charter, the Decade of Youth Action Plan and the Malabo Youth Empowerment Decision, all of which are being implemented through various programs leading up to 2063. The African Youth Charter aims to protect young people from discrimination and guarantees them freedom of movement, speech, association, religion, property and other human rights, and is committed to promoting their participation in society. The Action Plan for the Decade of Youth is based on five main priority areas, namely: education and skills development; youth employment and entrepreneurship ; security; youth health and sexual and reproductive health rights; agriculture, climate change and the environment. The Continental Strategy provides a comprehensive framework for designing and developing national policies and strategies to address the challenges of technical and vocational education and training in order to promote economic development and create greater national wealth, and contribute to poverty reduction by encouraging young entrepreneurs and innovation and creating workers. places [3]. The national youth policy of the Republic of Madagascar is to protect young people from any form of exploitation and alienation, from any factors of social deviation and from any activity that may jeopardize their self-realization and all-round development as a person; involvement of young people in public events to raise awareness in the fight against HIV / AIDS, endemic diseases, the fight against drugs, corruption and poverty [2].

So, in Russia, youth policy is revealed in the following areas: support for entrepreneurial initiatives and activities, promotion of living standards, housing, education, cultural development, health, physical development, guarantees of legal protection of youth and the activities of youth organizations. As the state correctly believes, all spheres do not exist in isolation, but are interconnected and interdependent. It is impossible to form a complete picture of the effectiveness of youth policy if one of the presented criteria is ignored [8,9].

Many studies and discussions show that it is important to focus on reversing the trend in youth unemployment and encouraging young people to take advantage of the opportunities available. The campaign should actively involve national and regional authorities, business and the private sector. Given the global nature of these challenges for the EU, it is necessary to strive for dialogue, exchange and cooperation with EU partners abroad. The success of this initiative depends on the support of European institutions and the active participation of all stakeholders [1,4]. In a rapidly changing world, as recent decades have shown, countries that are able to effectively mobilize and productively use human capital and the potential for innovative development, the main carriers of which are young people, have significant strategic opportunities [15].

Today, the problems of youth and the issue of training qualified personnel to work with them deserve special attention [6]. Internationalization requires not only the exchange of goods and capital, but also knowledge, students and teachers between universities and countries. The provision of educational institutions with qualified teaching staff is important for achieving a high level of student performance. It is important to introduce innovative technologies and develop communications to reduce the gap in the quality of education between rural and urban educational institutions. Teachers should apply personality-oriented, systematic, competence -based approach-

es in their activities, as well as carefully study child psychology, not forgetting their own continuous education and increasing research culture. The role of the state in this aspect includes the motivation of teachers, the provision of material and technical base and control over the process.

An important criterion should be the issue of the spiritual and physical health of young people. As key indicators, one should recognize the level of morbidity among young people (with the exception of congenital diseases and accidents), the number of suicide attempts and suicides among young people, and the level of deviant behavior [6]. As mentioned earlier, young people are one of the most vulnerable groups in society in the economic and socio-legal aspects, and live in conditions of increased social stress and psychological discomfort.

Another criterion for evaluating the effectiveness of youth policy implementation is the general level of youth social activity. A high level of social activity is inherent in young people who regularly participate in socially significant events and are their initiators [6]. There is a clear relationship between the level of development of social activity of young people, socialization, life satisfaction, spiritual and physical health, and crime among young people [7]. The rapid pace of development and change in modern society puts at the forefront the development and implementation of approaches focused on the direct involvement of young people in solving national problems. This aspect of youth policy will become a tool for the development and transformation of the country, allowing you to reach a new, qualitative level of development [16].

In Kazakhstan, youth policy is aimed at spiritual and moral education and informing young people about the development potential. But this approach focuses only on the most active and capable part of the youth. In fact, disadvantaged and less active youth remain on the sidelines, joining the ranks of marginal elements [10]. A significant part of the active young population of the state is socialized within the framework of informal leisure, political and extremist movements [13]. Research shows that the youth were the leading force in the civil unrest taking place around the world, in the "color revolutions" and in the "Arab Spring". Criminal forces use youth, which is not fully developed, as a tool to achieve their goal. In turn, this, of course, negatively affects the social, economic, demographic development of any country [11]. This use of the younger generation is due to the fact that some of the youth develop a specific distinctive feature - extremeness , which is manifested by an over-acute perception of reality, often inadequate. A maximalist, overly categorical attitude towards socially accepted values, a nihilistic attitude, gives rise to a state of social instability. Such young people do not have clear ideals and life guidelines, and are also easily suggestible and excitable [12]. The involvement of socio-political organizations in helping young people helps to reduce the activity of their natural radicalism. Socio-political associations should stimulate the development of civic culture and civic consciousness of young people. The personal participation of young people in public policy is necessary for the future of the country and for their own self-realization [17]. Many youth organizations and associations do not have the resources to carry out full-scale organizational activities. Therefore, the priority task of youth policy is to address issues of supporting the activities of public associations [13].

Among the main significant problems voiced by young people (Fig. 1) are for the younger group (under 18 years of age): smoking, alcohol consumption, drug use. For the group of young people aged 18-35, unemployment, an excess of free time against the backdrop of a lack of work, and a low standard of living become more significant problems. The use of alcohol and narcotic substances, although lowering their positions, also worries the people of this group.

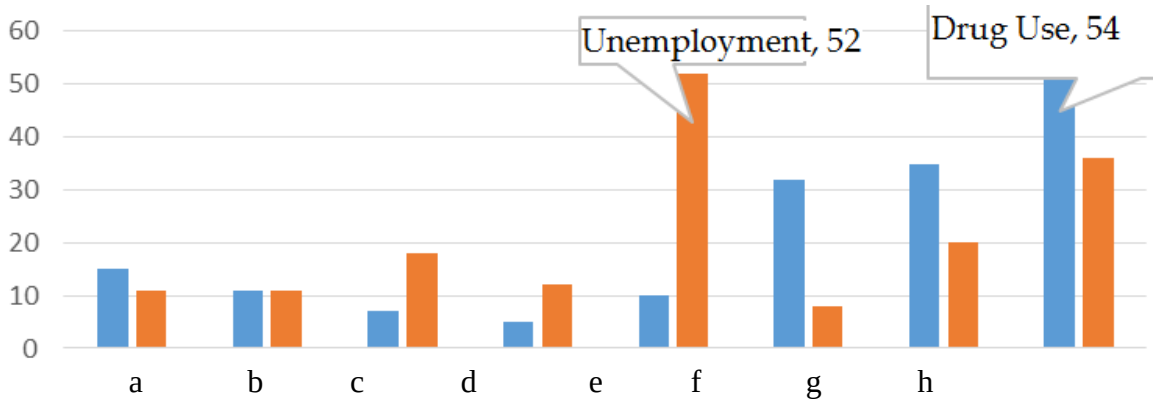

Figure 1. Main Problems of youth

a - Low standard of living, b – Crime, c – Lots of free time, d – Commercialization of education, e – Unemployment, f – Smoking, g – Alcohol consumption, h – Drug Use

Such surveys and analysis of their results are an illustration of the actual problem areas and the basis for the formation of the directions of the state youth policy. Continuous work on the Shewhart-Deming cycle (PDCA – Plan , Do , Check , Act) will reduce the level of youth problems and lead to stability and development of the state in the future. Compared to 2000, by 2050, global life expectancy is expected to increase from 65 to 74 years. Interdependence between young and old will increase in the future. Thus, youth development will increasingly become one of the prerequisites for meeting the growing demands of older people for their care and the development of society as a whole [14].

Conclusions

Based on the analysis carried out, it can be said without a doubt that the governments of many countries understand the importance of a comprehensive youth policy for ensuring state stability and economic development of the regions. The active involvement of young people in decision-making processes at the local, national and international levels is a condition for strengthening the position of the economy.

State regulation and solution of youth problems in relation to graduates of educational institutions is generally imperfect. It is necessary to develop an effective mechanism for the implementation of the state youth policy in the field of education. This will solve the issues of the quality of education, the problems of commercialization of education (and due to its inaccessibility for some of the youth), and the problems of employment. Work with children and young people under 18 years of age should focus on promoting a healthy lifestyle, controlling the use of alcohol, drugs and smoking. It is at this age that young people are most susceptible to suggestion, and bad habits leave a serious imprint on the health of the generation.

Successful state policy in the context of globalization involves an analysis of successful practical and promising solutions to foreign youth programs and the adaptation of effective foreign developments and methods for conducting Russian youth policy.

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ТЕОРЕТИЧЕСКИЙ АНАЛИЗ МОДЕЛЕЙ ПОЛИТИЧЕСКОГО УПРАВЛЕНИЯ

THEORETICAL ANALYSIS OF POLITICAL GOVERNANCE MODELS

Пятигорский институт (филиал) федерального государственного автономного образовательного учреждения высшего образования «Северо-Кавказский федеральный университет» / Pyatigorsk Institute (branch) of the Federal State Autonomous Educational Institution of Higher Education "North Caucasus Federal University"

Аннотация

В настоящей статье проводится теоретический анализ политического управления, рассматриваются уровни власти, а также рассматривается разделение на зоны влияния неполитических акторов политического правительства региона.

Материалы, методы, результаты и обсуждения

В работе выявлен механизм политологического анализа территориального управления, который позволяет дать интегральный срез проблемы, синтезирующие подходы выработанных в смежных с политологией науках.

Прослеживается взаимодействие исторических, юридических, экономико-географических и иных аспектов территориального управления. В целом это позволяет дать политологический анализ в исследовании проблемы. При этом политическое управление рассматривается как взаимообразный процесс, включающий как воздействие государства на территорию, так и обратное воздействие территориального сообщества на государственную власть.

Работа строится на политологическом анализе проблемы на основе системного подхода.

Заключение

Политическое управление является связующим элементом, синтезирующем, интегрирующем различные виды управления. Соответственно, велика и роль политологов для интеграции и координации различных отраслей знания (юриспруденции, социологии, экономической географии и менеджмента) при изучении различных видов политического управления.

Ключевые слова: политика, политический регион, политическое управление, государственное управление, экономическое управление, социальное управление.

Abstract

This article provides a theoretical analysis of political management, examines the levels of power, and also considers the division into zones of influence of non-political actors of the political government of the region.

Materials, methods, results and discussions.

The paper reveals the mechanism of political science analysis of territorial administration, which allows to give an integral cut of the problem, synthesizing approaches developed in sciences related to political science.

The interaction of historical, legal, economic-geographical and other aspects of territorial administration is traced. In general, this allows us to give a political analysis in the study of the problem. At the same time, political management is considered as a mutual process, including both the impact of the state on the territory and the reverse impact of the territorial community on state power.

The work is based on a political analysis of the problem based on a systematic approach.

Conclusion.

Political management is a connecting element, synthesizing, integrating various types of management. Accordingly, the role of political scientists is also great for the integration and coordination of various branches of knowledge (jurisprudence, sociology, economic geography and management) in the study of various types of political management.

Keywords: politics, political region, political administration, public administration, economic administration, social administration.

In political science there is a dynamic relationship between the terms of political and territorial administration. According to the theory of political management, there are a significant number of works by domestic and foreign authors in which the concept of political management is singled out, its differences from state, economic and social management [1-5]:

From a theoretical point of view, four departments of power are traditionally distinguished:

– mega level ;
– mesolevel ;
– macro level;
– microlevel.

Where is the boundary between levels of power, where the phenomenon of the political / non-political is clearly felt. What political actors are needed (groups of pressure, interests, influence, diversification of elites, mass media).

For the course of the political process, a conflict of interests and power groups is necessary. Society must have a developed political, social and economic infrastructure. Thus, a political territory is a territory that has political governing bodies, developed structures of civil society, a territory that is exposed to political structures, controlled by political methods [6].

What properties should a political region have?

The political government of the region is determined by the zone of influence of non-state actors :

– political parties;
– political unions;
– pressure groups;
– interest groups;
– non-profit organizations;
– scientific and educational communities.

The political government of the region does not include:

– transport infrastructure;
– raw material base;
– system of subcontractors and suppliers;
– subsidiaries of corporations.

It can be stated that territorial administration is one of the conditions for political administration, fettered by the framework of administrative boundaries.

What is the Russian experience of forms of territorial organization? We note the relationship between the terms "territorial administration" and "territorial pressure". All these elements correlate with each other as a whole territorial division and are determined by the form of the territorial structure. The dividing line runs along the border of toiletism / federalism. Unitarism - the presence of vertical ties, the subordination of all levels of government, strict centralization of government, the appointment of regional authorities. Federalism – the delimitation of powers between the center and the regions, the right of the regions to legislative activity, the presence of elected authorities, both in legislation and in the executive branches of government. Confederation – implies an inverted pyramid of distribution of powers, the region delegates part of the powers to the center, the legislation is based on subjective / objective grounds.

The political administration of Russia at various stages of history is an interweaving of the three listed principles of the territorial structure of unitary, federalism and confederation. Thus, one can judge the ambiguous definability of the form of the territorial structure not only for the past, but for the future state of the Russian state. In this article we will try to give a critical analysis in relation to models of political management. The aggravation of interethnic contradictions led to the creation of national-territorial autonomies, but this is not the most optimistic form of resolving contradictions, since the concept of a titular ethnic group appears, which leads to inequality of citizens [7].

The national-territorial federation favors the formation of regional political elites on an ethnic basis [8-10].

The contradictions between the administrative-territorial and national-territorial principles leads to the formation of the concepts of mixed, or asymmetric federation, contractual federation.

The presence of separate agreements between the federal center and the territories entails an inequality of rights and privileges of individual regions.

Thus, in the process of transformational transformations of the administrative-territorial political administration. Market relations make administrative borders more open, the outlines of regions are blurred. All this leads to an increase in informal ties between regions, emphasizing the political, rather than state, nature of the relationship between the territorial levels of government at the present stage. There are two main groups of contradictions in the territorial development of Russia:

– contradictions between the radical nature of political and economic changes and the immobility of territorial administration;

– contradictions between unitary, federal and confederate elements in the territorial structure.

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СОВРЕМЕННЫЕ ПОДХОДЫ К ИССЛЕДОВАНИЮ МАССОВОЙ ПОЛИТИЧЕСКОЙ КОММУНИКАЦИИ

MODERN APPROACHES TO THE STUDY OF MASS POLITICAL COMMUNICATION

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Аннотация

Принципиальным вопросом современных исследований остается изучение ситуации, когда масс-медиа стали продолжением нервной системы человека, влияют на сознание и поведение человека в процессе коммуникации. Цель статьи – определить, что современная коммуникация вобрала в себя не только передачу сообщения, но и конструирование ценностно-смыслового пространства и трансляцию образцов поведения и культуры. Сделан вывод о том, что глобальность информационного фрейма активно осваивается не только социальными акторами, но и различными политическими агентами, для которых неиспользование медиапространства означает упущение потенциальных возможностей воздействия на неограниченную аудиторию. Необходимо признать, что современная массовая политическая коммуникация вобрала в себя не только передачу сообщения, но и конструирование политического пространства, в чем и заключается ее изменившаяся сущность. Преобладающая доля политической коммуникации осуществляется посредством и в интересах субъектов политической коммуникации.

Ключевые слова: политика, политическая коммуникация, государство, масс-медиа, политический агент, политический дискурс.

Abstract

The fundamental issue of modern research remains the study of the situation when mass media have become an extension of the human nervous system, affect human consciousness and behavior in the process of communication. The purpose of the article is to determine that modern communication has absorbed not only the transmission of a message, but also the construction of a value-semantic space and the translation of patterns of behavior and culture. It is concluded that the globality of the information frame is being actively mastered not only by social actors, but also by various political agents, for whom not using the media space means missing potential opportunities to influence an unlimited audience. It must be recognized that modern mass political communication has absorbed not only the transmission of a message, but also the construction of a political space, which is its changed essence. The predominant share of political communication is carried out through and in the interests of the subjects of political communication.

Keywords: politics, political communication, state, mass media, political agent, political discourse.

Introduction. Despite the fact that today political communication is one of the most studied civilizational problems in the system of social sciences and humanities and in special works devoted to the study of certain aspects of political communication, both in modern domestic and foreign practice, nevertheless, we have to state that a coherent theory of mass political communication does not currently exist. It is going through a transitional stage, since it does not fully reflect the categories of mobility, interactivity and convergence of new media, and the following "preconditions for the paradigm crisis of the world civilizational order of life" [5, 281]. Science is at the stage of formation of such a subject paradigm, which is designed to move away from the dominant theories that prioritize either information or communication as a specific technical process that provides a dialogue between government and society, and pay attention to improved spatial and communication practices.

General principles and approaches, united within the framework of mass political communication and the phenomenon of mediatization of politics, are little actualized and developed. To

date, there is no generalizing, cumulative knowledge that takes into account the features, features, characteristics, means of implementation, etc., which require differentiation, analysis, synthesis and systematization. Thus, the state of development and study of a very important problem determines the need for this study.

The degree of development of the problem. Scientific research has paid great attention to the specifics of communication, and as a result, areas for studying the features of communication have been formed, represented by the study of: features of the communicative interaction between the institutions of political power and society [23]; technologies of Internet communications as a tool to influence the functioning of modern institutions of power [10]; as a factor in the formation of public opinion in modern Russia [22]; from the point of view of network political communication of power and society [16]; the effectiveness of communication [3], [15], including the state [19], etc. Nevertheless, one should point out the extreme insufficiency of works devoted to the subject of communication from the perspective of the problems of the relationship between the political and the media.

Research methods. Due to the interdisciplinary and complex nature of mass political communication, the theoretical issues of studying the phenomenon are among the problematic issues, the consideration of which does not fit into the usual framework of general political science paradigms, which to a certain extent claim to be universal metatheories.

Therefore, depending on the object, subject and methodology of research, it is possible to create a certain interdisciplinary level of analysis, which will allow obtaining specific results, more specific and methodologically supported. This goal required the solution of the following tasks: to consider the essence of mass political communication, as well as to determine the relationship between mass political communication and media space; focus on changing the functions of modern mass political communication.

Research results and their interpretation. In the conditions of a democratically developing state, the influence of the mass media on politics always increases dramatically. However, for a long time this influence could only be exercised through the press or through an open and direct meeting of politicians with citizens. Only since the 1960s can we talk about the penetration of mass communication into political life, but only since the end of the last century, with the development of the Internet, the implementation of public policy has become impossible without mass public participation. On the other hand, there is a potential opportunity to make any information global, to arouse interest in it among an unlimited audience. As a result, the growth of information and communication technologies has generally corrected ideas about political communication, however, political analysis as well, since “the property of unpredictability is increasingly becoming a property of a politician at all levels and scales of the event field” [4, 142].

Initially, the basic basis of the theory of mass communication was the constructivist approach in sociology, which studies communication as a social phenomenon. Among other sciences and scientific disciplines that study communications and related issues of communication systems, communication processes, and at the present stage of development of communication theory and practice - and communication technologies themselves - one can name anthropology, psychology, linguistics, semiotics, technical sciences and, of course, political science. , whose area of interest in the field of communication is extremely wide and important, as it touches upon the vital issues of the functioning of society and states on various scales, up to global ones.

Also of concern to the scientific community is the fact that mass political communication, one of the key vocations of which is the consolidation of society and the coordination of political interests, in fact, has practically ceased to serve the designated function, transforming into a field of targeted influence on the object by political and political interests interested in a certain benefit. other entities. But this position in science has not been properly reflected, and in the existing basic theories of political communication a generalized understanding of the phenomenon is given.

All definitions of political communication in a significant list of works carry a fairly broad semantic load, as, for example, in the founder of the theory of communication H. Innis , who un-

derstands political communication as “a mechanism by which the existence and development of human relations is ensured, including all mental symbols, means of transmission in space and preservation in time” [9, 167]. P. Smith, C. Barry, A. Pulford dwell on the understanding that “communication is the act of sending information from the brain of one person to the brain of another person” [24]. We are closer to the definition of communication given by the political scientist A.V. Atanesyan : “communication is a connection, a relationship between phenomena that may belong to one or different systems, respectively, communication supports a system or interaction between subsystems, creating a system at a higher, generalizing level” [2, 38]. It should be noted that the stated interpretations are generally characterized by a generalizing approach, which is inevitably accompanied by either an expanded understanding of the problem or a clear contradiction. While agreeing that communication is a connection and relationship between different subjects, we nevertheless emphasize that communication does not always create a system at a higher level. I would also like to draw attention to the fact that any field of studying communication, including political ones, initially assumes an interdisciplinary nature of work, which is not reflected in the proposed interpretations.

So, communication, including political communication, is a complex phenomenon that plays a leading role in the existence of society. As far as political communication is concerned, historical examples of its origin were demonstrated on the squares of ancient Greek city-states, where all the most important state-political issues were discussed. Ancient Greece is a vivid example of how mass character, publicity and openness were at the heart of everything political. With the departure of the Greek city-states from the forefront of political life, a tendency appeared in the state structure and government to deny democracy, and the number of authoritarian-type monarchies began to grow. But with the advent of technical means of disseminating information, the era of mass communication, mass awareness, active political participation, including the so-called “grassroots”, began.

The transmission of messages in any state structure inevitably implies the presence of certain technical means of communication, therefore communication imposes specific requirements on structural elements, which consist of technical channels, areas of control, preservation, accumulation of information, etc. But, even with such structures, not all information is able to generate the process of "establishing meaningful contacts between" political subjects: the recipient of information (recipient) and the sender (communicator) [14, 66].

Deutsch [27], a pioneer in the study of the political system as an information and communication system , gave rise to a twofold theoretical continuation. So, from the point of view of G. Szelsky , “the state should not follow the interests and will of individual citizens and groups”, and in the first place when considering political communication, it is necessary to put the technical aspect of the organization of political power, and not the social one [See: 8, 23]. In contrast to this concept, J. Habermas in his studies focused on learning activities and cultural norms, suggesting that social and political values should dominate political communication and follow the "interests of the general population" [28, 108].

The works of the founders of the theory of political communication, despite the polarity of views, have become an undoubted breakthrough in the scientific consideration of the problem. However, the development of information systems and the latest technologies did not lead to the solution of social problems. Moreover, new media only increased the possibilities for maneuvers for institutions and subjects of power, expanded the field of manipulative influence on the recipient in the course of mass political communication. Nevertheless, it should be noted that under certain political regimes, it became possible to strengthen the autonomy of grassroots government structures in the state, electronic voting and interactive communication systems appeared, the destruction of hierarchical ties in public administration, etc. With the emergence and penetration of new media into the broad masses, changes in the socio-political nature took place, which caused the prerequisites for active involvement in political relations of the broad masses.

Next, consider the structure of political communication, the formula of which was first

proposed by G. Lasswell. We emphasize right away that the researcher considered political communication as a complex process with a specific focus, internal structure and socio-political functions. He developed a linear model of the communication process based on the behavioral stimulus-response approach. In this case, the audience is the object of the "who reports? - what does it say? - to whom? - on what channel? – with what effect?", and the information transmitted by the communicator should have a direct impact on the recipient [18, 141].

Lasswell's rather optimistic formula considered political communications as an incentive, imperative process, ending with a certain, expected effect. R. Braddock improved this formula by adding two more points to the well-known scheme: "under what circumstances does it report? - What is the purpose of reporting? [7, 91]. Subsequently, the behaviorist B. Berelson proposed his understanding of the structure and model of political communication, the essence of whose theory is that one of the essential aspects of influencing power is elections and a referendum, in the process of which political communication plays an important role [26].

Characterizing the modern communicative space, the researchers write that it is distinguished by "the interaction of different cultures and the variety of communicative means and practices" [20, 12]. Indeed, the very relationship between political subjects in the course of their desire to use power for their own purposes cannot be carried out without information exchange, without communication. Any political activity is closely associated with its "communication dimension", which gives rise to M.N. Grachev to define political communication as "a special, special case of communication, which is the informational impact of political actors on each other and the surrounding social environment (society)" [12, 232]. As the author rightly believes, having certain advantages of a methodological, epistemological and ontological order, generally accepted concepts face considerable difficulties when considering communication processes, a phenomenon that has become an integral part of the life of modern society [13, 23]. Researcher I.S. Nikitina draws attention to the institutional nature and specific information content of political discourse [21, 9].

However, all existing theories adhere to either the information or communication paradigm, paying insufficient attention to the role of modern media in the implementation of mass political communication. In our opinion, it is with the advent of new media that one can forget about the previously announced objective essence of communication as a tool for the democratization of public life. On the contrary, the modern essence of mass political communication lies in the formation of the mass media as the main instrument of policy formation, and not in the direction of democratization, but to please a rather narrow circle of people. This process is partly objective, since the reasons for uneven access to sources of information are objective. In addition, the monopoly ownership of the media market by individual companies and government structures also dictates its own characteristics of the process.

We proceed from the position of R.V. Korotkevich that political communication is one of the main links of the political system of society, which provides the relationship between its other components through the translation of political values. But at the same time, political communication also acts as a process that includes the activities of political subjects in combining, producing, and disseminating values that are significant for political subjects through the media. The purpose of distribution is the formation in line with the stabilization of existing ideas or their change, as well as the way of thinking and actions of other social actors [17, 195].

However, despite the fact that the predominant share of political communication is carried out through and in the interests of media magnates (the founders of the mass media, advertisers, power structures using administrative resources, parties in power, oligarchic structures), globalization processes make their own adjustments in this direction. This means that in the environment of mass political communication, informal media based on the interactivity of the media space (for example, the blogosphere) began to take their place, which, in particular, began to be used, for example, by the organizers of color revolutions and adherents of eversion technologies.

Researchers rightly assume that "the acute problem of the formation in the field of public

policy of various values, ideologies, doctrines, symbols, feelings, oppositional opinions and speeches, the formation of official norms that are implemented in the field of communications" [6, 217]. Consequently, the traditional view of politics as a "socio-technological structure, whose institutions are oriented towards the purposeful transfer, exchange and protection of information" [25, 15], needs to be corrected, since from now on the institutions of mass media policy are also oriented towards construction of information for the purpose of not only interaction, but also impact. Therefore, we agree with the definition of M.N. Grachev that political communication is "communication in the sphere of politics, a type of communication that represents the informational impact of political actors on each other and the surrounding social environment" [13, 23] . We only add that mass political communication can also be considered as a projection of the political constructions of an interested political subject using the capabilities of the mass media into the fields of the socio-political media space and other subspaces.

In this regard, we would like to cite a scheme for the participation of the media in modern mass political communications, developed by P. Norris, who devoted her research to the media and political communications. According to the theory of P. Norris, the role of the media is the role of an intermediary between the subjects of socio-political relations and society as a system of views and ideas about the activities of these subjects [29, 14]. The media mediate the processes of political communications, providing a link between political institutions and society, between voters and those elected, between organizations at different levels.

Developing the ideas of P. Norris, S.D. Glukharev suggests that it is the symbolic space created by the mass media that forms the basis of the media space. At the same time, mass political communication is a projection of the selected information and its interpretation as a reflection of the actions, ideas and thoughts, first of all, of the ruling elite in the media space, since the media currently "is an economic enterprise whose financial well-being and existence depends on the state or representatives of the political elite" [11, 110].

Conclusions. Thus, the essence of mass political communication today has changed dramatically, which is largely due to the change in the functions of new media. The functions of the media that were previously inherent in them (integrative, educational, educational, etc.), and the functions of the media, or rather the dysfunctions that modern media perform (dysfunctions of drug addiction, disintegration, expectations and disappointments, etc.), differ significantly. In the era of the use of many digital technologies, the impact of the media extends to all spheres of an individual's life. The new era "invented" a new cycle in the classical three-stage information and communication structure: "message (message) – translation (communication) – perception (interpretation) – communion". It was the initiation that became the main task assigned by the function of modern media, which was reflected in the essence of mass political communication.

However, to date, researchers do not sufficiently take into account the important essential characteristic of mass political communication, which consists not only in the circulation, circulation and movement of information. In our opinion, it is necessary to take into account the goals and objectives of political communication, which consist not only in the transfer of information, but also in changing opinions, judgments, attitudes, attitudes, and behavior of the mass audience.

It should be emphasized that we are not considering individual cases of political communication, implying political management, but the general spatial and informational interaction of political subjects and their influence on the "agenda". In our opinion, it is important to take into account the "procedural" and "functional" components of mass political communication, which allows us to focus on the totality of the phenomena of information impact and the interaction of subjects in the sphere of politics regarding the power exercised in the media space.

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К ВОПРОСУ О ПОЛИТИКЕ ИМПЕРСКОГО УПРАВЛЕНИЯ ПОЛИТИЧЕСКИМИ ПРОЦЕССАМИ НА КАВКАЗЕ

TO THE QUESTION OF THE POLICY OF IMPERIAL MANAGEMENT OF POLITICAL PROCESSES IN THE CAUCASUS REGION

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Аннотация

Политический процесс на Северном Кавказе по значимости для российского общества является периферийным, т.к. не оказывает системообразующего влияния на основные формы и способы властвования. Он также носит идеократический характер, поскольку действия субъектов процесса нормируются этническими и конфессиональными нормами в большей степени, чем формализованным правом. Рассмотрен имперский период российского влияния на Кавказе при разнообразии стилей и форм политического управления.

Материалы, методы, результаты и обсуждения

В представленной работе выявлен механизм сравнительного анализа различных стилей и методов управления, используется системный метод, что помогает установить политическую подоплеку проводимых политико-управленческих мероприятий.

Заключение

Таки образом политика имперского управления политическими процессами на Кавказе в современной политологической науке изучена недостаточно глубоко и разносторонне. Гораздо шире изучаемый научный феномен представлен работами историков, юристов специалистов по политической географии, сам процесс вхождения Кавказа в ореол российской политики начинается с начала XVIII по XX вв. В настоящей статье была предпринята попытка описать его имперский период и персонифицировать отдельных государственных и политических деятелей ответственных за проводимую политику. Была дана деятельность князя Цицианова П.В., который первым пытался предпринять шаги по политической трансформации в области законодательства. В годы его правления на Кавказе стали формироваться условия для формирования местной политико-бюрократической элиты. Характеризую модель управления князя П.В. Цицианова можно признать наличие «европейского следа» в проводимой имперской политике. Годы правления Ермолова совпали с затяжной Кавказской войной и отмечены военно-силовыми методами управления. Управленческая политика и формы управления Воронцова М.С. отличались существенными, глубинными политико-административными реформами. Таким образом политико-имперского управления политическими процессами на Кавказе сочетало в себе различные типы и формы управления: от мирных гражданских, военно-силовых и была призвана усилить Российское имперское влияние на Кавказе.

Ключевые слова: политические процессы, политико-административное управление, политическое управление, горцы, элиты, наместничество, политико-административное деление.

Abstract

The political process in the North Caucasus is peripheral in terms of its significance for the Russian society. does not have a system-forming influence on the main forms and methods of ruling. It also has an ideocratic character, since the actions of the subjects of the process are normalized by ethnic and confessional norms to a greater extent than by formalized law. The imperial period of Russian influence in the Caucasus with a variety of styles and forms of political governance is considered.

Materials, methods, results and discussions.

In the presented work, a mechanism for a comparative analysis of various styles and methods of management is identified, a systematic method is used, which helps to establish the political background of ongoing political and management activities.

Conclusion.

Thus, the policy of imperial management of political processes in the Caucasus in modern political science has not been studied sufficiently deeply and diversified. The studied scientific phenomenon is much more widely represented by the works of historians, lawyers, specialists in political geography, the very process of the Caucasus entering the halo of Russian politics begins from the beginning of the 18th to the 20th centuries. In this article, an attempt was made to describe his imperial period and to personify individual state and political figures responsible for the policy pursued. The activities of Prince P. V. Tsitsianov, who was the first to try to take steps towards political transformation in the field of legislation, were given. During his reign in the Caucasus, conditions began to form for the formation of a local political and bureaucratic elite. I characterize the management model of Prince P.V. Tsitsianov, we can recognize the presence of a "European trace" in the ongoing imperial policy. The years of Yermolov's rule coincided with the protracted Caucasian War and were marked by military-power methods of control. Management policy and forms of management Vorontsova M.S. distinguished by significant, deep political and administrative reforms. Thus, the political-imperial management of political processes in the Caucasus combined various types and forms of management: from peaceful civilians, military forces, and was intended to strengthen the Russian imperial influence in the Caucasus.

Keywords: political processes, political and administrative management, political management, highlanders, elites, governorship, political and administrative division.

Introduction

The policy of imperial management of political processes in the Caucasus is quite widely represented by the works of historians, lawyers, geographers, but politically there are gaps that require closer study by political scientists [1-10].

In the system of political administration of the Russian Empire in the Caucasus, the autochthonous population of vassal relations, the "highlanders", with strictness not only moderate, even cruel, but fair, when it is combined with care for their welfare, become submissive to the point of slavery and faithful throughout the entire space of this word [eleven].

The Russian authorities organized political and administrative management in the likeness of the provinces of the Russian Empire [12]. The dissatisfaction of the local population was expressed in relation to the mixed system of legal proceedings in solving civil and criminal cases. The growth of discontent led to the removal of General K.F. Knorring on Lieutenant General Prince P.D. Tsitsianova [13].

Materials, methods, results and discussions

Prince Tsitsianov P.D., who was closely familiar with local customs (an ethnic Armenian), considered the problem of political leadership of the Caucasian region somewhat differently than his predecessor, believing that " laws should be bent according to customs, because these last are united centuries, and not violent are refracted in ways " [14].

The political transformation in the field of legislation provided for the reorganization of the judicial system in the Caucasus, which took into account local traditions and customs as much as possible [15].

In general, P.D. Tsitsianov managed to somewhat improve the judicial system and carry out a consistent series of measures that led to an improvement in the system of political equation in the Caucasus. Political and managerial activities of P.D. Tsitsianova led to the cultivation of their own officials in the Caucasus [16].

Realizing the perniciousness of coercive methods of force, the prince proposes a “velvet” style of forming the local political and bureaucratic elite [17]. The main measures should be and become “changes in education”, for which it was supposed to open “schools for teaching children of Kabardian owners and uzdens” in the cities of Georgievsk and Ekaterinograd, which pupils would then be moved from schools to cadet corps” [18]. P.D. Tsitsianov proposed "introducing luxury to Kabarda", organizing duty-free trade of local artisans and craftsmen. According to the reformer, the political rights of the nobility should have been extended to the local elites.

It can be argued that the proposed measures were one of the first attempts to find mutually acceptable ways to include the mountain elite in the imperial system of political governance based on convergence of worldviews [19].

The internal system of political administration did not quite fit into the mountainous part of the Caucasus. There have already developed their own universal societies:

– "free societies";
– khanates;
– shamkhalystvo.

Imperial civilian methods of government were replaced by military ones in the form of bailiffs. Describing the management models of Prince P.V. Tsitsianov, one can state a certain “European image” of colonial expansion.

The next stage of political management is associated with the name of General A.P. Yermolov.

Russian researchers Matveev V.A., Kharsiev B.M., Shapak M.E., Shafranova O.I. and others covered in detail the processes of political and state administration in the Caucasus during the imperial period [20-22].

Conclusion

The military period of Russia's actions in the Caucasus (1817-1864) was associated exclusively with military actions and it is not correct to talk about administrative policy in relation to the Caucasus. In the newly annexed territories, the Russian government tried to act by traditional methods without taking into account the specifics of the mountain worldview. The system of military political leadership based on forceful methods needed other forms of political and administrative management - governorship [23]. The first governor was Count M.S. Vorontsov. In St. Petersburg, the Caucasian Committee was established - the highest state structure created for the direct interaction of the governor with the supreme power. Reforms of Vorontsov M.S. concerned, among other things, changes in the political and territorial structure.

In 1846, the Caucasus region was divided into four provinces - Tiflis, Kutaisi, Shamakhi, and Derbent, and in 1847 the Caspian region was formed, which included the territory of Dagestan. The new political-territorial division implied the principle of centralization, which, in turn, contributed to the economic development of the national outskirts [24].

Analyzing the activities of M.S. Vorontsov as a conductor of imperial policy, it should be noted that he changed the vector of Russian policy towards rapprochement with the local elite, avoiding repressive measures against the highlanders, and creating the necessary economic conditions. Unfortunately, the process started by M.S. Vorontsov did not receive its further development with receivers. During the reign of Alexander III, the institute of governorship was liquidated and the Caucasian Committee in St. Petersburg was abolished, and military, judicial and executive power would be concentrated in military groups [25].

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СМИ КАК ИНСТРУМЕНТ СОЦИАЛЬНО-ПОЛИТИЧЕСКОЙ МАНИПУЛЯЦИИ

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MASS MEDIA AS A TOOL OF SOCIO-POLITICAL MANIPULATION

Аннотация

Актуальность подобных исследований обусловлена слабой разработанностью проблем влияния на массовую аудиторию технологий, основанных на возможностях СМИ. Сформулирован ряд положений и выводов, свидетельствующих о том, что 1) в массовом понимании регулятивные социальные и политические возможности современных технологов от СМИ не осознаются как важные; 2) СМИ сегодня стали тем средством и инструментом, при помощи которого правящему классу можно влиять на большие массы населения, поэтому целенаправленное манипулятивное воздействие на потребителя отныне все более становится главной функцией СМИ.

Ключевые слова: СМИ, масс-медиа, манипуляция, методы воздействия, лидеры общественного мнения, формирование общественного мнения, политическое влияние, политическое сознание

Abstract *The article is devoted to the study of the media as a tool of socio-political manipulation. The relevance of such studies is due to the weak development of the problems of influencing the mass audience of technologies based on the capabilities of the media. A number of provisions and conclusions are formulated, indicating that 1) in the mass understanding, the regulatory social and political capabilities of modern technologists from the media are not recognized as important; 2) The media today have become the means, the instrument by which the ruling class can influence large masses of the population, therefore, purposeful manipulative influence on the consumer is now increasingly becoming the main function of the media.*

Key words: mass media, mass media, manipulation, methods of influence, leaders of public opinion, formation of public opinion, political influence, political consciousness

Introduction. The issue of interaction between the media and society today is more relevant than ever and is debatable, since the problem is understood ambiguously. Nevertheless, real life shows how much the layman depends on the media, since "being determines consciousness", and we live in the era of "media", that is, the total influence of the media on the thoughts and behavior of citizens. At the same time, in the mass understanding, the regulatory social and political possibilities of modern technologists from the media are not recognized as important, remaining the area of interest of narrow specialists, although the so-called "soft" impact on the audience gives results that are comparable only with an intense impact on the subject of influence.

The purpose of this article is to identify the mechanisms for the formation of value attitudes through the use of the media in the process of political communication. We are talking about the increased influence of the media, which now participate in the construction of the political agenda.

The level of development of the discussed problem, despite its relevance, in domestic and foreign science is not high and is in its infancy. In surveys of manipulation in modern media are considered in more detail from the point of view of advertising, aspects of political manipulation remain under study. Thus, the socio-political influence of the media is considered by V.D. Bachurin [2], A.K. Botashev and S.V. Anufrienko [3], S.A. Zelinsky [5], A.A. Kazakov [7], V.V. Kikhtan and B.Yu. Mamieva [8]; V.L. Primakov [10], V.A. Slavin [12] and others. A number of Western researchers traditionally pay attention to the manipulation of the mass media with the consciousness of the masses, among which the works of M. Echugar [16] , T. Van Dijk [17] , G. Masolini and W. Schulz [18], Yu Habermas [13] and others.

Research methods. The thematic field of research contributed to the use of general scientific methods of theoretical knowledge, such as the scientific description of the object of knowledge, the method of axiomatization, the hypothetical-deductive method, the method of formalization, etc. From the particular scientific methods of research, the authors turned to the method of theoretical pluralism.

Research material. Let's consider what is the mental prototype of this mediative process of influence. It is known that the mental state of a person is determined by the conscious and the unconscious (subconscious) and a certain barrier between them – the censorship of the psyche. Despite the fact that "Views on the problem of the conscious and the unconscious are predominantly owned by the so-called Western scientists" [1, p. 8], we will single out some conditional directions, since the triad of the conscious, the unconscious and their relationship (thesis-antithesis-synthesis) influences and determines the memorization, creativity, imagination, behavior and attitudes of the individual. The Georgian scientist D.N. wrote about this back in 1923. Uznadze that conscious processes do not exhaust the entire content of the psyche. Accordingly, he suggested, "in connection with this, it is necessary to recognize the existence of such processes that occur outside of consciousness and essentially determine the weight of its movement" [14, p. 125]. The opinion of modern Russian scientists is also fair, who focus on such phenomena as unconscious motivation and psychological attitude, paying attention to "the issue of restructuring the structure of the unconscious, the solutions of which they see in studying the influence of socially "value-significant" information on the subject associated with his emotions. , beliefs and activities" [1, p. 6]. In particular, we are talking about ""receiving" and "delivery" of information, its processing and "formation" of new information on the basis of previously received" [1, p. 131].

Thus, the main movement of information passes through the censorship of the psyche (representative and signal systems), is generated and redistributed, while most of it is forced out into the subconscious, from where, over time, it begins to influence the consciousness, that is, the thoughts and actions of the individual. As suggested by S.A. Zelinsky, "It is on the subconsciousness that a person's realization of hidden, subliminal influences, or influences from manipulators, who, using the developed psycho-technologies, introduce psychological attitudes into the human subconsciousness, depends" [5, p. 28]. It turns out that the researchers are right when they write that "Manipulators program our reality, if not for everyone, then for the majority of people, because a person in the mass is not aware, does not think, and willingly succumbs to all the influences to which he is subjected" [11, With. 33].

Scientists explain the ability of the media to manipulate the behavior and consciousness of the individual with different prerequisites. For example, it is indicated that the desire of a person to belong to a certain social group motivates an individual to meet the expectations of the majority, represented by the media, when a person's views are formed in accordance with the provided position, allegedly characteristic of this social group (A. Maslow). This message is especially active in advertising: do you want to belong to the wealthy class? Look at what kind of watch (dress, jewelry, etc.) these people are wearing. By the way, Maslow's pyramid is not used in political propaganda and political influence, although there is a clear potential: in particular, those who think this way or adhere to just such views are the most successful and realized as a person (demonstrate, advertise with some examples).

One of the well-known researchers of political communication is J. Habermas, according to which politics is reflected in the system of communicative actions, acting as a chain of mediations [13]. But the manipulation of personality differs from the manipulation of political consciousness, since in the second case it is necessary to build a certain political picture of the world for a large audience, the masses of the population. Here, an important component is the low degree of awareness of the objects of manipulation by the consciousness of the goals and intentions of the media representatives.

The information impact of the subject on the object of communication pursues the goals set by the subject. At the same time, we are in solidarity with V.L. Primakov, that there are special media technologies as "techniques, methods, channels and tools for creating and distributing media content, focused on managing the perception of target groups in order to implement certain practices" [10, p. 213].

Research results and their interpretation. We list a number of ways, methods and technologies of influence through the media for the purpose of political domination:

1) Blatant lies and fakes in the media. It would seem that what prevents an individual from distinguishing a lie from the truth? The fact is that the majority of the population is sure that the media do not lie, that since these frames were shown, it means that it is so. Since respected journalists said so, it means that it is so. An illiterate audience that does not have critical thinking is happy to be deceived, taking on faith all the information presented in the media, which is what manipulators of all stripes use, from false advertising of goods to political influence.

2) The second tool that facilitates the media's manipulative impact on the audience is the effect of perception of primary information. This method of influence is based on such a property of the psyche, which encourages a person to more deeply believe in the information that came first. More truthful information received later loses in perception as more reliable due to subconscious distrust of it, since consciousness and subconsciousness are busy processing the first information. A certain effect of perceiving primary information as true is triggered, secondary information, albeit true, is "forced" to overcome the formed opinion. The paradox of the human psyche! But this phenomenon in political technologies is used quite often. For example, it can be a "accusatory" compromising evidence on an opponent during the election race, which forms a negative opinion about him. The subconscious attitude of the layman looks like this – it is justified – there are sins; is not justified – nevertheless, a residue of mistrust remains.

3) The third method of political influence on public consciousness is the creation of public opinion, which in terms of its effectiveness is difficult to surpass by other methods, therefore it is indispensable when unpopular decisions of power structures are put into practice. Assume that the working week is legally limited to 38 hours in a particular state entity. Changing the working week to 48 hours would be a very unpopular idea and how the law might not pass. But the advance release of this idea, negative for the majority of the population, by the media will cause public concern and negative resonance, but the audience will eventually get tired of the protests. In parallel, there should be a suggestion that this is necessary, extremely important, a forced measure, since the population is becoming obsolete, there is no progressive development, etc. Public opinion is developed through the mouths of stars, public figures, politicians, representatives of all parties, doctors, teachers, "ordinary people". Thus, this law can be discussed in the media for a long time, but there is no formal reason to protest, since the idea is simply being discussed (inoculated into the minds of the majority). Gradually prepared society, having gone through the first incandescence of passions, gets tired, gets used to this idea, but the new law, even after going through all the stages of parliamentary discussion, must be adopted with a delay in action, which will once again allow the dissenters to blow off steam and postpone the heat of indignation. The adoption of such an unpopular law, of course, will cause a series of protests, which will be extinguished by sending laws for revision. It is clear that by the time the law is finally adopted, public opinion will be finally formed and people will get tired of protesting.

4) The fourth method of manipulating public consciousness and behavior through the media is to use the media "witnesses". In this case, the media use the population's distrust of politicians who purposefully try to influence the audience in their own interests. Therefore, the appearance on the screen of an "unbiased eyewitness" brings a fresh stream to the perception of information, critical thinking is minimized, allowing the artist, whom the media passes off as an eyewitness, emotionally and "sincerely" pass off a lie for the truth. In such a case, the mechanism of association of an individual with an "unbiased" eyewitness is triggered, which allows one to trust, experience the same feelings and empathize. The two emotions that are particularly affected are anger and fear.

5) The fifth method of manipulating public consciousness and behavior through the media is to artificially create the image of the enemy. This is done in order to rally the population against a certain threat. Announcing the presence of an enemy - external or internal - is to appeal to such an emotion as fear. In a state of fear, the population is ready to forget about everyday problems, emotionally tense, which allows the power structures to make unpopular decisions, and the leaders of the nation to control the masses.

This method is closely connected with the emotional charging of the masses. Recall that even Adolf Hitler called himself "the greatest actor in Europe" [9], because his performances were expressive, emotional and expressive. Indeed, people believe more in what is said emotionally, since the human psyche has a number of protective barriers that limit the flow of unwanted information, but information that is associated with an impact on feelings easily passes this barrier. The actualization of needs, interests, values, attitudes, expectations, which stimulates and motivates them to make a certain choice, be it a politician, a car or a political course – everything relies on emotional charging through the media, since it is the media that have access to the widest audience and the ability to model the right emotions on the screen, charging the masses.

6) The sixth tool of the media is the use of "opinion leaders", the so-called "new type of independent third party". Thus, the results of a study by Netnatives show an increase in the popularity of using “opinion leaders” by American companies to promote their brands: 80% of marketers recognize them as an effective marketing communication tool, since 62% of buyers aged 18 to 24 are ready to buy a product on their recommendation [15, p. eighteen]. The situation is similar in political communication: opinion leaders impose their opinion in various areas, while the information is not perceived critically, since the thought is allegedly voiced by an expert or a figure authoritative for a certain category of the population. As Primakov rightly suggests, “This regulation is carried out through various social mechanisms, such as: – purposeful dissemination of information and communication” [10, p. 204].

7) The method of "change of concepts". It is used in text techniques, both voiced and printed. All negative connotations are excluded from the text, which allows you to control the consciousness of the individual. V.V. Kikhtan and B.Yu. Mamieva give such an example of information impact when words such as “victim”, “war”, “destruction”, “death” are excluded from the text, and then words with a positive or neutral color are introduced in the text, for example, “appeasement”, “ conflict”, “neutralization”, “location”, “controversial situation”. Thus, the audience gets acquainted with artificial information” [8, p. 237].

8) The technology of adjustment to the inner self. This technology is based on the knowledge of such a property of the psyche as a person’s tendency to trust more information that does not contradict his inner convictions, his inner self. The human psyche is designed in such a way that if an individual internally critically disagrees with this information, then the channel for receiving it is blocked. On the contrary, information that does not contradict our internal beliefs is absorbed more readily. The media often use the technique of adjusting to the inner self, when a part of obviously false information is thrown into plausible information, which makes its perception automatically provided.

9) Purposeful "information assault". The purpose of the method is to bring down on the audience a lot of unnecessary information, which will make it difficult to critically perceive it. A person who is tired of the flow of unnecessary information will most likely stop believing in the media and be interested in the news, which makes it possible not to publish information that is undesirable for demonstration to the general public.

10) The “good against the background of the negative” method or the so-called contrast method. We are talking about creating and promoting perception stereotypes through contrast, when, first of all, they show and talk about something negative, against which the hero of the next story looks more advantageous. For example, a crisis is going on in the camp of political opponents, which is analyzed and criticized in detail, and the necessary information comes second – how everything is fine in our camp.

11) Method "our everyday life". We are talking about the technology of displaying and textual accompaniment of negative information in a normal, calm tone. The method is designed to accustom the audience to negative information, and the usual and calm, calm tone of the presenter teaches the layman to perceive negative information without criticism.

12) The technology of using false statistics, links to which are often used in the media. The goal is to erase the barrier of criticality among the population. Often this technology is supplemented by the use of selective opinions of "random people" from the crowd.

13) The technology of using the effect of psychological shock caused by the demonstration of certain horrors. This regulation is carried out in order to shift the focus in a situation of indignation and fear among the audience.

14) The method of substitution of concepts. It manifests itself with particular effect in the media when journalists deliberately draw false analogies. For example, comparing a political opponent with a maniac, an aggressor, a criminal, a Nazi, etc. Thus, the protesters definitely become criminals, officials become thieves, and so on.

15) Creation of a mythical event, a high-like virtual event. The purpose of this method is to evoke the desired reaction of the audience with deliberately false information. As rightly suggested by V.L. Primakov, “most often a banal provocation is used for this” [10, p. 218].

16) The method of "distracting factoids" or framing. A classic example is the dilemma “the glass is half empty / the glass is half full”: “when choosing each formulation, the meaning of the statement will not be distorted ... And this is achieved by varying the nature of the presentation (salience) of a particular plot” [7, p. 89]. We are talking about manipulative commenting on an event, when the core idea of the event is replaced and attention is focused exclusively on those aspects that are beneficial for the commentators to present.

17) Method of repetition. “A lie repeated a thousand times becomes the truth,” said Joseph Goebbels [12, p. 384]. For example, the repeated repetition of speculation about the corruption of a single politician will raise doubts about the honesty of the subject and, as a result, the public will no longer be interested in the true goals of the informant.

18) Identification of social groups with individuals, when a person is not aware of himself as a person and internally resigns himself to the fact that he, for example, is a pensioner, and pensioners “should” vote for the communists: “Pensioners are for the communists, youth is for the Liberal Democratic Party!”. These generalizations are designed to level the personality, to unite a certain group.

Conclusions. What we have listed is not a complete list of methods, methods and technologies that are used in the media to manipulate the political consciousness of the layman. In general, in order to maintain and direct mass communication in the right direction, the media are trying to form certain standards of media consumption that would ensure the formation of imposed ideas about reality, including political reality.

Media aggression in relation to the referent and addressee is usually explained by the conduct of information warfare by the counterparty, when "The opinion is substantiated that in the situation of information warfare, the influencing function of the media is the main one, relegating even the information function to the background" [8, p. . 236]. In turn, the ability to involve large masses in communication makes the process of influencing mass consciousness an extremely accessible process.

Thus, the media today have become the means, the tool by which the ruling class can influence large masses of the population, so the targeted manipulative impact on the consumer is now increasingly becoming the main function of the media. The media obey and fulfill the requirements of the entity/subjects to whom the control of communications belongs. Moreover, “concentrated targeted clumps of informational aggression, which ensure the fulfillment of ... politically large social, ideological and other (very often military) tasks” are finding great use” [6, p. eight]. And today we are witnessing the information impact on a wide audience, which is directed against Russia. In the course of these deliberate manipulations by the media, the image of Russia and its president is deliberately distorted and demonized.

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ПОДХОДЫ К СОВЕРШЕНСТВОВАНИЮ ФОРМИРОВАНИЯ ПЛАНОВ ДЕЯТЕЛЬНОСТИ ФЕДЕРАЛЬНЫХ ОРГАНОВ ИСПОЛНИТЕЛЬНОЙ ВЛАСТИ

APPROACHES TO IMPROVING THE FORMATION OF ACTIVITY PLANS OF FEDERAL EXECUTIVE AUTHORITIES

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Аннотация

В статье рассматриваются актуальные вопросы институциональных преобразований в структуре функциональных задач органов исполнительной власти. В результате анализа функциональных задач федеральных органов исполнительной власти сформулированы выводы о необходимости усиления контрольно-надзорной деятельности и об упорядоченности нормативных правовых актов РФ.

Обсуждение. В статье аргументированы выводы по определению точек взаимодействия функционала ФОИВ с результатами нацпроектов. Ключевыми решениями явились: задачи по закреплению основной «точки взаимодействия» – горизонта планирования бюджетных инвестиций, которое является атрибутом оценки эффективности партнерства государственных органов с исполнителями национальных проектов. Исследование всех точек взаимодействия функционала ФОИВ с результатами нацпроектов позволило установить типы связей функциональных изменений в полномочиях государственных органов.

Заключение. Определена роль федеральных органов исполнительной власти при формировании и контроле достижения целевых показателей документов стратегического планирования РФ. Разработаны практические рекомендации по совершенствованию процесса формирования планов деятельности федеральных органов исполнительной власти.

Ключевые слова: государство, государственные органы, органы исполнительной власти, национальная экономика, результативность.

Abstract

The article deals with topical issues of institutional transformations in the structure of functional tasks of executive authorities. As a result of the analysis of functional tasks of federal executive authorities, conclusions are formulated on the need to strengthen control and supervisory activities and on the regularity of regulatory legal acts of the Russian Federation

Discussion. The article substantiates the conclusions on determining the points of interaction of the FOI functionality with the results of national projects. The key solutions were: tasks to consolidate the main «point of interaction» – the horizon of budget investment planning, which is an attribute of evaluating the effectiveness of partnership between government agencies and the executors of national projects. The study of all points of interaction of the FOIV functionality with the results of national projects made it possible to establish the types of connections of functional changes in the powers of state bodies.

Conclusion. The role of federal executive authorities in the formation and control of the achievement of targets of strategic planning documents of the Russian Federation is determined. Practical recommendations have been developed to improve the process of forming plans for the activities of federal executive authorities.

Key words: state, state bodies, executive authorities, national economy, effectiveness.

Introduction. In the modern system of national strategic planning, the executive authorities of the Russian Federation mediate government decisions to determine the quantitative and qualitative criteria for assessing the effectiveness of achieving the country's long-term economic goals as part of improving the state industrial policy. At the same time, the state economic policy should be aimed at increasing the effectiveness of priority national projects being implemented in Russia.

From the standpoint of a modern state, the evolutionary process based on the principle of expanding the functionality of the federal executive authorities without linking the scope of their powers to the results of the implementation of state programs, federal and national projects is not able to ensure the proper level of quality of public administration, taking into account the effectiveness of the administrative reform [1], implemented in Russia.

The largest number of strategic documents implemented under the auspices of the federal executive authorities falls on state programs: the National Project "Ecology" – 27.27%, the National Project "Education" – 18.18% (Figure 1).

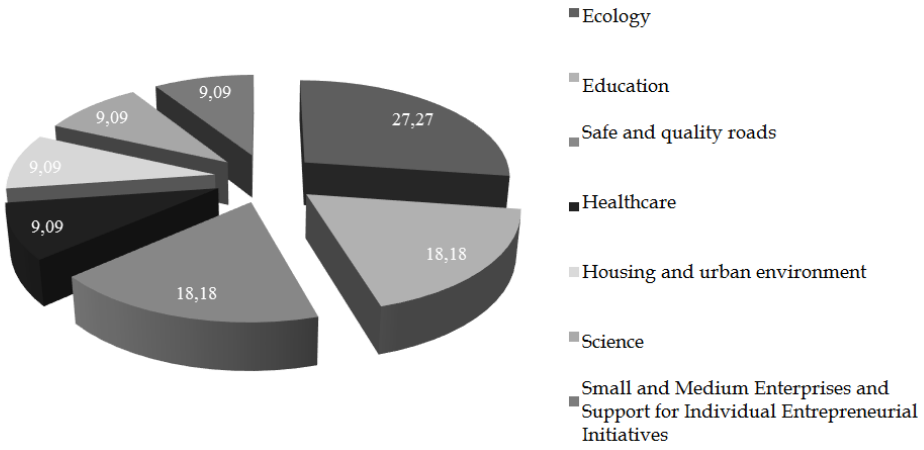

Figure 1. The structure of national projects in 2021,%
Source: compiled by the author according to [2].

The number of state programs implemented within the framework of national projects and the number of plans of the federal executive authorities may not correspond in structure and content, which gives rise to a number of problems in terms of unification and harmonization of long-term strategic guidelines for the development of the national economy.

Materials and methods. The decomposition method allowed us to identify several levels of formation of strategic planning documents, including: federal, sectoral and territorial levels, as well as levels of strategic forecasting, planning of subjects of the Russian Federation and municipalities (Table 1).

Table 1 – Indicators of strategic planning documents

Name of documents	Indicators	The role of participation of federal executive authorities
FEDERAL LEVEL		
Annual Address of the President of the Russian Federation to the Federal Assembly of the Russian Federation	The amount of federal budget funds for fundamental research until 2024 is 1,630 billion rubles. The growth rate of harmful emissions into the atmosphere in 2024 compared to 2021 is 80%. The share of modern weapons and equipment in the troops in 2024 is 76% [3]	Compliance with the procedures for the allocation and development of state support funds for scientific and technological development and the country's defense security
Economic Security Strategy of the Russian Federation	Growth in labor productivity. Growth of GDP per capita. Growth of investment in fixed assets. Growth in the share of innovative goods in the volume of exports of industrial production [4]	Protection of national interests and strategic national priorities of Russia
Strategy of scientific and technological development of the Russian Federa-	Growth in the volume of technology and high-tech escorts by 2025. The share of spending on research and development is at least 2% of GDP by 2035 [5]	Overseeing the status and implementation of long-term science and technology strategies

Name of documents	Indicators	The role of participation of federal executive authorities
tion		
INDUSTRY AND TERRITORIAL LEVEL		
Industry documents of strategic planning of the Russian Federation	Growth of interbudgetary transfers from the federal budget to the pension system to ensure its balance by 2030 to 103% of GDP. The increase in the average size of the old-age labor pension to 3 subsistence minimums for a pensioner [6]	Regulation of interbudgetary relations and improvement of the quality of life of the population of the territory
RF Spatial Development Strategy	The growth rate of GRP by 2025 is 103.7%, the index of export growth from transit traffic in 2025 compared to 2017 is 143% [7]	Federal executive authorities control over the production specialization of the constituent entities of the Russian Federation, monitoring the activities of macroregions and promising centers of economic growth
LEVEL OF STRATEGIC FORECASTING		
Forecast of scientific and technological development of the Russian Federation	Growth rate of new mining equipment. Index of growth of environmentally friendly materials. Minimization of production waste [8]	Participation of federal executive authorities in the development and implementation of promising areas of scientific research
LEVEL OF STRATEGIC PLANNING AND PROGRAMMING		
Spatial planning schemes of the Russian Federation	Index of growth by 2030 of the design capacity of nuclear, hydro - and power plants [9]	Supervision of federal executive authorities over the performance of nuclear and hydroelectric power plants
Action plans of federal executive bodies	The growth rate of investment in fixed assets by 2024 is 105.3%. The share of organizations implementing technological innovations by 2024 is 50% [10]	Monitoring of intermediate, final results of the execution of strategic planning documents [11]
LEVEL OF STRATEGIC PLANNING OF SUBJECTS OF THE RUSSIAN FEDERATION		
Scheme of territorial planning of the subject of the Russian Federation	The total number of settlements, the level of maturity of the settlement system of the constituent entities of the Russian Federation, the number of areas with disturbed natural complexes [12]	Formation of state registers, cadastres and territorial balances of reserves by the management bodies of property relations in the region, housing and communal services, industry and energy, education, etc.
LEVEL OF STRATEGIC PLANNING OF THE MUNICIPALITY		
Municipal programs	The growth rate of the efficiency of integrated development of the territory, the growth index of the volume of commissioning of new housing and non-residential facilities, the growth in the share of reconstructed buildings in the municipal district [13]	Control at the level of executive authorities over the results of the process of formation of new built-up areas for the purpose of their development with the adjustment of the address list of promising construction sites in the municipality

Source: compiled by the author according to [14].

An assessment of the current activity plans of federal executive authorities showed that the long-term targets for economic development, predicted on the basis of direct intervention of government agencies in the innovation environment of economic entities, are at odds with macroeconomic indicators. Especially the imbalance of indicators of strategic planning documents at the federal level and at the level of plans of federal executive authorities (Plan of activity of the Ministry of Economic Development of the Russian Federation for the period 2019 - 2024) is observed according to such criteria for the effectiveness of economic development as: the growth rate of investment in fixed capital, gross value added, export growth rate.

Meanwhile, federal executive authorities form their own management decisions, which may contradict other initiatives put forward within the powers of state bodies. For example, while supervising projects for the implementation of special investment contracts (hereinafter referred to as SPICs), which provide state incentives for high-tech mass production of target products, organized on the basis of the introduction of modern "breakthrough" technologies, the Ministry of Industry and Trade of Russia, at the level of its strategic plans, provides for a minimum investment under SPICs in the amount of 750 million rub. However, the Ministry of Finance of Russia, as part of its strategic plans, initiates the need to increase the minimum investment in SPIC projects to 1 billion rubles. It is quite obvious that the requirement to increase the basic amount of capital investments by 250 million rubles, or 33.3%, as part of the application of such an instrument of Russian industrial policy as a special investment contract, allows the Ministry of Finance of the Russian Federation to restrict access to budget investments, creating conditions more rational use of them within the national budgetary policy. This is explained by the fact that today "... the Russian Ministry of Finance proposes to increase the "entrance threshold" for concluding a SPIC to 1 billion rubles, while not taking into account borrowed funds and funds received from the implementation of an investment project under a SPIC…" [15].

An assessment of the current level of concentration of industry spending of the federal budget for the implementation of national projects and government programs in 2021 is shown in Figure 2.

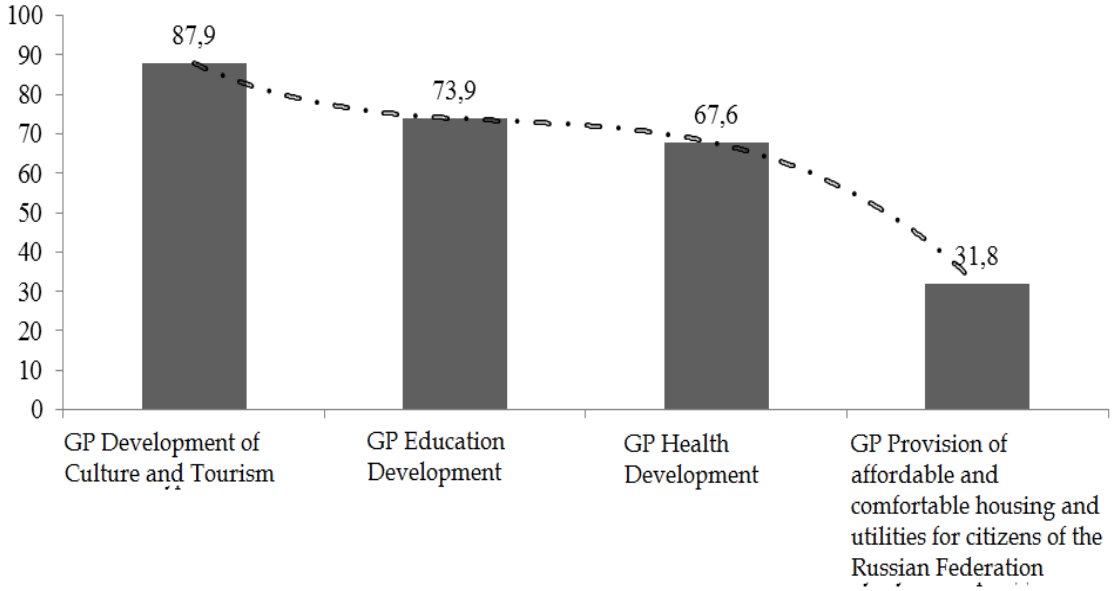

Figure 2. Estimation of the current level of concentration of sectoral expenditures of the federal budget for the implementation of national projects and government programs in 2021, %

Source: compiled by the author according to [2].

The share of budget expenditures varies from 31.8% when financing the state program "Provision of affordable and comfortable housing and utilities for citizens of the Russian Federation" to 87.9% under the State Enterprise "Development of Culture and Tourism".

A number of authors: Shabaev V.A., Govorin D.A. notes that "the goal-orientedness of public authorities is determined by assessing their organizational activities and their target orientation ..." [16]. The target and territorial orientation of decisions made by state bodies provides for the need to take into account the coefficients that determine regional specifics.

Based on the analysis of *territorial planning schemes* at the level of subjects of the Russian Federation and municipalities, the following areas of activity of federal executive authorities can be identified:

– control and analysis *concepts spatial development subjects of the* Russian Federation and municipal formations with the definition priorities spatial organizations ;

– monitoring and diagnostics forecast values restrictions use territories subjects of the Russian Federation and municipal formations ;

– agreement and approval budgetary forecasts on the long-term period and adjustment *regional programs development and concepts municipal formations* .

All these strategic planning documents are subject to harmonization as part of the application of the program-target method when calculating the effectiveness of the implementation of national projects for the economic development of Russia.

Results and discussion . In order to determine key areas for improving the functions and powers of executive authorities that meet the indicators of strategic planning documents, it is important:

– development approaches to establishing logical connections between volume authorities of the federal executive authorities and the number achieved long-term targeted landmarks on indicators strategic planning Russia ;

– grade analytical dependencies macroeconomic indicators from amplification controlling functions of federal executive authorities in part regulation results strategic planning economy ;

– production practical recommendations on definition systemic measures taken by federal executive authorities for improvements economic and information performance national economy .

The emergence of "bottlenecks" in the functioning of federal executive authorities is due to the irrationality of subordination schemes in sectoral departments (Table 2).

Table 2 – Causes and consequences in the event of "bottlenecks" in the current system of the federal executive authority's functionality

Problems of the current functionality of the authorities	The reason for the problems in the powers of federal executive authorities	Example of control and supervision activity	Conclusion
Difficulties in delimiting the functions of supervision and control in practice	Ambiguity and lack of clarity in the interpretation of key areas of activity of government agencies	Grant of a license. Option 1 – license as a document. The *process is considered as a public service.* Option 2 – a license as a tool (form) of control. Licensing is a way to establish compliance of a specific activity with the requirements of the law	One and the same instrument of public administration can be applied from the standpoint of different functions of executive authorities
Giving state powers of an	Legislated right for individual legal enti-	Assignment of power functions to legal entities that are not fed-	The same functionality belongs

Problems of the current functionality of the authorities	The reason for the problems in the powers of federal executive authorities	Example of control and supervision activity	Conclusion
executive and administrative nature to individual legal entities	ties in terms of: adoption of regulatory legal acts of the Russian Federation	eral executive authorities, but have the powers of state administration, control and supervisory processes: PFR, MHIF	to both federal executive authorities and other government agencies

Source: compiled by the author according to [17].

Currently, "…the rise of the executive power…" is taking place, which reflects the increasing influence of the decisions of the federal executive authorities on the implementation of "…a huge amount of tasks that modern governments deal with…" [18]. At the same time, the key economic indicators underlying the comparison of management procedures aimed at improving the quality of state programming allow us to once again emphasize the importance of the project approach to the management of national projects.

The formation of national projects is carried out for a six-year period, therefore, the most important criterion for the effectiveness of strategic planning is: the planning horizon of budget investments. The shorter the budget investment horizon, the lower the risk and the more stable the result of the effectiveness of strategic planning in Russia. The study of all points of interaction between the functional of federal executive authorities and the results of national projects allowed us to establish the types of links between functional changes in the powers of state bodies in accordance with the goals of national projects implemented in the Russian Federation (Table 3).

Table 3 – Features of the functional of federal executive authorities depending on the goals of the implementation of national projects

Communication direction	Communication type	Functions of federal executive authorities
National targets	Sustainability of economic development	Supervision of budget allocations for national projects
Regional Goals	Spatial development	Elimination of administrative barriers
Investment goals	Project management	Training of personnel for the management of national projects
Industry Goals	Achieving economic growth	Subsidy cost control
Other functional purposes	Improving the quality of public administration	Analysis of the concentration of resources in the areas of state policy implementation

Source: compiled by the author according to [19].

Based on the results of the study, it can be seen that the targets of federal executive authorities are very limited and are of a general nature.

In the system of interdepartmental relations, the "points of growth" in the effectiveness of control over national projects of the Russian Federation are estimated indicators in conjunction with the volumes of interbudgetary transfers (Figure 3).

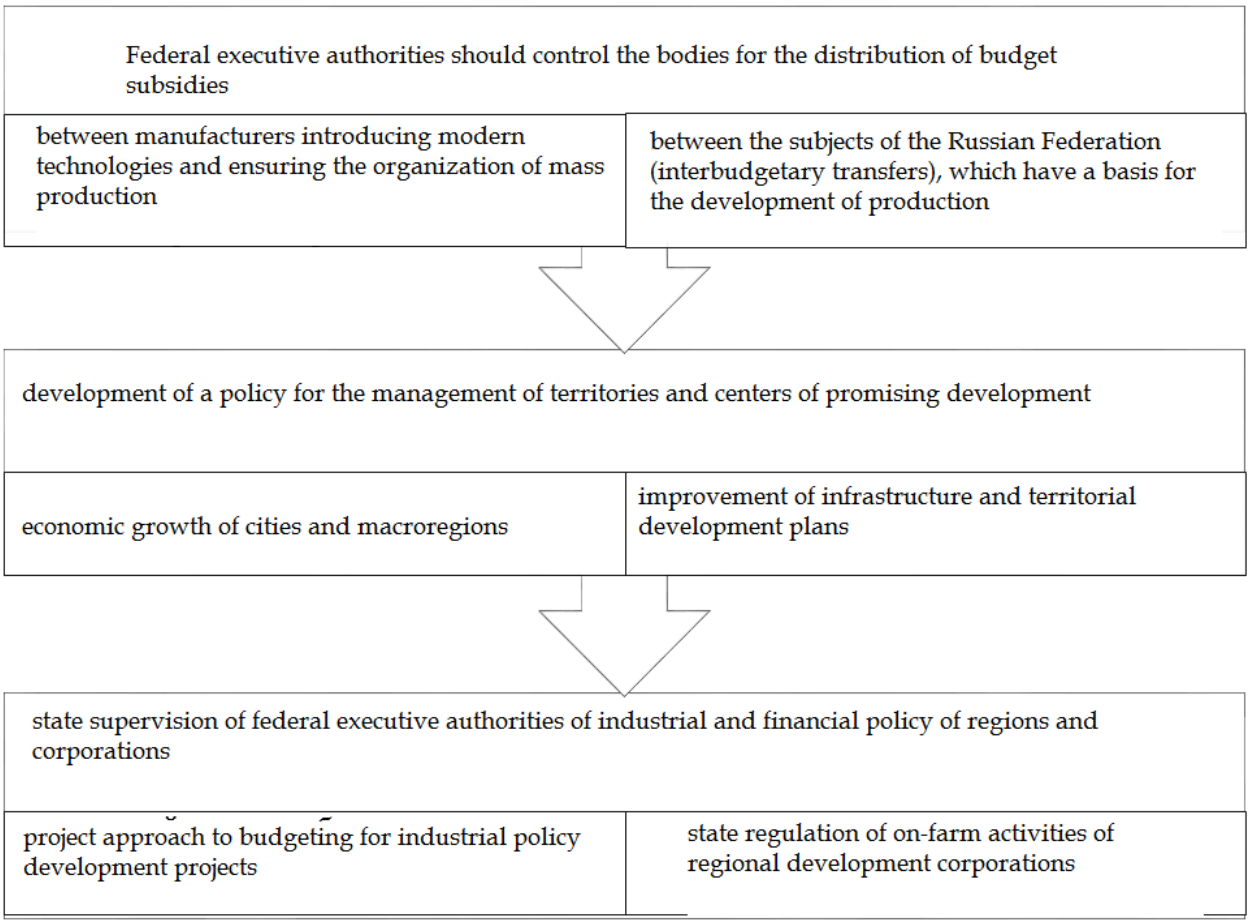

Figure 3. Improving the formation of activity plans for federal executive authorities
Source: compiled by the author

Recommendations for the development of state policy for the formation of long-term targets for planning the activities of federal executive authorities with the allocation of centers of strategic responsibility are: tools for control, monitoring and redistribution of budget subsidies between Russian producers and regions that have a sufficient base for self-sufficiency in raw materials; development of a policy for managing the development of territories based on the target – the growth of the economy of urban and rural infrastructure complexes; mechanisms of project goal-setting and budgeting for subsidizing corporations of regional development and national industrial policy.

As part of the practical recommendations that we offer for a possible strategic choice of state decisions in the field of improving the plans of federal executive authorities, the existence of "interaction points" between regional, municipal and federal authorities becomes obvious in terms of: choosing the scope and competencies of state financial supervision; determining the portfolio of strategic plans, including the forecast of the activities of subordinate budgetary and state institutions; increasing economic efficiency based on optimizing the planning horizon of budget subsidies.

Conclusion . The study of cause-and-effect relationships in the system of problem areas for regulating the activities of federal executive authorities allowed us to identify 2 major problems, the solution of which is possible in the event of modernization of the legislation of the Russian Federation in terms of the distribution and legal consolidation of administrative competencies between state bodies.

The first problem boils down to the lack of a clear mechanism for delimiting in practice the functions of supervision and optimization of lawmaking.

The second problem is the discrepancy between executive and administrative measures, the right to implement which is available to both federal executive authorities and public law entities

that perform functions that are not related to direct supervision of the results of public administration, but assist in making decisions to improve the system provision of public services (for example, state off-budget funds).

In addition, "... the incompleteness of federal relations has provided the regions with excessively complex management tasks for them ..." [17].

It should be noted that in order to solve the identified problems, government agencies can focus not on the economic, but on the political component. An important role is played by the strengthening of the control and supervision activities of the federal executive authorities and on the orderliness of the regulatory legal acts of the Russian Federation, which contain key indicators of the effectiveness of spatial and territorial development to ensure transparency of the results of the execution by state bodies of their planned functional tasks.

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ФАКТОР ТАЛИБАНА[1] В ПОЛИТИЧЕСКОЙ ЖИЗНИ АФГАНИСТАНА

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THE THE TALIBAN FACTOR IN THE POLITICAL LIFE OF AFGHANISTAN

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Аннотация

Статья посвящена анализу событий, последовавших в Афганистане после вывода войск США. Актуальность подобных исследований обусловлена критически важными событиями, связанными с налаживанием дипломатических мостов между Моской и Кабулом. Сформулирован ряд основных выводов: 1) Талибы продолжают испытывать серьезные проблемы с обеспечением экономической стабильности в стране, так как санкции, объявленные рядом мировых правительств в адрес Афганистана, привели к тому, что Афганистан потерял две трети своих финансовых поступлений от международного сообщества; 2) Кабул ведет активные переговоры о беспошлинных поставках в Россию фруктов и минералов, а взамен готов закупать газ, нефть и продукты нефтепереработки; 3) Легитимность афганских властей и их конструктивное сотрудничество с внешним миром находятся в прямой зависимости и от скоординированности политики международного сообщества в отношении сложной внутриполитической ситуации в Афганистане.

Ключевые слова: Афганистан, политические процессы Афганистана, США, НАТО, ООН, «Аль-Каида»[2], «Исламское государство»[3], «Талибан»[4], идеология талибов, Центральная Азия, международный терроризм, наркотрафик, миграционные потоки, линия Дюранда

Abstract

The article is devoted to the analysis of the events that followed in Afghanistan after the withdrawal of US troops. The relevance of such studies is due to critical events related to the establishment of diplomatic bridges between Moscow and Kabul. A number of main conclusions are formulated: 1) The Taliban continue to experience serious problems with ensuring economic stability in the country, as the sanctions announced by a number of world governments against Afghanistan have led to the fact that Afghanistan has lost two-thirds of its financial revenues from the international community; 2) Kabul is actively negotiating duty-free supplies of fruits and minerals to Russia, and in return is ready to purchase gas, oil and refined products; 3) The legitimacy of the Afghan authorities and their constructive cooperation with the outside world are directly dependent on the coordinated policy of the international community regarding the difficult domestic political situation in Afghanistan.

Keywords: Afghanistan, political processes of Afghanistan, USA, NATO, UN, Al-Qaeda, Islamic State, Taliban, Taliban ideology, Central Asia, international terrorism, drug trafficking, migration flows, Durand line

Введение. Организация «Талибан» признана террористической и запрещена на территории РФ решением Верховного Суда от 14 февраля 2003 г. [7] Возникнув в 1994 году, «Талибан», будучи радикализированным исламистским движением, вошел в политическую историю как союз сторонников введения жесткого исламистского законодательства и занял свое прочное место на политической арене на многие десятилетия вперед. Совет безопасности ООН жестко отреагировал на становление «Талибана», который получал поддержку от Пакистана и главаря террористической группировки «Аль-Каиды» Усамы бен Ладена, и создал «Комитет по санкциям в отношении «Аль-Каиды» и движения «Талибан».

[1] Запрещенное движение в Российской Федерации организация
[2] Запрещенная в Российской Федерации организация террористическая группировка
[3] Запрещенная в Российской Федерации организация
[4] Запрещенная в Российской Федерации организация

Костяк движения первоначально составили афганские беженцы-пуштуны на территории Пакистана во время войны 1979-1989 гг. в Афганистане. Специализированное обучение в медресе Пакистана для беженцев войны способствовало сплочению «студентов» (название «Талибан» происходит от арабского «талиб» - ученик, учащийся). Особенно активно внимание мировой общественности было обращено к движению «Талибан» в октябре 1994 г., когда члены группировки «Талибан» отбили караван с товарами, принадлежавший торговым кругам Пакистана от нападения моджахедов, зарабатывавших себе на хлеб вооруженными нападениями на грузы, пересекавшие границу. После защиты торговых обязательств Пакистана, отряды талибов двинулись на Кандагар, находившийся под диктатом воюющих между собой группировок моджахедов. После двух лет анархии и междоусобиц моджахедов, «Талибан» сумел обеспечить в Кандагаре относительный мир, что детерминировало интерес местного населения к «Талибану». Специалист в области идеологии «Талибана», английский исследователь Питер Саймондс предполагает, что успехам талибановцев дополнительно способствовали щедрые взятки командирам вооруженных формирований моджахедов [32].

Методы, результаты и обсуждение. Первая политическая задача радикального движения «Талибан» была амбициозной - добиться отстранения от власти действующего президента Афганистана Бурхануддина Раббани и заменить афганское правительство – то есть смена власти в соседнем государстве. Исторические события складывались удачно для талибановцев - распад Советского Союза ослабил правительство Демократической Республики Афганистан, экс-президент которой, Мохаммад Наджибулла, 49-летний врач по образованию, лишился внешней поддержки, был свергнут моджахедами и скрывался в здании представительства ООН. Первые военные столкновения афганских правительственных войск с отрядами талибов произошли осенью 1994 г. и были успешны: зимой 1994-1995 гг. талибы взяли под контроль почти половину Афганистана и вплотную подошли к Кабулу. Воспользовавшись безвластием, 27 сентября 1996 г. религиозно-политическое военизированное движение «Талибан» практически без боя захватило столицу Афганистана Кабул, экс-президент и его брат были похищены из здания правительства ООН, подверглись пыткам, без судебного разбирательства были убиты и вывешены на всеобщее обозрение.

Генеральная ассамблея ООН выступила с осуждением произошедшего, но талибы, вовлеченные в процесс захвата власти, заявили, что убили «убийцу нашего народа» и вскоре провозгласили основание Исламского Эмирата Афганистан, отличавшегося насаждением жестокого исламизма «по нормам шариата» [28]. Таким образом, начиная с 1996 года и по 2001 год талибы находились у власти, признанные в качестве легитимного правительства только Пакистаном, Саудовской Аравией и Объединенными Арабскими Эмиратами [7]. Действующий президент Афганистана - Бурхануддин Раббани, таджик по национальности, под угрозами физической расправы со стороны талибов покинул Кабул, жил в Файзабаде, затем поселился в Душанбе (Таджикистан). Тем не менее, периодом правления Бурхануддина Раббани считаются годы с 1992 по 2001 гг., так как он все это время, пока не подал в отставку в 2001 г., оставался главой Афганистана, официально признанным международным сообществом.

Совет безопасности ООН жестко отреагировал на становление «Талибана», который получал поддержку от Пакистана и главаря террористической группировки «Аль-Каиды» Усамы бен Ладена, и создал «Комитет по санкциям в отношении «Аль-Каиды» и движения «Талибан» [7]. Но полиэтничный Афганистан, входящий в геополитические интересы супердержав и региональных государств, к концу XX века находился в состоянии анархии и нестабильности, экономического и политического кризиса. Это было государство, где власть главы государства из-за вмешательства талибов в деятельность государственных структур и властные решения в течение пяти лет (с 27 сентября 1996 по 13 ноября 2001) не распространялись на территории Афганистана.

Надо сказать, что среди населения Афганистана талибы все же снискали славу нестяжателей и борцов с несправедливым правосудием. Исследователи отмечают, что, несмотря на создаваемый в иностранных СМИ образ кровожадного убийцы, талибы избегали кровопролития, что способствовало поддержке населением, уставшего от постоянных войн, курса «борцов за справедливость», который провозгласили талибы с целью восстановления мира и освобождения страны от междоусобных войн и соперничающих группировок. В итоге «Рост поддержки населения позволил «Талибану» значительно увеличить свою армию (до 50 тыс. человек в 1997 г.)» [31].

Отметим, что афганцы в большинстве своем поддерживали жесткое толкование талибами шариата, судя которому женщинам запрещено получать образование, работать, предписывается вести домашний образ жизни, не выходить без сопровождения и одеваться в длинное покрывало. Соответственно требованиям талибов мужчины должны носить длинные бороды и вне дома тюрбан. Экстремистское толкование шариата проявлялось в практике публичных казней, отрубании кистей рук ворам, арест и наказание за неучастие в общей молитве, запрет на изображения, музыку, песни. Тем не менее, талибы только декларативно запретили выращивание мака и торговлю наркотиками, так как учитывают, что эта статья дохода часто единственная у большинства населения. Опиум производится в десяти из 32 провинций страны, а продажа опия облагается налогом в 15-30%, что приносит талибам годовой доход в 15 млн. долларов (при общей сумме бюджетных поступлений в 80 млн. долларов) [30].

По сообщениям Управления ООН по наркотикам и преступности, производство опиумного мака в Афганистане в 2006 г. достигло 6,1 млн. т, что почти в полтора раза больше, чем в 2005 г., а нркопроизводители получили доход в размере 755 млн. долл. В 2006 г. в провинции Гильменд было произведено 46% общего объема опиумного мака, 8% - в Кандагаре, 25% - в северных районах Афганистана, граничащих с Таджикистаном, Узбекистаном и Туркменистаном. Согласно докладу ООН, производство опиумного мака возросло в районах продолжающихся боевых действий - Кандагаре и Гильменде, где коалиционные силы понесли 2/3 от общего числа потерь, причем эти потери возрастают в период сбора урожая мака. Известно также, что не менее 139 акций смертников в Афганистане было профинансировано за счет доходов от производства наркотиков [12, 126]. Таким образом, угроза трансфера наркотиков из региона Центральной Азии прямо связана, в том числе, и с низкой функциональностью талибов как государственных структур, способных бороться с выращиванием опиума.

Исследовательский интерес вызывает отношение и возможная конкуренция «Талибана», «Аль-Каиды» и «Исламского государства» (ИГ)[5]. «Талибан», который придерживается ракализированных законов шариата и заявляет о своей приверженности кодексу пуштунов, тем не менее, разделяет ряд идеологизированных концепций джихада (в понимании беспощадной борьба с врагами ислама), группировки «Аль-Каида». Талибановцы установили строгий кодекс поведения, запрещая телевидение и видео, насаждают определенный дресс-код и регламентированный образ жизни для населения.

Далее рассмотрим отношение талибов к линии Дюранда, проведенной в 1893 г., легитимность которой как в правительственных кругах Афганистана, так и среди широких слоев населения не признается изначально. Линия Дюранда – официально не установленная 2640-километровая граница между Афганистаном и Пакистаном - стала основным источником напряженности между Исламабадом и Кабулом с момента основания Пакистана в 1947 году, после искусственного раздела Британской Индии, когда к Пакистану отошли районы с численным преобладанием мусульманского населения.

Наследие колониального прошлого осложняет отношения двух стран – Афганистана и Пакистана до настоящего времени, и «никаких перспектив решения этого вопроса не

[5] Запрещенные в Российской Федерации террористические организации

предвидится» [14], так как наблюдается трансформация регионального порядка, вызванная, с одной стороны, тем, что пуштуны вынуждены проживать по обе стороны афгано-пакистанской границы («линии Дюранда»). Соответственно, пуштуны вынуждены находиться в статусе «разделенной нации». Осложняет ситуацию государственная позиция афганской стороны, «де-юре» не признающей «линию Дюранда» [16]. Как пишут А. Дхар, Т. Понька, П. Дхар, «Уже в самые первые годы с момента создания государства Пакистан, Афганистан категорически выступал против признания линии Дюранда границей между Афганистаном и Пакистаном» [8, 96], что вынудило Афганистан голосовать против членства Пакистана в ООН еще в 1947 г.

Со стороны талибов в период первого пребывания у власти (с 1996 года и по 2001 год), вопрос о границе между Пакистаном и Афганистаном не поднимался. Предполагается, что «талибы не знали историю вопроса и политические интересы Британской Индии в регионе, поэтому будучи ограниченными лишь экстремистской «идеологией», оставили данный вопрос» [8, 98].

На наш взгляд, причина столь равнодушного восприятия талибами линии Дюранда кроется в том, что талибы традиционно используют территорию Пакистана в качестве областей, где расположены лагеря для временного убежища. Более того, как справедливо замечают эксперты центра Льва Гумилева, «большинство лидеров движения проживают на территории Пакистана, это месторасположение обучающих баз, основное место для отдыха и оздоровления, а также место реабилитации раненых бойцов» [17]. Таков прозаичный ответ на показательное равнодушие со стороны руководства «Талибан» на проблему границы, протяженность которой составляет треть пограничной полосы Афганистана. И в условиях, когда на значительные отрезки границы стоит всего лишь один пограничный пункт (всего 20), а граница протяженностью в 2400 км в целом не имеет ни ограждений, ни опознавательных линий, [17] - говорить о сложности пересечения такой границы не стоит, чем и пользуются боевики «Талибан», контрабандисты, наркокурьеры, моджахеды и др.

После нападения «Аль-Каиды»[6] на башни-близнецы в Америке в 2001 году, движение «Талибан», носитель идеологии экстремизма и имевшее властные позиции в Афганистане в течение пяти лет, совместно с международной террористической группировкой «Аль-Каида»[7] были подвергнуты преследованиям со стороны блока НАТО. Совместные антитеррористические действия в Афганистане проводились силами контингента Международных сил содействия безопасности (МССБ) в Афганистане (International Security Assistance Force ISAF) под командованием представителей НАТО, действовавший в соответствии с резолюцией № 1386 Совета Безопасности ООН от 20 декабря 2001 года.

Операция, носившая военный характер, руководимая и координируемая из США, успешно выполнила задачу уничтожить террористов совместно с Усамой бен Ладеном, но разрозненные группировки экстремистов-талибов и террористов из «Аль-Каиды»[8] скрылись в горах Пакистана, переходя к тактике ведения партизанской войны. При этом сторонники «Талибан»[9], функционировавшие как властные структуры, потеряли на некоторое время власть, сохранив за собой свою основную военную силу [5]. Как следствие, Нуристан - восточная провинция Афганистана, граничащая с Пакистаном, - превратилась в талибскую республику.

28 декабря 2014 года возглавляемая Соединенными Штатами миссия НАТО в Афганистане была завершена и на территории афганского государства остались около 10 тыс. солдат американского контингента и около 3 тыс. солдат НАТО. Завершение самой длительной военной операции в истории США настало 31 августа 2021 года, и, по словам американского лидера Дж. Байдена, завершение операций НАТО «Страж свободы» и «Реши-

[6] Запрещенные в Российской Фдерации террористические организации
[7] Запрещенные в Российской Фдерации террористические организации
[8] Запрещенные в Российской Фдерации террористические организации
[9] Запрещенные в Российской Фдерации террористические организации

тельная поддержка» означало, что основная миссия союзников в Афганистане выполнена: были предотвращены террористические атаки на Америку [1].

За выводом войск коалиции и США последовало закономерное оживление боевиков движения «Талибан», которые выстроили линию противостояния афганским правительственным силам и захвата государственной власти. При этом талибы использовали риторику заверений об отсутствии стремления узурпировать власть, о ненарушении границ государств Центральной Азии (при условии невмешательства в дела Афганистана), о безопасности дипломатических миссий и т.д. [11]

Несмотря на внутреннюю разобщенность и отсутствие четкого плана и понимания ориентиров политического управления страной, «Талибану» удалось захватить власть в Афганистане в короткие сроки, в то время как президент Афганистана Ашраф Гани был вынужден покинуть страну [15] в то время, как северные полевые командиры совместно с правительственными силами не смогли организовать противодействие экстремистским силам.

Новая власть в лице талибов в первую очередь заменила афганский национальный трехцветный флаг на белый флаг движения, установив обязательность его использования в стране и за рубежом [22], запретила носить одежду зеленого и красного цветов (цвета бывшего афганского флага), ввела раздельное посещение парков развлечений для мужчин и женщин [23] и продолжает насаждать жесткие экстремистские правила с насильственной выдачей местных жительниц замуж за боевиков [24]. Эксперты предполагают, что далее стоит ожидать пуштунизацию населения и усиления репрессий в отношении политических противников [25].

Таким образом, обещания талибов на первой пресс-конференции после захвата власти отказаться от насилия, обеспечить свободу слова в СМИ, соблюдать права и свободы женщин, не разделять и не создавать конкуренцию этнических групп, соблюдать плюрализм в деятельности политических фракций – не говорит о действительном смягчении идеологии талибов. Талибы продолжают опираться на элементы радикального фундаментализма и пуштунского социального кодекса (пуштунвали), который ориентирован на жесткое соблюдение норм шариата в понимании радикалов.

Далее обратим внимание на стремление талибов решить институциональный кризис, так как управление государством требует определенных навыков управления бюрократическим аппаратом, выстраивания логистических цепочек, налаживания институтов власти. Талибы сократили государственный аппарат на 80 процентов и не лояльно относятся к образованной части населения, считая последних конкурентами во власти, поскольку костяк «Талибана»[10] составляют сельские жители. Соответственно, талибов не поддерживают пуштуны – городские жители, этнические группы узбеков, хазарейцев, таджиков и др., а также женщины Афганистана, которые организовали антиталибское сопротивление в северной, западной и центральной частях Афганистана [26].

Омар Нессар, директор Центра изучения современного Афганистана, правомерно предполагает, что талибы используют популистские обещания, и что в целом это не правительство, а запрещенная группировка, захватившая власть [4]. Солидарен с экспертом и востоковед-арабист и эксперт в области развития стран Ближнего Востока и Северной Африки А. Чупрыгин, что идеология «талибана» представляет собой угрозу современному светскому государству «вне зависимости от того, где оно находится» [4].

Одновременно представители талибов заявляют мировому сообществу, что не дадут действовать в Афганистане «Аль-Каиде» и «Исламскому государству» (запрещенные в России террористические организации). Тем не менее, точечные расправы над недовольным режимом талибов усиливает движение сторонников светского правления из Фронта нацио-

[10] Запрещенные в Российской Фдерации террористические организации

нального сопротивления во главе с Ахмадом Масудом, равно как и силы «Исламского государства», накапливающего свой потенциал на территории Афганистана.

Таким образом, движение «Талибан», который смог свергнуть правительство и повторно создать собственную структуру власти после ухода американских войск в 2021 г., на сегодняшний день в качестве государственной власти не создало конкретный тип управления, не выработало конкретный руководящий принцип и в целом не имеет четкого понимания того, как должно быть устроено политическое управление страной.

Талибы продолжают испытывать серьезные проблемы с обеспечением экономической стабильности в стране, так как санкции, объявленные рядом мировых правительств в адрес Афганистана, привели к тому, что Афганское государство лишилось основной части финансовых поступлений от международного сообщества – около 65% [13]. Галопирующая инфляция привела к росту стоимости доллара, и за пять месяцев власти талибов афгани упал в цене с 80 единиц до 120. В условиях, когда даже бойцы и низовые командиры получают жалование продуктами питания, Всемирная продовольственная программа вынуждена констатировать, что «в 2022 году две трети афганцев будут критически зависеть от иностранной помощи» [18].

Сложилась ситуация, когда афганцы пытаются массово эмигрировать в соседние страны, и, по сведениям ООН, только за 2021 год **покинули свои жилища 550 тыс. афганцев. Но судьба беженцев зависит от лояльности Пакистана, Ирана, Таджикистана, Узбекистана и других государств мира.** Так, не все пограничные с Афганистаном государства стали пускать афганских беженцев на свою территорию. Если Таджикистан декларирует, что он руководствуется принципом «гуманизма и добрососедства» и пропускает беженцев, то Узбекистан заявил о неприкосновенности своих границ и выдворяет беженцев обратно или помогает им с транзитом [10]. Иран разрешил развернуть палаточные лагеря в трех провинциях, около 4 млн. афганцев находится в Турции [19], Россия также предоставила возможность для въезда в страну тысячам афганцам [20].

Но российская экспертная мысль не всегда настроена пессимистично в отношении проблем, связанных с приходом талибов к власти. Так, мы поддерживаем мысль востоковеда В. Сотникова, который предполагает, что движение смогло сформировать политическое крыло, способное бороться с «Аль-Каидой» и «Исламским государством - Хорасан», усиление которых представляло бы угрозу для национальной безопасности России [29]. Действительно, для Российской Федерации важно не допустить распространения группировок «Аль-Каиды», «Исламского государства - Хорасан» и набирающей силы «Ансаруллах»[11] (террористическая организация, основанная таджикскими боевиками)» [27], поэтому де-факто признание Россией кабульской администрации отчасти вызвано тем, что Афганистан не должен вновь стать убежищем для террористов и «отрабатываются механизмы обеспечения надежной защиты южных рубежей ОДКБ» [6].

Также мы солидарны с мнением И.А. Сафранчука и В.М. Жорниста, что «талибы не просто будут в обозримой перспективе основным субъектом государства, но и являются наиболее самостоятельными из всех действующих лиц» [21, 24], поскольку на сегодняшний день талибы являются единственной силой, способной контролировать диалог как на внутреннем политическом поле, так и на внешнеполитическом направлении.

Выводы. Мировой политический процесс демонстрирует, что созданы все предпосылки «парадигмального кризиса мирового цивилизационного жизнеустройства» [2, 281], и настало время становления новой мировой геополитической конфигурации [3, 84], в которой наибольшую настороженность вызывает рост сети джихадистского подполья и активизация террористических организаций на территории Афганистана [9].

[11] Запрещенная в Российской Федерации террористическая организация

Захват правительственной власти в Афганистане сторонниками движения «Талибан»[12] свидетельствует не только о появлении новых вызовов и угроз, но и новых возможностей для Российской Федерации, поскольку региональное сотрудничество в борьбе с наркотрафиком и распространением терроризма, а также реализация инфраструктурных проектов в регионе - находятся в прямой зависимости и от скоординированности политики международного сообщества в отношении сложной внутриполитической ситуации в Афганистане, и от международной легитимности талибов, находящихся у власти. Остается надеяться, что легитимность афганских властей и их конструктивное сотрудничество с внешним миром будет способствовать минимизации рисков для многочисленных этносов Афганистана, решению экономических проблем афганского народа, позволит консолидировать внешнеполитические позиции Афганистана и в перспективе сделать Афганистан надежным партнером как стран-соседей, так и России.

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ДИСКУССИОННЫЕ СТАТЬИ| DISCUSSION PAPERS

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ИСПОЛЬЗОВАНИЕ ХОЛОДНОГО ЯДЕРНОГО СИНТЕЗА ДЛЯ ОТОПЛЕНИЯ ЗДАНИЙ И СООРУЖЕНИЙ

THE USE OF COLD NUCLEAR FUSION FOR HEATING BUILDINGS AND STRUCTURES

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Аннотация

Строительство зданий зародилось вместе с человеком и так же развивалось. Человек создавал для своего бытия и работы самые разные сооружения, обустраивая помещения для решения определённых задач. И, сталкиваясь с проблемами благоустройства, проектировал новые системы, одной из первых данных систем стала отопительная система. Она была индуцирована для воспроизведения и поддержания тепла в зданиях и сооружениях, с целью сохранения мебели и прочих предметов утвари, а также здоровья самого человека. Современные жилые и нежилые здания сложно представить без оборудования и приборов, создающих комфортную климатическую среду. И эта отрасль инженерных систем развивается с течением времени все быстрее. Однако, не каждый знает о том, что отопление зданий и сооружений может быть более выгодным.

Методология анализа

Холодный ядерный синтез для отопления зданий и сооружений: *в данной работе рассмотрено использование холодного ядерного синтеза, называемого кавитацией, для отопления зданий и сооружений. Проведен анализ видов теплогенератора, разобраны все преимущества и недостатки. Рассмотрены также условия установки и использования кавитационных теплогенераторов.*

Результаты и обсуждения *в результате проделанной работы можно сделать вывод, что использование холодного ядерного синтеза (кавитации) при помощи кавитационных теплогенераторов различных видов более экономически выгодное, экологическое, безопасное и удобное, в сравнении со стандартным оборудованием отопления. Из приведенных разновидностей теплогенераторов выбран самый комфортабельный относительно использования и обслуживания. Также, в результате изучения работы теплогенераторов было выведено, что помимо отопления здания или сооружения данная установка может обогревать проточную воду, используемую в быту для различных целей.*

Заключение: Можно сделать вывод, что холодный ядерный синтез (кавитация) при использовании его в бытовой среде, а конкретнее в отоплении зданий и сооружений является не только дешевым в установке и эксплуатации, но и экологичным и безопасным для здоровья человека.

Ключевые слова: кавитация, теплогенератор, кавитационный теплогенератор, роторный теплогенератор, статический теплогенератор, ультразвуковой теплогенератор, теплогенератор Потапова, отопление, здание, сооружение

Abstract

Introduction: *The construction of buildings originated with man and developed in the same way. Man created a variety of structures for his being and work, equipping premises to solve certain problems. And, faced with the problems of improvement, he designed new systems, one of the first of these systems was the heating system. It was induced to reproduce and maintain heat in buildings and structures, in order to preserve furniture and other utensils, as well as the health of the person himself. It is difficult to imagine modern residential and non-residential buildings without equipment and appliances that create a comfortable climatic environment. And this branch of engineering*

systems is developing faster and faster over time. However, not everyone knows that heating buildings and structures can be more profitable.

Cold fusion for heating buildings and structures: *This paper discusses the use of cold fusion, called cavitation, for heating buildings and structures. An analysis of the types of heat generator was carried out, all the advantages and disadvantages were analyzed. The conditions for the installation and use of cavitation heat generators are also considered.*

Results: *as a result of the work done, it can be concluded that the use of cold nuclear fusion (cavitation) using various types of cavitation heat generators is more cost-effective, environmentally friendly, safe and convenient, in comparison with standard heating equipment. Of the above varieties of heat generators, the most comfortable in terms of use and maintenance was selected. Also, as a result of studying the operation of heat generators, it was concluded that in addition to heating a building or structure, this installation can heat running water used in everyday life for various purposes.*

Conclusion: *It can be concluded that cold nuclear fusion (cavitation) when used in a domestic environment, and more specifically in heating buildings and structures, is not only cheap to install and operate, but also environmentally friendly and safe for human health.*

Keywords: cavitation, heat generator, cavitation heat generator, rotary heat generator, static heat generator, ultrasonic heat generator, Potapov heat generator, heating, building, structure

Introduction

Today's district heating and heat supply, as well as the modern concept of heat, are closely connected with the development of Russian scientific and engineering thought. Thanks to the work of domestic scientists and engineers, an independent way of forming heat supply in Russia was formed, different from Western Europe.

There is no factual data in history about when exactly a person began to switch to any organized methods of heating his home and those or other public buildings that had already arisen.

Indications and material confirmations of more advanced heating technologies refer to eras relatively close to us.

These confirmations are charcoal braziers found in a fairly significant number and in a wide variety of countries. Without, of course, having no idea about the chemical reactions of combustion and the chemical composition of the products of combustion, the ancient man exclusively by experience verified the safety of burning charcoal naturally in a heated room with the release of combustion products directly into this latter.

And indeed, as we know it today for certain, with a uniform influx of atmosphere to a thin cover of smoldering, well-burnt, charcoal, the product of combustion is only relatively harmless and odorless carbonic anhydride (carbon dioxide, CO2). It is extremely curious that this, from our point of view, primitive method of heating had such a coefficient of efficiency that we can only dream of in our current heating systems, because a charcoal brazier, in which all the calorific value of coal was absolutely used, efficiency was equal to 1, – in relation, of course, to charcoal, and not to the tree from which this coal was obtained.

This method of space heating earned a very extensive and very long-lasting distribution, covering, apparently, the entire European mainland and far Asia with China and Japan.

Being an indoor heating device, heating, of course, the premises of wealthy dignitaries and nobles, these braziers have achieved a high degree of figurative perfection: they were made from the best bronze. This is evidenced by the bronze braziers found in Pompeii. Thus, a Roman bronze tripod brazier with a diameter of 500 mm, a depth of 120 mm and a height of 1000 mm could heat a room with a heat loss of about 10 kcal / h, i.e. a cubic capacity of approximately 1000 m3.

We meet the initial signs of a more organized heating of buildings about 2200 years ago, that is, in the last centuries BC.

Archaeological excavations in the territories of present-day Italy, France, Switzerland, Germany and England open before us a picture of quite impressive achievements in those days in the field of heating, and even ventilation of buildings. These are scarlet heating systems with illegal chambers, invented, no doubt, by the Romans several centuries before our era. Despite the Roman invention, these heating systems bear the Greek name "hyupokaustum", meaning "warmed from below".

The room, heated by “hyupocausts”, had an underground covered along columns of stone or pottery pipes with clay slabs 50 mm thick, over which a continuous grease 150 mm thick was made. In this design there was a manhole, obviously for cleaning and repair, which was closed with a sandstone slab. This underground was intended as a continuous chimney for the hearth, which was outside the building in a recess in the ground. In the wall of this recess there was a furnace for burning charcoal. The underground channel, which led the hot products of coal combustion into the underground, left the last to the first row of brick columns. The shape of this channel in the project is unique, since it has two expansions and narrowings alternately placed. In the first of them, closest to the furnace recess, coal was obviously burned. An external air intake opening was intended to regulate the heating intensity of the underground and to heat the heated room itself. Outside air flowed through it into the underground room and from there through the opening into the hypocaustum itself. Here he was deflected by the rebound in order, apparently, to best mix with the hot gases coming from the coal furnace. The hole was covered with a clay slab in order to regulate the inflow of outside air. The same building, together with a chimney-like hail and ceramic channels coming from it, which probably (the wall was preserved only to a height of 1 m) above the roof, served as a supply and exhaust ventilation system after the burning of coal in the furnace ceased. With similar systems, the Romans heated both in their homeland and in more northern countries, their colonies, such as: in present-day France, Switzerland, Germany, England, both residential, civilian, and various kinds of military buildings of their military settlements and fortresses ("castellum").

Heating with an open fireplace using a chimney was available already in 820 in the monastery of St. Gallen (in Switzerland), as evidenced by the found plans of this monastery with the above date.

Subsequently, in the history of the formation of technologies and systems for heating buildings, the era of centralized systems is due, however, all types of previously used heating devices continued to exist simultaneously and very invariably did not give up their firmly occupied positions. After all, in essence, heating by underground fire and smoke channels is still alive today in the form of heating by hogs in simple greenhouses and greenhouses. By the way, it is interesting that all the centralized heating systems that appeared approximately alternately emerged and at first existed almost unlimitedly for the purpose of heating greenhouses and greenhouses and very slowly penetrated into residential and public buildings, where the old woman is a brick oven, continuing to improve and decorate in appearance , diligently held the place she won.

The first elements of centralized heating found their way into the water system. Rather, such elements are not a heating system, but the principle of its operation, which formed the basis for many centuries after the invented water heating system. These primary elements were found during archaeological excavations of the Roman city of Pompeii, which disappeared near the city of Herculaneum from the eruption of Vesuvius. Here we are talking about a circulating water-heating device for the hot baths so beloved by the Romans, discovered in one of the open villas. In this device we meet all the main elements of the circulating water system.

The next in time of occurrence was the air heating system, which stood out from the same air systems of Roman hypocausts and German fire-stone furnaces in that here the air, heated and supplied to heated rooms, washed the outer planes of a specific air-heating furnace, without coming into contact with those surfaces of the furnace that were washed by the products of combustion of fuel. Such a system provided not only hygienic, but also significant technical progress, since it increased the likelihood of heating the premises during the period of fuel combustion.

The first integrated heating system (high pressure steam) originated in 1818 in England for several greenhouses. But a full and clear awareness of the very great technical and economic benefits arising from the enlargement of the boiler industry for both power and heating needs was first awakened in the United States of America. There, in Lockport, New York, already in 1878, the first local heating plant of an urban scale arose, supplying its subscribers with steam through underground pipelines. Later, with the transfer of power plants far beyond the city limits, specifically

to the locations of coal and other natural fuel options (and with the emergence of electricity transport for many hundreds of kilometers), it became impossible to provide cities with thermal energy from such remote steam power stations. This gave impetus, on the one hand, to the construction in the cities of America of central powerful simple thermal stations (steam boilers), on the other hand, to the use of boiler units of liquidated intracity power plants to provide consumers with ready-made thermal energy. But at the same time, the very nature of the growth of American cities, in which streets and entire neighborhoods were built up at once in the shortest possible moment, made it possible to adapt the regional heat supply system and the type of heat carrier (hot water, steam) to the needs of consumers. This occupation was also very favorably aided by the division of cities adopted in America into residential, commercial, administrative, and industrial zones. The first ones usually use water, and the last two-steam heating systems.

In the USSR, the first steps in the field of urban heat supply date back to 1924. We had heat supply for groups of buildings of one household from a common boiler house or even a combined heat and power plant much earlier. So, for example, built on the initiative of prof. Dmitriev in 1913, the steam-water heating and ventilation system of the Pavilion Polyclinic. Mechnikov in Leningrad (formerly the hospital of Peter the Great) functioned immediately after its construction from its combined heat and power plant on the exhaust steam of a steam turbine of an electric generator.

The first city heat pipeline was laid in Leningrad in 1924 from the 3rd state. a galvanic station for supplying hot water to neighboring bathhouses in Kazachyi Lane and for heating the upper (6th) floor of a residential building also nearby. The following year, the buildings of the hospital named after V.I. Nechaev (former Obukhov hospital) on the other side of the Vvedensky Canal.

However, at present we use classical energy sources, which, even in the simplest version and with minimal heat loss of a building or structure, require significant costs, when alternative sources of relatively inexpensive energy have been known for many years.

This article will consider an alternative source of thermal energy using a variety of cold nuclear fusion, and for this you need to figure out which type will be used.

According to Christopher Brennen's definition: “When a liquid is subjected to a pressure below the threshold (tensile stress), then the integrity of its flow is broken and vapor cavities are formed. This phenomenon is called cavitation, it is also considered cold nuclear fusion.

Cavitation is the formation of air bubbles in the water column, caused by the force of the vortex energy of the water flow. The formation of bubbles is always accompanied by a certain sound and the formation of some energy as a result of their impact at high speed. Bubbles are cavities in water filled with evaporation from the water in which they themselves formed. The fluid exerts a constant pressure on the bubble, so it tends to move from an area of high pressure to an area of low pressure in order to survive. As a result, it cannot withstand the pressure and abruptly shrinks or "breaks", spraying out energy that creates a wave.

The "explosive" energy of a large number of bubbles is so powerful that it can destroy impressive metal structures. This is the energy that serves as an extra when heated. In the case of a heat generator, a completely closed circuit is provided, in which bubbles of very small sizes are formed, bursting in the water column. They do not have such destructive power, but provide an increase in thermal energy up to 80%. The system supports AC current up to 220V while maintaining the integrity of the electrons critical to the process.

As already mentioned, the operation of a thermal installation requires the creation of a "water vortex". This is the responsibility of the pump built into the heating system, which generates the required level of pressure and forces it to force it into the working tank. During the occurrence of turbulence in water, some changes occur in the mechanical energy in the liquid body. As a result, it starts to set the same temperature. Additional energy is created, according to Einstein, when a certain mass is converted into the necessary heat, the whole process is accompanied by cold nuclear fusion.

Then the question arises of how to use this reaction for heating. At the moment, one method is already known – devices with a fundamentally different type of effect on the coolant are used. Such devices include a cavitation heat generator, the work of which is to form gas bubbles, due to which heat is released.

The principle of operation of a cavitation heat generator is the heating effect due to the conversion of mechanical energy into thermal energy. Now let's take a closer look at the cavitation phenomenon itself. When excess pressure is created in a liquid, turbulence occurs, due to the fact that the pressure of the liquid is greater than that of the gas contained in it, the gas molecules are released into separate inclusions – the collapse of the bubbles. Due to the pressure difference, water tends to compress the gas bubble, which accumulates a large amount of energy on its surface, and the temperature inside reaches about 1000 – 1200ºC.

When the cavitation cavities pass into the zone of normal pressure, the bubbles are destroyed, and the energy from their destruction is released into the surrounding space. Due to which, thermal energy is released, and the liquid is heated from the vortex flow. The operation of thermal generators is based on this principle, then consider the principle of operation of the simplest version of the cavitation heater m – When the water flow reaches the nozzle, the liquid pressure increases significantly and the formation of cavitation bubbles begins. When the bubbles exit the nozzle, they release heat power, and the pressure after passing through the nozzle is significantly reduced. In practice, multiple nozzles or tubes may be installed to increase efficiency. (Figure 1.)

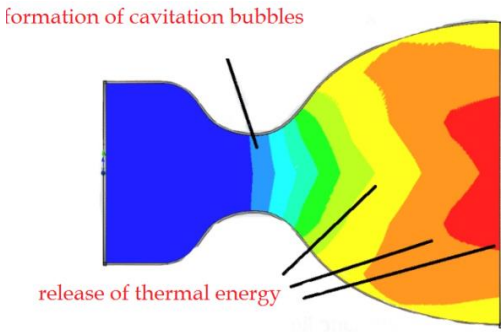

Figure 2. The principle of operation of the cavitation heat generator

The main task of a cavitation heat generator is the formation of gas inclusions, and the quality of heating will depend on their quantity and intensity. In modern industry, there are several types of such heat generators, which differ in the principle of generating bubbles in a liquid. The most common are three types:

The working element rotates due to the electric drive and generates fluid turbulence. It consists of an electric motor, the shaft of which is connected to a rotary mechanism designed to create turbulence in the liquid. A feature of the rotor design is a sealed stator, in which heating occurs. The stator itself has a cylindrical cavity inside – a vortex chamber in which the rotor rotates.

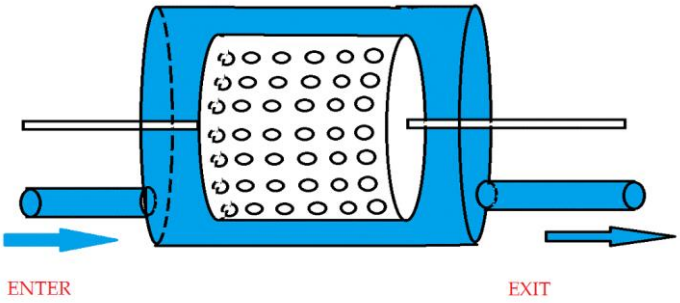

Figure 3. The design of the rotary heat generator

The rotor of a cavitation heat generator is a cylinder with a set of recesses on the surface, when the cylinder rotates inside the stator, these recesses create heterogeneity in the water and cause cavitation processes to occur. The number of recesses and their geometric parameters are determined depending on the model of the vortex heat generator. For optimal heating parameters, the distance between the rotor and the stator is about 1.5 mm. Rotor cells are needed so that in the thickness of the liquid jet, which constantly rubs against the surface of the movable and static cylinder, turbulences arise to form cavitation cavities. In the same gap, the liquid is heated. For the efficient operation of the heat generator, the transverse dimension of the rotor must be at least 30 cm, while the rotation speed of 3000 revolutions per minute is determined. If you make the rotor of a smaller diameter, then you should increase the number of revolutions. For all the seeming simplicity, the development of a clear action of all parts of the rotary heat generator requires quite accurate, including balancing the movable cylinder. The sealing of the rotor shaft is needed with the constant replacement of failed insulating materials. The efficiency of such generators is not impressive, the work is accompanied by a noise effect. Their service life is short, although they work 25% more productively than static models of heat generators;

Tubular – change the pressure due to a system of pipes through which water moves. A static heat generator does not have rotating elements. The heating process in them occurs due to the movement of water through pipes tapering in length or due to the installation of Laval nozzles. The water supply to the working body is carried out by a hydrodynamic pump, which creates a mechanical force of the liquid in a narrowing space, and when it passes into a wider cavity, cavitation turbulences occur. Unlike the previous model, tubular heating equipment does not produce much noise and does not wear out so quickly. During installation and operation, you do not need to worry about precise balancing, and if the heating elements are destroyed, their replacement and repair will be much cheaper than for rotary models. The disadvantages of tubular heat generators include significantly lower productivity and bulky dimensions;

Static generator pump – to create cavitation processes in a liquid, a design of nozzles is used. Recreating the phenomenon of cavitation requires a high speed of water movement, for which a powerful centrifugal pump is used. The pump applies increased pressure to the flow of water, which rushes into the inlet of the nozzle. The outlet diameter of the nozzle is much narrower than the previous one and the liquid receives additional energy of movement, its speed increases. At the outlet of the nozzle, due to the rapid expansion of water, cavitation effects are obtained with the formation of gas cavities inside the liquid body. Water heating occurs according to the same principle as in the rotary model, only the efficiency is somewhat reduced. Static heat generators have a number of advantages over rotary models:

- The design of the stator device does not require fundamentally precise balancing and fitting of parts;
- Mechanical preparatory operation does not require precise grinding;
- Due to the absence of moving parts, sealing materials wear out much less;
- The operation of the equipment is longer;
- In the conditions of the nozzle becoming unusable, its replacement will require less costs than in the rotary version of the heat generator, which needs to be recreated
- It can provide a large temperature difference at the hot and cold ends, operate at low pressure.
- Efficiency not less than 90%.
- Never overheats.
- Fire and explosion proof. Can be used in explosive environments.
- Provides fast and efficient heating of the entire system.
- Can be used for both heating and cooling.

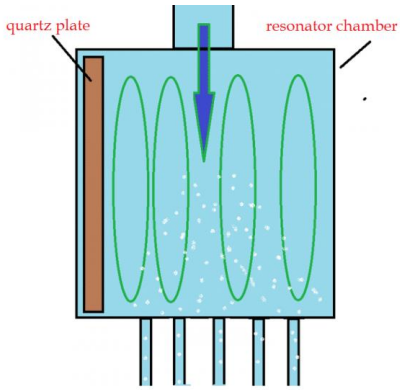

Figure 4. The principle of operation of the ultrasonic heat generator

Ultrasonic (Figure 3.) – fluid inhomogeneity in such heat generators is created due to low-frequency sound vibrations. This type of device has a resonator chamber tuned to a certain frequency of sound vibrations. A quartz plate is installed at its input, which produces oscillations when electrical signals are applied. The vibration of the plate creates a wave effect inside the liquid, which reaches the walls of the resonator chamber and is reflected. During the return motion, the waves meet with direct oscillations and create hydrodynamic cavitation. Further, the bubbles are carried away by the water flow through the narrow inlet pipes of the thermal installation. When passing to a wide area, the bubbles are destroyed, releasing thermal energy. Ultrasonic cavitation generators also have good performance, as they do not have rotating elements.

Popular and more studied is the invention of Potapov's heat generator (Figure 4.). It is considered a static device.

The pressure force in the system is created by a centrifugal pump. A jet of water is fed with high pressure into the snail. The liquid begins to warm up due to rotation along the curved channel. She enters the vortex tube. The footage of the pipe must be ten times greater than the width, as shown in the first figure of the principle of operation of the heat generator.

Water passes along the spiral spiral located along the walls. Next, a brake device was installed to remove part of the hot water. The jet is slightly leveled by plates attached to the sleeve. Inside there is an empty space connected to another braking device.

High temperature water rises and a cold swirling fluid flow descends through the interior. The cold flow comes into contact with the hot flow through the plates on the sleeve and heats up.

Warm water descends to the lower brake ring and is further heated by cavitation. The heated flow from the lower braking device passes through the bypass to the outlet pipe.

The upper brake ring has a passage whose diameter is equal to the diameter of the vortex tube. Thanks to him, hot water can get into the pipe. There is a mixing of hot and warm flow. Further, the water is used for its intended purpose. Usually for space heating or domestic needs. The return is connected to the pump. Branch pipe – to the entrance to the heating system of the house.

To install the Potapov heat generator, diagonal wiring is required. Hot coolant must be supplied to the upper course of the battery, and cold will come out of the lower one.

Having dealt with the operation of heat generators, it is worth considering the very principle of heating with the help of cavitation.

The pump increases the water pressure and delivers it to the working chamber, the pipe of which is connected to it by means of a flange.

In the working body, the water must receive increased speed and pressure, which is carried out using pipes of various diameters, tapering along the flow. In the center of the working chamber, several pressure flows are mixed, leading to the phenomenon of cavitation.

In order to be able to control the speed characteristics of the water flow, braking devices are installed at the outlet and during the working cavity.

Water moves to the branch pipe at the opposite end of the chamber, from where it flows in the return direction for reuse by means of a circulation pump. Heating and heat generation occurs due to the movement and sharp expansion of the liquid at the outlet of the narrow nozzle opening.

Having dealt with the types of heat generators and their principles of operation, the question arises: How much more advantageous is this than varieties of standard heating.

The task of economical heating of water, which is used as a heat carrier in water heating and hot water supply systems, has been and remains important regardless of how these processes are carried out, the design of the heating system and heat production sources. There are four main types of heat sources for this task:

- Physical and chemical (combustion of fossil fuels: oil products, gas, coal, firewood and the use of other exothermic chemical reactions);
- Electricity, when heat is generated by components in an electrical circuit that have a sufficiently high ohmic resistance;
- A fusion based on the use of heat from the decay of radioactive materials or the synthesis of heavy hydrogen nuclei, including those found in the Sun and deep in the earth's crust;
- Mechanical, when heat is generated by surface or internal friction of materials. It should be noted that the property of friction is inherent not only in solids, but also in liquids and gases.

The rational choice of the heating system is influenced by many factors:

- Presence of specific fuel
- Environmental aspects, design and architectural solutions,
- The volume of the building under construction,
- Financial capabilities of a person and much more.

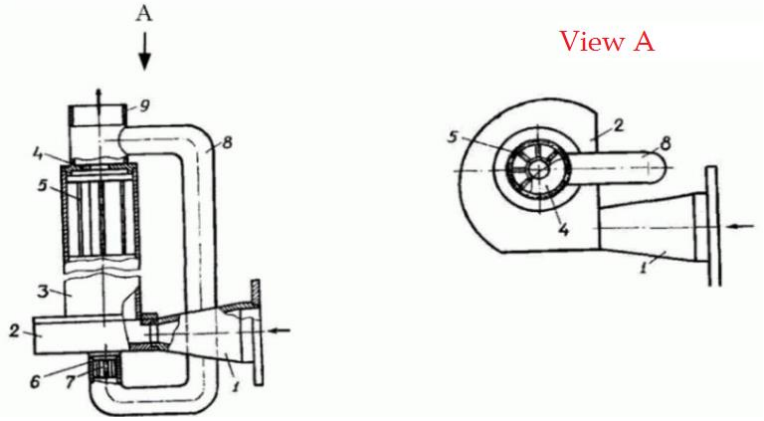

Figure 4. Scheme of the generator device. 1 – Branch pipe, 2 – Volute, 3 – Whirlpool pipe, 4 – Upper brake, 5 – Water rectifier, 6 – Coupling, 7 – Lower brake ring, 8 – Bypass, 9 – Branch line.

1. Electric boiler – all boilers must be purchased with a power reserve (+ 20%) due to heat loss. They are fairly easy to maintain, but require a decent power supply. This requires connecting a powerful power cable, which is not always realistic outside the city.

Electricity is an expensive form of fuel. Payment for electricity very quickly (after one season) exceeds the cost of the boiler itself.

2. Electric heaters (air, oil, etc.) are easy to maintain.

Very uneven space heating. Rapid cooling of the heated space. High power consumption. The constant presence of a person in an electric field, breathing superheated air. Low service life. In many regions, payment for electricity used for heating occurs with a growth factor of K = 1.7.

3. Electric underfloor heating – the complexity and high cost of installation.

It is not enough to heat the room on cold days. The use of a high-strength heating element (nichrome, tungsten) in the cable provides good heat dissipation. Simply put, the carpet on the floor will create conditions for overheating and failure of this heating system. When using tiles on the floor, the concrete screed must be completely dry. In other words, the first safe trial run of the

system takes at least 45 days. The constant presence of a person in an electric and / or electromagnetic field. Significant energy consumption.

4. Gas boiler – significant initial costs. Design, permits, gas supply from the gas pipeline to the house, a special room for the boiler, ventilation, etc. other. The negative pressure of pressurized gas affects operation. Poor-quality liquid fuel leads to premature wear of the components and assemblies of the system. Environmental pollution. High prices for services.

5. Diesel boiler – there is the most expensive installation. Additionally, it is required to install tanks for several tons of fuel. Availability of access roads to the tanker. Ecological problem. Dangerous. Dear service.

6. Electric generators – requires professional installation. Extremely dangerous. Mandatory grounding of all metal heating elements. High risk of electric shock in the event of the slightest failure. They require the unpredictable addition of alkaline components to the system. There is no stability at work.

The trend in the development of heat sources is moving towards the transition to environmentally friendly technologies, among which electricity is currently the most common.

And yet, now we will consider separately all the advantages of a cavitation heat generator:

The most obvious advantage of heat generators is the rather simple maintenance, despite the possibility of free installation without special permission from the power grid staff. Once every six months, it is enough to check the friction of the parts of the device – bearings and seals. At the same time, according to suppliers, the average guaranteed service life is up to 15 years or more.

The Potapov heat generator is completely safe and safe for the environment and users. Environmental friendliness is justified by the fact that during the operation of a cavitation heat generator, emissions of harmful products during the processing of natural gas, solid fuel and diesel fuel are excluded. They are simply not used.

Makeup comes from the net. Ignition due to lack of contact with an open flame is excluded. Additional safety is provided by the instrument panel of the device, which is used to control all processes of temperature and pressure changes in the system.

The economic efficiency of space heating with heat generators is expressed in several advantages. Firstly, you don't have to worry about the quality of the water when it plays the role of a coolant. One should not think that this harms the entire system only because of its poor quality. Secondly, there is no need to make financial investments in the organization, laying and maintenance of thermal routes. Thirdly, water heating according to physical laws and the use of cavitation and vortex flows completely eliminate the appearance of calcium stones on the internal walls of the installation. Fourthly, cash costs for transportation, storage and purchase of previously required fuel materials (natural coal, solid fuel, oil products) are excluded.

The undeniable advantage of heat generators for home use is their unique versatility. The scope of use of heat generators in everyday life is very wide:

- As a result of passing through the system, water is transformed, structured, and pathogenic microorganisms die under such conditions;
- Water from the heat generator can be watered with plants, which will contribute to their rapid growth;
- The heat generator is capable of heating water to a temperature above the boiling point;
- The heat generator can interact with already used systems or be built into a new heating system;
- The heat generator has long been used by people who are aware of it as the main element of the heating system in homes;
- The heat generator easily and at no extra cost prepares hot water for domestic use;
- The heat generator can heat liquids used for various purposes, in addition to heating, for example: heating running water, which is used in everyday life. A heat generator that is connected to the network can heat water quite quickly. As a result, such equipment can be

successfully used for heating water in swimming pools, autonomous water supply, saunas, and laundries.

Attention should be paid to the ability of heat generators to work completely autonomously. This means that the intensity mode of its work can be set independently. In addition, all heat generator projects are very easy to install. There is no need to involve employees of service organizations, all installation operations can be performed independently.

The cavitation heat generator can be made in several versions. Therefore, you need to choose such a device for heating your home, taking into account a number of parameters:

- It is necessary to select a heat generator based on the area for which heating is needed. You should also consider what kind of weather is observed in winter. An important characteristic will be the thermal insulation of the walls. That is, you need to choose a device that will provide the required amount of heat.
- If you purchase a standard installation (rotary heat generator), then it is necessary that it be equipped with devices for controlling the generated heat and protection sensors. It is better to install immediately with an automatic control and management unit.
- If the equipment is purchased separately, it is important to determine the features of all elements of the system. The pump must be able to handle liquids that are heated to high temperatures. Otherwise, the system will quickly become unusable and will have to be repaired. In addition, the pump must provide pressure from 4 atmospheres.

Results

As a result of the work done, it can be concluded that the use of cold nuclear fusion (cavitation) during the operation of a cavitation heat generator is cost–effective, environmentally normalized, safe and convenient for heating buildings and various structures. Also, this installation during the study showed that the use of cavitation significantly exceeds the characteristics of standard heating methods. Depending on the building or structure, you can choose the types of cavitation heat generators:

- Rotary;
- Tubular;
- Ultrasonic;
- Statistical;
- Potapov's heat generator.

To introduce cavitation for heating and heating running water of a building and / or structure, it is necessary to build on the thermal insulation, the area of \u200b\u200bthe room and the region in which the object is located. If you choose the right installation of a cavitation heat generator, then heating and water heating will not bring a lot of costs and inconvenience, increasing the efficiency over 90%.

Conclusion

In the course of the studies on the operation of cavitation heat generators, as well as the analysis of cold nuclear fusion, it can be concluded that the use of cavitation for heating buildings and structures is a profitable and comfortable solution. This is due to the following benefits:

- The design of the stator device does not require fundamentally precise balancing and fitting of parts;
- Mechanical preparatory operation does not require precise grinding;
- Due to the absence of moving parts, sealing materials wear out much less;
- Equipment operation is longer, up to 5 years;
- In the conditions of the nozzle becoming unusable, its replacement will require less costs than in the rotary version of the heat generator, which needs to be recreated
- It can provide a large temperature difference at the hot and cold ends, operate at low pressure.

- Efficiency not less than 90%.
- Never overheats.
- Fire and explosion proof. Can be used in explosive environments.
- Provides fast and efficient heating of the entire system.
- Can be used for both heating and cooling.

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СОВРЕМЕННЫЕ НАПРАВЛЕНИЯ КЛАСТЕРИЗАЦИИ ТУРИСТСКОЙ ОТРАСЛИ: ЦИФРОВАЯ КОНВЕРГЕНЦИЯ

THE MODERN DIRECTIONS OF CLUSTERING TOURISM INDUSTRY: DIGITAL CONVERGENCE

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Аннотация

В глобализационном пространстве туризм представляет процесс, либо же явление, которое оказывает воздействие на уровень благосостояния различных контингентов, государств и народов. На современном этапе социально-экономического развития необходима трансформация, сформировавшийся модели кластеров в туристической отрасли глобальные тенденции и тренды диктуют переход к новым реалиям развития, которые предполагают переход от инновационных систем к цифровым системам. В данном контексте, необходимо разработка и внедрение концептуально новых моделей управления туристическими системами как на федеральном уровне, так и на локальном.

Можно сделать заключение, что ключевой целью стимулирования туризма с цифровыми технологиями является поощрение цифровой и физической конвергенции и достижение целей интеллектуального туризма по средствам создания цифровых платформ.

Ключевые слова: туризм, туристическая отрасль, туристические кластеры, туристические системы, цифровая трансформация, цифровые технологии, цифровая туристическая платформа, цифровая конвергенция.

Abstract

In the globalizing space, tourism is a process or phenomenon that affects the level of well-being of various contingents, states and peoples. At the present stage of socio-economic development, the transformation of the formed cluster model in the tourism industry is necessary. Global trends and trends dictate the transition to new development realities that involve the transition from innovative systems to digital systems. In this context, it is necessary to develop and implement conceptually new models of management of tourist systems both at the federal level and at the local level. The key goal of stimulating tourism with digital technologies is to promote digital and physical convergence and achieve the goals of intellectual tourism through the creation of digital platforms.

Key words: tourism, tourism industry, tourism clusters, tourism systems, digital transformation, digital technologies, digital tourism platform, digital convergence.

Современные тенденции экономического развития, как в мировом масштабе, так и отдельно взятого государства или региона определяют туризм, как одну из перспективных отраслей. Направление и интенсивность развития туристской отрасли зависят от того, как

государственный и частный сектор кооперируются для достижения целевых показателей социально-экономического развития, касающихся повышения уровня жизни населения, наращивания конкурентоспособных преимуществ и формирование доступной инфраструктуры, а также защиты, сохранения и приумножения ресурсной базы, культурных ценностей и природно-рекреационного потенциала.

Основными тенденциями в области туризма в современных рамках глобальных потрясений в связи с пандемией являются возможности модификации туристической отрасли по средствам цифровой трансформации. Как следствие, вышеизложенного большинство стран предпринимают различные законодательные и стратегические инициативы в области оцифровки ключевых направлений туризма, что предполагает процесс коллаборации государственного и частного сектора, научно-образовательного пласта и технологической среды.

Цель исследования: провести анализ современных направлений кластеризации туристической отрасли в условиях цифровизации.

По мере того, как туризм продолжает расти, все большее значение приобретают меры по поощрению регионального развития и рассредоточению посетителей в менее развитые районы, призванные снизить нагрузку на наиболее посещаемые направления и более широко распространить экономические выгоды от туризма. Стимулирование разработки продукта - важная функция для правительства, поскольку оно позволяет более равномерно привлекать новые виды посетителей и даже совершенно новые рынки в течение года.

Туристический потенциал региона как движущей силы устойчивого развития, основанный на широком участии заинтересованных сторон и принципах устойчивого развития, признан в глобальном контексте основным направлением политики в области туризма для устойчивого и инклюзивного роста. Государственные власти должны играть важную роль в обеспечении руководства и поддержки, но также все более широко признается, что это должно осуществляться комплексно, на основе разумной политики, эффективного управления и структур, которые включают частный сектор и многие агентства и органы, все уровни, деятельность которых может повлиять на показатели и воздействие туризма.

Ряд тенденций, проистекающих в различных секторах экономики, определяются цифровой трансформацией, характеризующейся автоматизацией процессов, усилением взаимосвязи между кибернетическими и физическими системами, а также повышением эффективности управления, обеспечиваемое аналитикой больших данных и облачными вычислениями. Цифровизация направлена на преобразование деловой практики за счет внедрения цифровых технологий и открытых инноваций, является доминирующей парадигмой, изменяющей и трансформирующей традиционно-устоявшиеся системы в новое пространство цифровой экономики. Туризм, как отрасль производства и сектор услуг, претерпевает масштабную трансформацию в результате достижений в области информационных технологий и процессов цифровизации.

Технологические решения оказывают существенное влияние на развитие туристической отрасли. В данном контексте, инновации варьируются от технологий управления бизнесом (например, мобильные технологии/облачные вычисления, автоматизация и передовая робототехника, блокчейн, аналитика данных, облачные вычисления) до технологий, которые производят инновационные туристические продукты, услуги и опыт (например, виртуальная/дополненная реальность, Интернет вещей), а также технологий, которые помогают, понимают и связываются с рынками (например, аналитика данных, облачные вычисления и искусственный интеллект).

Технологии, способствующие формированию туристической экосистемы:

1. Мобильные технологии/облачные вычисления. Облачные технологии, Wi-Fi и мобильные провайдеры делают мобильные устройства все более распространенными и важными средствами для путешествий, в том числе для доступа к информации о пункте назначения в режиме реального времени, онлайн-бронирования, мобильных платежей. Об-

лачные технологии позволяют малым и средним предприятиям управлять своим бизнесом из любого места, где есть высокоскоростной Интернет.

2. Аналитика данных. В цифровую эпоху потребители и компании постоянно генерируют новые данные. Способность предприятий использовать данные стимулирует новые бизнес-модели и производительность. Аналитика данных может предсказывать предпочтения клиентов и определять покупательское поведение потребителей. Он также используется для управления доходами и динамического ценообразования. Сотрудники МСП должны развивать навыки, чтобы быть частью этой управляемой данными экосистемы, и вопросы конфиденциальности, обмен данными являются ключевыми заботами правительства.

3. Искусственный интеллект. Искусственный интеллект, чат-боты и голосовые технологии позволяют клиентам выполнять поиск в Интернете, выполнять цифровую регистрацию, пользоваться услугами цифрового консьержа, голосовыми помощниками и умными комнатами. Эта технология предлагает персонализированные индивидуальные услуги по запросу, которые упрощают путешествие.

4. Интернет вещей. Интернет вещей может подпитывать сектор туризма, богатого данными, и поддерживать умный туризм, делая города более эффективными. Взаимодействие датчиков, данных и автоматизации позволяет получать аналитические данные и информацию в реальном времени для маркетинга и управления туризмом, для улучшения впечатлений посетителей, повышения эффективности работы и ресурсов, а также снижения воздействия на окружающую среду.

5. Дополненная реальность / виртуальная реальность. Системы дополненной реальности показывают виртуальные объекты в реальном мире. Использование в туризме может включать замену бумажных маркетинговых и рекламных материалов, геймификацию и расширенный опыт посетителей в месте назначения, а также помощников для путешественников, которые проводят пользователей через сложные системы общественного транспорта в режиме реального времени.

6. Блокчейн. Смарт-контракты, основанные на блокчейне, могут использоваться по всей цепочке поставок. В будущем появятся удобные приложения, предназначенные для широкого распространения среди туристических компаний любого размера, чтобы повысить прозрачность для пользователей.

По мере развития цифровизации появляющиеся технологии объединяются поновому, чтобы подтолкнуть цифровую трансформацию к новым и часто непредсказуемым направлениям. В туризме это конвергенция происходит в двух ключевых областях: объединение цифровых технологий и слияние цифровых технологий с физическим миром (например, носимые технологии, дополненная реальность, распознавание изображений и т. д.).

Цифровая конвергенция — это новая экосистема, которая соединяет в себе несколько цифровых технологий объединяются для синхронной работы, направленных на оптимизацию и автоматизацию традиционных процессов, и оцифровки существующей реальности. Например, после того как транспорт забронирован, путешественникам могут быть отправлены автоматические предложения, основанные на их предыдущем поведении, в отношении трансфера, проживания и занятий в пункте назначения. С минимальным количеством щелчков мышью можно забронировать машину, пройти регистрацию в отеле, зарезервировать ресторан и получить билеты. Автоматизация, искусственный интеллект и аналитика больших данных облегчают взаимодействие систем бронирования, но уже существующие партнерские отношения могут также закрепить выбор клиентов в пользу предпочтительных партнеров и заблокировать МСП, предлагающие альтернативные продукты и услуги. Аналитика данных и алгоритмы могут работать в пользу определенных поставщиков, настраивать и объединять продукты и вовлекать клиентов до, во время и после поездки. Перед представителями малого и среднего предпринимательства стоит задача понять, привлечь и выработать стратегию, чтобы они могли заявить о своем присутствии в этих цифровых се-

тях, поскольку клиенты могут выбрать удобство предложения вместо проведения собственного исследования. Динамический сбор данных и аналитика уточняют знания о потребителе, упрощают настройку и повышают удовлетворенность посетителей.

В туризме цифрово-физическая конвергенция направлена на создание новых туристических продуктов и услуг по средствам коллаборации всех участников инновационного процесса. Примеры включают электронные велосипеды, электронные скутеры и электронные автомобили, к которым можно получить доступ в любом месте и в любое время с помощью мобильного приложения, что снижает потребность в присутствии фронт-офиса и персонала, которые потенциально могут быть заменены средствами технической поддержки и технического обслуживания. При масштабировании по городам, регионам или стране возможно развитие интеллектуального туризма.

Целью интеллектуального туризма является развитие информационной и коммуникационной инфраструктуры и возможностей для содействия инновациям, улучшения впечатлений посетителей, а также более эффективного управления и совместного управления туризмом. Технологии, способствующие конвергенции, были определены как основной источник создания ценности, инноваций и производительности для будущего туризма.

Когда цифровые технологии используются в рамках инновационных кластеров, динамика конкуренции, инноваций и инвестиций может резко измениться. Конвергенция цифровых технологий и физической среды создает динамичную экосистему, направленную на масштабирование туристских возможностей по средствам коллаборации государства, частного сектора и научного сообщества и информационно-коммуникационной среды.

Цифровизация расширила число заинтересованных сторон и разнообразных ценностей, которые могут быть совместно созданы в сфере туризма в глобальных сетях с цифровым комплектующими. Объем и гибкость этих бизнес-экосистем могут, например, помочь в разработке продуктов и услуг, повышении эффективности, расширении доступа и охвата рынка. Важное значение имеют стратегии, поддерживающие развитие цифровых платформ, и системы регулирования, учитывающие новые бизнес-модели и структуры.

Цифровые платформы являются «точками» роста, инноваций и конкурентных преимуществ региона. На сегодняшний день цифровая трансформация, наблюдаемая в туризме, была обусловлена главным образом новыми и инновационными системами, использующими аналитику данных (т. е. цифровыми аборигенами, превращающими данные в интеллект), или адаптацией и эволюцией существующих бизнес-моделей и цепочек создания стоимости.

Деятельность государственных институтов призваны должна быть направлена на создание условий для цифровой трансформации кластеров в экосистеме туризма. Необходимы комплексные и последовательные подходы для использования возможностей цифровизации, а также для решения

Политика в области цифровой трансформации включает сочетание краткосрочных и долгосрочных инициатив, создающих условия для увеличения распространения цифровых технологий; стимулирование участия представителей малого и среднего предпринимательства за счет снижения барьеров и расширения возможностей для цифровизации, что повлечет новые способы взаимодействия между участниками кластера, новые подходы к управлению и сформирует цифровую культуру. В результате исследования автором были определены следующие траектории формирования цифровой экосистемы внутри региона:

Сложность политической среды в сочетании с уникальными характеристиками малых и средних предприятий в области туризма может отрицательно сказаться на внедрении цифровых технологий, восприятии риска и доверии. Государственные структуры и органы местного самоуправления могут взять на себя ведущую роль в создании условий для формирования туристических кластеров, основанных на цифровых технологиях. В качестве государственных мер следует обособить:

– поддержка практических инноваций и развития потенциала с помощью инкубаторов туристических технологий, акселераторов, возможностей наставничества и других нетехнических инициатив (например, туристических сетей) для поощрения распространения, активизации экосистем туристического бизнеса и продвижения цифрового мышления.

– создание благоприятной среды путем модернизации нормативной и правовой базы для содействия справедливой конкуренции и разработки инноваций.

Стимулирование внедрение новых цифровых технологий и инвестиции в них туристическими компаниями. Политическая среда, которая поддерживает и делает возможным цифровую трансформацию туристических институтов и направлена на повышение производительности и инноваций, может включать следующие меры:

– к человеческим ресурсам, навыкам и информации, чтобы повысить осведомленность о возможностях и преимуществах, облегчить внедрение цифровых технологий и укрепить потенциал для участия в новых и возникающих цифровых экосистемах.

– создать базы данных по ключевым аспектам и последствиям цифровизации для туристических предприятий, целевые и детализированные подходы к регулированию, финансированию, инвестициям и стимулам должны основываться на лучшем понимании различных потребностей местных цифровых компаний и традиционных туристических компаний с низким уровнем распространения цифровых технологий.

– обеспечивать доступности цифровых технологий, инструментов и решений для малых и средних предприятий в сфере туризма, включая первоначальные инвестиции и текущие расходы.

Формирование экосистемы происходит за счет конвергенции, взаимодействия и внедрения аналитики данных и других технологий. Цифровые платформы - это рычаг для оптимизации преимуществ цифровой трансформации. Меры, которые помогают обновлять бизнес-модели и методы управления, а также преобразовывать традиционные методы работы, будут дополнять другие политические инициативы. Ключевой целью стимулирования туризма с цифровыми технологиями является поощрение цифровой и физической конвергенции и достижение целей интеллектуального туризма. Конкретные действия могут включать:

– расширение доступа к высокоскоростной широкополосной связи и другой цифровой инфраструктуре для туристических предприятий и посетителей в городах, регионах и сельских районах, чтобы получить выгоду от производства и доставки беспрепятственного туристического опыта, управления туризмом, обмена данными и аналитики.

– государственно-частное партнерство и сотрудничество между представителями малого и среднего предпринимательства и цифровыми предприятиями и образовательными учреждениями для расширения обмена знаниями, инноваций и распространения.

– объединение участников с разнообразным и взаимодополняющим опытом в сфере технологий, туризма и других секторов, чтобы создать динамичную цифровую экосистему кластера, в которой смогут процветать как начинающие, так и существующие туристические компании.

Как следствие вышеизложенного, в ходе исследования автором была предложена модель регионального туристской цифровой платформы, в которую внедрены цифровые технологии. В основу платформы заложена концепция цифрово-физической конвергенции.

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ПЕРСПЕКТИВЫ ПРИМЕНЕНИЯ ЧИСТЯКА ВЕСЕННЕГО FICARIA VERNA HUDS В МЕДИЦИНЕ И ПИЩЕВОЙ ПРОМЫШЛЕННОСТИ, ХИМИЧЕСКИЙ СОСТАВ И БИОЛОГИЧЕСКАЯ АКТИВНОСТЬ

THE PROSPECTS OF APPLICATION OF SPRING CHISTYAK FICARIA VERNA HUDS IN MEDICINE AND FOOD INDUSTRY, CHEMICAL COMPOSITION AND BIOLOGICAL ACTIVITY

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Аннотация

Ficaria verna – многолетнее травянистое инвазивное растение, широко распространённое в России. В качестве основных групп биологически активных соединений его надземной части описаны фенольные (флавоноиды, фенолокислоты), терпеновые (тритерпеновые, каротиноиды, фитостеролы, фталаты) соединения.

Растение использовалось в народной медицине некоторых европейских стран при лечении кашля, цинги, геморроя, а также как гепатопротекторное средство. В качестве токсического вещества, содержащегося в растении, описан протоанемонин – нестабильный летучий лактон, легко преобразующийся в нетоксичное соединение анемонин.

Исследование различных извлечений из Ficaria verna позволило установить их антиоксидантную, противовоспалительную и антимикробную активность, что представляет несомненный интерес для дальнейшего более глубокого изучения.

В обзоре представлены научные данные, полученные из доступных открытых источников литературы, содержащие информацию о биологически активных веществах широко распространённого растения – чистяка весеннего. Кроме того, приведены сведения об использовании данного вида и извлечений на его основе в народной и научной медицине, установленной биологической и фармакологической активности и токсичности.

Ключевые слова: чистяк весенний, Ficaria verna, биологически активные вещества, токсичность

Abstract

Ficaria verna is a perennial herbaceous invasive plant widely distributed in Russia. Phenolic (flavonoids, phenolic acids), terpene (triterpene, carotenoids, phytosterols, phthalates) compounds are described as the main groups of biologically active compounds of its aerial part.

The plant was used in folk medicine in some European countries in the treatment of cough, scurvy, hemorrhoids, and also as a hepatoprotective agent. As a toxic substance contained in the plant, protoanemonin is described - an unstable volatile lactone, which is easily converted into a non-toxic compound anemonin.

The study of various extracts from Ficaria verna made it possible to establish their antioxidant, anti-inflammatory and antimicrobial activity, which is of undoubted interest for further in-depth study.

The review presents scientific data obtained from available open sources of literature containing information on biologically active substances of a widespread spring chistyak plant. In addition, information is provided on the use of this species and extracts based on it in folk and scientific medicine, established biological and pharmacological activity and toxicity.

Keywords: spring chistyak, Ficaria verna, biologically active substances, toxicity

Введение

Чистяк весенний (*Ficaria verna* Huds., синонимы *Ficaria ranunculoides* Roth, nom illeg., *Ranunculus ficaria L.*) [1, 2] представляет собой многолетнее травянистое растение высотой 8-30 см.

Этот вид чистяка встречается в восточной Европе, на Британских островах, юго-западе Норвегии, на юге Европы вплоть до самых западных районов Средиземноморья. Чистяк весенний широко распространен в европейской части России, Предкавказье, отдельные местонахождения известны в Западной Сибири. В средней России обычен на всей территории [1, 2].

Химический состав

Флавоноиды и фенолокислоты

J. Gudej и соавт. [3] в метанольном извлечении из высушенных цветков чистяка обнаружены следующие флавоноиды и их гликозиды: кемпферол (**42**), кемпферол 3-O-β-D-глюкозид (**29**), кверцетин-3-O-β-глюкопиранозид (**30**), 3-O-[α-L-рамнопиранозил-(1→6)-β-D-глюкопиранозил]-7-O-(β-D-глюкопиранозил] кверцетин (**36**), а также ванилиновая (**43**), феруловая (**44**), синаповая (**45**), п-кумаровая (**46**), кофейная (**47**), п-гидроксибензойная (**48**), протокатеховая (**49**) и п-гидроксифенилуксусная кислоты (**50**).

M. Tomczyk и соавт. [4] при фракционировании на полиамидной колонке этилацетатного извлечения из цветков чистяка были обнаружены никотифлорин (**32**), витексин (**33**), ориентин (**34**) и флавосативазид (**35**), а в подобном извлечении из листьев – только флавосативазид (**35**). Дальнейшее исследование метанольного извлечения из цветков [5] выявило присутствие в нем двух гликозидов: 3-O-[α-L-рамнопиранозил-(1→6)-β-D-глюкопиранозил]-7-O-(β-D-глюкопиранозил] кверцетин (**36**) и 3-O-[α-L-рамнопиранозил-(1→6)-β-D-глюкопиранозил]-7-O-(β-D-глюкопиранозил] кемпферол (**37**). Кроме того, были количественно определены С-гликозиды и агликоны флавоноидов (после кислотного гидролиза в 10% растворе хлористоводородной кислоты) в листьях и цветках чистяка весеннего в разные фазы его роста и развития [6] (см. таблицу 1).

Таблица 1 - Результаты количественного определения флавоноидов в листьях и цветках чистяка весеннего [6]

Образец/дата	Флавоноиды, мг/г высушенного сырья						
	Изоориентин	Ориентин	Витексин	Изовитексин	Кверцетин	Кемпферол	Сумма (Σ)
1 (12.04.1999)	с/к*	0,03	с/к	0,21	4,27	1,45	5,96
2 (19.04.1999)	с/к	0,02	с/к	0,09	3,40	2,20	5,71
3 (30.04.1999)	с/к	0,40	0,83	0,49	1,82	3,20	6,74
4 (01.04.1999)	0,05	0,08	0,85	0,49	0,82	1,10	3,39
5 (16.04.1999)	0,03	0,08	0,83	0,47	0,16	0,10	1,67
6 (19.04.1999)	0,18	0,19	1,41	0,76	1,20	0,19	3,93
7 (06.05.1999)	0,14	0,27	2,05	1,29	0,96	с/к	4,71

*Примечание. * - с/к – следовые количества*

1 – цветочные бутоны, 2 – цветки (полном цветение), 3 – цветки (конец цветения), 4 – листья (образование и рост побегов), 5 – листья (бутонизация), 6 – листья (цветение), 7 – листья (конец цветения)

Из данных таблицы 1 следует, что согласно результатам ВЭЖХ исследования, в цветках чистяка весеннего суммарное содержание флавоноидов значительно больше, чем в листьях за счёт высокого содержания производных кверцетина и кемпферола. В листьях в большем количестве обнаруживаются С-гликозиды (изоориентин, витексин, изовитексин).

N. G. Hadaruga были получены спиртовые извлечения (96% этанол) в аппарате Сокслета из листьев и цветков чистяка весеннего и проведено определение суммы флавоноидов.

Сырье собиралось в Румынии (область Банат) в апреле в период цветения растений. Содержание флавоноидов в пересчете на кверцетин в цветках составляло 202,0 мг/100 г сырья, а в листьях 223,3 мг/100 г сырья (свежее сырье) [7].

V. Karpuik и соавт. [8] проводили исследование суммы фенольных соединений и суммы флавоноидов в спиртовых извлечениях из надземной части растения, листьев и цветков. Сбор проводили весной в западной Украине в 2020 году. Для экстрагирования использовали 20%, 40%;70% и 90% водно-спиртовые растворы. Максимальные значения измеряемых показателей были получены при использовании 70% водно-спиртового раствора: в надземной части – 20,35 мг в пересчёте на галловую кислоту/г и 18,37 мг в пересчёте кверцетин/г, в листьях – 11,58 мг в пересчёте на галловую кислоту/г и 10,37 мг в пересчёте кверцетин /г, в цветках – 8,51 мг в пересчёте на галловую кислоту/г и 6,32 мг в пересчёте кверцетин /г.

J. Malik и соавт. [9] оценивали сумму фенольных соединений в спиртовом (80%) извлечении из корней чистяка с использованием реактива Фолина-Чокалтеу. Сумма фенольных соединений составила 0,039 ± 0,017 в пересчёте на галловую кислоту/г.

G. Luta с коллегами [10] проводили исследование суммы фенольных соединений и флавоноидов в листьях чистяка весеннего. По их данным сумма фенольных соединений составляла 275,74 ± 21,39 мг в пересчёте на галловую кислоту/100 г свежего сырья.

Таким образом, флавоноиды и фенолокислоты присутствуют во всех частях чистяка весеннего, но в значительно большем количестве в надземной части растения, которая характеризуется наибольшим содержанием фенольных соединений. Цветки накапливают флавоноидов больше, чем листья. Растение интересно значительным содержанием С-гликозидов флавоноидов, таких как витексин, ориентин, флавосативазид, изориентин и изовитексин.

Аскорбиновая кислота

G. Luta и соавт. также проводили количественное определение аскорбиновой кислоты в листьях растения колориметрическим методом, используя 2,6-дихлорфенолиндофенол. Содержание витамина С составляло 93,84 ± 2,66 мг/100 г свежего сырья [10].

Пентациклические тритерпеноиды и их гликозиды

Б.А. Фигуркиным и соавт. [11] проводилось изучение пентациклических тритерпеноидов в надземной части и клубнях перезимовавших и молодых растений чистяка. В период цветения (июнь) были заготовлены надземные части и клубни перезимовавших растений, а также молодые клубни, образовавшиеся после усыхания надземной части (июль). Сумма гликозидов в фазу цветения составляла соответственно 0,73%, 1,80% и 0,53% в пересчёте на воздушно-сухое сырьё. Во всех испытуемых частях после гидролиза были идентифицированы хедерагенин и олеаноловая кислота.

H. Pourrat и соавт. в патенте [12], посвященном разработке способа получения экстракта из корней чистяка весеннего, также указано, что основными пентациклическими тритерпеноидами являются хедерагенин (**2**) и олеаноловая кислота (**3**).

М.В. Зелениной [13] показано, что наибольшее содержание пентациклических тритерпеноидов и их гликозидов наблюдается в подземной части чистяка. По ее мнению, вероятно, они расходуются на ростовые процессы.

O. Texier и соавт. [14] из клубней чистяка весеннего был выделен один из основных пентациклических тритерпеноидов 3-O-(α-арабинопиранозил-1’)28-O-[β-глюкопиранозил-l”” → 6”(α-рамнопиранозил-1”’→4”)-β-глюкопиранозил-1”] (**4**).

В работе A. Marston и соавт. [15] в извлечениях из высушенных клубней обнаружили шесть гликозидов хедерагенина и олеаноловой кислоты (**6-11**) (см. таблицу 2). Извлечения получали с помощью дихлорметана и метанола с последующим фракционированием.

Каротиноиды

B. Czeczuga [16] изучалось влияния степени освещённости на содержание каротиноидов в листьях чистяка. Было установлено, что сумма каротиноидов в листьях растений,

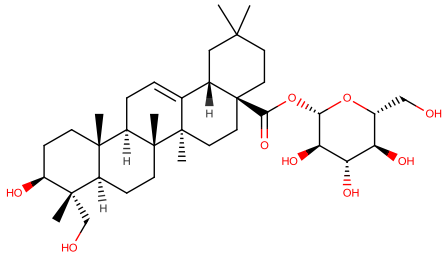
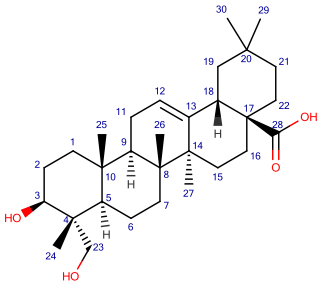
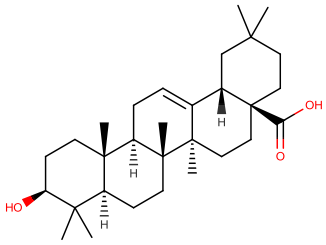
произрастающих в тени, выше (196,3 мкг/г высушенного сырья), чем у растений, растущих без затенения (101,7 мкг/г высушенного сырья). При этом содержание β-каротина (**12**) в тени выше (44,5 мкг/г высушенного сырья), чем на солнце (3,8 мкг/г высушенного сырья), а лютеина (**13**), наоборот, выше на солнце (78,9 мкг/г высушенного сырья), чем при выращивании в тени (35,9 мкг/г высушенного сырья).

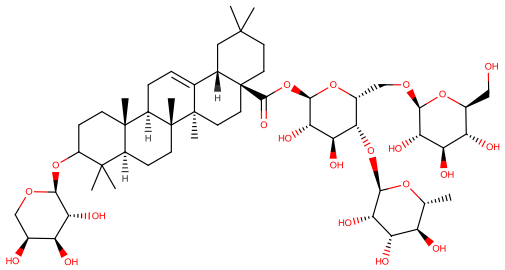
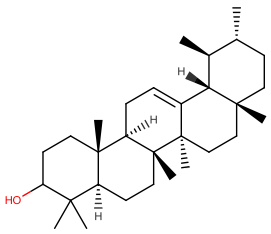
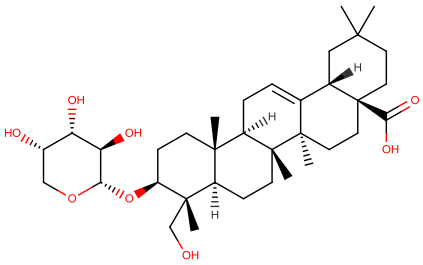
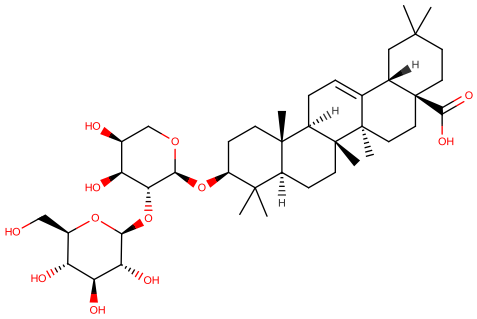
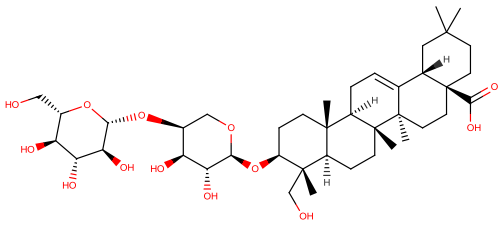
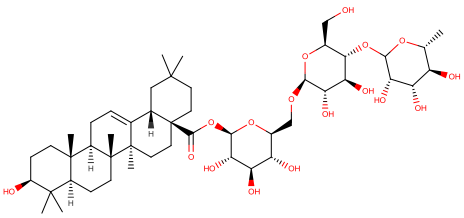
Согласно данным G. Luta и соавт. [10] сумма каротиноидов в листьях чистяка весеннего составляла 6,92 ± 0,09 мг/100 г свежего сырья.

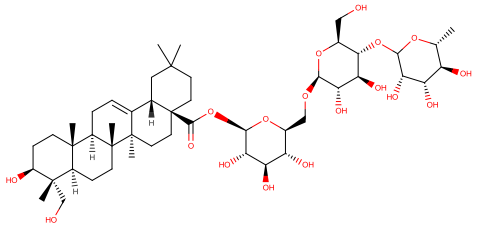
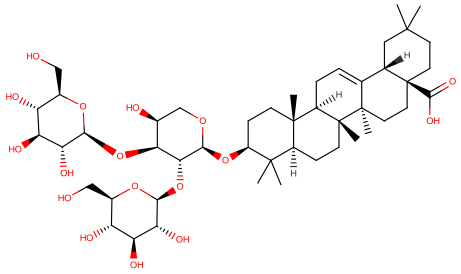
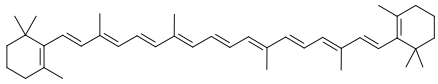
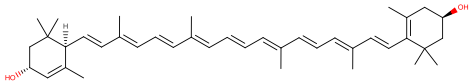
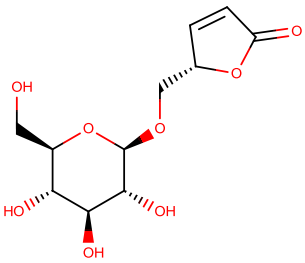
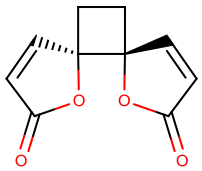
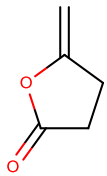
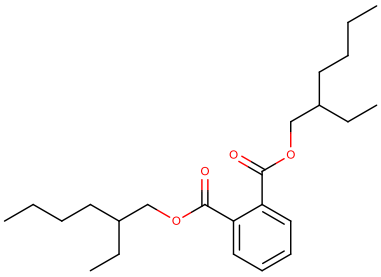
Жирные кислоты, фталаты, эфиры дикарбоновых кислот, фитостеролы

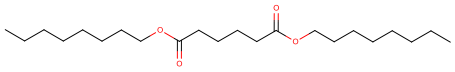
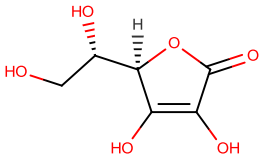
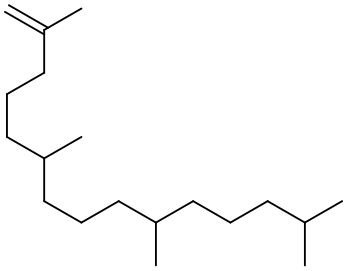
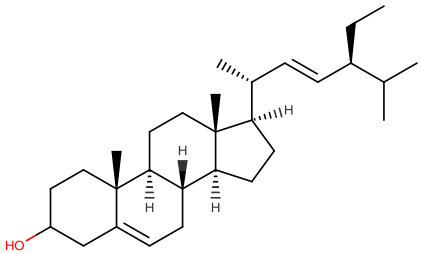
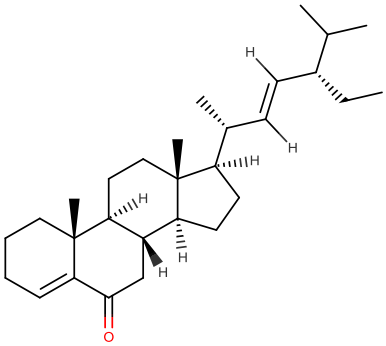
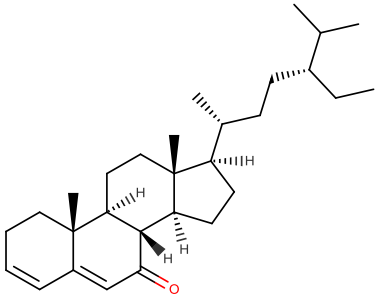
M. Tomczyk и соавт. [4] при фракционировании петролейноэфирного и трихлорметанового извлечений из цветков чистяка весеннего методом ГХ-МС были идентифицированы жирные кислоты – миристиновая (**20**), пальмитиновая (**21**), стеариновая (**22**), сесквитерпен – гексагидрофарнезилацетон (**23**), эфир дикарборновой кислоты - диоктиладипинат (**18**), фталат - бис(2-этилгексил) фталат (**17**) и пентациклический тритерпеноид α-амирин (**5**), а также фитостеролы – стигмастерол (**24**), 24S-этилхолеста-4,22E-диен-6-ол (**25**), стигмаст-3,5-диен-7-он (α-сахаростенон) (**26**) и стигмаст-4-ен-3-он (**27**).

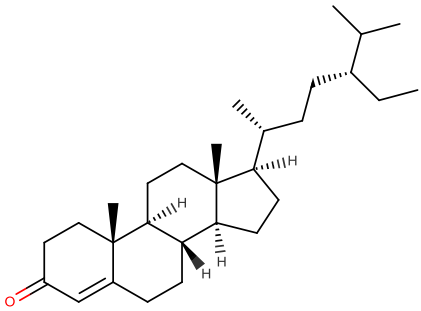
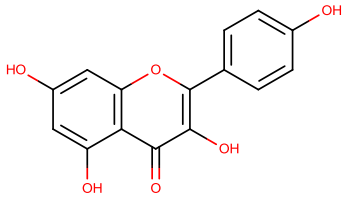
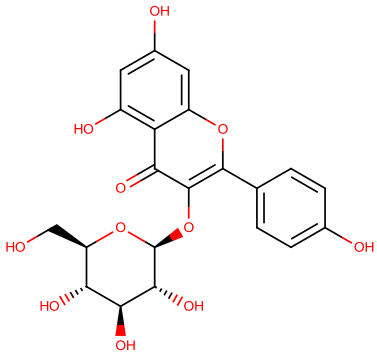
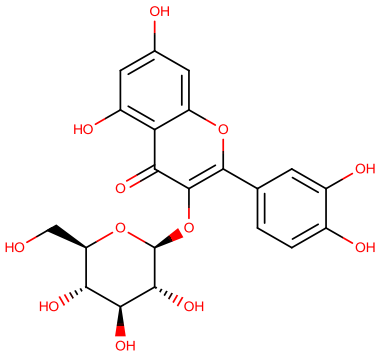
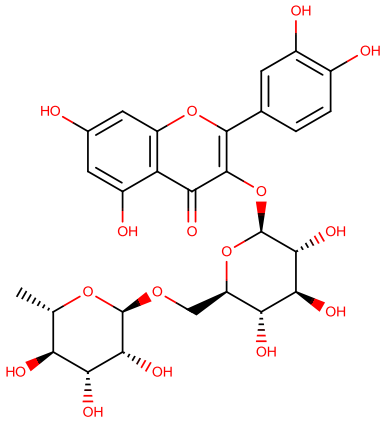
Таблица 2 – Химический состав чистяка весеннего

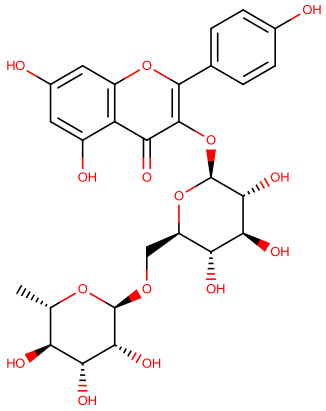
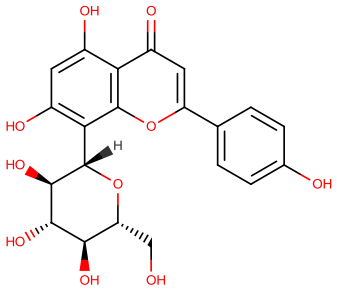
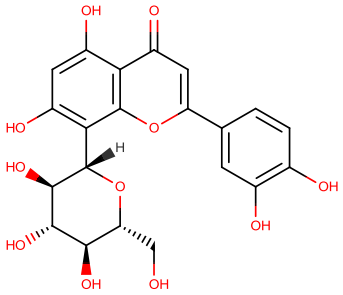
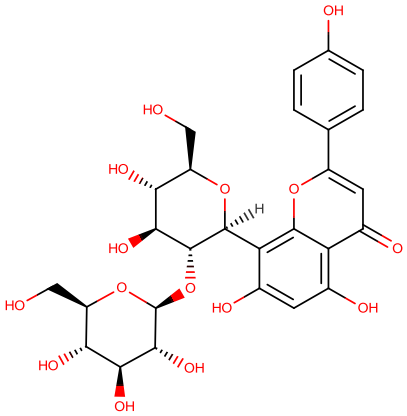
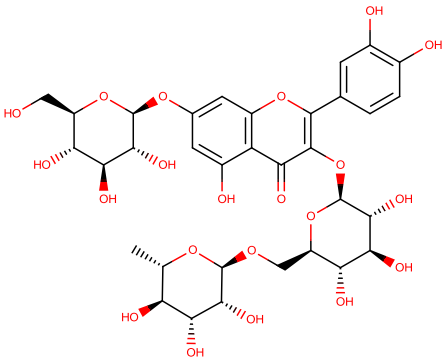
№ п/п	Название вещества	Структурная формула	Орган / часть растения	Источ точники литературы
Пентациклические тритерпеноиды				
1	Хедерагенин-28-О-β-глюкопиранозид		Корни и клубни	[17]
2	Хедерагенин		Корни и клубни	[11,12, 18,19, 20, 21,22, 23]
3	Олеаноловая кислота		Корни и клубни	[11,12, 20,22, 23]

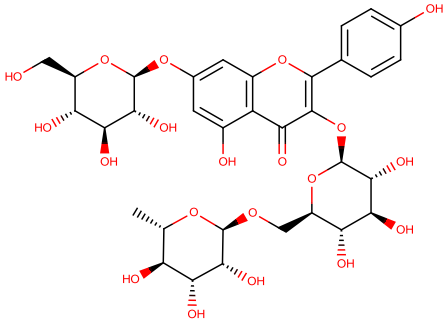
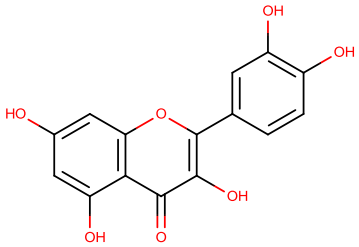
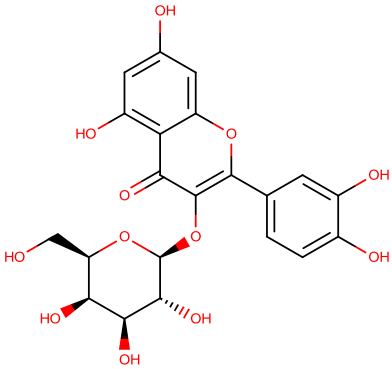
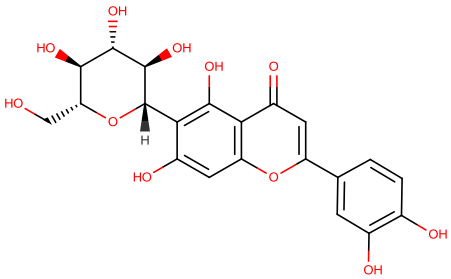
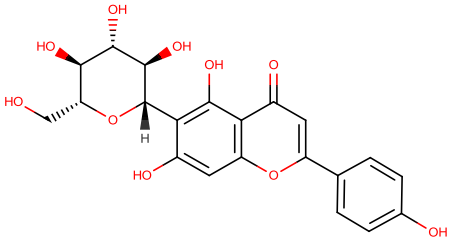
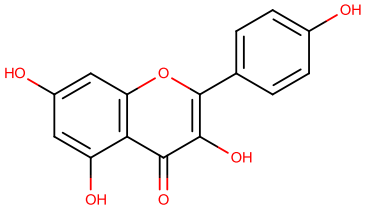
4	3-O-(α-арабинозил-1')28-O-[α-гнлюкопиранозил-l'''' → 6''(α-рамнопиранозил-1'''→4'')β-глюкопиранозил-1'']-хедерагенин		Клубни	[14,24]
5	α-амирин		Цветки	[4]
6	Хедерагенин 3-O-α-L-арабинопиранозид		Клубни	[15]
7	Олеаноловая кислота 3-O-β-D-глюкопиранозил-(1→2)-α-L-арабинопиранозид		Клубни	[15]
8	Хедерагенин 3-O-β-D-глюкопиранозил- (1→4)-α-L-арабинопиранозид		Клубни	[15]
9	Олеаноловая кислота 28-O-[α-L-рамнопиранозил (1→4)- β -D-глюкопиранозил-(1→6)] β-D-глюкопиранозид		Клубни	[15]

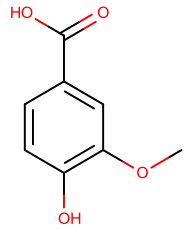
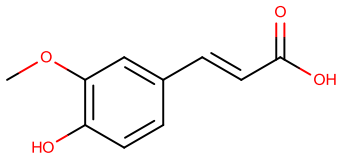
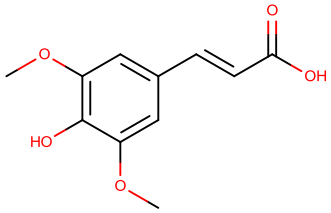
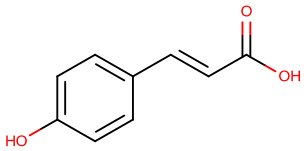
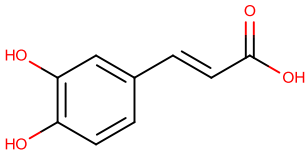
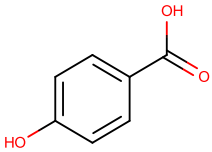
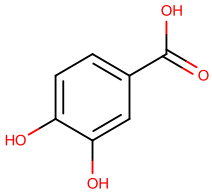
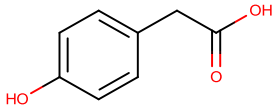
10	Хедерагенин 28-O-[α-L-рамнопиранозид (1→4)- β -D-глюкопиранозил-(1→6)] β-D-глюкопиранозид		Клубни	[15]
11	Олеаноловая кислота 3-O-β-D-глюкопиранозил-(1→3)-[(β -D-глюкопиранозил-(1→2)]-α-L-арабинопиранозид		Клубни	[15]
Каротиноиды				
12	β-Каротин		Листья	[16]
13	Лютеин		Листья	[16]
Лактон				
14	Ранункулин		Все части растения	[25]
15	Анемонин		Все части растения	[25]
16	Протоанемонин		Все части растения	[26]
Фталаты				
17	Бис(2-этилгексил) фталат		Цветки	[4]

Эфиры дикарбоновых кислот				
18	Диоктиладипинат		Цветки	[4]
Витамины				
19	Аскорбиновая кислота		-	[27]
Жирный кислоты				
20	Миристиновая кислота	$CH_3(CH_2)_{12}COOH$	Цветки	[4]
21	Пальмитиновая кислота	$CH_3(CH_2)_{14}COOH$	Цветки	[4]
22	Стеариновая кислота	$CH_3(CH_2)_{16}COOH$	Цветки	[4]
Сесквитерпены				
23	Гексагидрофарнезил-ацетон		Цветки	[4]
Фитостеролы				
24	Стигмастерол		Цветки	[4]
25	24S-этилхолеста-4,22E-диен-6-он		Цветки	[4]
26	Стигмаст-3,5-диен-7-он		Цветки	[4]

27	Стигмаст-4-ен-3-он		Цветки	[4]
	Флавоноиды			
28	Кемпферол		Цветки	[3]
29	Кемпферол 3-О-β-D-глюкозид		Цветки	[3]
30	Кверцетин-3-О-β--глюкопиранозид		Цветки	[3]
31	Рутин		Цветки	[3]

32	Никотифлорин		Цветки	[28]
33	Витексин		Цветки	[28]
34	Ориентин		Цветки	[28]
35	Флавосативазид		Цветки, листья	[28]
36	3-O-[α-L-рамнопиранозил-(1→6)-β-D-глюкопиранозил]-7-O-(β-D-глюкопиранозил] кверцетин		Цветки	[5]

37	3-O-[α-L-рамнопиранозил-(1→6)-β-D-глюкопиранозил]-7-O-(β-D-глюкопиранозил] кемпферол		Цветки	[5]
38	Кверцетин		Цветки, листья	[6]
39	Гиперозид		Цветки, листья	[6]
40	Изориентин		Цветки, листья	[6]
41	Изовитексин		Цветки, листья	[6]
42	Кемпферол		Цветки, листья	[6]

		Фенолокислоты		
43	Ванилиновая кислота		Цветки	[3]
44	Феруловая кислота		Цветки	[3]
45	Синаповая кислота		Цветки	[3]
46	п-Кумаровая кислота		Цветки	[3]
47	Кофейная кислота		Цветки	[3]
48	п-Гидроксибензойная кислота		Цветки	[3]
49	Протокатеховая кислота		Цветки	[3]
50	п-Гидроксифенилуксусная кислота		Цветки	[3]

В чистяке весеннем, как и в других представителях семейства *Ranunculacea*, в случае повреждения растительных тканей задействуется защитный механизм, опосредованный гидролизом ранункулина с дальнейшим высвобождением токсического компонента протоанемонина (см. рис. 1). При этом отмечается наибольшее содержание протоанемонина в стеблях. Также чистяк весенний содержит фенолокислоты и флавоноиды, большая часть которых сконцентрирована в надземной части растений, особенно в цветках. Встречается

ряд редких С-гликозидных флавоноидов. Подземная часть растения, корни и клубни богаты пентациклическими тритерпеноидами, основными представителями которых являются олеаноловая кислота и хедерагенин, а также их гликозидные формы.

Этнофармакологические исследования

Во многих источниках литературы указывается, что чистяк весенний используется для лечения геморроя, а также патологий ЖКТ, включая констипацию, диарею и нарушение пищеварения.

При изучении гербария и записей проживавшего в Каталонии фармацевта и натуралиста Francesc Bolòs (1773 – 1844) было установлено, что чистяк весенний использовали в Европе в 18 веке при лечении кашля, цинги, геморроя, а также как гепатопротекторное средство [29].

В центральной Сербии, население горной области Копаоник использует чистяк весенний для лечения геморроя: одну столовую ложку мелкоизмельченных корней настаивают с одним стаканом вина и медом, принимают три раза в день до еды [30].

В Турции, провинция Мерсин, г. Боязы используют отвар из семян чистяка весеннего для лечения геморроя: одна чашка 3 раза в день в течение 2-3 недель [31].

В восточной и юго-восточной Сербии отвар из корней, листьев, цветков, плодов применяют для стимулирования пищеварения, лечения геморроя и боли в животе [32].

Для лечения констипации, снятия спазма ЖКТ, а также в качестве ветрогонного средства в г. Сарыгёль (провинция Маниса, Турция) используют горячий компресс, порошок из семян, а также употребляют в сыром виде [33].

В Ливане население в окрестностях горы Хермон использует отвар из всего растения чистяка весеннего для лечения диареи [34].

В области Кампания на юго-западе Италии используют отвар из листьев чистяка весеннего при коликах у детей [35].

В Ираке – отвар из листьев и цветков для лечения артрита [36].

В Иране, провинция Курдистан, г. Сервабад употребляют отвар для стимулирования пищеварения [37].

В Румынии применяют отвар в качестве вяжущего и противовоспалительного средства при варикозном расширении вен, геморрое и заболеваниях кожи [25].

Токсичность

Лактоны

Протоанемонин (**16**) является одним из самых изученных растительных лактонов, обладает токсическими свойствами и обнаруживается во многих родах семейства *Ranunculaceae*. В 19 веке было найдено кристаллическое вещество, получаемое при дистилляции с водяным паром разных видов *Ranunculus.* После отделения данного вещества растение теряло способность вызывать раздражение кожных покровов человека и животных. Кристаллическое вещество было признано не токсичным и названо анемонин. Однако, при проведении дистилляции в несколько иных условиях было получено масло с крайне раздражающими свойствами, которому дали название протоанемонин [17].

Было установлено, что протоанемонин может вызывать летальный исход экспериментальных животных и домашнего скота. Симптомы отравления последних включает слюнотечение, диарею и признаки боли в животе. Ткани ротовой полости могут быть раздражены. В тяжелых случаях наблюдаются конвульсии. Признаки отравления людей схожи с таковыми у животных: острая боль в животе, чувство воспаления горла, слюнотечение, кровоизлияния в роговицу глаза [17,26].

Известно, что протоанемонин крайне нестабильное вещество. Оно образуется из гликозида ранункулина (**14**) при разрушении тканей растения. Широкий спектр микроорганизмов чувствителен к действию протоанемонина, В случае сушки растения или контакта с воздухом или водой протоанемонин димеризуется в анемонин (**15**), а последний гидролизуется в нетоксичную дикарбоновую кислоту (рис. 1) [26,38].

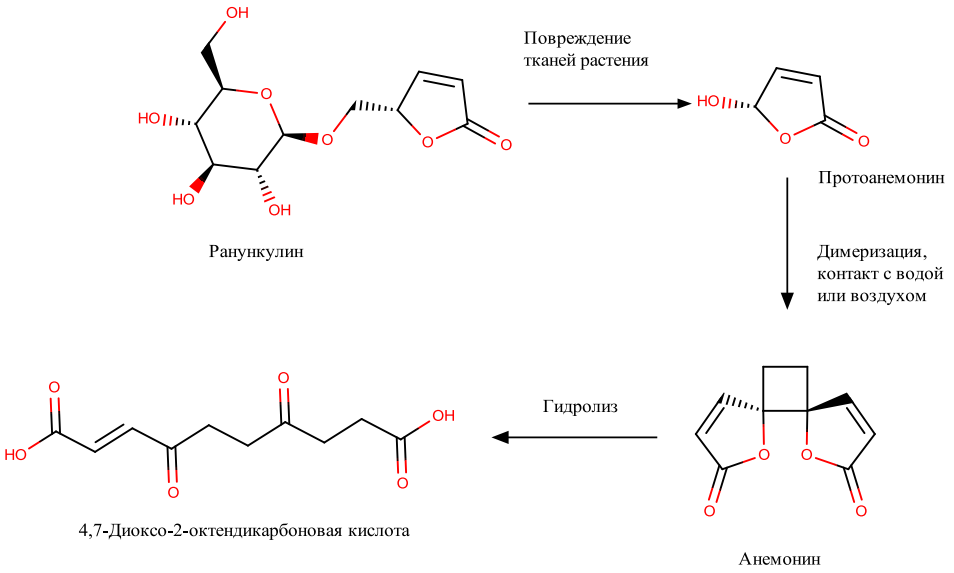


Рисунок 1. Схема превращений ранункулина [38]

Проводилась компьютерная оценка токсичности молекулы протоанемонина с использованием программы Derek Nexus компании Lhasa. По результатам вычислений не было обнаружено структурных фрагментов, указывающих на генотоксичность или канцерогенность. Однако протоанемонин по классификации Крамера относится к III классу веществ в связи с наличием α,β-ненасыщенного лактонного кольца. Согласно указанной классификации доза для приема внутрь 90 мкг/сутки, т.е 1,5 мкг/кг/сутки для человека массой 60 кг будет носить очень низкий риск проявления токсических свойств. Согласно уточненным данным ТТС (порог токсической угрозы) составляет 180 мкг/сутки. [2].

А. Borona и соавт. [26] исследовали распределения протоанемонина в разных частях чистяка весеннего. Растительный материал был собран ранним летом около 12 – 13 часов дня. Протоанемонин присутствовал во всех частях растения, однако, наибольшее содержание было установлено в стеблях и цветках, что составляло примерно 67% и 25% от общего содержания протоанемонина в растении (см. таблицу 3).

Таблица 3 - Содержание протоанемонина в разных частях чистяка весеннего [26]

Орган растения или его часть	**Содержание протоанемонина, мкг/г свежего сырья**
Растение целиком	1476,9
Корни	469,8
Стебель, связанный с цветком	3475,8
Стебель, связанный с листом	2590,0
Лист	121,5
Цветок целиком	1890,9
Чашечка	29,4
Венчик	75,9
Андроцей	2873,7
Гинецей	8800,0

Т. Neag и соавт. [25] количественно определили анемонин в водно-спиртовом извлечении (70% этанол) из надземной части чистяка, собранной в Румынии в июне 2015 года. Содержание анемонина составляло 2,14 ± 0,007 мг/мл извлечения.

Использование и биологическая активность

Использование

Извлечение из чистяка весеннего входит в состав противогеморроидальной гомеопатической мазы «Авенок» компании Буарон в количестве 0,003 г на 30 г мази [https://www.rlsnet.ru/tn_index_id_12804.htm].

H Pourrat и соавт. [18] был получен патент на способ получения извлечения из корней чистяка весеннего для включения в косметические средства, такие как крема и лосьоны. В двух похожих патентах АО «LABORATORES MAURICE MESSEGUE» [43] и L'OREAL USA [39] приводятся составы косметических средств для кожи, содержащих отжатый сок из свежего сырья растения.

Антиоксидантная активность

В работе N. G. Hadaruga [7] с помощью ДПФГ-теста (способности восстанавливать стабильный 2,2-дифенил-1-пикрилгидразил радикал) анализировалась антиоксидантная активность спиртовых извлечений из листьев и цветков чистяка весеннего. В качестве референтных использовались четыре раствора кверцетина с концентрациями 1600 мкМ, 160 мкМ, 16 мкМ и 1,6 мкМ. Антиоксидантная активность извлечений при 25-кратном разведении была сопоставима с активностью раствора кверцетина в диапазоне концентраций 16 – 160 мкМ.

J. Malik и соавт. [9] проводили исследование антиоксидантной активности спиртового извлечения из корней *чистяка* путем оценки адсорбционной емкости по отношению к кислородным радикалам (ORAC). Референтом был выбран тролокс. Результат измеряли в эквивалентах тролокса/1 г высушенного извлечения. Для извлечения результат составил 0,017, для тролокса – 3,100.

S. Inci с коллегами [40] исследовали антиоксидантную активность метанольного извлечения надземной части *чистяка* (в концентрациях 1,25, 2,5, 5 и 10 мг/мл) с использованием ДПФГ-теста. В качестве референта использовали бутилгидроксианизол. Процент максимального ингибирования наблюдался для концентрации извлечения 10 мг/мл и составлял 95,98%, тогда как активность референта – 91,70%.

В работе G. Luta и соавт.[10] антиоксидантная активность (EC_{50}) метанольного (80%) извлечения из листьев чистяка весеннего в подобном тесте составила 14,22 ± 1,68 мг/мл.

Влияние на содержание гемоглобина в крови

Известно, что многие алкилирующие средства, используемые для лечения раковых заболевания вызывают снижение содержания гемоглобина, в том числе известный и широко используемый препарат цисплатин, который снижает содержание гемоглобина в крови примерно на 20%. В исследовании на лабораторных крысах C. Balta и соавт. [41] показали, что совместное введение цисплатина, β-циклодекстрина и спиртового извлечения (96%) из чистяка весеннего приводило к меньшему снижению содержания гемоглобина в сравнении с контролем (цисплатин) и введением цисплатина с β-циклодекстрином. Авторы предположили, что присутствующие в извлечении антиоксиданты усиливают защитные способности β-циклодекстрина при действии цисплатина.

V. Karpuik и соавт. [8] проводили исследование антиоксидантной активности (ДПФГ-тест) ряда спиртовых извлечений из надземной части, листьев и цветков чистяка весеннего. В качестве референтов использовали кверцетин и витамин С. Наиболее высокая антиоксидантная активность (максимальный процент ингибирования) составила для надземной части – 80,71 ± 0,01% при использовании в качестве экстрагента 20% водно-спиртового раствора; для листьев – 67,33 ± 0,01% при использовании экстракции 20% водно-спиртовым раствором; для цветков – 77,19 ± 0,01% при исследовании 70% водно-спиртового извлечения. Для референтов кверцетина и витамина С – 78,54 ± 0,01% и 76,23 ± 0,01% соответственно. Таким образом, извлечение полученное из надземной части чистяка весеннего с помощью 20% водно-спиртового раствора, показало наибольшую антиоксидантную активность, превышающую активность референтов.

Противовоспалительная активность

J. Malik и соавт. [9] оценивали противовоспалительную активность спиртового извлечения (80%) из корней чистяка. В частности исследовали ингибирование COX-1/COX-2, используя в качестве референтов NS-398 (ингибитор COX-2) и индометацин, а также ингибирование 5-LOX. Референтом служил зилеутон. IC50 исследуемого извлечения в отношении циклооксигеназы-1 составляло 59,10 ± 13,95 мкг/мл, индометацина 0,20 ± 0,11 мкг/мл, NS-398 25,57 ± 0,48 мкг/мл. IC50 исследуемого извлечения в отношении циклооксигеназы-2 составляло 22,97 ± 3,45 мкг/мл, индометацина - 0,15 ± 0,11 мкг/мл, а для NS-398 равнялось 0,57 ± 0,35 мкг/мл. Результаты исследования ингибирования 5-липоксигеназы показали, что IC50 извлечения 124,52 ± 22,91 мкг/мл существенно ниже зидеутона – 0,97 ± 0,23 мкг/мл.

Антимикробная активность

S. Inci и соавт. [40] была изучена противомикробная активность метанольного, этанольного и хлороформного извлечений (в количестве 500 мкг и 1000 мкг) надземной части чистяка весеннего диско-диффузионным методом. В качестве тестовых штаммов использовали *Staphylococcus aureus* ATCC25923, *Escherichia coli* ATCC25322, *Klebsiella pneumoniae* ATCC 700603, *Bacillus megaterium* DSM32, *Salmonella thypii*, *Candida albicans* FMC17. Хлороформное извлечение при обеих концентрациях не показало какой-либо активности. Этанольное извлечение в количестве 1000 мкг давало зоны ингибирования роста 16 мм, 11 мм, 14 мм, 10 мм и 14 мм на средах засеянных *E. coli, K. pneumoniae, S. aureus, S. thypii* и *C. Albicans* соответственно. В случае меньшей концентрации эффекта не наблюдалось. Для метанольного извлечения в количестве 1000 мкг зоны ингибирования составляли от 17 до 21 мм в ряду исследованных микроорганизмов.

Выводы

Одной из основных перспективных групп для исследования фармакологической активности чистяка весеннего являются пентациклические тритерпеноиды, представленные в основном олеаноловой кислотой, хедерагенином и их гликозидными производными. В литературе встречаются результаты исследований разных видов фармакологической активности указанной группы веществ. Однако, для извлечений из чистяка проведен небольшой объем работ по изучению биологической активности, что открывает перспективы дальнейших исследований. Кроме того, на основании данных этнофармакологических исследований, а также использования извлечения чистяка весеннего в гомеопатической мази компанией перспективно дальнейшее исследование данного растения для лечения геморроя в рамках разработки аллопатических лекарственных форм. Наличие редких С-гликозидных флавоноидов в надземной части растения и их широкий спектр биологической активности также может представлять интерес для дальнейших исследований.

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