Improvement of sausage production technology

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Abstract. The article presents the results of research on the use of the commercial drug Psyllium in boiled sausage technology, in order to inhibit the possible residual amount of antibiotics. Based on the data of the indicator changes, the optimal dosage was determined, which amounted to 2% of the weight of the main raw material, while maintaining the moisture-binding, water-holding, and fat-holding capacity at 78.85, 85.68, and 80.11%, respectively, and emulsifying ability and stability of the emulsion at 60.12 and 53.48%, respectively. Experimental tests have allowed us to design the recipes of boiled sausages enriched with the biologically active additive Psyllium with high mass fraction of protein (from 12.5 to 15.8%) and low fat content (from 17.2 to 27.3%) compared to the ones presented in the market. It was demonstrated that inhibition of the antibiotic activity is manifested when the biologically active additive Psyllium is introduced into the recipes of boiled sausages at the concentration of 2% of the weight of raw materials.

1. Introduction

Currently, Russian meat industry companies use forage products manufactured in the EU countries for feeding animals, where a few years ago a ban on the antibiotic use was imposed; however, almost all foreign companies that supply products for the manufacturing forage in the Russian Federation, apply various antibiotics, quietly breaching the ban on their use. The use of antibiotics in forage allows one to achieve a growth-promoting effect, reduces feed conversion, and shortens the fattening period. It is difficult for veterinarians working in livestock and poultry farms to determine which drugs enter the animals or birds in their charge. Therefore, there is a risk that the presence of various drugs in the forage (not specified in the quality certificate), when interacting with each other, may cause various kinds of disturbances in the vital activity of the animal organisms [1].

Deficiencies of the existing control methods may lead to underestimation of sub-standard products, and thus there is need to develop and implement more adequate methods of control over residual antibiotics [2].

The problems of reduction of hazardous effects of antibiotics on human organisms were studied by numerous scientists such as A.S.Pototskaya, A.V.Aleshkov, N.V.Strelnikova, I.P.Koltsou, I.A.Zhebeleva, T.V.Ivannikova, N.F.Kim, V.I.Krishtafovich, Jette Kjeldgaard, Marianne T. Cohn, Pat G. Casey, Colin Hill, and Hanne Ingmera, etc.

For example, there is the method of boiled sausage production enriched with the flour of the seedcoats of flaxseed plantain (plantago psyllium l) [3-6]. As an alternative technology it is possible to use sodium alginate in recipes of boiled sausages. For example, the production of boiled sausage involves the use of food sodium alginate in the amount of 1.45% of the total weight of raw meat. Food
alginate can be added in several ways: in dry form together with common salt at the stage of salting and aging of meat in the salting; in the form of water solution in the first or second stage of the production of minced meat in the cutter; together with soy protein isolate in the gel form [7].

Plantaginaceae family includes 3 geni and 270 species, most commonly found in lukewarm areas. The flora of CIS countries includes 54 species of 2 geni. Two species of plantain are worked in Russia as medicinal plants: dooryard plantain Plantago major L. and flaxseed plantain Plantago psyllium L. The medicinal raw materials of the plantains are: leaves and fresh leaves of dooryard plantain; fresh grass and seeds (“flea seed”) of flaxseed plantain [8, 9].

In 2018, large-scale studies of the boiled sausage quality were performed in the Russian Federation. The studies involved 70 positions of sanitary norms and rules, mandatory for all manufacturers of meat products, including compliance with the GOST (all-Russian standards) requirements. The results of the study performed by the Commission of Russian Quality System, all selected product samples, more than 30 manufacturers were found to be safe for humans and the environment, but in some traces of antibiotics were detected, although within the maximum allowable concentration. The goal of this work is to improve the boiled sausage technology by means of using the commercial drugs Psyllium. Within the framework of this goal, the tasks of the work are thus formulated: to study the effect of the mass fraction of the biologically active additive based on Psyllium on the functional and technological properties of minced meat; to model recipes of cooked sausage products enriched with Psyllium, to determine the effectiveness of inhibition of the pathogenic microflora by the biologically active additive Psyllium.

2. Materials and methods

The materials used for the study are: Psyllium flour (Psyllium Husk Powder) made in India in packs from 100 to 1000 g; Psyllium (Psyllium Husk) Hashmi (India) 290 g; Psyllium (Psyllium Husk) Now Foods (USA) 454 g [10]; boiled sausages Russkaya, Krasnodarskaya, Molochnaya manufactured in compliance with GOST [11]. Tests of qualitative and quantitative indicators of boiled sausage products were performed in accordance with traditional procedures. The chemistry of boiled sausages was determined based on the procedure described in GOST 9793-2016 – moisture content [12], GOST 23042-2015 – mass fraction of protein fat by Soxhlet method [13], GOST 25011-2017 – mass fraction of protein by Kjeldahl metod [14]. Moisture-binding and water-holding capacities of semi-finished and finished products were determined by the method of G. Grau and R. Hamm. On the automatic amino acid analyzer AAA 400 using the method of classical ion-exchange chromatography was determined by the method indicated in GOST 34132-2017 [15]. Organoleptic evaluation of finished products was performed according to GOST 9959-2015 [16]. The biological value of proteins was determined by the calculation method according to the recommendations of Academician N. N. Lipatov on the software “Biocen” developed at the department of animal origin product technology of Voronezh State University of Engineering Technologies according to MG 4.2.1890-04 Determination of the microorganisms’ sensitivity to antibacterial drugs. Procedural guidelines, we tested the microorganisms’ sensitivity to antibacterial drugs by disk diffusion test [17].

3. Results and discussion

In order to study the chemistry of boiled sausages we selected three brands manufactured in compliance with GOST R 56196-2011 Boiled sausage products [11]. Product specification: boiled sausage Russkaya; boiled sausage Krasnodarskaya; boiled sausage Molochnaya, made by different manufacturers. Each of the selected samples was testes to find the presence and content of protein, fat, mineral matter (ash), moisture, starch, and comparison of the obtained results with the indicators stated on the products’ labels (paper label and thermos label). The results of the experiments are shown in Table 1.

| Table 1. Comparative description of the chemistry of boiled sausages. |
The data obtained from the experimental studies were compared with those indicated on the label to identify deviations, as well as possible violations and falsifications. It can be seen from the experimental data presented in the Table that there is no deviation in the content of protein, fat, minerals, and moisture. No starch is found in the samples.

The mass ratio of the recipe components is important when one uses food ingredients of various functional orientations in recipes of meat products, in particular, cooked sausages. In order to determine the optimal dosage of the commercial drug *Psyllium*, tests have been performed concerning the change in the functional and technological properties of cooked sausage products. *Psyllium* was added to the standard stuffing of minced beef, pork, pork fat, water and salt in a dosage of 2 to 8% instead of the main raw material. The test results are presented in Table 2.

**Table 2.** Functional and technological properties of the standard minces.

| Indicator                      | Boiled sausage |                         | Boiled sausage |                         | Boiled sausage |
|-------------------------------|----------------|--------------------------|----------------|--------------------------|----------------|
|                               | According to   | Experimental data        | According to   | Experimental data        | According to   |
| Mass fraction of protein, %   | GOST           |                          | GOST           |                          | GOST           |
| minimum                       | 10.0           | 10.2                     | 13.0           | 13.9                     | 11.0           | 11.1           |
| Mass fraction of fat, %       | 30.0           | 28.5                     | 20.0           | 19.1                     | 22.0           | 21.3           |
| maximum                       | 65.0           | 58.6                     | 65.0           | 64.3                     | 65.0           | 64.9           |
| Mass fraction of ash, %       | 2.7            | 2.7                      | 2.7            | 2.7                      | 2.8            | 2.7            |
| Starch test, %                | Not detected   |                          |                |                          |                |

Graphical interpretation of the change regularity of moisture-binding capacity and water-holding capacity demonstrates that the maximum values are achieved with introduction of 8 % of *Psyllium* in the mincemeat instead of the main raw material and amount to 82.32 % and 88.1 % correspondingly. Fat-holding capacity of the standard minces in case of *Psyllium* introduction instead of the main raw material grows up to 82.87 %. It should be noted that the maximum emulsifying capacity was observed in the protein-fat-water system with the introduction of 6-8% protein instead of the main raw material and was 62.32, 62.94%. The graphical function demonstrates that increase in the mass fraction of substitution to 6-8% leads to a certain reliable increase in the indicator of the emulsion stability of the standard mincemeat and amounts to 56.48-56.98%. The experimental data concerning the dynamics of functional and technological properties of the standard mince show that the *Psyllium* dosage of 2 % of the raw material weight does not considerably affect the moisture-binding, water-holding and other capacities, while the increase of the dosage up to 8 % of the raw material weight leads to the changes
increasing the moisture-binding and water-holding capacity. However, extra dosage may alter organoleptic properties of the product, so we set the optimum dosage of Psyllium at 2% of the main raw material weight.

One of the tasks of this work is simulation of the boiled sausage recipes enriched with a dietary supplement based on the psyllium planus Psyllium; the boiled sausage recipes most popular in the market were selected as the modeling objects. To achieve the goal of enriching the product, the raw materials with low fat concentration were used. The composition of boiled sausages according to GOST R 52196-2011 includes: Russkaya - beef, pork, fat, water, salt, garlic, granulated sugar, spices (black pepper, nutmeg or cardamom); Krasnodarskaya - beef, pork, brisket, tongue, water, salt, garlic, granulated sugar, spices; Molochnaya - pork, beef, water, whole or skimmed cow dry milk, chicken eggs or egg melange, salt, granulated sugar, spices (black pepper, allspice, nutmeg or cardamom).

The following raw materials were used in the newly designed recipes: premium-grade and first-grade beef, first-grade (young) beef or veal, lean pork, chicken eggs or egg melange, non-fat dry cow milk, rabbit meat, Psyllium flour from various manufacturers. In order to create the formula-component solutions, we applied the system of computer modeling of formula-component solutions "Generic 2.0" [18] (Table 3, Figure 1).

Table 3. Boiled sausage recipes, kg/100 kg.

| Raw materials and spices | Boiled sausage Russkaya GOST New recipe | Boiled sausage Krasnodarskaya GOST New recipe | Boiled sausage Molochnaya GOST New recipe |
|-------------------------|----------------------------------------|---------------------------------------------|-----------------------------------------|
| Trimmed beef, premium grade | 50 | 30 | - |
| Trimmed beef, first grade | - | - | 35 |
| Trimmed young beef or veal, premium grade | - | - | 35 |
| Trimmed lean pork | 23 | 15 | - 30 |
| Trimmed semifat pork | 25 | 60 | - |
| Brisket pork | - | 25 | - |
| Beef or pork tongue, salted, boiled | - | 28 | - |
| Back fat | 25 | - | - |
| Chicken eggs or egg melange | - | 2 | - |
| Non-fat dry cow milk | - | 3 | - |
| Rabbit meat | - | - | 30 |
| Psyllium flour (Psyllium Husk Powder) | - | 2 | - |
| Psyllium (Psyllium Husk) Hashmi | - | 2 | - |
| Psyllium (Psyllium Husk) Now Foods (USA) | - | 2 | - |

Spices and materials, g (per 100 kg of salt-free raw materials)

| Ingredient | 2500 | 2500 | 1750 | 1750 | 2090 | 2090 |
|------------|------|------|------|------|------|------|
| Kitchen salt | 5.6 | 5.6 | 5.3 | 5.3 | 7.1 | 7.1 |
| Sodium nitrite | 100 | 100 | 100 | 100 | 120 | 120 |
| Granulated sugar or glucose | 130 | 100 | 100 | 100 | 120 | 120 |
| Black pepper or ground white pepper | - | 65 | 65 | 80 | 80 |
| Ground allspice | 50 | 50 | 35 | 35 | 40 | 40 |
| Ground nutmeg or cardamom | 60 | 60 | - | - | - | - |
| Fresh or canned garlic | Spice mix #4 | 300 | 300 | 360 | 360 |
Figure 1. Modelling of the recipe for Russkaya boiled sausage and the diagram of the desirability function.

Experimental tests were carried out during this work in order to determine mass fractions of protein, fat, moisture, and mineral matters (ash) in the sample. All experimental tests were performed according to standard procedures. The obtained results are summarized in Table 4.

Table 4. Results of the chemistry studies of the boiled sausages.

| Indicator               | Boiled sausage |            | Krasnodarskaya | Yuzhnaya | Molochnaya | Osobennaya |
|-------------------------|----------------|------------|----------------|----------|------------|------------|
|                         | Russkaya       | Rossiyskaya| Krasnodarskaya  | Yuzhnaya | Molochnaya | Osobennaya |
| Mass fraction of protein, % | 10.2          | 12.5       | 13.9           | 15.8     | 11.1       | 13.8       |
| Mass fraction of fat, % | 28.5           | 27.3       | 19.1           | 17.2     | 21.3       | 18.5       |
| Mass fraction of moisture, % | 58.6          | 57.5       | 64.3           | 64.3     | 64.9       | 65.0       |
| Mass fraction of ash, % | 2.7            | 2.7        | 2.7            | 2.7      | 2.7        | 2.7        |

The simulated boiled sausage recipes enriched with the biologically active additive Psyllium have higher values of the mass fraction of protein; the total increase in protein was about 2%. At the same time the mass fraction of fat decreased due to the use of lean and low-fat raw materials in recipes. Concerning the moisture, the values were normal, meeting the requirements of the regulatory documentation, i.e. no higher than 65% \[19, 20\]. The technological process of cooked sausage production is carried out according to the traditional technological scheme, where the biologically active additive Psyllium is added at the cutting stage which is at the finish.

We applied standardized disk diffusion test in order to define the efficiency of inhibition of the antibacterial activity of preservative agents in the food systems (MG 4.2.1890-04 Determination of the microorganisms’ sensitivity to antibacterial drugs. Procedural guidelines). The samples for comparison were as follows: sample 1 – standard mincemeat with additive Psyllium; sample 2 – standard mincemeat
sodium alginate (which is used by many manufacturers for mincemeat sticking in boiled sausages); sample 3 – standard mincemeat without additive Psyllium.

The comparative monitoring of the efficiency of inhibition of the activity of preservative agents in the food systems is shown in Figure 2.

As it was demonstrated by the experimental data, the maximum inhibition efficiency was detected with the introduction of biologically active additive Psyllium at a concentration of 2% by weight of raw materials (sample 1), with no visible growth delay of microflora detected; in sample 2 the inhibition efficiency was significantly lower, which was manifested by the presence of growth delay zone of 7 mm. The study of the inhibition efficiency in sample 3 revealed significant growth delay of 13 mm. It indicates the total absence of the inhibition effect.

For the analysis of functional and technological properties, standard minced meat was prepared according to the recipes of sausages produced according to GOST Russkaya, Krasnodarskaya, Molochnaya, and developed recipes for sausages with Psyllium additives, such as Rossiyskaya, Yuzhnaya, Osobennaya. The functional and technological properties were studied in order to prove the possibility of introducing the biological additive Psyllium into the recipe and the absence of negative effect on the properties of the standard stuffing. The obtained data allow the assumption that introduction of vegetable oil in the boiled sausage recipes improved the functional and technological properties of the finished product, as the value of those indicators as water-holding capacity, water-holding capacity, and water-holding capacity is higher than in the mincemeat made in accordance with GOST, and amounts to 86.07 / 58.98 / 53.18; 87.85 / 60.11 / 55.89; 87.18 / 59.17 / 53.85 % for boiled sausages Rossiyskaya, Yuzhnaya, Osobennaya, correspondingly. The performed organoleptic tests have shown that the newly designed boiled sausages meet all the requirements for high-quality sausages. The amino acid composition of meat products analyzed by us as one of the main sources of protein in the human body is of utmost importance. The mass fraction of the essential amino acids in finished products is not fully sufficient characteristic of biological value. In this regard, when studying the amino acid composition, it is necessary to calculate such indicators as amino acid score, utility coefficient, comparable redundancy ratio, amino acid score difference coefficient (AASDC) and the actual biological value of the boiled sausages. The calculated indicators of biological value allow an assessment of the balance of essential amino acids in the finished product, since protein digestion is determined by the minimum of the amino acid scores [21].
4. Conclusion

The results of the analysis of literature data showed that the use of antibiotics in animal forage affects the quality indicators of boiled sausages, which requires the destruction of their traces by using human-safe dietary additives in recipes, in particular, the commercial drug Psyllium.

Analyzing the experimental data on the study of the main functional and technological properties of the standard mincemeat types, the optimal dosage of the Psyllium drug was determined, which was 2% by weight of the raw material, the proven dosage does not reduce the functional and technological properties and does not affect the organoleptic features. The obtained test results allowed to model new recipes of boiled sausages with reduced fat content and guaranteed destruction of antibiotics traces.

A comparative monitoring of the effectiveness of inhibition of the antibiotics activity in boiled sausages proved to be effective with the introduction of the biologically active additive Psyllium at the concentration of 2% by weight of raw materials. Evaluation of the finished product quality confirmed the compliance with the stated requirements for the mass fraction of essential nutrients, including proteins, fats and carbohydrates.

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