The use of lentil proteins in the technology of production of raw smoked sausages

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Abstract. On the basis of the obtained research results, it was concluded that it is advisable to use lentil proteins in the technology for the production of raw smoked sausages. A model minced meat has been developed and the effect of lentil proteins on the functional, technological, physicochemical properties of the model minced meat has been studied. When lentil proteins are added, a decrease in moisture-binding and water-retaining capacities is noticeable, which is a positive side in the technology for the production of raw smoked sausages. A more active development of the starting microflora is observed as compared to the control as a result of the appearance of an additional nutrient medium in the form of plant polysaccharides. As a consequence, a rapid and uniform decrease in the pH of minced meat can lead to a decrease in the amount of "wild microflora" as a result of an intensive accumulation of lactic acid. Lowering the pH to the isoelectric point of the protein will allow the sausages to dry quickly.

1. Introduction

Analysis of the food market indicates an increase in demand for food products of animal origin, including sausages [1-3]. As a rule, the demand and the level of "buyability" of sausages exceeds the production of raw meat. The lack of meat raw materials forces manufacturers to introduce modern technologies [4-10], including the partial replacement of meat raw materials with vegetable ones. When developing new products, it is necessary to take into account the requirements of nutritionology and the food safety management system [11-23].

The use of vegetable proteins in the production of sausages has become widespread due to the stability of the technological process, which helps to prevent the occurrence of broth-fat edema and other technological types of marriage. Legumes are of particular interest, since they contain the largest mass fraction of protein in comparison with other plant crops. Among other things, legumes are the most readily available in comparison with others grown in Russia [24].

The use of vegetable proteins makes the product the most easily digestible, forms good organoleptic characteristics and reduces the cost of the finished product, which, perhaps, is one of the factors in the
formation of high consumer demand. The use of vegetable protein components improves the quality of finished products by reducing the content of cholesterol and fatty acids.

The most famous plant proteins are soy proteins [24]. They are most common in the production of sausages due to technological features and low cost. However, a consumer survey found that soy protein in food products is of concern lately, one of the reasons for which is its frequent production through the use of gene modification. Therefore, it becomes necessary to search for an alternative source of soy protein replacement. As a promising source, it is advisable to use lentil protein, which also has a rich amino acid composition and good organoleptic, functional and technological properties [25, 26].

The introduction of starter cultures into the recipe for raw smoked sausages accelerates the maturation process of sausages. In the process of biomodification of raw meat raw smoked sausages acquire certain organoleptic and physicochemical properties [27-32]. During the ripening process, a certain color, taste and structure of raw smoked sausages are formed [33]. However, the biomodification of plant materials is still poorly understood.

The aim of the work is to study the possibility of using vegetable lentil proteins in the technology of production of raw smoked sausages.

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2. Materials and methods
To prepare the model minced meat, beef and pork were taken in equal proportions. Raw meat was ground in a meat grinder with a lattice hole diameter d = 3 mm. Starter cultures were added to the model minced meat according to the manufacturer's recommendations.

For the experiment, the starting culture Bessastrat of the Mongucia company was chosen. The culture includes microorganisms of the species P. pentosaceus and Staphillococcus xylosus, Staphilococcus carnosus. The determination of pH was carried out on a potentiometer pH-340 in accordance with GOST R 51478. The number of mesophilic aerobic and facultative anaerobic microorganisms was determined in accordance with GOST 10444.15.

Moisture binding capacity by the Grau-Hamm method. Mass changes were determined by weighing on a balance and in the ratio in% to the weight of the feedstock. The water retention capacity of minced meat was determined as the difference between the mass fraction of moisture in the minced meat and the amount of moisture separated during heat treatment. Stickiness was determined by the Sokolov-Bolshakov method. The fractional composition of proteins was determined based on their solubility.

Amino acid analysis was carried out by the method of ion exchange chromatography on the basis of the State Scientific Research Institute of Research and Development of the Russian Agricultural Academy at the ARGUS Testing Center. The method for the quantitative determination of lactic acid with para-oxydiphenyl is based on measuring the color intensity of the compound formed during the reaction of acetaldehyde with n-oxydiphenyl in the presence of sulfuric acid.

Proteins are removed by precipitation with trichloroacetic acid, and carbohydrates by precipitation with calcium hydroxide in the presence of copper sulfate; acetaldehyde, which is formed from lactic acid when heated with sulfuric acid, gives a color reaction with para-hydroxydiphenyl (purple color).

Acetaldehyde is formed when lactic acid is heated with mineral acids. When it interacts with two molecules of n-oxydiphenyl, dioxydiphenylethane is formed, which in the presence of H₂SO₄ is oxidized to a violet product with an absorption maximum at 574 nm. The method allows you to determine lactic acid in quantities from 0.03 to 0.2 μmol in the sample.

3. Results and discussions
To study the effect of vegetable proteins on the functional and technological properties of minced meat, soy protein and lentil protein were taken as a basis.

Comparative analysis of the amino acid composition of the proteins under study, mg per 100 g of the edible portion is shown in table 1.
Table 1. Amino acid composition of the studied plant proteins.

| Amino acid name (AA)       | Content, mg per 100 g of edible part | in the egg | in soy   | in lentils |
|----------------------------|-------------------------------------|-----------|---------|-----------|
|                            |                                     |           |         |           |
| Isoleucine                 |                                     | 597       | 1810    | 1020      |
| Valine                     |                                     | 772       | 2090    | 1270      |
| Leucine                    |                                     | 1081      | 2670    | 1890      |
| Lysine                     |                                     | 903       | 2090    | 1720      |
| Phenylalanine + Tyrosine   |                                     | 652+476   | 1610+1060 | 1250+780 |
| Methionine + cystine       |                                     | 424+293   | 560+620 | 290+220   |
| Threonine                  |                                     | 610       | 1390    | 960       |
| Tryptophan                 |                                     | 204       | 450     | 220       |
| Amount AA                  |                                     | 6012      | 14350   | 9620      |

At the first stage of the research, the growth rate of starter cultures was analyzed with different amounts of substitution of meat raw materials for vegetable proteins. The replacement of raw meat was made from 10 to 40%. The result is shown in table 2.

Table 2. Analysis of the growth rate of crops on model minced meat.

| Quantity, g/100 kg of minced meat | Duration of the experiment, h | Number of cells, CFU/g |
|----------------------------------|-----------------------------|------------------------|
|                                  | 0              | 3            | 6            | 9            | 12           |
| Control                          | 4,6×10⁵        | 5×10³        | 6,5×10³      | 8,5×10³      | 1,0×10⁶      |
| 10 %                             | 4,4×10⁵        | 4,9×10⁵      | 7,4×10⁵      | 9,6×10⁵      | 3,1×10⁶      |
| 20 %                             | 4,7×10⁵        | 5,2×10⁵      | 6,4×10⁵      | 9,4×10⁵      | 2,9×10⁶      |
| 30 %                             | 4,6×10⁵        | 5,1×10⁵      | 5,9×10⁵      | 6,7×10⁵      | 7,3×10⁵      |
| 40 %                             | 4,6×10⁵        | 5,0×10⁵      | 5,8×10⁵      | 6,1×10⁵      | 6,8×10⁵      |

The best moisture-binding capacity (WCC) is possessed by raw meat in comparison with vegetable raw materials. For the study of VSS, model minced meat with starter cultures was kept for 12 hours at a temperature of 3±1 °C. The result of the study of the moisture-binding capacity of the model minced meat samples is shown in figure 1.

Figure 1. Moisture binding capacity of model minced meat.
The higher the water-holding capacity of the model minced meat, the longer the drying process takes. The result of the study of the water-holding capacity is shown in figure 2.

![Figure 2. The water-holding capacity of the model minced meat.](image)

The activity of starter cultures is directly related to protein hydrolysis, during which the protein breaks down into easily digestible amino acids. Table 3 shows data on the amino acid composition of model minced meat before and after biomodification.

| AA name            | Control sample Content, mg/100 g of product | Prototype Content, mg/100 g of product |
|--------------------|--------------------------------------------|---------------------------------------|
|                    | Before | After | Before | After |
| Isoleucine         | 10.0   | 10.4  | 10.7   | 11.2  |
| Valine             | 13.2   | 13.7  | 13.8   | 14.2  |
| Leucine            | 20.2   | 21.0  | 20.9   | 21.4  |
| Lysine             | 14.6   | 15.2  | 15.1   | 15.7  |
| Phenylalanine+Tyrosine | 11.0+10.2 | 11.2+10.6 | 11.4+10.7 | 11.8+11.2 |
| Methionine + cystine | 5.0+2.0  | 5.1+1.5 | 5.5+2.7 | 5.9+2.3 |
| Threonine          | 10.6   | 11.1  | 11.2   | 11.7  |

The results of studying the dynamics of changes in the pH of the model minced meat are presented in figure 3.

![Figure 3. Change in pH in the model minced meat.](image)
The dynamics of changes in the content of lactic acid in the model minced meat is shown in figure 4.

![Figure 4. Change in lactic acid content in model minced meat.](image)

The use of vegetable proteins in technology allows not only to increase the output of finished products, but also to reduce the cost;

The most commonly found vegetable proteins in the meat industry are soy proteins. They are used as concentrates, isolates and flour. Soy proteins are distinguished by a wide range of essential and essential amino acids.

However, the oversaturation of the market for meat products containing soy proteins has led to a decrease in demand. From the data of the sociological survey, it can be concluded that consumers began to pay the most attention to the composition of the product. When buying, preference is given to products that do not contain soy.

Analysis of table 1 indicates an increase in the amount of vegetable proteins is higher compared to egg proteins. It is worth noting the advantage of soy protein in terms of the number of amino acids compared to lentils. The presence of a large amount of lipids in soy can affect the quality of the finished product. Additional oxidation of soy lipids can lead to a deterioration in the aroma and taste of the product. Unlike soy, lentils contain negligible amounts of lipids.

The data in table 2 indicate that there is an increase in all samples of the model minced meat. However, the most optimal development of microflora is observed when lentil isolate is applied at a rate of 10–20%. With the introduction of 30–40%, a slower growth of the starting microflora is observed. In addition, this ratio of raw materials can lead to a deterioration in the organoleptic characteristics of the finished product. The optimal replacement rate is 20%. Further research will be carried out when replacing raw meat in 20%.

In the production of raw smoked sausages, moisture binding and water retention capacity is of great importance.

Moisture binding ability. For the technological process of making raw smoked sausages, the presence of weakly bound moisture is most preferable, and not tightly bound. In the presence of weakly bound moisture, the drying process proceeds better, since this type of moisture is well removed from the product. The lower the grade of trimmed meat, the lower its BCC [12].

The data in figure 1 shows that the control sample is superior to the sample in which the lentils are applied in terms of moisture binding capacity. The moisture binding capacity of the experimental model minced meat was 75.8%, which is 1.8% less than the control. The introduction of vegetable protein into the composition helps to reduce the moisture binding capacity (WCC), which is more optimal for the drying process of raw smoked sausages.
The data in figure 2 prove a noticeable decrease in the water-holding capacity of the test sample, compared to the control. The water-holding capacity of the prototype of the model minced meat was 70.5%, which is 2.7% less than in the control.

The data in table 3 indicate a more intense protein breakdown in the experimental sample, which indicates a more intensive development of starter cultures.

One of the main physicochemical indicators affecting the model minced meat is pH. It not only affects the growth and development of the starting microflora, but also the correctness of the technological process.

Lactic acid bacteria, which are part of the starter cultures, process carbohydrates in the course of their life, and lactic acid is formed. Due to this, the pH shifts towards an acidic environment, and a more intense accumulation of lactic acid can lead to souring of sausages. Such products are already considered a defect.

The rapid growth of beneficial microflora and the accumulation of lactic acid helps to inhibit the development of unwanted microflora, the development of organoleptic characteristics of the finished product. Lactic acid bacteria, which are part of the starter cultures, process carbohydrates in the course of their life, and lactic acid is formed. Due to this, the pH shifts towards an acidic environment, and a more intense accumulation of lactic acid can lead to souring of sausages. Such products are already considered a defect.

In the experimental sample of model minced meat (figure 3), a more intense decrease in pH is observed. The protein's isoelectric point is reached after 48 hours. A rapid decrease in pH in the experiment occurs as a result of a faster increase in the number of starter cultures. An intensive decrease in pH helps to preserve the color and quickly compact the sausage loaves.

In the experimental sample (figure 4) of the model minced meat, a more intense accumulation of lactic acid is observed. The rapid accumulation of lactic acid in the experiment occurs as a result of the intensive growth of the number of bacteria that make up the starter cultures. Intense accumulation of lactic acid can lead to souring of sausages.

4. Conclusion
A model minced meat has been created and the effect of lentil proteins on the functional, technological, physicochemical properties of the model minced meat has been studied. When lentil proteins are added, a decrease in moisture-binding and water-holding capacities is noticeable. What is the positive side of the technology for the production of raw smoked sausages.

A more active development of the starting microflora is observed as compared to the control as a result of the appearance of an additional nutrient medium in the form of plant polysaccharides. As a consequence, a rapid and uniform decrease in the pH of minced meat can lead to a decrease in the amount of "wild microflora" as a result of an intensive accumulation of lactic acid. Lowering the pH to the isoelectric point of the protein will allow the sausages to dry quickly.

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