Ham production using processed apple products

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Abstract. The article analyzes the possibility and rationality of using apple processing products as food additives to increase the nutritional value of products, substantiates the expediency of using a vegetable component (apple pomace) in the technology of smoked-boiled ham products. To assess the technological potential of using apple pomace in the production of smoked-cooked sausages, experimental studies were carried out using generally accepted methods to study the basic properties of raw materials and control samples - products without the addition of powdered apple pomace, and prototypes - products with the addition of apple pomace according to the developed recipe. Formulations have been optimized and a method has been developed for the production of a combined composition of protein-fat emulsion, which is recommended to be introduced instead of 22% of the main unsalted meat raw materials. According to the results obtained, a sample containing 6% apple pomace has the best quality indicators.

1. Introduction
The development of the domestic food industry, including the meat processing industry, is urgent. For the growth of competitiveness in the markets of meat products, a necessary and indispensable condition is the substitution of imported raw materials with domestic ones. In this regard, at present, it is required to use all available reserves of animal protein to the maximum and efficiently. One such source is poultry meat, in particular ducks.

The good digestibility of poultry meat (96%) is explained by its chemical composition. Due to the fact that connective tissue is relatively poorly developed in poultry meat, it contains more complete and digestible proteins in comparison with meat of slaughter animals, and proteins are mainly water-soluble. Collagen and elastin are practically absent in proteins of duck meat, which characterizes its good digestibility and nutritional value [1, 2, 3].

In modern meat-processing industry, the use of protein-fat emulsions is widely used, this is justified by the need to bind fatty raw materials, improve its quality, avoid the appearance of fatty edema, reduce its cost in some cases, etc. [4, 5].

Collagen-containing raw materials, in particular chicken skin, are a promising source of food protein in the meat industry. The advantage of using chicken skin is that collagen has a high water-holding and texture-forming ability, which allows it to be used in various food systems. The use of chicken skin in the composition of protein-fat emulsion (PFE) will stabilize the quality of hams, which are emulsified products, expand the possibilities of using secondary protein-containing resources from the processing of poultry meat and the range of finished products [6, 7, 8].
The use of apple pomace, formed in the production of directly squeezed juice from apple varieties growing in large quantities in the Lower Volga region of Russia, in particular, the Volgograd region, in the formulations of ham products, is promising not only from an economic point of view. The chemical composition of apple pomace determines their high nutritional value (they are a source of pectin, fiber, water-soluble vitamins and minerals). In addition, they exhibit antioxidant properties due to the presence in the composition of organic acids, vitamins (ascorbic acid) and water-soluble antioxidants (quercetin), which are synergists of the nitrite salt in stabilizing the color of the finished product.

The aim of this work is to improve the technology of smoked-boiled ham products from poultry meat using PFE of a complex composition. In accordance with the set goal, the following tasks were solved:

- substantiate and select the ingredient composition;
- to optimize the formulation of the protein-fat emulsion and to improve the technology of the restructured ham;
- to develop an original recipe and method of production of the product.

2. Materials and methods

The work was carried out on the basis of the educational and scientific center "Department Technologist" of the Department of Food Production Technologies of the Volgograd State Technical University and the complex analytical laboratory of the State Scientific Research Institute of the Russian Academy of Medical Sciences and consisted of the following stages: selection and preparation of raw materials, development of prototypes of ham products, conducting organoleptic and physico-chemical studies to assess the quality of the products obtained, optimization of the recipe and development of the method of production of the product in accordance with the research scheme (Figure 1).

The objects of research were duck meat (State Standard 31990-2012); broiler chicken meat (State Standard 31962-2013); soy protein isolate (State Standard R 53861-2010); apple pomace, which is a secondary resource of apple processing, formed in the production of direct-pressed juice from apple varieties Golden Delicious, Rennie Simirenko, Granny Smith; as well as samples of smoked-boiled ham, developed on the basis of these components using PFE combined composition.

Sampling and preparation of samples for laboratory studies was carried out according to a single method in accordance with the requirements of State Standard R 51447-99 (ISO 3100-1-91).

In the course of experimental studies, the following indicators were studied: 1 – organoleptic parameters (State Standard 9959-91; State Standard R 53159-2008; State Standard R 53161-2008); 2 – pH value (using a portable measuring device Testo 206 pH2 using a piercing electrode); 3 – dry matter content (State Standard 9793-2016); 4 – fat mass fraction (State Standard 23042-86); 5 – protein mass fraction (State Standard 25011-2017); 6 – sodium chloride mass fraction (State Standard P 51480-99); 7 – the content of residual sodium nitrite (State Standard 29299-92); 8 – moisture binding capacity (according to the method of Grau and Hamm in the modification of Volovinskaya and Kelman); 11 – product yield (by weight method); 12 – organic acid content (State Standard 32771-2014); 13 – pectin content (State Standard 32223-2013); 14 – fiber content (State Standard 31675-2012); 15 – thiobarbitur number (State Standard R 55810-2013); 16 – peroxide number (State Standard 34118-2017); 17 – computer modeling using the Microsoft Office software package on a PC; 18 – energy value (calculated by the actual content of proteins, fat, and carbohydrates in the sample).

The cost of production of experimental samples was calculated on the basis of actual costs and prices at the end of 2020, taking into account shop costs in the "Department Technologist" of the Volgograd State Technical University.

Product safety is ensured by the implementation of the technological process and compliance with the expiration dates (TR CU 034/2013 Technical Regulations of the Customs Union "On the safety of meat and meat products").

The experimental data were processed using mathematical statistics methods using a computer. The repeatability of the experiments is at least 3 times with a 3-to 4-fold repeatability of the analyses. Confidence level = 0.95.
3. Results and discussion

Duck meat with the following functional and technological parameters was used as the main raw material in the preparation of the ham recipe: pH was 6.27; dry matter content – 38.8%; fat content – 17%; protein content – 18%. To optimize the functional and technological properties of duck meat in the production of ham, minced meat was prepared using the meat of broiler chickens. The recipe also included ingredients such as poultry skin, soy protein isolate and apple pomace.

According to the chemical composition and biological value of poultry skin (from the neck, legs), it contains 14-17% protein and 20-25% fat and vitamins (A, B1, B2, B3, PP, C, E), Ca. Due to the fact that there is a lot of fat in the skin, it is prone to rancidity. The connective tissue in the fat can split into gelatin and fat during frying, thereby contributing to the formation of a porous texture. To eliminate this disadvantage and stabilize the fat present in the skin, it must first be converted into an emulsion.

![Research scheme](image)

Figure 1. Research scheme.

Also, the developed PFE recipe is enriched with apple pomace, which are secondary resources of apple processing formed during the production of direct-pressed juice from local Volgograd apple varieties (Golden Delicious, Renet Simirenko, Granny Smith). Apple pomace is a fine powder without foreign impurities. It is allowed to have a fibrous fraction of pectin in the form of flakes, slightly acidic taste, without foreign smell, from light gray to cream color. According to the chemical composition and biological value, the pomace of the selected apple varieties contains about 13.5% dry matter, 17-1.9% fiber, and 1.8-4.4% organic acids. The studied varieties are characterized by a high content of carbohydrates, mineral and pectin substances (Figure 2). At the same time, the chemical composition of apple pomace changes depending on the botanical characteristics, morphology and anatomy of plant tissue, the variety and degree of maturity of apples. Pomace is a valuable source of complex antioxidants such as phenolic compounds, contains pectin substances, cellulose and hemicellulose, B vitamins,
macro-and microelements. Pectin, in turn, plays the role of a stabilizer and a moisture-retaining component.

![Bar charts showing the characteristics of apple pomace of different apple varieties.](image)

*content in terms of raw weight

**Figure 2.** Characteristics of apple pomace of different apple varieties.

During the research, a method of ham production was developed, which includes the following main stages: acceptance of raw materials, grinding on a top, mixing, maturation in a refrigerator, molding, heat treatment, cooling, quality control, packaging, labeling and sales. In parallel with the main stages of production, PFE was prepared in the following sequence of stages: grinding of fat raw materials, represented by the skin from the carcass of birds, on a cutter, adding apple pomace and hydrated soy protein, mixing, directing PFE to mix with minced meat. The technological diagram of the production of experimental ham samples is shown in Figure 3.

The recipes of the developed products are presented in Table 1. The use of emulsions is justified by the need to bind fat raw materials, improve their quality, avoid the appearance of fat edema, reduce its cost in some cases, etc., but the main task of using fat emulsions is to improve the quality of the finished product, its appearance, consumer and organoleptic properties [4].

For the production of PFE, low-grade fat raw materials (chicken skin and fat), drinking water and protein are used. The ratio of components can be different (for example, protein: fat: water = 1:5:5) [4].

Studies of the dynamics of the water-binding capacity of meat raw materials during salting have established that the nature of the change depends on the quality of raw materials and the composition of PFE. Figure 4 shows the dynamics of changes in the water-binding capacity of experimental samples during the exposure of minced meat without and in the presence of PFE in the composition of minced meat.

When salting with the use of PFE and without, the maximum values of water-binding capacity are reached by 12 hours of maturation. The air force level stabilizes after 10 hours of exposure.

Further treatment does not lead to noticeable changes in pH, but contributes to a gradual increase in destructive changes in muscle tissue and a decrease in the level of moisture binding.

The developed ham samples have high organoleptic characteristics: straight loaves, with a clean, dry surface, non-uniform structure on the cut (there are pieces of chicken fillet in the minced meat) on the cut, light pink muscle tissue of various intensity, elastic consistency, with a ham smell, a moderately salty pleasant taste, without foreign tastes and odors.
**Figure 3.** Technological scheme of ham production.

**Table 1.** Recipes of experimental ham samples.

| Name of raw materials, materials, spices | control sample (without pomace) | Experimental No. 1 (4% pomace) | Experimental No. 2 (6% pomace) | Experimental No. 3 (8% pomace) |
|-----------------------------------------|---------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Duck carcasses                          | 50.0                            | 39.0                          | 39.0                          | 39.0                          |
| Meat of broiler chickens                | 50.0                            | 39.0                          | 39.0                          | 39.0                          |
| Protein-fat emulsion, including         |                                |                               |                               |                               |
| poultry thigh fillet with skin          | 0                               | 22                            | 22                            | 22                            |
| soy protein isolate                     | 0                               | 8                             | 7                             | 6                             |
| apple pomace                            | 0                               | 2                             | 2                             | 2                             |
| water                                   | 0                               | 4                             | 6                             | 8                             |
| TOTAL unsalted raw materials            | 100.0                           | 100.0                         | 100.0                         | 100.0                         |
| Nitrite salt                            | 2                               | 2                             | 2                             | 2                             |
| Food phosphates                         | 0.2                             | 0.2                           | 0.2                           | 0.2                           |
| Dried garlic                            | 1                               | 1                             | 1                             | 1                             |
| Black pepper                            | 0.5                             | 0.5                           | 0.5                           | 0.5                           |
| Ground paprika                          | 1                               | 1                             | 1                             | 1                             |
| Water                                   | 25                              | 25                            | 25                            | 25                            |
According to the comparative assessment of organoleptic parameters presented in Figure 5, it can be noted that the prototypes have a slight advantage due to the slightly more intense color of the minced meat and a more delicate consistency due to the addition of PFE of the combined composition.

![Figure 4](image)

Figure 4. Change in the water-binding capacity of the prototypes of finished minced meat for ham without and in the presence of different compositions in the composition of PFE during ripening.

![Figure 5](image)

Figure 5. Profilogram of organoleptic indicators prototypes: 1 - unsatisfactory; 2 - satisfactory; 3 - good; 4 - very good; 5 – excellent.

The results of the analysis of the main indicators of the quality of experimental samples are presented in Table 2.
Table 2. Results of the analysis of indicators of quality and yield of finished products.

| Indicator                              | Characteristic | control sample (without pomace) | Experimental No. 1 (4% pomace) | Experimental No. 2 (6% pomace) | Experimental No. 3 (8% pomace) |
|----------------------------------------|----------------|----------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Mass fraction of sodium chloride (%)   |                | 2.0                              | 2.0                             | 2.0                             | 2.0                             |
| Protein mass fraction (%)              |                | 19.0                             | 22.6                            | 22.5                            | 22.4                            |
| Mass fraction of fat (%)               |                | 10.0                             | 9.6                             | 9.0                             | 8.8                             |
| Mass fraction of sodium nitrite (%)    |                | 0.005                            | 0.005                           | 0.005                           | 0.005                           |
| Caloric content 100 g, kcal            |                | 195                              | 180                             | 177                             | 174                             |
| Product yield, % not less than         |                | 94                               | 96                              | 97                              | 97                              |

On the basis of the carried out, the main indicators of quality were analyzed and it was concluded that the optimal sample, with the best indicators, is the sample with the addition of 6% apple pomace, taking into account the highest yield (97%) and high physical and chemical characteristics (fat content - no more than 9.0%, protein content - not less than 22.5%).

At the next stage, we studied the changes in thiobarbituric and lipid peroxide numbers of control and experimental ham samples during storage. The samples were stored for 30 days at a temperature of 4 ± 2 °C (Figure 6).

![Figure 6. Changes in thiobarbituric and peroxide numbers during storage of samples.](image-url)
According to the results obtained, it was found that during storage of ham samples developed according to new formulations with the addition of apple pomace, oxidative processes in the lipid fraction proceeded less actively than in the control sample. The best result was noted in samples with the addition of 6% and 8% apple pomace, which is explained by the presence of substances with antioxidant properties (organic acids, vitamins (ascorbic acid) and water-soluble antioxidants (quercetin), etc.).

An assessment of the economic efficiency of ham production was carried out by calculating the cost of the product, presented in Table 3.

The cost of production of a prototype ham from poultry meat, enriched with PFE of a complex composition, amounted to 269 rubles per 1 kg, which at the moment, taking into account other costs of the manufacturer and the distribution network, is the average for the market (the average retail price of ham from poultry meat of well-known manufacturers in St. Volgograd at the end of 2020 amounted to 280-300 rubles per 1 kg).

**Table 3.** Calculation of the cost of production of an experimental sample.

| Raw materials              | Price for 1 kg | Quantity, kg | Experimental No. 2 (6% pomace) |
|----------------------------|----------------|--------------|--------------------------------|
| Duck carcasses             | 350            | 0.42         | 145.0                          |
| Broiler chicken meat       | 170            | 0.43         | 73.1                           |
| TOTAL for the main raw materials | 520          | 0.85         | 218.1                          |
| Nitrite salt               | 200            | 0.02         | 4.0                            |
| Food phosphates            | 790            | 0.002        | 1.6                            |
| Dried garlic               | 145            | 0.01         | 1.45                           |
| Black pepper               | 82             | 0.005        | 0.41                           |
| Ground paprika             | 340            | 0.01         | 3.4                            |
| Soy Protein Isolate        | 1000           | 0.02         | 20                             |
| Pomace                     | 30             | 0.06         | 1.8                            |
| Water (* RUB per 1 m³)     | 23*            | 0.32         | 0.007                          |
| TOTAL for additional raw materials | -            | 0.45         | 32.7                           |
| Supporting materials       | –              | –            | 10                             |
| Total                      | –              | –            | 261                            |
| Output, % not less         | –              | –            | 97                             |
| Cost price, RUB per 1 kg of finished product for raw materials and materials | – | – | 269 |

**4. Conclusion**

As a result of the conducted experimental studies, it can be concluded that the use of PFE in the formulations of various meat products allows:

- to solve the technological problem of forming the necessary consistency and improving the functional properties of meat products;
- increase the yield of the finished product;
- reduce moisture loss during storage and stabilize the consistency of finished products;
- get a juicy product of a monolithic structure with increased nutritional value;
- reduce the rate of oxidative processes of lipids, thereby ensuring the stability of the quality during storage;
- reduce the cost of raw meat.

The expediency of introducing PFE in an amount of up to 22% instead of the main meat raw materials in order to improve the functional and technological properties of the minced meat system and the quality of the finished product is proved.
The developed products have a pleasant taste and aroma, characteristic of this type of product, elastic consistency, and are characterized by high quality indicators. When storing samples of smoked-boiled ham with apple pomace in the composition of PFE, a decrease in the activity of oxidative processes in the lipid fraction was noted, which will allow maintaining high consumer properties for at least 5 days of the shelf life. The cost of a sample of poultry ham was 269 rubles per 1 kg, which confirms the feasibility of this development.

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