Manufacturing process efficiency analysis of fried sausages with original additives

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Abstract. Currently, the use of food additives of plant origin is widely used in technologies of meat products, that allow not only to expand assortment, but also to increase biological value, improve the organoleptic characteristics of prepared food products. The purpose of this work was to develop a recipe for fried sausage products with original food additives. During the research, the main quality indicators of enriched fried sausages: organoleptic and physicochemical, were studied. The developed products have elastic consistency and spicy taste, that is characteristic for each sample with a brown color on the cut, as well as a pleasant aroma, that is specific to this type of product. Calculation of the production cost showed the feasibility of introducing the developed formulations into manufacturing process. The use of these sausages in diet will enrich it with micronutrients.

1. Introduction

Currently, there are a large number of different types of sausages on sales market, and they are especially popular with consumers. If earlier sausages were bought mainly on holidays and were considered a delicacy, now a large number of people consume them practically every day. However, quality and assortment of certain of their types is poor. Therefore, solving the problems of expanding range of fried sausage products through the use of original additives that not only meet the requirements of food safety, but also have high organoleptic characteristics and nutritional value, good compatibility with other components of food products, is very relevant and significant. Herbal raw materials are used as original food additives - lentils, fennel and lovage.

Lentils contain a large amount of easily digestible vegetable protein. At the same time, its seeds contain less fat than peas and are an excellent source of iron. Lentils, like all legumes, are rich in trace minerals, especially magnesium, that is necessary for stable functioning of heart and nervous system [1-3].

Fennel is widely used in food as a spice. It contains phenolic compounds, including antioxidants - vitamins B3, C, as well as flavanoids - quercetin, rutin and various kaempferol glycosides. This plant has beneficial bactericidal, antioxidant, healing, anti-inflammatory and analgesic effects. Outwardly, fennel is similar to dill, but has a sweetish taste and a slight anise aroma. The mature fruit contains from
5 to 7% essential oil. This essential oil is a colorless liquid that tastes bitter at first, then sweet, and it is because of it that fennel has its medicinal and taste properties.

Lovage is a medicinal plant widely used in dietary nutrition. Due to content of phthalides, lovage has a powerful antispasmodic effect, increases appetite and improves digestion. All parts of the plant contain an essential oil consisting mainly of terpineol, cineole and carvacrol. Lovage has a spicy smell, so it is widely used in cooking. In recent decades, there has been a noticeable increase in the part of elderly population in Russia. Developments in field of identifying effective measures to preservation of health and prevent diseases of this part of population are relevant and have social, economic and political significance. For such a large part of the population, the most important factor of healthy old age is a balanced diet [4-14].

2. Goals and objectives
The purpose of this work is to develop formulation and a method for production of fried sausage products with original additives.

Research objectives: to substantiate and select ingredient composition; develop an original recipe, determine the products yield, evaluate organoleptic, physicochemical characteristics and effectiveness of developed production technology and recipe.

3. Methods and materials
The sequence and interconnection of the stages of the research of fried sausage products are shown by block diagram in figure 1. To complete the assigned tasks and achieve the goals of experimental study, it was necessary to perform the following steps.

a) Analysis of literary sources, selection of meat and vegetable raw materials
To develop production of fried sausage products, the literature sources were analyzed, on the basis of which the recipe for the production of fried sausage products was selected, meat and vegetable raw materials were selected. To develop the production of fried sausage products, literature sources were analyzed, that served as basis for choice of formulation for fried sausages, the choice of meat and vegetable raw materials. As an analogue (control sample), classic formulation for fried sausage «Ukrainian» (I A Rogov, A G Zabashta, B E Gutnik et al. Handbook of a sausage production technologist, 1993) was adopted. Trimmed semi-fat pork and raw fat were selected as raw meat, lentils, fennel and lovage - as herbal raw materials.

For experimental production of the samples of fried sausage products, selection of raw materials for recipes was made, taking into account introduction of new components. To select final technology of fried sausage products, test production of experimental samples was carried out.

b) Optimization of technology and recipes
A method for optimizing a multicomponent recipe mixture with original additives for the production of fried sausage products based on test production, taking into account the organoleptic and functional-functional technological indicators of minced meat systems, was developed.

c) Production of samples of fried sausages
Classic technology for fried sausage «Ukrainian» (I A Rogov, A G Zabashta, B E Gutnik et al. / Handbook of a sausage production technologist, 1993) was adopted as the basis for the production method.

Four samples of the sausages are produced: control sample (without additives), sample № 1 with addition of lentils, sample № 2 with addition of fennel, and sample № 3 with addition of lovage. Mass of each sample is at least 250 g.

d) Determination of organoleptic characteristics
According to generally accepted scoring method, organoleptic indicators of the prototypes containing fillers: lentils, fennel, lovage, were determined in a comparative aspect.

e) Determination of yield and shelf life
Product yield is calculated by formula (1):
where \( M_1 \) – mass of unsalted raw materials, g; 
\( M_2 \) – weight of prepared product, g.

Shelf life is determined by keeping the products under optimal storage conditions for the longest possible period with analysis of microbiological indicators of the samples at the end of shelf life.

f) analysis of physical-chemical indicators

Mass fraction of moisture, protein, fat, sodium chloride in meat products was determined according to generally accepted methods.

g) calculation of energy value of each sample.

The energy value of sausages is calculated by formula (2):

\[
EV = 4 \cdot P + 9 \cdot F + 4 \cdot C
\]

where \( EV \) - energy value, kcal / 100 g;
\( P \) – protein content, g / 100 g;
\( F \) – fat content, g / 100 g;
\( C \) – carbohydrate content, g / 100 g.

4. Results and discussion

4.1. Optimization of technology and formulation

The purpose of formulations optimization is to identify such a combination of ingredients that would allow achieving high taste characteristics and an attractive appearance of the products.

Formulation optimization options are shown in table 1.

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**Figure 1.** Research scheme.
Table 1. Recipe optimisation.

| Raw material                  | Product, g per 1 kg of unsalted raw materials |
|------------------------------|-----------------------------------------------|
|                              | sample №1 | sample №2 | sample №3 | control sample |
| Pork bold                    | 850       | 850       | 850       | 850            |
| Crude fat                    | 150       | 150       | 150       | 150            |
| Sum                          | 1000      | 1000      | 1000      | 1000           |
| Table salt                   | 18        | 18        | 18        | 18             |
| Fennel                       | –         | 2         | –         | –              |
| Lentils                      | 30        | –         | –         | –              |
| Lovage                       | –         | –         | 5         | –              |
| Complex food additive        | 5         | 5         | 5         | 5              |
| Total                        | 1053      | 1025      | 1028      | 1023           |

According to the data presented in table 1, four samples of fried sausage products were produced. In the formulations of samples №1, №2 and №3 the studied food additives were used in an optimal amount, determined according to preliminary production of model minced meat, taking into account main characteristics of the minced meat. Deviation of component quantity in formulations from recommended ones leads to a deterioration in organoleptic, functional and technological properties of minced meat. Technology of fried sausage products consists in preparation of meat and vegetable raw materials, minced meat with addition vegetable components, in its further molding, frying sausage loaves, cooling and packaging the product. Fennel seeds are pre-fried for two minutes, then added to the rest of spices. Dried lovage is added along with the rest of the additional ingredients. This technology does not require additional innovations already in the existing line for the production of fried sausage products, but to soften product structure, preliminary preparation of plant raw materials in form of cooking will be required. Lentils are boiled in water for 5 to 10 minutes at 100 °C, then left to cool for further cooling for 30 minutes, after which cooled prepared raw material goes to machine salting department for further use. Next comes the preparation of minced meat, stuffing the minced meat into the casing, tying the loaves and frying in the oven, then cooling from 6 to 8 hours, after which the sausages are packed and sent to finished products warehouse for further storage.

4.2. Determination of organoleptic indicators

Samples were taken for the study: № 1 with lentils, № 2 with fennel and № 3 with lovage in comparison with a control sample without additives. Sensory evaluation results is presented in table 2.

Table 2. Organoleptic characteristics of samples.

| Parameter            | Sample № 1                          | Sample № 2                          | Sample № 3                          | Control sample |
|----------------------|-------------------------------------|-------------------------------------|-------------------------------------|----------------|
| Shape, surface       | loaf twisted in a spiral 2-4 times, clean, dry | loaf twisted in a spiral 2-4 times, clean, dry | loaf twisted in a spiral 2-4 times, clean, dry | in casings: loaves with a clean, dry surface, not damaged |
| Structure, consistency| evenly mixed mass, contains inclusions of non-meat ingredient - lentils | evenly mixed mass with inclusions of fennel, dense consistency | evenly mixed mass with inclusions of lovage, dense consistency | homogeneous, evenly mixed mass |
| Taste                | specific to this type of product, moderately salty | specific to this type of product, moderately salty | specific to this type of product, moderately salty | specific to this type of product |
| Flavor               | specific to prescription product composition, with a pronounced aroma of spices | specific to prescription product composition | specific to prescription product composition | specific to prescription product composition, with a scent of spices from light brown to brown |
| Color                | Brown                               | brown                               | brown                               | brown          |
As a result of optimization of formulation of the samples, it was possible to achieve high organoleptic characteristics with a balanced combination of components. Sample № 1 contains lentil inclusions, consistency is dense. Sample № 2 has a fennel aroma, and sample № 3 has lovage.

According to generally accepted methods, organoleptic assessment was carried out on a five-point scale. The results of the assessment are presented in form of a profilogram in figure 2.

4.3. Determination of product yield

Standardization of the sausage output indicator is aimed to establishing the procedure for consumption of main raw materials of meat production for the purpose of its rational use and ensuring the production of products that meet current quality indicators.

Results of determination of product yield presented in table 3.

| №  | Sample      | Mass of unsalted raw materials, $M_1$, г | Prepared product weight, $M_2$, г | Product yield, $W$, % |
|----|-------------|----------------------------------------|----------------------------------|-----------------------|
| 1  | sample № 1  | 100                                    | 143                              | 83                    |
| 2  | sample № 2  | 100                                    | 133                              | 77                    |
| 3  | sample № 3  | 100                                    | 132                              | 76                    |
| 4  | control sample | 100                                    | 129                              | 74                    |

As a result of the experiment, it was found that yield of samples № 1, № 2 and № 3 exceeds that parameter in the case of control sample. Sample № 1 with lentils has the highest product yield. The use of a vegetable component - lentils - increases the yield of prepared product by increasing water-binding capacity of minced meat.

The shelf life of fried sausage products from the end of technological process at a temperature from 0 to 6 ℃ and a relative humidity of 75 ± 5 ℃ is no more than 15 days, including at manufacturing plant - no more than 6 days.

Fried sausage products were stored at temperatures from 0 to 6 ℃, relative humidity 75 ± 5 ℃ for 20 days. During this period, no changes were observed in organoleptic, physicochemical and microbiological indicators.

After expiration of shelf life of the fried sausage products, microbiological indicators of the samples corresponded to standards presented in table 4.
Table 4. Microbiological parameters.

| Parameter                                                                 | Norm       |
|---------------------------------------------------------------------------|------------|
| The number of mesophilic aerobic and facultative anaerobic microorganisms, in 1 g of product, no more than | $5 \times 10^2$ |
| Escherichia coli bacteria, in 1 g of product                               | Not allowed |
| Sulfite-reducing clostridia, in 0.01 g of product                         | Not allowed |
| L. Monocytogenes, in 25 g of product                                       | Not allowed |
| Pathogenic microorganisms, including bacteria of the genus Salmonella in 25 g of product | Not allowed |

4.4. Analysis of physical-chemical indicators and energy value

The results of physicochemical analysis of produced samples (determination of the mass fraction of protein, fat, moisture, sodium chloride) and assessment of the energy value are presented in table 5.

Table 5. Physicochemical indicators of fried sausage products.

| Parameter                              | Sample № 1 | Sample № 2 | Sample № 3 | Control sample |
|----------------------------------------|------------|------------|------------|----------------|
| Amount of moisture, % not more than    | 44.0       | 40.0       | 40.0       | 40.0           |
| proteins, % no less than               | 16.0       | 14.0       | 14.0       | 14.0           |
| fat, % not more than                   | 40.0       | 45.0       | 45.0       | 50.0           |
| sodium chloride %, not more than       | 2.5        | 2.5        | 2.5        | 3.0            |
| energy value, kcal / 100 g, not more than | 424        | 461        | 461        | 506            |

As a result of the study, it was revealed that sample № 1 has a higher protein content compared to other samples: protein enrichment occurred due to addition of lentils to the recipe. The high protein content of lentils increases nutritional and biological value of the product. The mass fraction of fat in these samples was lower than in the control, due to addition of plant components to the formulations. Content of sodium chloride, both in the test samples and in the control, did not exceed permissible values of TR TS 021/2011. The developed sausages compared to the control sample have a lower energy value: in range from 424 to 461 kcal.

4.5. Confirmation of economic efficiency of production

Based on production of experimental samples economic efficiency of the production was assessed by calculating the cost of product. Cost price of production for each assortment position presented in table 6.

The cost of production of control samples of fried sausage products was from 293.0 rubles per 1 kg. At the same time, the cost price of experimental samples produced according to the developed formulations, is 443.0 and two samples are 393.0 rubles each for 1 kg, respectively. At the moment, taking into account other costs of manufacturer and retail network, this is average for Russian market.

Table 6. Calculation of production cost of the experimental samples.

| Raw material                              | Sample № 1 | Sample № 2 | Sample № 3 | Control sample |
|-------------------------------------------|------------|------------|------------|----------------|
| Price per kg, rubles                      |            |            |            |                |
| amount, kg                                | cost, rubles| amount, kg | cost, rubles| amount, kg     |
| Sample № 1                                |            |            |            |                |
| Sample № 2                                |            |            |            |                |
| Sample № 3                                |            |            |            |                |
| Control sample                            |            |            |            |                |

Main raw material
Pork bold trimmed 175 85 14875 85 14875 85 14875 85 14875 85 14875
Crude fat 86 15 1290 15 1290 15 1290 15 1290 15 1290
Sum 261 100 16165 100 16165 100 16165 100 16165 100 16165
Additional raw materials
Lentils 50 3 150 – – – – – – –
Fennel 500 – – 0.2 100 – – – – –
Lovage 1215 – – – – 0.2 100 – – –
Table salt 9 1.8 16.2 1.8 16.2 1.8 16.2 1.8 16.2 1.8
Complex food additive 400 0.5 200 0.5 200 0.5 200 0.5 200
Total 2174 5.3 366.2 2.5 316.2 2.5 316.2 2.3 216.2
Sausage casing, twine 180 (m, rubles) 33 5940 33 5940 33 5940 33 5940
Product yield, % 83 77 76 74
Cost price, rubles per kg 443 393 393 293

5. Conclusions
Production process of fried sausage products with various additives includes all stages typical for production of fried sausages. The added herbal ingredients: lentils, fennel and lovage, increase content of vitamins and minerals in prepared products, that are practically not exhausted even during heat treatment and long-term storage. Product yield of sample № 1 – 83%, cost price 443 rubles; sample № 2 – 77%, cost price 393 rubles; sample № 3 – 76%, cost price 393 rubles.

The developed products have elastic consistency and spicy taste, that is characteristic for each sample with a brown color on the cut, as well as a pleasant aroma, that is specific to this type of product. The products are recommended to a wide range of consumers of different age groups, that is an integral plus in implementation of products.

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