



Developing the formulation and method of production of meat frankfurters with protein supplement from meat by-products

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Abstract

y-products and horse meat are presented. The formulation of meat frankfurters is calculated by mathematical modeling. The physico-chemical characteristics and sensory properties of meat frankfurters satisfy the requirements for meat products. Sodium chloride and nitrite are not exceeded 1.7 and 0.0005%, the moisture content is varied from 70 to 75%. The concentration of toxic elements is far below the allowable concentration by regulation standards. The pathogenic bacteria and microorganisms are not detected. The meat frankfurters produced by the developed method enables a more rational use of meat by-products and can lead to meat product-line expansion.

Keywords: meat frankfurters, horse meat, protein supplement, modeling, toxic elements, technology

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INTRODUCTION

Healthy nutrition is a major factor in ensuring optimal growth and development of the human body. It has also effect on working capacity and human activity, adaptation to the effects of various environmental agents and healthy life years. The nutritional value of any product can be assessed by the degree of compliance of its chemical composition with the requirements of balanced nutrition, which determines the human need for essential nutrients and energy to maintain health (Okuskhanova et al. 2017, Rogov et al. 2009).

For improving the nutritional value of products, the following methods are used: enrichment of traditional food products with missing essential nutrients; development of new foods of high value and regulation of the content of undesirable components in food products. It is of great practical importance to increase of the efficiency of dietary proteins by combining them

with other proteins, which in their amino acid composition complement the main protein of the product (Okuskhanova et al. 2017, Toldrá and Reig 2011).

Horse meat takes a special place in the diet of people of Republic of Kazakhstan. It contains significant amounts of proteins, fats, and other nutrients. Thus, consumption of 100 g of horse meat gives 10% of the daily need for energy, 20% - in proteins, (20 - 30) % - in fats, and also contains vitamins and minerals. It is known that low consumption of animal protein is often combined with low vital activity (Kakimov et al. 2018, Duysssembaev et al. 2016).

The prospects and expediency of using high-collagen raw materials in the production of meat products is determined by a number of positive moments

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- the expansion of raw materials of the meat industry, the enrichment of products with analogues of dietary fiber and economic expediency (Zinina et al. 2016, Hashim et al. 2015).

Secondary meat by-products (blood, skins, bone, etc.) are good source of protein and depending on their use, are divided into food and technical by-product. By nutritional value, offal I category (liver, heart, tongue, kidney) is not inferior, and the content of vitamins and minerals, in some of them (for example, in the liver, kidneys, brains) are superior to meat (Kakimov et al. 2017, Kriger 2014).

To substantiate technological solutions, data on the nutritional and biological value of horse meat trimmings and liver were studied and analyzed in the works of Kazakh scientists (Kozhakhievya et al. 2018, Kakimov et al. 2019). However, due to the presence of a large amount of connective tissue in meat trimming and increased rigidity, the horse meat trimmings are used less. The chemical composition of the meat trimming of different parts is almost the same. It is known that the addition of 30% of horse meat trimmings to the meat products provides a stable yield of finished products (114.5-116.0)%, stable bright red color and better consistency (Abzhanova et al. 2018).

The aim of this paper is to develop the formulation and method of production of the meat frankfurters and study its chemical composition and food safety.

MATERIALS AND METHODS

For the manufacture of sausages should use the following raw materials:

- 2 grade beef according to GOST 12512-67;
- processed meat by-products (horse meat trimmings) according to the regulatory documentation in force in the Republic of Kazakhstan (RK);
- pork trimmed bold according to GOST 7724-77
- bone melted fat food according to the regulatory documentation in force in the Republic of Kazakhstan;
- food blood in accordance with the regulatory documentation in force in the Republic of Kazakhstan;
- food component from bone (application No. 2003/0692.1 of 26.05.2003);
- broth from cooking by-products according to the current regulatory documentation:
- egg melange GOST 30363-9;
- fresh onion in accordance with GOST 1723-86;
- food table salt according to CT RK GOST R 51574-2003, not less than grade 1;
- black pepper or ground white according to GOST 29049-91;
- granulated sugar according to GOST 21 -94;
- cardamom according to GOST 29052-91;
- natural and artificial casings permitted by the State Sanitary and Epidemiological Surveillance of the Republic of Kazakhstan;

- twine from bast fibers according to GOST 17 308;
- viscose twine according to the current regulatory documentation;
- linen thread according to GOST 2350;
- cotton sewing thread according to GOST 10 354;
- wrapping paper according to GOST 8273;
- parchment paper according to GOST 1341;
- parchment imitation according to GOST 1760.

Raw materials are not allowed for processing, in which the content of toxic elements, pesticides, mycotoxins and radionuclides exceeds the permissible levels established by the "Hygienic requirements for assessing the quality and safety of food raw materials and food products", Sanitary Rules 2.3.2.-560 (4.01.097).

Technological Process

The technological process is carried out according to the technological scheme.

Raw Material Preparation

Raw materials for production are beef, pork, horse trimming, meat-bone paste, protein components based on meat-bone paste and food complex made from bone, protein - fat emulsions and other ingredients: nitrite, water, ice, spices, etc. Not required use meat frozen more than once.

Beef and horse trimming are washed, blanched in water at a temperature of 100 °C with a ratio of raw materials and water of 1:3 for 30 minutes, weighed according to the recipe, grinded on crusher with a hole diameter of 2-3 mm.

The pork is washed, blanched in water at a temperature of 100 °C with a ratio of raw materials and water of 1:3 for 30 minutes, weighed according to the recipe, crushed on top with a hole diameter of 2-3 mm.

Onions cleaned, sorted, soaked in water for 1 hour, roughly crushed, fried in fat for 15 minutes until golden brown, weighed, re-crushed more finely.

According to the recipe, egg melange, spices, protein complex and protein-fat emulsion are pre-prepared and weighed.

Preparation of the Food Component from the Bone

When receiving cattle bone material, it is thoroughly washed with warm water at a temperature of 40 °C, finely ground to a particle size of 1-0.1 mm. Cook in a solution of whey pH 4.3 at a temperature of 100 °C for 2-3 hours to obtain a homogeneous mass of light cream color with a pleasant smell characteristic of curd whey. Processed bone material (the food component of the bone) is directed to the production of the protein complex.

Preparation of Protein Complex

To do this, first, broth from blanching by-products (temperature 80-85 °C), bone fat (temperature 70-75 °C) is emulsified into the cutter for 3-5 minutes, whole cattle

blood is added to the resulting protein-fat emulsion (temperature 20-22 °C).

The process of emulsification continues for another 2-3 minutes. The resulting protein-fat-blood emulsion in accordance with the recipe is mixed with the food component of the bone and muffled for 3-5 minutes. The resulting protein complex has a uniform structure of pink minced meat. The protein complex is cooled to a temperature of 2-4 °C and used for its intended purpose.

Preparation of Protein Complexes Using Secondary Raw Materials

Components for this complex are by-products II category, blood of cattle or pigs, soy gel, broth, bone or other fat, meat-bone paste or food component from the bone. For the preparation of a mixture of protein complexes does not require special equipment, you can use standard industrial equipment.

At the first stage, by-products II category (light, udder, spleen, etc.) at temperature $t = (2-4) ^\circ\text{C}$ crushed on a crusher with a diameter of holes in the output grating $d = (2-3) \cdot 10^{-3} \text{ m}$.

At the second stage, protein-fat emulsion is obtained. To do this, the broth at a temperature $t = (80-85) ^\circ\text{C}$ and bone or other fat at a temperature $t = (70-75) ^\circ\text{C}$ is emulsified in a stuffing preparation unit or cutter for 180-300 s.

At the third stage, protein-fat-blood emulsion is obtained. To do this, blood of cattle or pigs at $t = (20-22) ^\circ\text{C}$, soy gel at $t = (20-22) ^\circ\text{C}$ and prepared protein-fat emulsion are emulsified in a stuffing preparation unit (FPA) or cutter for 120-180 s.

At the fourth stage, bone-protein-blood-fat complex is obtained directly. For this purpose, a stuffing preparation unit, a cutter or a mixer with a rotary chopper are used. Shredded by-products of category II, meat and bone paste or food component from bone are served in stuffing preparation unit, cutter or mixer at $t = (2-4) ^\circ\text{C}$ and protein-fat-blood emulsion.

When using stuffing preparation unit or a cutter, the mixture is treated for 180–240 s, and when using a mixer with a rotary chopper, the mixture is first mixed in a mixer for 360–420 s, then passed through the working bodies of a rotary chopper with a gap between the knives $H < 10^{-3} \text{ m}$.

Preparation and Preparation of Minced Meat

Compilation of recipes and stuffing preparation is carried out in a stuffing preparation unit, cutter and agitator with sequential filling of raw materials: first, horse meat trimming, semi-fat pork, liver, protein complex, then egg melange, salt, spices, onions are loaded. Protein-fat emulsion is introduced into the mixture in portions during the entire process of cutting. The total duration of cutting 8-10 minutes. Next, produce fine grinding on a rotary grinder.

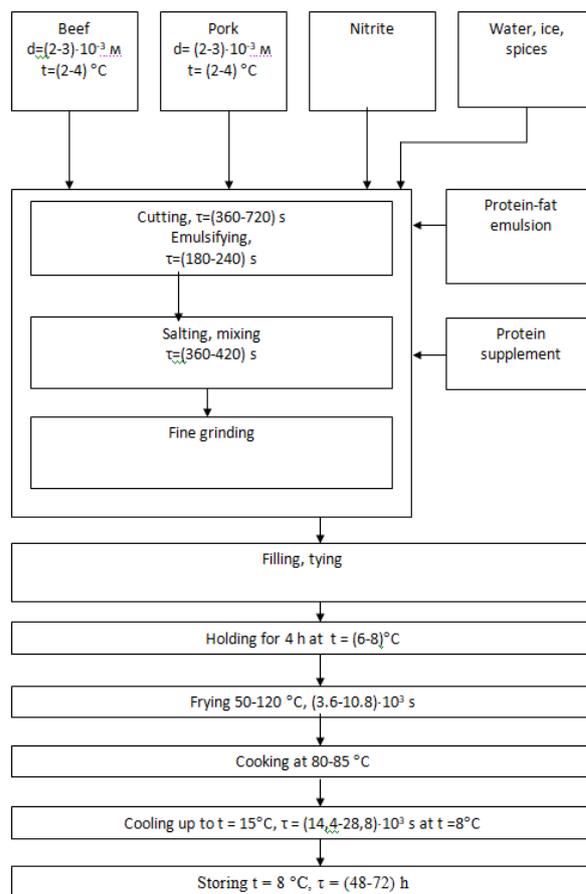


Fig. 1. Meat frankfurters production scheme

Injection and Bale Loading

Forming is carried out on syringes or a stuffing preparation unit equipped with a shaping device. Mince syringe in a natural shell (beef circle number 2,3,4). For the production of piece sausages used dosing machines, which should provide a certain mass of the finished sausage.

The sausages are twisted with bars of a certain length, depending on the diameter of the casing, or separated from one another by tying the casing with thin twine.

Heat Treatment

Our prized loaves are cooked in heat chambers at a temperature of 85 °C for 60 minutes before reaching the center of the loaf temperature of 75 °C.

Cooling

After cooking, the sausages are cooled under the shower for 15-20 minutes, and then in the chambers to a temperature in the thickness of the loaf not higher than 6 °C.

Storage

The shelf life and sale of wieners at 4 °C is 5-7 days from the date of the technological process, including at the manufacturer for no more than 24 hours.

Production Control

All stages of the production of meat frankfurters are monitored for compliance with technological parameters. Temperature control in the salting chambers, thermal chambers, cooling of the finished product and inside the loaf is carried out by glass liquid thermometers, alcohol thermometers with a temperature scale from 0 to 150 °C.

Weighing components at the time of salting and formulating are made on a general-purpose balance in accordance with GOST 23711 and GOST 23676. After the end of the technological process, the meat frankfurters are assessed for sensory properties.

RESULTS AND DISCUSSION

Mathematical Modelling of Meat Frankfurters Formulation

For producing high nutritive and biological value meat products with collagen-containing raw materials it is necessary to design their formulations with better ratio of amino acid composition. The most operational tasks of optimization of formulations are solved by computer modeling of the amino acid composition (Shazzo et al. 2007). As a result of modeling the amino acid composition of multicomponent meat products, a recipe with optimal balanced of the essential amino acids can be obtained.

The development of the recipe for a new meat product was carried out by simulating a variety of possible combinations. The recipe optimization was carried out using computer simulation using "EXCEL" program. As an optimization criterion, we used the criterion of the minimum deviation of the amino acid composition of the total protein from the accepted FAO / WHO standard.

During the development of recipes for meat products it is recommended to follow the recommendation of the Institute of Nutrition of the Academy of Medical Sciences of Russia, according to which the ratio of protein and fat in finished products is considered ideal 1:(1-0.8), and the ratio of saturated, monounsaturated and polyunsaturated fatty acids is 3:6:1 (Paliy et al. 2019, Tutelian 2005).

In view of the fact that according to modern concepts, the product should have a low energy value, the ratio of protein:fat varied in the direction of increasing protein, i.e. the main optimization task: max - protein.

1. The structural model of meat frankfurters:

$$X^* = (X_j) \quad (1)$$

where (j =5,6,7,8,9,10,11,12,13,14), j – number of ingredients.

Ingredients:

X₅ – pork; X₆ – beef; X₇ – horse meat cut; X₈ – protein supplement; X₉ – starch or flour; X₁₀ – garlic; X₁₁ – salt; X₁₂ – sugar; X₁₃ – black pepper; X₁₄ – coriander.

Mathematical statement of the problem:

Table 1. Final results of mathematical modeling of meat frankfurters' ingredients composition

X ₅	40,0	X ₁₁	2,0
X ₆	20,0	X ₁₂	0,2
X ₇	20,0	X ₁₃	0,1
X ₈	18,0	X ₁₄	0,1
X ₉	2,0		
X ₁₀	,01		
Value of objective function X ₁₅ =18.20			

Table 2. The formulation of meat frankfurters

Ingredients	kg per 100 kg
Pork	40.0
Beef	20.0
Horse meat trimmings	20.0
Protein supplement	18.0
Wheat flour	2.0
Garlings	0.1
Salt	2.0
Sugar	0.2
Black pepper	0.1
Coriander	0.1

Table 3. Sensory properties of meat frankfurters

Indicator	Description
Appearance	Linked meat frankfurters with clean and dry cases, free of damage
Taste and odor	Pleasing taste with pronounced flavor of spices, free of foreign taste and odor
Consistency	Spreadable
Color and sectional view	Finely ground and homogeneously mixed groundmeat, pink colored
Shape	Each linked meat frankfurter is 10±1,5 cm

Objective function (protein content):

$$F(X)_{max} = 16.4 \cdot X_5 + 20.09 \cdot X_6 + 23.19 \cdot X_7 + 75.39 \cdot X_8 + 46.0 \cdot X_9 + 7.07 \cdot X_{10} \rightarrow max \quad (2)$$

Constraints

1. by amino acid composition:

$$\sum_{j=1}^n a_{ij} \cdot x_j \geq b_i \quad (3)$$

where a_{ij} – content of protein in j-ingredient; b_i – FAO/WHO requirement

2. by ingredient composition:

$$\sum x_j \left(\begin{matrix} \geq \\ \leq \end{matrix} \right) \cdot g_i \quad (4)$$

3. by ratio of protein:fat = 1:1; (1:0,8)

$$X_i \geq X'_i \quad (5)$$

where X_i – protein content in ready food (g/100g);

$X_{15} = 18,20$;

X_i – fat content in ready food (g/100g);

$X = 13,4$;

$X_{15}:X = 1:0,8$

The calculation results are presented in **Table 1**.

Based on the mathematical simulation the following optimal quantity of ingredients is recommended for production of meat frankfurters (**Table 2**).

Physical and Chemical and Sensory Profile of Meat Frankfurters

Sensory properties of meat frankfurters are indicated in **Table 3**.

The physico-chemical characteristics of the meat frankfurters are presented in **Table 4**.

Table 4. Physico-chemical characteristics of the meat frankfurters

Indicator	Value
Moisture, %	70-75
Sodium chloride, %	1.7
Nitrite, %	0.0005
Salt, %	2.0
Outlet temperature of meat frankfurters, °C	6-8 °C

Table 5. Concentration of toxic elements in meat frankfurters, mg/kg

Toxic element	Allowable concentration by regulation standards	Concentration in meat frankfurters
Lead	0.5	0.016
Arsenic	0.1	0.062
Cadmium	0.05	0.006
Mercury	0.03	0.0

In terms of microbiological and bacteriological indicators and the content of toxic elements, the meat frankfurters should comply with the requirements established in San PiN 4.01.071.03 and indicated in **Tables 5 and 6**.

Table 6. Bacteriological indicators of meat frankfurters

Indicator	Allowable concentration by regulation standards	Concentration in meat frankfurters
Total viable count, CFU/G	$1 \cdot 10^3$	Not detected
Escherichia coli group bacteria – CGB in 1.0 g	Prohibited	Not detected
Sulfite-reducing clostridia in 0.1 g	Prohibited	Not detected
S.aureus in 1.0 g	Prohibited	Not detected
L. monocytogenes in 25,0 g	Prohibited	Not detected
Pathogenic bacterium, including Salmonella, in 25,0 g	Prohibited	Not detected

CONCLUSION

Thus, as a result of research, the formulation and technology of meat frankfurters using secondary raw materials have been developed. As a secondary raw material, horse meat trimming and protein fortifier were used. The introduction of this technology into production will reduce the cost of production and increase its nutritional and biological value.

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