

OPTIMIZING THE FORMULA OF MEAT-CONTAINING HALF-FINISHED PRODUCTS IN DOUGH

Valentina Krishtafovich¹, Dmitry Krishtafovich^{2,3*},
 Miroslav Djordjevic², Diana Shara Futdinova⁴

¹Department of commodity research and examination of goods, Russian University of Cooperation, V. Voloshinoy street 12/30, Mytischy, Moscow region, 141014, Russia

²Department of commodity research and customs examination, Russian Customs Academy, Komsomolsky prospect street 4, Lyubertsy, Moscow region, 140009, Russia

³Department of customs payments and currency control, Russian Presidential Academy of National Economy and Public Administration, Prospect Vernadskogo 82/5, Moscow, 119571, Russia

⁴Department of Commodity and Food Technology, Russian University of Cooperation (branch in Kazan), Nikolay Ershov street 58, Kazan, Republic of Tatarstan, 420081, Russia

*e-mail: dvkrish@mail.ru

Abstract

The given research is based on a system approach with the application of mathematical modeling methods, statistical data processing, and comparative analysis. We were trying to solve a problem of optimizing the formula of pelmeni minced meat and dough with the defined chemical composition and predictable consumer properties.

Several calculated variants of formulae for pelmeni minced meat and dough were obtained as a result of solving the task; the expected values of chemical composition properties and the cost of formula composition were defined for those variants. All the calculated variants of minced meat formulae are different from the control variant in having lower cost of raw materials and lower fat content, making it possible to reduce energy value, and higher content of balanced protein.

The model formulae of pelmeni minced meat and dough obtained by calculation provides the basis for drafts of production forms and records for manufacturing frozen half-finished products in dough.

The results made it possible to solve important tasks of both supplying people with complete scarce protein,

and enlarging the range of half-finished products meant for medium and low income consumers.

Key words: *Mathematical modelling, Optimization of the formula, Half-finished products in dough, Pelmeni, Ravioli.*

1. Introduction

Active implementation of modern resource-saving technologies in meat-processing enterprises, which provide a high quality level of finished products, is the most efficient way to increase processed meat production. Intensification of meat processing, the condition of the resource base in Russia, and tough competitive environment require from manufacturers to search for viable solutions of usage for processing not only traditional meat raw materials, but general-purpose ingredients as well, which provide both well-balanced nutrition value of finished products and retain traditional organoleptic characteristics. The use of protein agents and food additives in the technology of meat

raw materials contributes to higher output of finished products, reduction of costs, and makes it possible to solve the problem of rational use of raw materials, and to improve their functional and technological properties [1, 2]. Animal proteins produced from connective tissues and blood plasma are particularly important among all protein ingredients used in meat industry [3, 4]. Connective-tissue proteins based on collagen can be considered as functional analogs of food fibers which stimulate digestion processes, have adsorption properties, and provide the formation of the prescribed functional properties of both meat and meat-containing products [5, 6]. Besides, connective tissue and blood, as well as protein agents on their basis, are natural structural elements of meat, which allows considering them as a basic raw material [7].

According to the leading experts of meat market, one of the newest and the most dynamic markets in the food industry in Russia is frozen meat products, where the bulk of the sales is held by pelmeni (Russian ravioli), traditional for meat-containing half-finished products in dough. The products are characterized by high gustatory qualities, high nutrition and biological value, and extended storage period. Traditionally, pelmeni filled with minced beef, pork or mixture of these two types of meat form the basis of any assortment stock list. Lately, pelmeni manufacturers have been trying to diversify their range and offer products made with the use of non-traditional meat for processing (venison, mutton, horsemeat, bear meat, poultry meat etc.) [8]. Pelmeni with mince of different raw materials are becoming especially popular.

Economy-class products occupy a significant share of pelmeni market; their low prices are conditioned by the corresponding formula. As a rule, such products now have low consumer properties (nutrition value and food flavouring qualities). In connection with this, optimization of pelmeni formula with the aim of creating an inexpensive product with a high biological value and good organoleptic properties is getting particularly topical.

2. Materials and Methods

The given research is based on a system approach with the application of mathematical modeling methods, statistical data processing, and comparative analysis.

We were trying to solve a problem of optimizing the formula of pelmeni minced meat and dough with the defined chemical composition and predictable consumer properties. The methodology of calculating an optimal formula is based on the iterative application of linear programming method and calculating a complex quality index. The methodology was developed by scholars in the Gorbатов's All-Russian Meat Research Institute

for different meat and meat-containing products [9].

The main task of optimizing the formula was to determine, what amount of ingredients would be appropriate to add to the formula in order to achieve the minimum (maximum) value of optimization criterion, while meeting the requirements for weight fraction of certain ingredients, and chemical and amino-acid composition of the finished product. The solution of this task included accomplishing the following stages:

- Justification of the list of ingredients for filling (mince) and dough, collecting, systematizing and analyzing the literature data and the results of our own research which characterize their chemical composition.
- Justification of the requirements for the product (mince, dough, half-finished product) and establishing the criteria of optimizing, choice of objective function.
- Justification of restrictions to the characteristics of the projected product and the level of using ingredients.
- Calculation of mince and dough formulae variants in the context of the chosen optimization criteria and the imposed restrictions.
- Evaluation of the obtained formulae in relation to the balance of amino acid composition.
- Comparative analysis of the calculated formulae variants and choice of the optimal ones for experimental tests.

When choosing the list of ingredients, we proceeded from the fact that both traditional and new ingredients permitted for use in pelmeni manufacturing, can be added to mince and dough formula. We proposed the following ingredients as the basic ones for pelmeni dough [10]: straight white wheat flour, proteins based on pork connective tissue Scanpro BR95 and Scanpro Super, refined oil, drinking water, cooking salt; and for pelmeni minced meat - pork heart, mechanically deboned poultry meat, protein based on pork blood plasma Scanpro 325/1, drinking water, cooking salt, and spices recommended for pelmeni in accordance with technical specifications. The use of protein additives based on connective tissue in pelmeni dough formula makes it possible to exclude hen eggs, improves its rheological properties, especially when using low-quality flour, and contributes to better organoleptic properties of half-finished products [11]. The choice of pork heart as an ingredient of pelmeni mince is justified by its high biological value, low fat content and lower cost comparing to low fat pork [12].

When choosing the optimization criteria, we proceeded from the fact that the projected product should retain its traditional nutrition value, provide the level of animal protein concentration of 12 - 15%, vegetable

protein of 6 - 8%, have lower energy value due to the reduction of total fat content down to 5 - 8%, and have the maximum biological value due to achieving the balance of amino acid composition of protein when projecting.

We chose the condition of minimizing the cost of raw materials, included into the formula, as an objective function for optimization.

When choosing the restrictions for quantitative content of ingredients in pelmeni minced meat and dough formula, we took into account their composition and properties, influencing consumer properties of the finished product, and the possibility of quantitative replacement of one ingredient by a different one.

When justifying restrictions for the characteristics of the finished product, we proceeded from the fact that justification of the prescribed chemical composition is one of the most important issues. Certain values of characteristics of the finished product were taken as its given parameters, namely: cost of the finished product - A_1 , the value of protein balance coefficient (PBC) in composition to the formula of an ideal protein recommended by the FAO (Food and Agriculture Organization) and the WHO (World Health Organization) for mince - A_2 , for dough - A_3 ; the content of balanced protein in the product (calculated as the difference between the total content of protein in the product and the surplus content of amino acids) - A_4 ; energy value of the finished product - A_5 . When solving the task we set, the restrictions for the characteristics of the finished product must be subject to the following conditions:

$$\begin{aligned} A_1 &\rightarrow \min, \\ A_2 &\geq 0.8; A_3 \geq 0.5, \\ A_4 &\rightarrow \max, \\ A_5 &\rightarrow \min, \end{aligned}$$

After solving the task of linear programming of calculating the formula for the chosen criteria of optimization and the formed restrictions, the evaluation of the obtained formulae was conducted regarding the balance of amino acid composition. The calculation of PBC for each formula was conducted in the following way:

- Determination of the limiting essential amino acid (EAA), which has the minimum score size ($SC_i = F_i / A_i$);
- Calculation of the PBC according to the formula:

$$PBC = SC_{\min} \times \frac{\sum_{i=1}^n F_i}{\sum_{i=1}^n A_i},$$

where SC_{\min} - is the minimum score value of the limiting essential amino acid; F_i - content of the i^{th} essential amino acid according to the FAO/WHO scale, g/100 g of protein; A_i - the calculated content of the i^{th} essential amino acid in the product, g/100 g of protein.

Further the comparison of the calculated value of PBC with the prescribed A_2 and A_3 was conducted. If $PBC < A_2(A_3)$, then we got back to the stage of choosing restrictions for amino acids content in the protein of the product. At the same time, A_{\min} was increased for the essential amino acid that has the minimum score value, so that its score value would not be less than for the amino acid with the nearest score value. A_{\max} of the essential amino acid that has the maximum score value was reduced in a similar way.

If $PBC > A_2(A_3)$, then the task of optimization of the formula for amino acid balance was considered solved.

Traditional pelmeni "Domashnie", a popular recipe manufactured by many industrial enterprises, were chosen for the purpose of comparing the calculated formulae variants in the context of optimization. Preparation of minced meat for the formula includes using low fat pork (23%), deboned poultry meat (43%), and hydrated soy flour (20%).

3. Results and Discussion

Several calculated variants of formula for pelmeni minced meat and dough were obtained as a result of solving the task; the expected values of chemical composition properties and the cost of formula composition were defined for those variants (Table 1).

The data in the Table 1 demonstrate that all the calculated variants of minced meat formulae are different from the control variant in having lower cost of raw materials and lower fat content, making it possible to reduce energy value, and higher content of balanced protein. The analysis of pelmeni dough formulae reveals that use of protein additives Scanpro BR95 and Scanpro Super reduces the cost of raw materials by 1.6%. We were unable to solve the task of increasing PBC of pelmeni dough; however, the use of Scanpro Super protein made it possible to retain the present level of amino acid balance with simultaneous improvement of pelmeni dough technological properties.

When choosing a formula for preparing test samples of pelmeni, we conducted complex evaluation of the calculated model formulae of pelmeni minced meat and dough, taking into account relative values of the formerly chosen unit indices (y_{rel}), which were calculated according to the formula:

Table 1. Comparative characteristics of pelmeni minced meat and dough formulae

Properties	Minced meat				Pelmeni dough		
	For "Domashnie" pelmeni	For calculated formula			For "Domashnie" pelmeni	For calculated formula	
		1	2	3		1	2
Content, %:							
Moisture	65.83	74.66	75.59	74.12	40.80	40.87	40.88
Fat	13.98	6.50	6.73	6.50	1.58	1.62	1.21
Protein	11.38	12.71	14.43	12.99	7.19	7.14	7.53
Ash	2.33	2.74	2.90	2.80	2.32	2.29	2.29
Carbohydrates	6.48	3.39	0.35	3.59	48.11	48.08	48.09
Content of essential amino acids, g/100 g of product:							
Valine	0.591	0.693	0.795	0.710	0.355	0.321	0.322
Isoleucine	0.530	0.550	0.627	0.563	0.303	0.288	0.290
Leucine	0.911	1.017	1.160	1.041	0.566	0.542	0.543
Lysine	0.958	1.047	1.183	1.069	0.195	0.183	0.184
Methionine+cystine	0.431	0.441	0.500	0.450	0.256	0.240	0.239
Threonine	0.529	0.601	0.682	0.613	0.225	0.214	0.214
Tryptophane	0.167	0.163	0.183	0.166	0.073	0.066	0.066
Phenylalanine+tyrosine	0.772	0.936	1.075	0.938	0.531	0.511	0.507
Minimum score	Valine (1.039)	Met+cys 0.991	Met+cys 0.990	Met+cys 0.989	Lysine 0.493	Lysine 0.466	Lysine 0.444
Content of balanced protein, %	10.75	11.80	13.37	12.08	5.98	5.97	6.38
PBC	0.870	0.833	0.829	0.834	0.514	0.506	0.509
Energy value, kcal	197	123	120	125	235	235	233
Cost of raw materials, USD/kg	2.08	1.40	1.53	1.42	0.30	0.29	0.28

$Y_{rel} = y/y_{st}$, with the required minimization of the index ($y \leq y_{st}$)

$Y_{rel} = y_{rel}/y$, with the required maximization of the index ($y_{st} \leq y$),

Where y - is a unit index absolute value of the formula variant, y_{st} - an absolute value of the standard unit index.

The following values were chosen as the standard ones for the indices: A_1 (minced meat) = 1.40 USD/kg (calculated formula 1); A_1 (dough) = 0.28 USD/kg (calculated formula 2); A_2 = 0.87 ("Domashnie" pelmeni); A_3 = 0.514 ("Domashnie" pelmeni); A_4 (dough) = 6.38% (calculated formula 2); A_4 (minced meat) = 13.37% (calculated

formula 2); A_5 (minced meat) = 120 kcal (calculated formula 2); A_5 (dough) = 233 kcal (calculated formula 2). The index value of the product formula complex evaluation was calculated as the total of unit indices relative values (Table 2).

The analysis of the data represented in the Table 2, determines the calculated formula 2 for minced meat and dough as the best ones having complex indices of 3.865 and 3.990 correspondingly. Test preparation of minced meat according to the given formula showed a high degree of agreement between the actual values of chemical composition indices, amino-acid balance, and raw materials cost with the predicted ones. The model formula of pelmeni minced meat and dough obtained by calculation provides the basis for drafts of

Table 2. Comparative complex evaluation of the calculated pelmeni formulae

Properties	Relative values of formulae indices						
	Of "Domashnie" pelmeni	Minced meat			Pelmeni dough		
		Of the calculated formulae	1	2	3	Of "Domashnie" pelmeni	Of the calculated formulae
		1	2	3		1	2
Content of balanced protein	0.804	0.883	1.000	0.904	0.937	0.936	1.000
Balance coefficient	1.000	0.957	0.953	0.959	1.000	0.984	0.990
Energy value	0.609	0.976	1.000	0.960	0.991	0.991	1.000
Cost of raw materials	0.670	1.000	0.912	0.983	0.984	0.991	1.000
Complex evaluation of formula	3.083	3.816	3.865	3.806	3.912	3.901	3.990

production forms and records for manufacturing frozen half-finished products in dough (pelmeni).

4. Conclusions

- Thus, the results of optimizing the formula of minced meat and pelmeni dough, which were presented in the article, made it possible to solve important tasks of both supplying people with complete scarce protein, and enlarging the range of meat-containing half-finished products meant for medium and low income consumers.

- The use of protein additives of animal origin on the basis of connective tissue, blood plasma, and edible of-fal's in the developed formulae contributes significantly to solving the topical problem of shortage of quality meat for processing and its rational use.

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