Conference Paper

Composition Designing of Cooked Sausage ``Udachnaya" Based on Optimization Principles

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Abstract

This article deals with the process of composition designing of the cooked sausage "Udachnaya" by adding non-meat ingredients to reduce material costs for production, obtain a product with given chemical composition and technological properties, as well as to minimize the occurrence of defects characteristic of cooked sausage products, in particular broth-fat runoffs. As part of the research, complete preparations of the new generation "Biophos 90" and "Bioton gel 651" were used, which did not reduce the nutritional and biological value of meat products and also produced sausage products with high organoleptic and technological properties that are safe for consumer health and the environment. Synthesis of lessons learned in the development of the rational formulation of cooked sausage products shows that the use of mathematical modeling makes it possible to implement a targeted combination of ingredients and deliver the specified chemical composition and variable processing properties with an insignificant change in prime cost. The study was conducted using the technical base and laboratory areas of the Department of Commodity Research, Standardization and Quality Control (Faculty of Animal Science, Commodity Research, and Standardization), as well as the common use center of scientific equipment of FSBEI HE "Omsk State Agrarian University named after P.A. Stolypin". The analytical data presented in this publication may be of interest to students of industry-specific colleges, as well as specialists in the meat industry, and can be implemented in real enterprises.

Keywords: Construction, composition, cooked sausage, nutrient additives.

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1. Introduction

Modern realities of the development of the agro-industrial complex are inextricably linked with the achievements of scientific and technological progress and information and communication technologies [1]. Currently, the Russian Federation has adopted the FoodNet program-the basis of an innovative market in the AIC based on cutting-edge

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technologies that can be applied both in agriculture in general and in the processing industry in particular [2, 3]. The most important achievement of the FoodNet market will be the possibility of designing and subsequent mass production of balanced food products with a regulated and predictable composition, containing quality ingredients and at the same time, economically accessible to all segments of the population [4, 5].

Designing food products with predictable consumer properties is scientific and applied directly in the food industry, which is based on the achievements of fundamental sciences, engineering, and technology [6]. The principles of food combinatorics remain particularly relevant for meat products, the formulation of which, in addition to the actual meat component, includes a variety of non-meat components that affect both the nutritional value of the finished product and its technological and consumer properties. Thus, the creation of combined meat products is a promising direction for the development of the processing industry, which requires information methodological support for modeling processes and software implementation in solving specific tasks [7].

The design issues and optimizing the composition of balanced quality products are covered in the scientific works of Lisin P.A. [6], Lipatov N.N. [8], Muratova E.A. [9], Kolesnikova N.V. [10], Dvoretsky S.I. [11] and other researchers.

The industrial growth of combined meat products is associated not only with saving meat, but also with the creation and production of new high-quality products that have balanced medical and biological properties for various professional and age groups of the population [12].

A significant change in the food patterns of the population, a decrease in meat production, and instability in its quality characteristics have caused the need to use new-generation ingredients in recipes for meat products, primarily nutrient additives. They are used as enriching ingredients, food value regulators, consistency stabilizers, emulsifiers, and also contribute to increasing the yield of finished products [13]. Numerous scientific works by P.A. Lisin and scientists of the Omsk State Agrarian University prove that a targeted combination of prescription ingredients in production can provide a nutritional composition with a given chemical properties [14] have been scientifically based the fact of creation of the rational formulations of multi-component products by mathematical model methods, which makes it possible to implement a targeted combination of ingredients used and ensure that the prescription controlled technological properties [6, 15, 16].

The scientific article subject is a composite mixture of minced meat for cooked sausage "Udachnaya", containing:

1) food additive "Biophos 90" - food-grade modification phosphate used to increase the moisture-binding and emulsifying capacity of muscular tissue proteins; improve organoleptic indicators; stabilize the process of color formation; inhibition oxidative processes at various processing stages and storage conditions of meat products;

2) "Bioton gel 651" - a mixture of refined kappa-carrageenan powder type with a high moisture-binding, gel-forming capability; improving the consistency and product characteristics of the finished product; reducing the percent of defective goods by eliminating the probability of formation of broth-fat pocket; reducing the effect of moisture in vacuum-packed products; increasing the output of the finished product by reducing heat losses; stabilizing the quality of products obtained by using low-quality raw materials

Work objective: To develop the optimal formulation composition of cooked sausage "Udachnaya" with a mass fraction of moisture no more than 70%, fat no more than 29%, protein no less than 7%. It is necessary to determine in what combination and in what quantity the existing raw materials should be added to the raw mix of the minced meat formulation, to ensure a minimum cost and high moisture resistance of the finished product.

2. Methods and Equipment

The implementation of this goal is achieved by building a mathematical model, through:

1) X_j – the number of units of the j-th formulation component;

2) a_{ij} – the amount of the i-th micro-and macro-nutrient in the j-th formulation component (mass fraction of moisture, protein, fat, etc.);

3) b_i – upper limit of the i-th micro - and macro-nutrient in cooked sausage "Udachnaya";

4) C_j – the cost of a raw material unit of j-th type.

The amount of micro - and macro-nutrient in the cooked sausage "Udachnaya" is expressed by inequalities 1-4:

$$a_{11} x_{(1)}+a_{12} x_2+...+a_{1n} x_n \leq b_1; \qquad (1)$$

$$a_{21} x_{(1)}+a_{22} x_2+...+a_{2n} x_n \leq b_2; \qquad (2)$$

$$a_{m1} x_{(1)}+a_{m2} x_2+...+a_{mn} x_n \leq b_m; \qquad (3)$$

$$x_1 \geq 0, x_2 \geq 0, ...x_n \geq 0. \qquad (4)$$

It is necessary to find a rational constraint where the target function is minimal.

Assessment of the moisture-retaining capacity of minced meat of the developed formulations consists of determining the difference between the amount of the mass

fraction of moisture in the original minced meat mixture and the amount of moisture separated during heat treatment.

3. Results

The initial data for calculating the variant of boiled sausage "Udachnaya" formulations are presented in table 01.

At the first stage of the research, we will introduce the variables x1, x2, x3, x4, x5, x6, respectively, the required specific weight of adding in the composition of cooked sausage "Udachnaya" the introduced ingredient for formulation № 1. It is necessary to find the values x1, x2, x3, x4, x5, x6, where F(x) = min {206x1 + 180x2 + 66x3 + 13x4 + 28x5 + 0x6} (5) if the following conditions are met:

1) 0.2x1+0.13x2+0.02x3+0.11x4+0.09x5+0x6 $\geq$ 0.07 (protein mass fraction is not less than 7%) (6);

2) 0.04x1+0.31x2+0.86x3+0.11x4+0.09x5+0x6 $\leq$ 0.29 (mass fraction of fat is no more than 29%) (7);

3) 0.74x1+0.54x2+0.11x3+0.77x4+0.45x5+1x6 $\leq$ 0.70 (mass fraction of moisture is no more than 70 %) (8);

4) calculation of the product unit x1+x2+x3+x4+x5+x6 = 1; (9)

5) the constraints of variables are represented as follows: x1 $\geq$0; x2=0.18; x3$\geq$0; x4$\leq$0.05; x5$\leq$0.02; x6 $\geq$0.2 (10)

The use of the simplex method made it possible to find the mass of added ingredients (table 02) in the production of a unit of cooked sausage "Udachnaya" with a minimum cost of 81 rubles.

At the second stage, we denote x1, x2, x3, x4, x5, x6, x7, respectively, the required specific weight of adding in the composition of cooked sausage "Udachnaya" the introduced ingredient for formulation № 2. It is necessary to find the values x1, x2, x3, x4, x5, x6, x7 where F(x) = min {206x1+180x2+66x3+13x4+28x5+0x6+122x7} (11) if the following conditions are met:

1) 0.2x1+0.13x2+0.02x3+0.11x4+0.09x5+0x6+0x7 $\geq$ 0.07 (protein mass fraction is not less than 7%) (12);

2) 0.04x1+0.31x2+0.86x3+0.11x4+0.09x5+0x6+0x7 $\leq$ 0.29 (mass fraction of fat is no more than 29%) (13);

3) 0.74x1+0.54x2+0.11x3+0.77x4+0.45x5+1x6 +0.022x7$\leq$ 0.70 (mass fraction of moisture is no more than 70 %) (14);

TABLE 1: The initial data for calculating the variant of boiled sausage "Udachnaya" recipe mixture

Raw material name	Content, %					Caloric content, cal	Cost, rub/kg	Quantity per 100 kg of minced meat
	moisture	proteins	fats	ash	carbohydrates			
Variant № 1:								
1. trimmed beef. 1 category	74.3	20	3.89	0.91	0.89	119	206.4	
2. trimmed pork. semi-fat	54.7	13	30.68	0.82	0.8	331	180	
3. flank fat	11.4	2.2	85.91	0.5	-	779	66	
4. emulsion formulation of pork skin	77	11.5	11	0.5	-	145	13.05	≤ 5 %
5. protein-in-oil emulsion	45	45	9	1	-	261	28	≥ 2 %
6. water / ice	100	-	-	-	-	-	-	≥ 20 %
Variant № 2:								
1. trimmed beef. 1 category	74.3	20	3.89	0.91	0.89	119	206.4	
2. trimmed pork. semi-fat	54.7	13	30.68	0.82	0.8	331	180	
3. flank fat	11.4	2.2	85.91	0.5	-	779	66	
4. emulsion formulation of pork skin	77	11.5	11	0.5	-	145	13.05	≤ 5 %
5. protein-in-oil emulsion	45	45	9	1	-	261	28	≤ 2 %
6. water / ice	100	-	-	-	-	-	-	≥ 20 %
7. Biophos 90	2.2	-	-	97.8	-	-	122	≤ 0,5 %
Variant № 3:								
1. trimmed beef. 1 category	74.3	20	3.89	0.91	0.89	119	206.4	
2. trimmed pork. semi-fat	54.7	13	30.68	0.82	0.8	331	180	
3. flank fat	11.4	2.2	85.91	0.5	-	779	66	
4. emulsion formulation of pork skin	77	11.5	11	0.5	-	145	13.05	≤ 5 %
5. protein-in-oil emulsion	45	45	9	1	-	261	28	≤ 2 %
6. water / ice	100	-	-	-	-	-	-	≥ 20 %
7. Bioton gel 651	2.1	90	-	0.5	7.4	389.6	493.6	≤ 0,2 %

4) the calculation of the product unit is presented by the formula (15):

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 = 1; \quad (15)$$

TABLE 2: Calculated variant of formulation № 1

Name of raw material components	Raw material weight, kg, per 100 kg of minced cooked sausage "Udachnaya"
1. trimmed beef. 1 category	18.0
2. trimmed pork. semi-fat	18.0
3. flank fat	16.6
4. emulsion formulation of pork skin	5.0
5. protein-in-oil emulsion	2.0
6. water / ice	40.4

5) the constraints of variables are represented as follows: $1 \geq 0$; $x_2 = 0.18$; $x_3 \geq 0$; $x_4 \leq 0.05$; $x_5 \leq 0.02$; $x_6 \geq 0.2$; $x_7 \geq 0.005$ (16)

The composition and mass of raw materials of formulation № 2 are shown in table 03, while the minimum cost of a unit of cooked sausage "Udachnaya" will be 84 rubles.

TABLE 3: Calculated variant of formulation № 2

Name of raw material components	Raw material weight, kg, per 100 kg of minced meat
1. trimmed beef. 1 category	18.0
2. trimmed pork. semi-fat	18.0
3. flank fat	16.6
4. emulsion formulation of pork skin	5.0
5. protein-in-oil emulsion	2.0
6. water / ice	41.0
7. Biophos 90	0.5

Thus, the formulation of the second variant will require more costs than the formulation of the first variant. Therefore, when adding "Biophos 90" into the formulation, it is recommended to use low-grade raw materials, for example, beef of the second category, in order to ensure the minimum cost of the finished product.

The formulation of the third variant provides for the introduction of "Bioton gel 651", the peculiarity of the adding is to maintain the ratio of fat:protein. In this case, it is envisaged to replace raw meat with a composition containing a complex additive "Bioton gel 651", water and fat. Namely: 10 kg of 1 category beef, consisting of 80 % of muscle and 20 % of fat, contain 1.8 kg of protein, 6 kg of water and 2 kg of fat. In turn, 2 kg of "Bioton gel 651" protein also contains 1.8 kg of protein. Thus, 10 kg of beef can be equivalently replaced with 2 kg of complex additive, 6 kg of water for hydration, and 2 kg of fat. The composition and mass of the components of formulation № 3 are shown in table 04.

Moreover, the minimum price of cooked sausage "Udachnaya", which is made by mixing these types of raw materials in the specified ratios, will be 72 rubles. Ultimately,

TABLE 4: The composition of optimized formulation № 3

Raw material name	Raw material weight, kg, per 100 kg of minced meat
1. trimmed beef. 1 category	8.0
2. trimmed pork. semi-fat	18.0
3. flank fat	18.6
4. emulsion formulation of pork skin	5.0
5. protein-in-oil emulsion	2.0
6. water / ice	46.4
7. Bioton gel 651	2.0

formulation № 3 requires less costs and is advantageous for eliminating problems associated with the need to release raw meat, increase production volumes, while increasing nutritional value, finished product yield and reducing production costs.

At the final stage of research, the moisture-retaining capacity of minced meat was determined in three different formulations. The results of the study are presented in table 05.

TABLE 5: Evaluation of moisture retention capacity of minced meat of different formulations

Indicators	Formulation 1	Formulation 2	Formulation 3
For raw minced meat samples, g:			
Sample weight before pressing	10.0	10.0	10.0
Sample weight after pressing	7.2	7.5	7.7
Moisture retention capacity, %	72	75	77
For samples of minced meat after cooking, g:			
Sample weight before pressing	10	10	10
Sample weight after pressing	7.5	7.8	7.9
Moisture retention capacity, %	75	78	79

The results presented in table 05 show that both raw minced meat (formulation 3) and minced meat after heat treatment have a high moisture retention capacity that exceeds this characteristic for other formulations

4. Discussion

The obtained results confirm the hypothesis about the possibility of producing a high-quality meat product based on the principles of optimization and food combinatorics. As a result of a series of experiments established that the formulation No. 3 with complex additive "Bioton gel 651" keeping the ratio of fat: protein, not only reduces the cost of the finished product (72 rubles), to improve the technological properties of meat, but

is most beneficial for the manufacturer, leads to a reasonable economy of raw meat, growth in production volumes, while increasing nutritional value.

5. Conclusion

Based on the research and subsequent analysis of the data obtained, it was found that the third version of the formulation for cooked sausage products is preferable not only for economic criteria but also for technological properties. Sausage meat with the received characteristic of the high CWS is accompanied by the cooking, low desiccation, which gives a high yield of the finished product, its richness, and pronounced flavor properties; achieved the target for prevention education water-fat pocket.

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Conflict of Interest

The authors have no conflicts of interest.

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