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ПЕРСПЕКТИВЫ ИСПОЛЬЗОВАНИЯ ТЫКВЕННЫХ КУЛЬТУР В КАЧЕСТВЕ НАТУРАЛЬНОГО БИОКОРРЕКТОРА В ТЕХНОЛОГИИ МЯСОПРОДУКТОВ ФУНКЦИОНАЛЬНОГО НАЗНАЧЕНИЯ

PROSPECTS FOR THE USE OF PUMPKIN PLANTS AS A NATURAL BIOCORRECTOR IN THE TECHNOLOGY OF FUNCTIONAL MEAT PRODUCTS

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Аннотация

В сложившихся условиях поиск новых биологически активных веществ различной функциональной направленности из доступного и недорогого растительного сырья, разработка мясных продуктов с функциональными добавками, изучение их потребительских свойств и эффективности - являются перспективными задачами. Тыквенная мука является природным биологически активным белково-витаминно-минеральным комплексом растительного происхождения, сочетающим в себе основные незаменимые аминокислоты, макро- и микроэлементы, витамины и клетчатку. Цель работы - изучить химический состав и функционально-технологические свойства семян кабачка с перспективой использования в качестве биокорректора в технологии мясорастительных продуктов функционального назначения. Исследования выполнены на кафедре пищевых технологий ФГБОУ ВО «Донской государственный аграрный университет» и на ООО «Мясокомбинат», с. Развильное, Песчанокопский р-н, Ростовская обл. Установлено, что введение в рецептуры мясопродуктов добавки семян кабачка улучшает органолептические и физико-химические характеристики готовых изделий. Опытные образцы отличались более нежной консистенцией и более высокой однородностью фарша на разрезе, отмечено также увеличение массовой доли белка и уменьшение доли жира.

Ключевые слова: тыквенная мука, пищевая ценность, витаминно-минеральный состав, мясопродукты, функциональные свойства.

Abstract

In the current conditions, the search for new biologically active substances of various functional orientation from affordable and inexpensive plant raw materials, the development

of meat products with functional additives, the study of their consumer properties and effectiveness are promising tasks. Pumpkin flour is a naturally biologically active protein-vitamin-mineral complex of plant origin, combining the main essential amino acids, macro- and microelements, vitamins and fiber. The purpose of the work is to study the chemical composition and functional and technological properties of zucchini seeds with the prospect of being used as a biocorrector in the technology of functional meat products. The research was carried out at the Department of Food Technologies of the Don State Agrarian University and at the Meat Processing Plant LLC, Razvilnoye village, Peschanokopsky district, Rostov region. It has been established that the introduction of zucchini seed additives into the formulations of meat products improves the organoleptic and physico-chemical characteristics of finished products. The prototypes were distinguished by a more delicate consistency and higher uniformity of minced meat on the cut, an increase in the mass fraction of protein and a decrease in the proportion of fat were also noted.

Key words: *pumpkin flour, nutritional value, vitamin and mineral composition, meat products, functional properties.*

Introduction. Throughout the existence of a biological species, a person received the necessary biologically active substances with food and satisfied the needs of the body. Now the situation has changed dramatically. In the modern world, food products undergo very severe heat treatment, are subjected to conservation, long-term storage, and transportation, which negatively affects their quality and the content of biologically active substances in them [4, 9, 12, 14].

When developing modern biotechnology for obtaining protein preparations from plant seeds, special attention is paid to the maximum preservation of the entire complex of biologically active compounds that make up their composition [2, 11].

As promising sources of plant raw materials for the creation of biologically active additives, along with secondary resources of the food and processing industry, vegetable raw materials, in particular, seeds of pumpkin plants and products of their processing, which have a unique chemical composition, are of practical interest [1, 10].

The most famous plants of the Pumpkin family include pumpkin, zucchini, watermelon, melon, etc. The popularity of zucchini among Russian consumers has increased significantly, including due to the excellent dietary properties of this plant: a harmonious ratio of potassium and sodium salts in zucchini, a small amount of coarse dietary fiber, low calorie content, the presence of proteins, minerals, vitamins. Zucchini is rich in folic acid, which plays an important role in the process of hematopoiesis and should be included in the diet of the elderly, children and pregnant women [13, 15].

A by-product of the processing of pumpkin plants are seeds, which have a unique chemical composition and pharmacological properties. The chemical composition of pumpkin seeds of various varieties is presented in table 1.

Table 1 – Chemical composition of pumpkin seeds

Index	Pumpkin Table Winter A-5	Zucchini Aral F1
Moisture and volatile substances, %	6.36	6.45
Protein, %	31.36	34.03
Lipids, %	28.42	29.19
Carbohydrates, %	30.82	26.19
Including: fiber	17.25	19.82
soluble sugars	13.57	6.37
Minerals, %	3.04	4.14
Including: insoluble in 10% HCl	0.29	0.42

The seeds of pumpkin plants contain a large amount of protein, are a source of oil rich in vitamin E, they contain the most valuable complex of vitamins, resins, glycosides and other substances necessary for a person. The protein content is more than 30%, according to this indicator, the seeds of pumpkin plants are not inferior to traditional protein supplements of plant origin used in the production technology of meat and vegetable products [3].

When studying the chemical composition of pumpkin seed samples, it was found that the amount of lipids ranges from 28.42% to 31.79%, which determines the high biological value of the studied seeds and, therefore, can be used in recipes for meat and vegetable products, improving their chemical composition and nutritional value.

To assess the biological value of seeds, the following were calculated: amino acid score, coefficient of difference in amino acid score (CDAAS) and biological value (BV) (Table 2).

The minimum value of the amino acid score in the studied samples was found for tryptophan, slightly higher for the sum of amino acids methionine and cysteine. The amino acid score of valine and isoleucine is significantly lower than the FAO/WHO requirements.

Table 2 – Biological value of pumpkin seeds

Index	Pumpkin Table Winter A-5	Zucchini Aral F1
Amino acid score, %: valine	94.0	82.8
isoleucine	86.3	87.8
leucine	110.3	103.6
lysine	100.6	101.5
methionine + cystine	73.1	74.0
threonine	158.0	163.5
phenylalanine	150.5	138.7
tryptophan	70.0	76.0
CDAAS, %	35.4	29.5
BV, %	64.6	70.5

In general, the proteins of the seeds of pumpkin crops of various varieties have a high biological value, but the highest value of BC in the seeds of the vegetable marrow of the Aral F1 variety is 70.5%.

Evaluation of the nutritional value of raw materials is impossible without determining its mineral composition. The content of mineral substances in the seeds of pumpkin crops indicates that the bulk of macronutrients is represented by phosphorus, potassium, magnesium and calcium. Of the trace elements, a significant amount of zinc and iron was found (Table 3).

Table 3 – Mineral content (per 100 grams)

Index	Pumpkin Table Winter A-5	Zucchini Aral F1
Potassium	536 mg	924 mg
Calcium	289 mg	380 mg
Magnesium	345 mg	507 mg
Phosphorus	1388 mg	2292 mg
Sodium	14 mg	16 mg
Iron	6210 mcg	8220 mcg
Zinc	6540 mcg	8330 mcg
Copper	960 mcg	1460 mcg
Manganese	2730 mcg	3740 mcg

Data on the chemical composition, content of macro- and microelements, as well as indicators of the biological value of pumpkin plant seeds indicate the prospects for their use as a natural biocorrector in the technology of functional meat products.

Materials and research methods. The studies were carried out at the Department of Food Technologies of the Federal State Budgetary Educational Institution of Higher Education “Don State Agrarian University” and at LLC “Myasokombinat”, p. Razvilnoye, Peschanokopsky district, Rostov region

The following were used as objects of research: meat raw materials – trimmed beef first grade, trimmed semi-fat pork; white-fruited squash variety "Aral F1" (manufacturer – LLC "Sakata-Kuban", Krasnodar, Russia) and products of its processing.

Experimental studies included the use of modern physical-chemical, structural-mechanical, functional-technological, microbiological and organoleptic research methods, according to GOST [5, 6, 7, 8].

Research results and their discussion. Assessing the prospects for the use of pumpkin seeds in the technology of meat products as components that give new products functional properties, it is important to know the level of their safety. The research methodology included the study of the main microbiological indicators of the safety of seeds of pumpkin plants (Table 4).

Table 4 – Microbiological safety indicators of cucurbit seeds

Name of indicator	Indicator value	
	Pumpkin seeds	GOST 31645-2012
The number of mesophilic aerobic and facultative anaerobic microorganisms., CFU/g	3.2×10^{3}	No more than $5\text{-}10^{4}$
Yeast, CFU/g	Not detected	No more than 100
Molds, CFU/g	Not detected	no more than 200
Coli group bacteria in 0.1 g of the product	Not detected	Not allowed

The data obtained indicate that according to SanPin 2.3.2.1078–01, no excess of the established norms was found, which characterizes the studied samples of pumpkin plant seeds as a safe raw material suitable for use as food components in food products.

Flour from squash seeds was produced in accordance with the regulatory documentation according to TU 9195-001-60742274-2015. Waxy marrow seeds were crushed in a mill for 60 seconds at 1500 rpm, the core was separated from the shells by sifting through a sieve with a diameter of 1.0 mm.

In appearance, zucchini seed flour is a finely ground greenish-yellow powder (Fig. 1).

Figure 1. – Flour from zucchini seeds

Organoleptic characteristics of flour from zucchini seeds are presented in table 5.

Table 5 – Organoleptic indicators of flour from zucchini seeds

Name indicator	Flour characteristic from zucchini
Appearance	fine grinding powder
Color	greenish yellow
Taste	Peculiar to zucchini seed flour, with a characteristic nutty flavor
Smell	Peculiar to flour from zucchini seeds, without foreign odors

Zucchini seed flour has a high nutritional value (Table 6).

Table 6 – Nutritional value of zucchini seed flour

Name of indicator	Mass fraction, %
Moisture	12±0.3
Fat	10.0±0.2
Protein	38.0±0.4
Carbohydrates	23.0±0.3
Ash	3.5±0.1
Cellulose	18.5±0.3
Energy value, kcal	286.0 _

In order to establish the influence of a natural biocorrector based on zucchini seed flour on the functional and technological properties of model minced meats, model minced meats were developed under the production conditions of Myasokombinat LLC.

As a control, we used the recipe for minced meat for boiled sausage "Stolovaya" (category B). A vegetable additive was introduced into the experimental model minced systems, replacing part of the trimmed beef of the 1st grade with flour from squash seeds in an amount of 5% to 25% (Table 7).

Table 7 – Recipes of experimental model mince systems

Name of ingredients	Control	Replacement level				
		5%	10%	15%	20%	25%
Unsalted raw materials, kg (per 100 kg of raw materials)						
Trimmed beef 1 grade	40.0	38.0	36.0	34.0	32.0	30.0
Pork trimmed bold	59.0	59.0	59.0	59.0	59.0	59.0
Whole or skimmed cow's milk	1.0	1.0	1.0	1.0	1.0	1.0
Hydrated Zucchini Seed Flour	-	2.0	4.0	6.0	8.0	10.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

The effect of a protein supplement based on hydrated flour from zucchini seeds on the moisture-binding and emulsifying abilities of minced meat systems is shown in Figures 2 and 3.

It should be noted that with an increase in the dosage of hydrated powder from zucchini seeds, applied to minced meat, there is an increase in moisture-binding and emulsifying capacity, which is one of the important factors in the production technology of boiled sausages, increases the yield of finished products and shelf life.

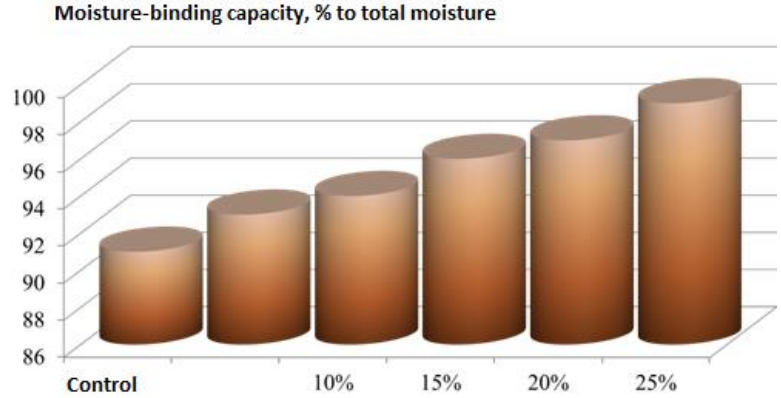

Figure 2. – The effect of hydrated flour from zucchini seeds on the moisture-binding capacity of minced meat

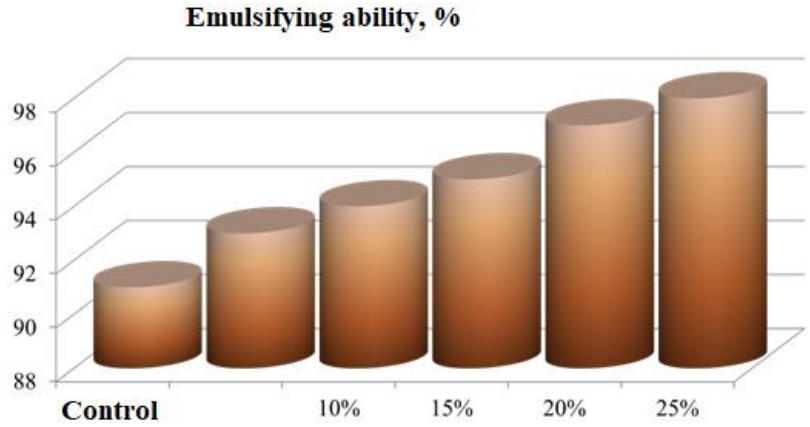

Figure 3 – The effect of hydrated flour from squash seeds on the emulsifying ability of minced meat

Preliminary data obtained on minced meat served as the basis for the development of a recipe and technology for boiled sausage with the addition of flour from zucchini seeds. The development of prototypes of boiled sausages with a natural biocorrector based on flour from zucchini seeds was carried out on the basis of the recipe for sausage "Stolovaya" (control sample). In experimental samples, from 5 to 25% of trimmed beef of the 1st grade was replaced with a vegetable supplement based on flour from zucchini seeds (Table 8).

Table 8 – Recipe for prototypes of boiled sausages with different levels of replacement of meat raw materials with flour from zucchini seeds

Name of ingredients	Control sample	Prototype (replacement level)				
		5%	10%	15%	20%	25%
Unsalted raw materials, kg (per 100 kg of raw materials)						
Trimmed beef 1 grade	40.0	38.0	36.0	34.0	32.0	30.0
Pork trimmed bold	59.0	59.0	59.0	59.0	59.0	59.0
Whole or skimmed cow's milk	1.0	1.0	1.0	1.0	1.0	1.0
Hydrated Zucchini Seed Flour	-	2.0	4.0	6.0	8.0	10.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
Food additives, spices, materials, g (per 100 kg of unsalted raw materials)						
Sugar	150	150	150	150	150	150
Salt	2475.0	2475.0	2475.0	2475.0	2475.0	2475.0
sodium nitrite	7.4	7.4	7.4	7.4	7.4	7.4
Black pepper	100.0	100.0	100.0	100.0	100.0	100.0
Allspice	100.0	100.0	100.0	100.0	100.0	100.0
fresh garlic	120.0	120.0	120.0	120.0	120.0	120.0

One of the technological risks in food fortification, which is accompanied by the modification of the recipe composition, is a change in their organoleptic properties. Therefore, special attention was paid to the preservation of the organoleptic characteristics of samples of sausages when replacing raw meat with flour.

According to organoleptic indicators, prototypes with a level of replacement of raw meat up to 20% met the requirements of GOST 23670-2019 “Cooked meat sausage products. General technical conditions” (Table 9).

Table 9 – Organoleptic quality indicators of prototypes of boiled sausages with different levels of replacement of meat raw materials

Name of indicator	Characteristics of the indicator				
	Control	Replacement level			Requirements GOST 23670-2019
		15%	20%	25%	
Appearance	Loaves with a clean, dry surface, without slips, stains, damage to the shell of minced meat				
Consistency	elastic				elastic
Color and type of minced meat on the cut	Pink	Light pink		light gray	Pink or light pink minced meat, evenly mixed, and contains pieces of bacon of white color or with a pinkish tint, side size not more than 6 mm
Smell and taste	Peculiar to this type of product, with the aroma of spices, moderately salty			Peculiar to this type of product, with the aroma of spices, moderately salty, with a characteristic nutty flavor	Peculiar to this type of product, with the aroma of spices, moderately salty

The introduction of flour from zucchini into boiled sausages slightly affects the indicators – the type and color of the cut, consistency, juiciness. The prototypes were distinguished by a more delicate consistency and a higher uniformity of minced meat.

According to the totality of indicators, preference was given to products with a level of replacement of meat raw materials with flour from zucchini seeds up to 20%. A higher level of introduction – 25% replacement of meat raw materials, leads to a deterioration in the taste and aroma of sausages and is undesirable due to the presence of a characteristic aftertaste and a grayish tint of the sausage on the cut. The cyclogram with organoleptic evaluation data is shown in Figure 4.

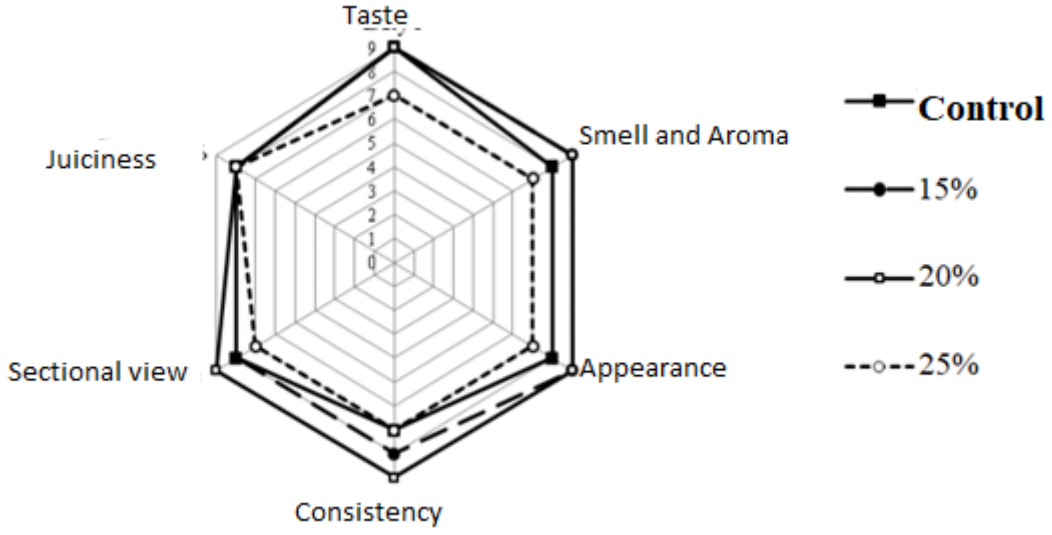

Figure 4. – Cyclogram with organoleptic evaluation data

The results of tasting monitoring of the organoleptic evaluation of prototypes of boiled sausages with different levels of replacement of meat raw materials are presented in table 10.

Table 10 – Results of tasting monitoring, in points

The level of replacement of meat raw materials	General organoleptic evaluation, points
Control	8.60
5% prototype replacement	8.60
10% replacement	8.47
15% replacement	8.35
20% replacement	8.13
25% replacement	7.36

The results of chemical and technological studies of boiled sausages of control and experimental batches, made using flour from zucchini seeds, are given in table. eleven.

Table 11 – Chemical and technological indicators of boiled sausages made using zucchini seed powder

The level of replacement of meat raw materials	Mass fraction, %			Yield of finished products,%
	moisture	fat	squirrel	
Control	70.5	16.20	12.60	118.0
5% replacement	70.6	14.55	13.30	118.9
10% replacement	71.0	14.44	14.05	119.5
15% replacement	71.1	13.52	14.30	119.7
20% replacement	71.2	13.02	14.85	119.9
25% replacement	71.3	12.50	15.30	120.2

Analysis of the data indicates that the use of flour from zucchini seeds in the recipe of boiled sausage as a substitute for part of the main raw material causes minor changes in the overall chemical composition of the finished product, provides an increase in protein content and a decrease in fat content. The content of the mass fraction of protein in the test samples averaged 14.36%, in the control – 12.60%, which meets the requirements of GOST 23670-2019.

The introduction of a herbal supplement enriches the prototypes of boiled sausages with vitamins, macro- and microelements and other biologically active substances, which increases their biological value and translates them into a range of functional food products.

Along with organoleptic and physico-chemical properties, an equally important indicator is the safety indicator. In order to determine the safety indicators of boiled sausage, the dynamics of changes in the composition of microflora during storage of control and experimental samples of boiled sausages was studied for eight days at a temperature of 6°C and relative humidity of about 75-80%. Research data are presented in table 12.

Table 12 – Microbiological studies during storage of a prototype with a 20% replacement level for eight days

Day of testing	The number of mesophilic aerobic and facultative anaerobic microorganisms., CFU/g	Coli group bacteria (coliforms)	Sulfitred cicating clostridia	S. aureus	Pathogenic, incl. salmonella ly
1	200	not discovered	not discovered	not discovered	not discovered
2	355	not discovered	not discovered	not discovered	not discovered

3	465	not discovered	not discovered	not discovered	not discovered
4	640	not discovered	not discovered	not discovered	not discovered
5	708	not discovered	not discovered	not discovered	not discovered
6	760	not discovered	not discovered	not discovered	not discovered
7	805	not discovered	not discovered	not discovered	not discovered
8	995	not discovered	not discovered	not discovered	not discovered

As a result of research, it was found that the introduction of flour from zucchini seeds has a positive effect on the safety of boiled sausage in microbiological terms. The total microbial number ranges from 200 to 995 microbial cells per 1 g of the product for up to eight days of storage, after which this indicator increases. The presence of pathogenic and opportunistic microflora at the indicated storage periods was not detected.

Evaluation of the economic efficiency of production is one of the main factors, since an important position is occupied not only by the quality of products, but also by the profit from its sale.

The studies included the calculation of the cost of the main and auxiliary raw materials for the production of boiled sausages using a natural biocorrector based on hydrated flour from zucchini seeds with a 20% level of meat raw material replacement in Tables 13, 14.

Table 13 – Calculation of the cost of the main raw materials for the production of boiled sausages

Name of the main raw material	Price 1 kg, rub.	"Canteen" (control)		" Dining Room +" (Experience)	
		Consumption, kg	Cost, rub.	Consumption, kg	Cost, rub.
Trimmed beef 1 grade	460.00	40.0 _	18400.00 _	32.0 _	14720.00 _
Pork trimmed bold	220.00	59.0 _	12980.00 _	59.0 _	12980.00 _
Whole or skimmed cow's milk	195.00 _	1.0 _	195.00 _	1.0 _	195.00 _
Hydrated Zucchini Seed Flour	95.00	-	-	8.0 _	760.00
Total:		100.0	31 575.00	100.0	28 655.00

From the above data, it can be seen that the cost of the main raw materials for the production of prototypes is lower than for the control.

Table 14 – Calculation of the cost of auxiliary raw materials for the production of boiled sausages

Name of the main raw material	Price 1 kg, rub.	"Canteen" (control)		" Dining Room +" (Experience)	
		Consumption, g	Cost, rub.	Consumption, g	Cost, rub.
Food salt	10.00	2475.0	24.75	2475.0	24.75
sodium nitrite	68.00	7.4	0.50	7.4	0.50
Sugar	27.00 _	150.0	4.0 5 _	150.0	4.0 5 _
Ground black pepper	145.00	100.0	14.50 _ _	100.0	14.50 _ _
before fragrant	170.00 _	100.0	17.00 _ _ _	100.0	17.00 _ _ _
fresh garlic	137.00	120.0	16.44	120.0	16.44
Total:			77.24		77.24

The calculation of economic efficiency confirms the feasibility of using a natural biocorrector based on flour from zucchini seeds in the technology for the production of boiled sausages. The use of vegetable protein supplements in sausage production technology contributed to reducing the cost of raw materials and increasing the profitability of the product. The economic effect at a 20% level of replacement of meat raw materials amounted to 2,920 rubles.

Conclusions. Studies have confirmed the feasibility of using zucchini seed flour as a natural biocorrector in the technology of functional meat products. The developed technology for the production of pilot batches of boiled sausages using zucchini seeds makes it possible to partially replace animal protein with vegetable protein, improve the quality of meat products and increase the economic efficiency of production. The test samples were distinguished by a more delicate consistency and a higher uniformity of minced meat on the cut; an increase in the mass fraction of protein and a decrease in the proportion of fat were also noted.

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