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Development Of The Prescribed Foodstuff Composition For Diabetes Mellitus Prevention.

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ABSTRACT

The discrepancy between the quantitative content of essential nutritional substances in the daily average menu with consumption criteria recommended by nutritionists was established. The lack of essential amino acids and other essential components contained in food products is recommended to be helped out by developing a meat product formulation with food additives of preventive purposes: chitosan succinate, edible soybean enrichment, melange, edible gelatine and rice flour. The formulation was developed using mathematical planning. The chemical composition of the developed formulation was evaluated and the biological value of the finished product was studied with relation to the amino acid composition balance. The calculated coefficient of the amino acid composition rationality was 0.818; the total proportion of amino acids, biosynthesis precursors of replaceable ones was 0.264, the mass fraction of essential amino acids, being an ergogenic material, was 0.2. The biological safety of the experimental product was determined on the higher animals (white mice) of the BALB / C line (females and males). Hematologic indices of blood of experimental animals were studied. Haematological indices of the experimental animals' blood were studied. As a result of the studies, the safety and harmlessness of the developed composition was confirmed.

Keywords: diet and preventive nutrition, diabetes mellitus, meat product, component analysis, biosafety.

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INTRODUCTION

One of the forms of prevention a number of diseases is associated with the creation and active introduction the prophylactic products, the regular use of which will be consistent with the principles of healthy nutrition on the one hand, and eliminate the micronutrient deficiency within the physiological needs of human on the other. Many researchers that are involved in the issues of healthy nutrition proved that the combination of vegetable and animal raw materials allows complementing food products with missing biologically active substances and influencing on their chemical composition. The advantage of this approach is the possibility of mutual enrichment of the formulation ingredients by one or several essential components [1, 2].

The principle of building a diet for diabetics is determined by the physiological needs of the organism in feedstuff, the degree of functional disturbance and the metabolic processes disturbance peculiar to this disease. Dietology should be an integral part of the combination therapy and diabetes mellitus prevention [3].

With diabetes mellitus all types of metabolism are disturbed, but the carbohydrate metabolism disorders, caused by insulin deficiency are most expressed.

The exchange of some vitamins is also disturbed, in particular, ascorbic acid insufficiency develops, the formation of vitamin A in the liver is disrupted, and the lack of vitamin B complex may develop [4, 5].

It is known that when prescribing preventive nutrition, many factors must be taken into account: the choice of products, the specificity of their chemical composition, the proportions of isolated constituents and feedstuff, the methods for their cooking, the use of salt and flavoring substances, the degree of mechanical grinding, the rhythm of food intake etc. When choosing food, it is necessary to take into account the balance of the diet and the possibility of eliminating the essential nutrients deficiency. One of the most promising areas is the creation of recipes for multicomponent feedstuff. In developing the formulation, it is necessary to consider the preventive and healthfulness of each component, as well as the mutual enrichment of the chemical and amino acid compositions to enhance the biological value of the final product. It is advisable to design the food product on a meat basis, since the meat proteins contain all the amino acids that are necessary for building the body tissues. The meat contains nitrogenous and nitrogen-free extractives, as well as fat-soluble and water-soluble vitamins. In the treatment and prophylactic diet for diabetic patients, in addition to meat raw materials, it is recommended to use the cattle liver, since it contains a significant amount of B, PP, C, and A vitamins, along with iron, it contains a significant amount of copper, other micro-elements and hormonal substances [6].

From the non-meat components of the prophylactic product formulation, it was proposed to include chitosan succinate, nutritional soyabean enricher, melange, edible gelatine and rice flour in the composition.

One of the important usage of chitosan and chitosan succinate is the food industry. Chitin derivatives promote intestinal peristalsis, decreasing the digestion of harmful food components by the body, prevent the rectal cancer nascency, revitalize lymphatic cells, also there is evidence that the using of chitin derivatives in food reduces blood glucose levels [7]. Since chitosan exhibits its emulsifying and gelling properties in the acidic range of active acidity, it is advisable to use chitosan succinate to develop a meat product formulation. Nutritional soybean enricher (NSE) with a high content of dietary fiber (DF) is obtained during the production of soy milk. The high content of potassium in the nutritional soybean enricher positively affects the cardiovascular system, the presence of bivalent bioavailable iron promotes the formation of some enzymes and hemoglobin [8].

Melange, that contains a significant amount of easily digestible fats (including phospholipids), polyunsaturated fatty acids (up to 11% of the total lipid content), vitamins A, D, E, B1, B2, etc gained a widespread usage in the production of meat-based products. Melange contains 185 mg% of phosphorus, 2-7 mg of iron and 55 mg of calcium. The melange component composition has a beneficial effect on the functioning of living cells in the body. Eggs and products of their processing are recommended for using in nutrition of patients with diabetes mellitus [9].

The use of connective tissue proteins (for example, gelatin, that is a product of processing collagen-containing raw materials) in meat product compositions is justified by the fact that its introduction into the

meat product in an amount of up to 30% increases the biological value and does not reduce the quality indicators of finished products. Gelatin has the properties of dietary fiber, plays a critical part in the functioning of the colon, stimulates the coagulation of blood [10].

When developing the formula composition of meat products, rice flour is also proposed, which contains a high-grade protein as well as silicon (68 mg per 100 g of product), which contributes to the normalization of metabolic processes in the human body. In addition, relatively large amount of biotin, as well as trace elements (sodium, 26, potassium-54, phosphorus-97 mg per 100 g of product), which are of great medical and biological importance especially for people with diabetes mellitus [11, 12] are present in rice flour.

The purpose of the research is to develop a formula of the product based on meat, which makes it possible to fill the deficiency of essential chemical ingredients for patients with diabetes mellitus.

MATERIALS AND METHODS

Meat raw materials (GOST 18157-88 slaughter products, terms and definitions), chitosan succinate (TU 9289-003-11734126-98 chitosan succinate), food soybean enricher (TU 9146-027-10126558-98 Food grade soybean enrichment (okara), melange (GOST 30363-2013 Liquid egg products and dehydrated foods. Technical specifications), edible gelatine (GOST 11293-89 Gelatin. Specifications (with Change No. 1)) grade K13, rice flour (GOST 31645-2012 Flour for infant food products. Technical specifications), other food ingredients and materials, permitted for using in the Russian Federation.

Evaluation of the finished product biological value with regard to the mutual balance of the amino acid composition was determined by the method of N. N. Lipatov [13].

The biological value of the feedstuff composition was studied on white mice of the BALB / C line (females and males) with an initial mass of 20-30 g. The animals were kept on a sawdust litter in cages under the standard lighting regime and at a temperature of about 20 ° C in the conditions of the Stavropol State Agrarian University (Stavropol) vivarium. The experiment was carried out in accordance with sanitary, sanitary-epidemiological and hygienic regulations, requirements and rules of laboratory practice [14, 15, 16, 17, 18]. The laboratory animals were divided into 3 groups (control 1, control 2 and group 3) for 5 individuals in each. The hematologic indicant in the blood of laboratory animals was determined using an automatic biochemical analyzer Cobas s 111 (manufactured by Roche Diagnostics).

The results of the studies were analyzed in the Annexes of Statistic v. 10, 12 using the Statistic Neural Networks module. The experiments were carried out in 3-5 fold replicates. The reliability of the obtained results was monitored in the Error per Case module, the significance level (q) in each experiment didn't exceed 0.05.

RESULTS AND DISCUSSION

The calculation of the component constitution of a one-day menu* of a common diet for people with diabetes mellitus was made and its comparison with the recommended consumption standards was made (Table 1).

*Rations are taken from the reference book on dietology, the calculation is performed taking into account the losses of substances during heat treatment

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Table 1: Design of the chemical and amino acid compositions of a preventive feedstuff E.P.C. <0.05

Exponent	Diabetes mellitus		
	Actual consumption by diabetics [3]	Recommended daily intake for people with diabetes mellitus	Projected product
Irreplaceable amino acids, g / 100g of protein			
Tryptophane	1.00	1.40	1.40
Leucine	5.20	4.00…6.00	5.20
Isoleucine	2.50	3.00…4.00	3.50
Valine	1.80	3.00…4.00	3.00
Threonine	3.00	2.00…3.00	3.50
Lysin	4.40	3.00…5.00	4.40
Methionine	1.30	2.00…4.00	2.70
Phenylalanine	3.70	2.00…4.00	3.70
Vitamin A. mg / d	0.01	25.00…30.00	25.00
Dietary fiber. g / d	13.00	20.00	7.00
Calcium. mg / d	667.00	800.00…1000.00	133.00

As a result of the average daily diet analysis of patients with diabetes mellitus, it has been established that the chemical and amino acid composition of the consumed products does not fully satisfy the recommended consumption norms, a lack of certain vitamins, minerals and dietary fiber is found. Correction of the consumed ingredients adequacy was carried out with a meat-based product. Since the vitamins B1, B2, PP and C are water-soluble and are mainly in plant raw materials, and the content of Na, K, P, and Fe in the diet corresponds to the consumption norms, no optimization was performed for the design of the reference foodstuff formulation for these components. As a result of comparison the recommended daily consumption rates and the actual availability of useful ingredients in the analyzed diet for the diabetes mellitus prevention, the chemical and amino acid compositions of the food product that is designed are calculated (Table 1).

Balancing of the diet essential components constitution of the diet was carried out by including in the meat product recipe the ingredients listed in the fragment of the planning matrix based on the Greek-Latin squares and consisting of 100 experiments (Table 2).

Table 2: Fragment of the matrix for planning the formulation of meat products E.P.C. <0.05

Number of experiment	Components of the formulation.%								
	Beef prima	Beef first quality	Pork low-quality	Beef liver	Chitosan succinate	Food soybean enricher	Egg mixture	Edible gelatine	Rice-flour
1	0	96.2	0	0	0	1.9	0	1.9	0
2	14.0	49.0	21.0	14.0	0.0	1.4	0.0	0.7	0
3	25.2	56.6	6.3	9.4	0.0	1.9	0.0	0.6	0
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99	44.4	0.0	14.8	0.4	3.7	1.1	1.5	4.4	18.5
100	37.1	16.5	8.2	0.3	0.4	0.8	1.2	2.5	13.9

To determine the optimal formula of meat products, approximated by chemical and amino acid composition to the calculated parameters, the methods of neural networks, cluster analysis and multidimensional scaling were used. According to the developed planning matrix, the quantitative content of amino acids, dietary fibers, minerals and vitamins was calculated for each experience of the plan, taking into account losses during heat treatment. A fragment of the planning matrix output parameters can be found in Table. 3.

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Table 3: Fragment of the planning matrix output parameters E.P.C. <0.05

Number of experimen	Amino acid g / 100 g protein								Dietary fiber.g	Mg per 50 g of protein								
	Valine	Isoleucine	Leucine	Lysin	Methionine	Threonine	Tryptophan	Phenylalanine		Na	K	Ca	Mg	P	Fe	A	B_1	B_2	PP
1	5.1	4.0	7.6	7.6	2.4	4.0	1.0	3.7	1.3	175	860	67	68	489	7	0	0.2	0.4	11.5
2	5.6	4.4	8.1	8.3	2.5	4.3	1.1	4.2	1.0	198	890	46	69	562	9	3	0.8	0.5	10.5
3	5.5	4.3	8.0	8.2	2.5	4.2	1.1	4.1	1.4	193	899	48	69	544	8	2	0.5	0.5	11.4
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99	5.1	4.0	7.6	7.6	2.4	4.0	1.0	3.7	1.3	188	891	127	238	530	7	0	0	0	10
100	5.6	4.4	8.1	8.3	2.5	4.3	1.1	4.2	1.0	175	860	67	68	489	7	0	0	0	11

To assess the influence of acting factors on the quality characteristics of the product, the neural network architecture in the form of a multilayer perceptron was developed. Having evaluated the technological process adequacy of the developed neural network architecture, the obtained model was used to process a virtual factorial array created in the algorithmic language Pascal. To identify the optimal combination of the formulation components that provide the desired composition of the product being designed, the array of functional parameters (fiber content, vitamin A, calcium, amino acid composition) were clustered into 80 clusters according to similar characteristics and compared to benchmarkable metric.

Input parameters (content of components in the formulation) were subjected to multidimensional scaling (MNS) in two-dimensional measurement. The output variables (functional indicators), together with the indices of the meat products being projected, were subjected to the MNS in a one-dimensional measurement.

Previous experience has shown that, when an optimal combination of factors is identified, the neural network approximation is the most effective. Therefore, in order to identify the optimal composition using the "neural networks" methodology, a scaled and clustered function surface was plotted on the cluster diagram of the factors (Figures 1, 2).

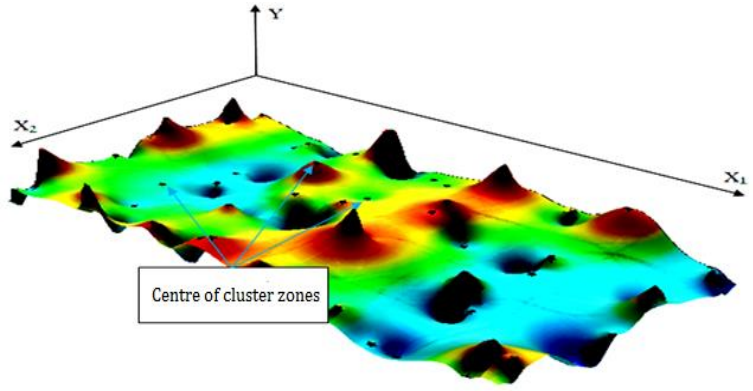

Figure 1: Three-dimensional diagram of neuronet approximation of the projected meat product composition

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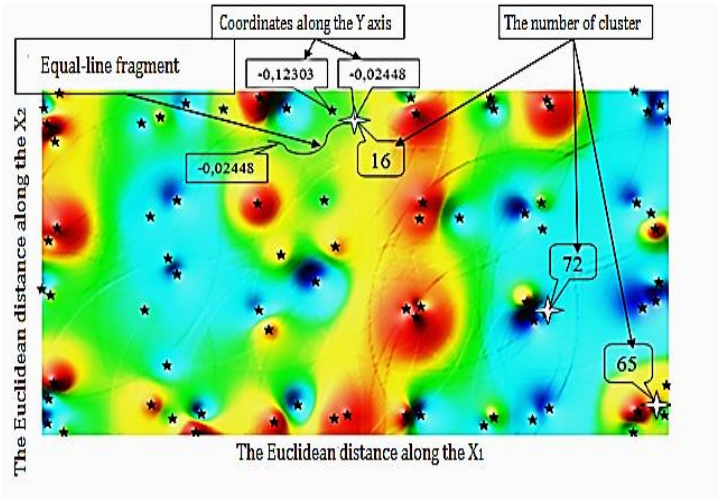

Figure 2: Contour diagram of neural network approximation of the projected meat product composition

The coloring of the diagram indicates that the functional scaled indicators correspond not to one variant of scaled factor values along the axes X1 and X2, but to the great many. The presence of a different variants multiplicity of factors combinations (components of the formulation), corresponding to the standard composition of the projected meat products, is indicated by the lines of equal yield. The three-dimensional diagram (Figure 1) characterizes the complexity of the technological process, the effective optimization of which is possible only with the use of modern methods of Data Mining.

Confirmation of the multivariate compositions can be the results of the functional indices repeated clustering of virtual experiments in clusters No. 72, No. 16, No. 65 (Fig. 3).

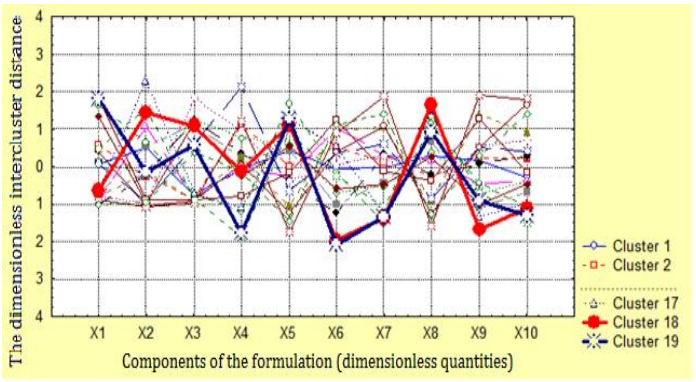

Figure 3: Average values of the optimal clusters input variables of formula for people with diabetes mellitus

The analysis of the factor characteristics (components of the formulation) showed that the product being designed with a given chemical and amino acid composition can be obtained with different variants of the quantitative combinations of the raw materials components used in formula. This is evidenced by the standardized values of the input variables, the investigated optimal functional clusters. As a result of cluster analysis, compositions with functional parameters corresponding to reference values (content of dietary fiber, vitamin A, calcium, amino acid composition) were identified.

Some compositions were unacceptable in terms of the ratio of meat raw materials and food additives. A number of compositions were identical in composition, i.e. slightly differed in the quantitative content of the components. Analysis of the composition formulation in the investigated clusters revealed the most appropriate rational combinations of the used components.

The optimal composition of the meat product for the diabetes mellitus prevention is given in Table. 4.

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Table 4: Composition constitution of a meat product for the diabetes mellitus prevention

Name	Compositional analysis							
	Beef prima	Beef first quality	Pork low-quality	Beef liver	Chitosan succinate	Food soybean enricher	Egg mixture	Edible gelatine
Components. %	54.0	16.0	14.0	1.0	3.0	1.0	4.5	6.5

Thus, using the technique of neural networks, cluster analysis, multidimensional scaling, a prescription composition of a meat product for preventive purposes for people suffering from diabetes mellitus is defined.

The mutual balance of the amino acid composition of the developed meat product was evaluated, it was established that the coefficient of the amino acid composition rationality (Rc) is 0.818; the total proportion of amino acids, the precursors of biosynthesis of replaceable (ΣBSNAC), was 0.264, the mass fraction of essential amino acids, being an energy-generating material (EGNAC), is 0.2.

Since it is possible to obtain a reliable idea of the biological value of a meat product for prophylactic purposes only on the basis of experiments conducted on animals, determining the growth-weight changes in the organism, analyzing biological rhythms, the final stage was the study in vivo on higher animals, the criteria characteristics of biological value and the safety of a new kind of meat product. The effect of introduction the samples of a new type of meat product into the ratio of experimental animals (mice) on the hematological picture of blood and changes in growth-weight parameters was studied. Observations of the animals were carried out within 30 calendar days. The physiological state of the animals was assessed by hematological and biochemical blood parameters. The results of the studies at the end of the experiment (on the 30th day of observations) are presented in Table. 5.

Table 5: Hematologic indices of the animals blood in the study groups

Index	Units of measurement	One day before feeding (7^{th} day of observations)	Control №1 (basic diet)	Control №2 (basic diet and meat product without preventive additives	Group 3 (basic diet and meat product for the prevention of diabetes mellitus)
Erythrocytes	10^{12}/л	8.16 ± 0.21	8.64 ± 0.17	8.78 ± 0.07	8.22 ± 0.11
Leukocytes	10^{9}/л	8.64 ± 0.13	8.94 ± 0.15	9.32 ± 0.12	9.16 ± 0.13
Hemoglobin	г/л	126.00 ± 1.31	128.60 ± 1.20	129.40± 0.55	127.10 ± 0.50
Crude protein	г/л	59.60 ± 0.28	61.40± 1.05	66.20 ± 0.85	64.41 ± 0.95
Albumens	г/л	36.62 ± 1.22	39.40 ± 0.70	42.80 ± 0.90	42.01 ± 1.25
Glucose	Моль/л	4.11 ± 0.81	4.18 ± 0.11	4.16 ± 0.13	3.94 ± 0.06
Asparagine aminotransferase	МЕ/л	421.40 ± 9.57	520.00 ± 16.79	617.20 ±13.68	549.00± 14.28
Alanine aminotransferase	МЕ/л	107.00 ± 2.76	130.60 ± 3.40	146.60 ± 2.05	135.00 ± 0.75
Asparagine aminotransferase/Alanine aminotransferase	-	3.94 ± 0.08	4.00 ± 0.11	4.21 ± 0.08	4.06 ± 0.08

It was found that the introduction of a preventive food into the diet of experimental animals contributed to a decrease in the average live weight of one individual by 0.4 g, the level of glucose in the third group decreased by 0.24 mol / l compared to control No. 1. When studying the serum activity of marker blood enzymes, it is established that the additives introduced into the meat product do not have a toxic effect on the body and do not lead to an increase in cytolysis.

CONCLUSION

Thus, as a result of the one-day diet analysis for the prevention of diabetes mellitus, it is established that these diets do not fully provide the recommended norms for the consumption of dietary fiber, minerals and vitamins. There was an imbalance in the daily intake of amino acids into the body. In order to eliminate the deficit in the essential components of the diet, the composition of the meat product was developed, which includes: 1st grade beef, low-fat pork, beef liver, chitosan succinate, food soybean dressing, melange, edible gelatine, rice flour. The biological value and food safety of the new meat product is confirmed as a result of the *in vivo* experiment on higher animals.

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