Developing a technology for ground meat low-fat semi-products

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Abstract. In this research work, a method of technology for ground meat products with a low fat content is presented. The authors studied the market of ground meat semi-finished products of the Voronezh region (Russia). The analysis showed that 43.75 % of the sold semi-products contain no more than 15 % of fat, 20.83 % contain no more than 15–20 % of fat, 16.67 %–20–25 %, 14.58 – 25–30 %, 4.17 % – 40 %. Using mathematical modeling, the recipes for new ground semi-finished products were developed and their desirability function was determined, which amounted to 0.94 for Domashnie legkie rissoles, 1.04 for Babushkiny plus rissoles, and 0.86 for Govyazhii dieticheskie (beef diet) rissoles, which is within normal limits. The study of the fatty acid composition of the fat from the produced rissoles showed a shift in the balance of fatty acids towards unsaturated ones and an increase in the omega 3-6-9 complex by 7.7 %.

1. Introduction

In recent years, the population of the Russian Federation has been facing a decline in the health condition, which leads to a decrease in life expectancy and an increase in cardiovascular and oncological diseases. As many scientists note, most cardiovascular diseases begin with an improper lifestyle, unhealthy diet, when gradual clogging of the arteries occurs. The artery walls condense, as a result of accumulation of fats, especially cholesterol, atherosclerosis and other diseases begin from this point [1, 2].

The reason for its appearance is a disturbance of fat metabolism, when with a decrease in fat absorption, fat droplets settle on the blood vessel walls. Gradually, the vessels lose their elasticity, their lumen narrows. Atherosclerosis of the blood vessels of the heart leads to circulatory failure and poor supply of oxygen to the heart muscle. All this can lead to angina pectoris, heart pain, heart attacks. Excessive consumption of trans fats (saturated fats), which are quite abundant in animal products, red meat, margarine, confectionery, fried foods, increases the likelihood of developing coronary thrombosis. In the blood, trans fats become triglycerides, an excessively high level of which can aggravate the course of cardiovascular diseases and increase the level of bad cholesterol in the blood. The more trans fats we include in our diet, the higher the level of bad cholesterol in our body becomes [2].

The main risk factors are: unhealthy diet and obesity, lack of physical activity, alcohol and tobacco consumption. The state is gradually starting to work on the problems of alcohol abuse and smoking, developing and enacting the laws aimed at reducing these risk factors in both adults and children [3,
4). To maintain optimal health, one must adhere to both the general rules of good nutrition and the rules for consuming fats. Russian and international experience proves that preventive work is more effective than the clinical approach to solving these problems [5–7].

That is why today it is necessary not only to significantly improve the technology of traditional products of animal origin, but also to develop technologies for a wide range of new-generation food products that meet market requirements, consumer preferences and the requirements of a healthy and balanced diet. One of such products can be meat products with a balanced composition of the main nutrients. An important role is played by the technologies of low-calorie, low-fat products, enriched with healthy ingredients, with an extended shelf life and safe for the human body.

2. Materials and methods

The following products were selected as the objects for the present research: Domashnie rissoles manufactured by OJSC Kursk cold-store facility in accordance with industry standard (STO) 01444377-003-2009; Babushkiny rissoles manufactured by IP (unincorporated private entrepreneur) G.I.Lapenkov in accordance with TU (product specification) 9214-001-75238481-09; Govyazhie rissoles manufactured by IP D.V.Tarnovskiy in accordance with TU 9214-028-54899698-09; soybean refined deodorized oil Zlato manufactured by Labinskiy oil-extracting factory, Ltd. in accordance with GOST R 53510-2009; rapeseed refined deodorized oil Verkino maslo manufactured by Yug Rusi oil-extracting factory, Ltd. in accordance with GOST 31755-2012; gold-of-pleasure unrefined oil Yug Rusi manufactured by Yug Rusi oil-extracting factory, Ltd. in accordance with TU 9141-004-45830549-2011; corn refined deodorized oil Sloboda manufactured by OJSC EFKO in accordance with GOST 8808-2000; olive refined oil Olympic Foods manufactured by Olympic Foods, Ltd. in accordance with TU 9141-002-566119993-03. To determine the fatty acid methyl esters (GOST 30418-96 “Vegetable oils. Method for determining the fatty acid composition”) of the studied objects, the gas chromatography method using the Agilent 7820A system equipped with a flame ionization detector and Supelka capillary column with a size of 100 m × 0.25 mm was used. The determination of the total chemistry of meat products was carried out according to generally accepted methods: determination of the mass fraction of protein – by the Kjeldahl method according to GOST 25011-2017; determination of the mass fraction of fat – by the Soxhlet method in accordance with GOST 23042-2015; determination of the mass fraction of moisture – in accordance with GOST 33319-2015; determination of the mass fraction of total ash – according to GOST 31727-2012 (ISO 936: 1998).

3. Results

Today, Russia faces serious economic challenges caused by the sanctions policy from a number of countries in North America, Europe and others. One of the most important problems is the change in the supply and sale of food raw materials and finished products. Despite the difficulties, the restrictions imposed on the import of foreign products provide an opportunity for the development of domestic production and contribute to the development of import substitution, at the same time implement the Food Security Doctrine of the Russian Federation.

Based on the marketing research of the semi-finished product market of the Voronezh region (Russia), the authors developed technologies for combined ground meat semi-products, in particular rissoles, which contain various types of vegetable oils along with animal fats, which makes it possible to significantly enrich the diet with polyunsaturated fatty acids while reducing cholesterol, saturated fatty acids and energy values. The task of marketing research was to study the price positioning of the manufacturers on various types of meat products; calculation of the representation and share of the shelf products of the manufacturers. The study was performed through a continuous census of a storefront. For this study, a representative sample of retail shops in the Voronezh region in the amount of 20 % of the total number was formed, in accordance with the structure, according to the types of shops and administrative regions – shopping centers “Okay”, “Centrtorg”, “Europe”, “5 × 5". The results of the study determined that the main manufacturers of the semi-products are Bort Farm, Miratorg Zapad Ltd., Morozko Ltd., RAVIOLI Ltd., Russky Kholod, Sytny Krai Farm and others.
Analysis of the study showed that 38 titles of meat semi-products, including semi-products in dough, were produced according to product specifications (TU), 10 according to industry standards (STO). The study on the mass fraction of fat of selected semi-products identified 2 items with the fat content less that 40 %, 7 items with the fat content of not exceeding 25–30 %, 8 items – not exceeding 20–25 %, 10 items – not exceeding 15–20 % and 21 items – no more than 10–15 %. The study determined that 43.75 % of semi-products sold in the Voronezh Region contain no more than 15 % of fat, and 20.83 % are the semi-products with the fat content of 15–20 %, 16.67 % – 20–25 %, 14.58 – 25–30 %, 4.17 % – 40 %.

Earlier studies of the same authors of the fatty acid composition of vegetable oils confirm that the selected research objects contain a fairly large amount of unsaturated fatty acids, and it was noted that the mass fraction of oleic acid in olive and rapeseed oils is 64 and 48 %, linoleic acid in corn oil is 54 % and in soybean oil – 62 %, linolenic acid in soybean and rapeseed oils 7.8 and 5.2 %, correspondingly [8]. The most important characteristic of meat products, in particular rissoles, is their general chemistry, which is why we analyzed it for the compliance of the selected research objects with the requirements of regulatory documentation (Table 1).

Table 1. General chemistry of the studied semi-products (difference between the actual nutrient contents and the one stated at the label, % of the stated content)

| Semi-product         | Proteins, % | Fat, %  | Moisture, % | Ash, %  |
|----------------------|-------------|---------|-------------|---------|
|                      | According to TU | Actual content | According to TU | Actual content | According to TU | Actual content | According to TU | Actual content |
| Domashnie rissoles   | 10.0        | 9.80    | 21.0        | 16.46   | 57.0        | 59.66          | 12.0          | 14.08          |
| Babushkiny rissoles  | 9.0         | 12.65   | 30.0        | 29.10   | 59.0        | 56.90          | 2.0           | 1.35           |
| Govyazhii rissoles   | 16.9        | 13.30   | 8.6         | 12.20   | 65.5        | 64.69          | 9.0           | 9.81           |

The analysis of the experimental data in table 1 shows the absence of a significant discrepancy between the actual and stated mass fractions of the main nutrient components, however, there is a violation of the requirements of regulatory documentation, which is within the experimental error.

The use of computer modeling in the development of recipes for multicomponent products allows us to create products with a given composition and properties in a short time, we used the software Generic 2.0, designed by the employees of Kuban state university of technology [9].

The key objective of this work is to develop a meat product with low fat content, ground meat semi-products Domashnie, Babushkiny and Govyazhii rissoles selected as the object of modeling. To achieve the objective of reducing the fat content of the product, it is proposed to use low-fat raw materials in the composition, vegetable oil will also be introduced to replace some share of animal fat and increase the amount of unsaturated fatty acids in the composition of the product. The following raw materials will be used in the new recipes: beef, pork, chicken fillet, corn oil, soybean oil, onion, etc. Modeling of the formulations was carried out according to the criterion of fat content, in order to establish it at a certain level. The proposed formulations of meat semi-products using vegetable oils are presented in table 2 and the evaluation of the desirability function is given in figures 1–4.

The developed recipes for ground semi-products have high biological value. The general desirability function of Domashnie legkie rissoles is 0.94, Babushkiny plus rissoles 1.04, and Govyazhii dietitcheske rissoles 0.86, which is within the normal range. The developed meat semi-products (rissoles) are well-balanced products. The study of the chemistry of the developed samples was carried out on the example of model versions of minced meat. Studies have been performed to determine the sample content of protein, fat, moisture and minerals (ash). The results are presented in table 3.

Experimental data show that in the developed samples the mass fraction of protein is increased by almost 1.5 times, the mass fraction of fat is reduced by more than 2 times. The obtained values allow us to talk about improving the nutritional value of the developed product, which corresponds to modern requirements of food hygiene.
Table 2. The proposed formulations of meat semi-products using vegetable oils, kg/100 kg

| Raw material       | Domashnie legkie rissoles | Babushkiny plus rissoles | Govyazhii dieticheskie rissoles |
|--------------------|---------------------------|--------------------------|-------------------------------|
| Beef premium       | 31.26                     | 25.00                    | 46.50                         |
| Low-fat pork       | 31.08                     | 24.00                    | –                             |
| Chicken fillet     | –                         | 17.50                    | 27.00                         |
| Corn oil           | 6.00                      | 3.50                     | –                             |
| Soybean oil        | –                         | 3.50                     | 6.00                          |
| Potable water      | 18.50                     | –                        | 13.09                         |
| Onion              | 1.60                      | 12.67                    | 6.00                          |
| Wheat bread        | 10.00                     | –                        | –                             |
| Kitchen salt       | 1.50                      | 0.95                     | 1.36                          |
| Powdered black pepper | 0.06                 | 0.05                     | 0.05                          |
| Rich dry milk      | –                         | 4.75                     | –                             |
| Potato flakes      | –                         | 3.00                     | –                             |
| Dry egg melange    | –                         | 5.07                     | –                             |
| Garlic             | –                         | 0.01                     | –                             |
| Total:             | 100.00                    | 100.00                   | 100.00                        |
| Breadcrumbs        | 5.00                      | 5.00                     | 5.00                          |

Figure 1. Recipe calculation for Babushkiny plus rissoles
Figure 2. Recipe calculation for Govyazhii dieticheskie rissoles
Figure 3. Desirability function diagram for Babushkiny plus rissoles

Figure 4. Desirability function diagram for Govyazhii dieticheskie rissoles

Table 3. General chemistry of the development recipes of meat semi-products

| Ground meat semi-products             | Protein, % | Mass fraction of fat, % | Moisture, % | Ash, % |
|--------------------------------------|------------|-------------------------|-------------|--------|
| Domashnie rissoles                    | 9.80       | 16.46                   | 59.66       | 14.08  |
| Domashnie legkie rissoles             | 16.48      | 6.75                    | 69.12       | 7.65   |
| Babushkiny rissoles                   | 12.65      | 29.10                   | 56.90       | 1.35   |
| Babushkiny plus rissoles              | 16.22      | 12.78                   | 68.65       | 2.35   |
| Govyazhii rissoles                    | 13.30      | 12.20                   | 64.69       | 9.81   |
| Govyazhii dieticheskie rissoles       | 15.19      | 7.21                    | 68.88       | 8.72   |

The presence of vegetable fats makes the product enriched with unsaturated fatty acids. To verify the last statement, we carried out a comparative characteristic of the fatty acid composition of the fat of meat semi-products of the developed and model formulation. The Soxhlet fat extraction method yielded fat, which was analyzed by gas chromatography. The research results are presented in figures 5–6 and table 4.

Figure 5. Chromatogram of fat acid composition of Domashnie rissoles
The analysis of experimental data showed that the total mass fraction of unsaturated omega 3-6-9 fatty acids increased in the developed formulation by 7.7%. Our studies allow us to design recipes for meat semi-products with a given composition and properties using computer simulation, the use of vegetable oils in recipes reduces the total fat content by 2–3 times, and the optimal ratio between proteins, fats, and carbohydrates in food is 1: 1: 4.

Table 4. Mass fraction of omega 3-6-9 fatty acid complex in the fat of the ground meat semi-products

| Symbol for fat acids | Methyl ethers of fat acids | Domashnie rissoles | Domashnie legkie rissoles |
|---------------------|---------------------------|------------------|--------------------------|
|                     |                           | Retention Time   | Concentration            | Retention Time   | Concentration |
| C18:1               | Methyl oleate             | 34.791           | 0.293                    | 34.796           | 0.291         |
| C18:2               | Methyl linoleate (cis-9,12) | 37.335         | 46.555                   | 37.405           | 57.964        |
| C18:2               | Methyl linoleaidate (trans-9,12) | 38.063   | 10.473                   | 38.060           | 6.748         |
| C18:3               | Methyl linolenate         | 38.308           | 2.182                    | 38.307           | 1.526         |
| C20:1               | Methyl eicososnoate       | 43.012           | 4.460                    | 43.010           | 4.460         |
| C20:5               | Methyl eicosapentaenoate  | 47.164           | 0.794                    | 47.166           | 0.632         |
| C22:1               | Methyl erucate            | 49.488           | 0.270                    | 49.498           | 0.450         |
| C22:6               | Methyl docosahexaenoate   | 52.118           | 0.045                    | 52.112           | 0.372         |
| C24:1               | Methyl nervonate          | 54.618           | 0.120                    | 54.645           | 0.695         |

As the research results show, the use of meat semi-products in recipes allows increasing the content of the omega 3-6-9 fatty acid complex by 7.7%.

4. Conclusion

The developed technology of ground meat semi-products allows for creation of an assortment of meat products related to preventive nutrition, where a special role is given to reducing the proportion of saturated animal fats by replacing them with unsaturated vegetable fats.

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