The use of vegetable proteins in summer sausage production

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Abstract. Vegetable proteins have become widespread in sausage production due to the need to lower its cost. Lentil is a promising vegetable protein. The study focuses on changes in the functional and technological, and physicochemical parameters of model sausage meat for the production of summer sausage. The dynamics of the growth of starter cultures for the model sausage meat with partial substitution of raw meat was found positive. The moisture-binding and water-holding capacity reduces, and this speeds up the rate of sausage drying.

1. Introduction

Meat products (sausage, semi-finished products, pastes and others) are in high demand among the population [1–4]. The compliance with the requirements for quality and safety of meat products is assessed in accordance with international rules, standards and norms [5, 6]. The ingredients used in sausage production are meat (beef, pork, offal, bacon, etc.) along with additives, for example, butter, starch, sugar, salt, spices, various types of cereals, etc. [7, 8].

During industrial processing, the product acquires certain organoleptic properties. Modes and methods of thermal processing, such as cooking and smoking, facilitate this process. Thermal processing ensures the natural ratio of proteins, fats and the amount of moisture specified for a particular type of sausage products. The process of summer sausage production does not imply thermal processing of the link sausage. This process employs biomodification of raw meat by starter cultures and drying to attain certain moisture content [9, 10]. Biomodification imparts taste, color and aroma to the sausage. The accumulated lactic acid suppresses the vital activity of undesirable microflora [11, 12].

Production of high-quality sausage products needs advanced production technology, state-of-art equipment and expanded assortment to meet consumer demands. In conditions of the raw meat shortage, many manufacturers try to reduce the production cost, and the search for alternative sources of substitutes for raw meat is therefore considered promising [13, 14].

In modern sausage production, animal and vegetable proteins are used to replace expensive raw meat. Plasma proteins, soy and lentil proteins, casein, caseinates, proteins made from collagen-containing raw materials, and whey protein concentrates can be used as substitutes. Both vegetable and animal proteins can be balanced in amino acid composition to be close to the reference protein [16–17].

Modern sausage production employs soy proteins in various forms. Yet, in recent times, soy protein has caused negative perception among consumers due to its frequent production from genetically modified organisms (GMOs). This necessitates the search for an alternative substitute for soy protein. Lentil protein is considered to be a promising substitute [19, 20].
The study aims to analyze the possibility and prospects of using lentil proteins in summer sausage production.

2. Materials and methods
For the experiment, the chosen raw meat included chilled beef and pork, Bessastrat starter cultures by Mongucia, lentil vegetable protein hydrated in a ratio of 1:3 (lentil protein : water).

The studies were conducted in accordance with the technique described in [21].

PH control was performed using pH-340.

The growth and amount of microflora was determined in accordance with the procedure reported in [21].

The weight was measured using a laboratory balance to determine a percentage of the original mass. The moisture mass ratio was determined by drying in an oven to constant weight.

Amino acid analysis was performed by ion exchange chromatography in the ARGUS test center. Quantitative determination of lactic acid with paraoxydiphenyl is performed through measuring the color intensity of the compound formed during the acetaldehyde-n-oxydiphenyl reaction in the presence of sulfuric acid.

The main indicators for proteins, fats and carbohydrates were determined according to the procedure reported in [21].

3. Results and discussion
A comparative analysis of the amino acid composition of the studied proteins, mg per 100 g of the edible part is shown in table 1.

| Amino acid (AA)       | Content, mg per 100 g of the edible part |
|-----------------------|-----------------------------------------|
|                       | egg | soy | lentil   |
| 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      |
| Tryptophane           | 204 | 450 | 220      |
| Total AA              | 6012| 14350| 9620     |

The analysis of the data presented in table 1 indicates an increased amount of vegetable proteins compared to egg proteins. It should be noted that soy protein is superior to lentil proteins in the amount of amino acids. The presence of a large amount of lipids in soy can affect the quality of the finished product. Additional oxidation of soy lipids can deteriorate the aroma and taste of the product. In contrast to soy, lentil contains a small amount of lipids.

In addition, beans are digestive enzyme inhibitors. In this case, lentil is superior to soy. Lentil contains trypsin inhibitors only, and soy contains trypsin and chymotrypsin inhibitors. During thermal processing, trypsin inhibitors are destroyed, and the nutritive value becomes comparable to that of milk proteins [22, 23].

To prepare model sausage meat, beef and pork were taken in equal proportions. Raw meat was grounded using a meat grinder with a diameter of the holes in the disk equal to 3 mm. Starter cultures were added to model sausage meat in accordance with the manufacturer’s recommendations.

Starter cultures in the recipe of summer sausage accelerates ripening of sausage. In the process of biomodification of raw meat by starter cultures, summer sausage acquires certain organoleptic and
physicochemical properties. During the ripening process, sausage acquires a certain color, taste and structure.

For the experiment, Bessastrat starter culture by Mongucia was chosen. This culture includes microorganisms of the species *P. pentosaceus* and *Staphilococcus xylosus*, and *Staphilococcus carnosus*.

For summer sausage, the growth rate of positive microflora (in our case, starter cultures) is an important characteristic [7, 9, 12]. Partial substitution of raw meat can affect the growth rate of starter cultures, and excessive substitution of raw meat can lead to deterioration of the organoleptic properties of the finished product.

At the first stage of the study, the growth rate of starter cultures with different amount of vegetable proteins as substitutes for raw meat was analyzed. The amount of substitutes varied from 10 to 40%.

The results are presented in table 2.

| Amount, g/100 kg of sausage meat | Duration of experiment, h | Number of cells, CFU/g |
|---------------------------------|--------------------------|------------------------|
| control                         | 0                        | 4.6×10⁵                 |
|                                 | 3                        | 5.0×10⁵                 |
|                                 | 6                        | 6.5×10⁵                 |
|                                 | 9                        | 8.5×10⁵                 |
|                                 | 12                       | 1.0×10⁶                 |
| 10 %                            | 4.4×10⁵                  |                         |
| 20 %                            | 4.7×10⁵                  |                         |
| 30 %                            | 4.6×10⁵                  |                         |
| 40 %                            | 4.6×10⁵                  |                         |

The data presented in table 2 indicate an increase in the growth rate of starter cultures for all samples of model sausage meat. However, the most optimal growth of microflora can be observed when 10–20% of lentil isolate is added to sausage meat. When 30–40% of substitutes are added, the growth rate of microflora is observed to slow. In addition, this ratio of raw materials can result in deterioration of the organoleptic properties of the finished product. The optimal amount of substitutes is 20%. Thus, further research will be conducted for raw meat substituted with additives in an amount of 20%.

Moisture-binding and water-holding capacity is of high importance in summer sausage production.

Moisture-binding capacity. For summer sausage production, the presence of loosely bound moisture rather than tightly bound is required. The presence of loosely bound moisture contributes to the drying process, since this type of moisture can be successfully removed from the product.

Raw meat exhibits better moisture-binding capacity (MBC) compared to vegetables.

To study MBC, sausage meat with starter cultures was kept for 12 h at 3±1 °C.

The result of study of the moisture-binding capacity of model sausage meat samples is presented in figure 1.

Table 2. Analysis of the growth rate of starter cultures for model sausage meat.
Figure 1. Moisture-binding capacity of model sausage meat.

The data presented in figure 1 show that the control sample is superior in MBC to the sample with lentil additive. The MBC of the experimental model sausage meat was 75.8%, which is 1.8% less than that of the control. Addition of vegetable protein reduces MBC, which is more optimal for the drying process of summer sausage.

The higher the water-holding capacity of model sausage meat, the longer the drying process. The result of study of water-holding capacity (WHC) is presented in figure 2.

Figure 2. Water-holding capacity of model sausage meat.
The data presented in figure 2 show a distinct decrease in the WHC of the experimental sample compared to the control. The WHC of the experimental sample of model sausage meat was 70.5%, which is 2.7% less than that of the control.

A rapid growth of beneficial microflora and the accumulation of lactic acid inhibits the growth of undesirable microflora and improves organoleptic properties of the finished product. Lactic acid bacteria, which are part of starter cultures, process carbohydrates to produce lactic acid. Due to this, the pH shifts to acidic medium, and a more intense accumulation of lactic acid can lead to acidification of sausage products. Such products are regarded as defective.

The results of study of the dynamics of changes in the acidity of model sausage meat are presented in figure 3.

Figure 3. Dynamics of pH of sausage meat.

In the experimental sample of model sausage meat, pH decreases more intensively. The proteins reach their isoelectric point after 48 hours. A rapid decrease in pH in the experiment is due to a more rapid increase in the amount of starter cultures. Intensive pH decrease contributes to the preservation of color and rapid compaction of the link sausage.

4. Conclusion
Substitution of raw meat with lentil proteins is optimal in an amount of up to 20%. When substituting raw meat with lentil proteins, an intensive growth of starting microflora can be observed. Moisture-binding and water-holding capacity decreases by 1.8 and 2.7%, respectively, compared to the control. An intensive growth of starting microflora in the experimental sample of model sausage meat contributes to the pH decrease from 5.85 to 4.95 over 96 hours. Based on the data obtained, a partial substitution of raw meat with lentil proteins in an amount of up to 20% can be recommended.

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