Method for producing sausages, lycopine enriched

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Abstract. The use of additives of plant origin allows to stabilize the functional and technological properties of raw materials, increase the biological value, improve the organoleptic characteristics of the finished product. Lycopene is one of the supplements of interest. Like other carotenoids, lycopene is a fat-soluble nutrient. This means that it is better absorbed when consumed with fats. The product with the highest concentration of lycopene is tomato. Although it is found in many other plant products. The aim of this work was to develop a recipe for sausages with a filler containing lycopene. In the course of the research, the basic quality indicators of enriched cooked sausage products were studied: organoleptic and physicochemical. In addition, an experiment was carried out that revealed the quantitative content of lycopene in three variations of the filler: tomato juice, fresh tomato and ketchup. Sausages with a filling inside provide an opportunity to enrich and diversify the diet of consumers. And also they allow the manufacturer to increase the yield by introducing filler.

1. Introduction

The use of various biologically active substances (BAS) of natural origin as antioxidant ingredients is one of the key trends in the modern food industry [1, 2]. Such popularity is due to the fact that such additives not only satisfy safety requirements, but also have biological value and are well combined with food components [3, 4].

Lycopene is a natural chemical compound that gives fruits and vegetables a red color. It belongs to the group of pigments, known under the general name - carotenoids. Substances of this group are necessary for the human body, but are not synthesized in it. In particular, this supplement, although not involved in the synthesis of vitamin A, is, however, the strongest antioxidant of all carotenoids [5].

Lycopene (E160d) is obtained from red tomatoes of the species Lycopersicon esculentum L. by extraction with the permitted solvents: ethanol, methanol, hexane, ethyl acetate, acetone, dichloromethane, propan-2-ol, carbon dioxide. Extraction of lycopene from tomatoes by extraction is, although the most common, but quite expensive way. In addition to this, you can get the dye biotechnological method from mushrooms of the species Blakeslea trispora - this method is cheaper [6].

In nature, this compound is found in the red-orange parts of plants. Its greatest amount is in tomatoes, as well as in guava, watermelons, rosehips, apricots and palm oil. The finished additive is insoluble in water, but soluble in oils and organic solvents. Outwardly, it looks like a viscous dark red liquid or a
solution in orange-red oils and fats. In Russia, the additive is present in the list of products allowed for use in food technology [7, 8].

The recommended daily intake is set at 5 mg per day, and the maximum allowable — 10 mg per day. But even with excessive consumption, lycopene is non-toxic [9, 10].

It is known that lycopene fights peroxidation in the body by blocking free oxygen radicals. Scientists give feedback on lycopene as one of the most powerful natural antioxidants, comparing it with vitamins A, E, C [2]. In addition, the need for supplementation increases with an increased risk of cardiovascular diseases (ischemic heart disease, atherosclerosis) — it is used for the prevention and treatment in the early stages. In inflammatory diseases, lycopene is an immunostimulant.

2. Goals and objectives
The goal is to study lycopene-enriched sausages.

In connection with the goal, it is necessary to solve the following tasks: optimization of technology and formulation of experimental samples; analysis of the quantitative ratio of lycopene in tomato products; development of experimental samples, determination of the yield of the product; assessment of organoleptic indicators; determination of sodium chloride in the finished product; determination of the dynamic viscosity of minced meat; assessment of the effectiveness of the developed production method and recipes.

3. Methods and materials
The sequence and interconnection of the stages of the study of sausages enriched with lycopene are reflected in the block diagram in Figure 1. To analyze the product, it was decided to conduct eight consecutive experiments.

To accomplish the tasks and achieve the goals of the experimental study, it is necessary to perform the following steps:

a) technology optimization
   For experimental production of sausage samples, the technology is being processed taking into account the introduction of new technological stages.

b) recipe optimization
   For experimental production of sausage samples, the recipe is processed taking into account the introduction of a new component.

c) production of sausage samples
   Four sausage samples are produced. Control, sample No. 2.1 with ketchup as part of the filler, sample No. 2.2 with tomato paste and sample No. 2.3 with fresh tomato juice. The mass of each sample is 100 g.

d) organoleptic indicators
   Determine for comparison the organoleptic characteristics of prototypes containing in their fillers: ketchup; tomato paste; fresh tomato juice.

e) determination of the output
   It is determined to assess the effect of a filler with carrageenan on the yield of the finished product.

The product yield W is calculated by the formula (1):

$$W = \frac{M_1 \cdot 100}{M_2},$$

(1)

where $M_1$ — is the mass of unsalted raw materials, g;

$M_2$ — mass of finished product, g.

c) determination of the qualitative content of lycopene
   It is carried out to determine the lycopene content in the samples. The method is based on the dissolution of tomato products in gasoline, and the conversion of lycopene to the hexane fraction [10]. The mass of the sample for analysis is 2.5 g. Three samples are compared: with ketchup, with tomato paste and with fresh tomato juice.
g) determination of the dynamic viscosity of minced meat
It is carried out to determine the effect of the filler on the rheological properties of the stuffing mixture depending on temperature.

h) determination of the mass fraction of sodium chloride
Determination of the mass fraction of table salt in meat products is carried out according to GOST 9957 Meat and meat products. Methods for determination of sodium chloride content. 
Mass fraction of sodium chloride \( W_{NaCl}, \% \), calculated by the formula (2):

\[
W_{NaCl} = \frac{0.00292 \cdot K \cdot v \cdot 100 \cdot 100}{v_1 \cdot m},
\]

where 0.00292 is the amount of sodium chloride equivalent to 1 cm³ 0.05 mol / dm³ silver nitrate solution, g;
K – correction for the titer of 0.05 mol / dm³ of a solution of silver nitrate;
\( v \) – is the amount of 0.05 mol / dm³ of a solution of silver nitrate due to the consumption of titrated test solution, cm³;
\( v_1 \) – is the amount of water extract taken for titration, cm³;
\( m \) – mass of sample, g.

4. Results and discussion

4.1. Technology Optimization
In the process of optimizing the technology, it was revealed that the three-stage cutting is most effective in order to maintain the integrity of the filler structure in the mass of minced meat. The process of preparation of minced meat begins with processing on a cutter of low-fat raw materials with the addition of the entire amount of salt provided for by the recipe [11]. Then, water is added in the minimum amount necessary for the maximum extraction of salt-soluble meat proteins.

After obtaining a bound mass of non-greasy raw materials with water (matrices), a fat-containing raw material is added in the second stage of chopping, which has a softer structure and requires a shorter processing time for dispersion.

At the third stage, the filler and the meat component of the minced meat are mixed, the duration of the stage should not exceed two minutes, in order to maintain the integrity of the filler cubes. Finished products from such stuffing have the best consistency.

4.2. Recipe optimization
The aim of recipe optimization is to identify such a combination of ingredients that would allow to achieve high taste characteristics and an attractive appearance of the product.

Options for optimizing recipes are presented in table 1.

When preparing the filler for sausages, carrageenan, tomato products and water are mixed in a ratio of 0.5: 1.5: 4. Then the emulsion is heated to 80 °C for 10 minutes with constant stirring.

Cooling is carried out by pouring the emulsion into rectangular containers with a layer thickness of not more than 10 cm, then the filler cools down for 20 minutes at a temperature of 4 °C.

In order to form an attractive appearance of the product in the section, the filler is crushed by a size of 0.5 cm³. When filled into shells, the cubes are additionally self-grinding. Preparation of filler for sausages is carried out by cooling the cheese to a temperature of 4 °C, and then grinding into cubes of 0.5 cm³ in size.

According to organoleptic indicators, it was revealed that samples with pork veined bold and poultry meat in a ratio of 70/30%, with the addition of carrageenan and a complex additive GOST FS No. 2 have a better structure and consistency compared to other samples. It was also established that the optimal amount of filler in the composition of the product is 20%.

Thus, for further use, the recipe of sample No. 2 was selected, containing the largest amount of pork and the least amount of poultry meat, as well as balanced by the amount of tomato product.
It was found that the use of carrageenan allows you to save the structure and pattern in the context of the product.

**Table 1.** Formulation optimization.

| Ingredient                        | Product’s name, gr per 1 kg of unsalted raw materials |
|-----------------------------------|------------------------------------------------------|
|                                   | sample №1     | sample № 2 | sample № 3 | control sample |
| Veined pork bold                  | 500           | 700       | 500         | 930            |
| Salted bacon                      | 100           | –         | –           | 70             |
| Poultry meat                      | 400           | 300       | 500         |                |
| **TOTAL**                         | 1000          | 1000     | 1000        | 1000           |
| Edible salt                       | 9.0           | –         | –           | 15.0           |
| Sodium nitrite                    | 6.0           | 6.0       | 6.0         | 0.01           |
| Granulated sugar or glucose       | 2.0           | –         | –           | 2.0            |
| Black or white pepper powder      | 1.3           | –         | –           | 1.3            |
| Ground coriander                  | 1.3           | –         | –           | 1.3            |
| Fresh garlic                      | 0.6           | –         | –           | 0.6            |
| Carrageenan                       | 10.0          | 10.0      | –           | –              |
| Gelatin                           | –             | –         | 30.0        | –              |
| Complex additive GOST FS No. 2    | –             | 11        | 11          | –              |
| Water                             | 270           | 360       | 430         | 200            |
| Tomato product                    | 20.0          | 30.0      | 40.0        | –              |
| **TOTAL**                         | 1320.2        | 1417.0    | 1517.0      | 1220.21        |

4.3. Determination of organoleptic indicators

The main goal of organoleptic assessment is to determine the result of the use of various fillers in the composition of the sausage. Samples were taken for evaluation: No. 2.1 with ketchup, No. 2.2 with tomato paste and No. 2.3 with fresh tomato juice. Organoleptic evaluation is presented in table 2.

**Table 2.** Organoleptic indicators

| Indicator                          | Sample № 2.1 | Sample № 2.2 | Sample № 2.3 | Control sample |
|------------------------------------|--------------|--------------|--------------|----------------|
| Shape, surface                     | Straight loaves, oval in shape with a length of 10 cm and a diameter of 30 mm; with a clean, dry surface | Straight loaves, oval in shape with a length of 10 cm and a diameter of 30 mm; with a clean, dry surface | Straight loaves, oval in shape with a length of 10 cm and a diameter of 30 mm; with a clean, dry surface | Bar-shaped bars with oval ends 12.5 cm long and 22 mm in diameter |
| Structure and consistency          | Minced meat sausage with a heterogeneous structure, contains inclusion of an obscure ingredient - ketchup. Elastic consistency | Minced meat sausage with a heterogeneous structure, contains inclusion of an obscure ingredient - tomato paste. Elastic consistency | Minced meat sausage with a heterogeneous structure, contains inclusion of an obscure ingredient - fresh tomato juice. Elastic consistency | Minced meat with a homogeneous structure, evenly mixed up. The consistency is tender, juicy |
| Taste                              | Intrinsic recipe with a pronounced taste of seasonings and tomatoes | Intrinsic recipe with a pronounced salty taste of tomatoes | Intrinsic light tomato flavor recipe | Intrinsic this type of product is moderately salty |
| Smell                              | Intrinsic prescription of the composition of the product, with a pronounced aroma of spices | Characteristic of the formulation of the product | Characteristic of the prescription composition of the product | Characteristic of this type of product with the aroma of spices |
Colour: pink, with inclusions of dark red, pink, with inclusions of red, pink, with inclusions of transparent pink, pink.

It was established that the sample with tomato paste loses in taste fullness to sample No. 2.1, and not the pronounced color of tomato juice in sample No. 2.3 is likely to reduce consumer interest in the product. Thus, sample No. 2.1 stands out against the background of others with a pleasant aroma of spices, a more saturated taste of seasonings and tomatoes, as well as color.

4.4. Output definition

The rationing of sausage yield is aimed at establishing order in the consumption of the main raw materials of meat production in order to rationally use it and ensure the production of products that meet current quality indicators. Since the amount of filler does not affect the yield of the finished product, the experiment was carried out on only one sample. The product yield is presented in table 3.

| №  | Sample      | The mass of unsalted raw materials, $M_1$, gr | The mass of the finished product, $M_2$, gr | Output, $W$, % |
|----|-------------|---------------------------------------------|---------------------------------------------|----------------|
| 1  | Sample № 2.1| 100                                         | 143                                         | 143            |
| 2  | Control sample | 100                                         | 115                                         | 115            |

As a result of the experiment, it was found that the yield of sample No. 2.1 exceeds the yield of the control sample by 24%. The value is obtained as a result of introducing 20% of the filler to the mass of unsalted raw materials, as well as due to the content of stabilizer E 450 in the composition of the additive GOST FS No. 2 introduced into the minced meat. It helps to retain moisture, improve the structure, increase juiciness and increase the yield of the finished product.

4.5. Determination of lycopene content

An experiment was also conducted to determine the quantitative content of lycopene in filler samples. The method is based on the dissolution of the tomato product in gasoline, and the transition of lycopene to the hexane fraction. [10]

The purpose of the experiment was to identify a filler sample containing the largest amount of lycopene antioxidant in its composition. For the subsequent introduction of the filler in the composition of minced sausages. The determination of lycopene content in tomato products is presented in table 4.

| Sample            | Amount, ml | Hexane volume, ml |
|-------------------|------------|-------------------|
| Tomato juice filler | 2.5        | 2.5               | 2.2 |
| Fresh tomato filler | 2.5        | 2.5               | 2.3 |
| Ketchup filler    | 2.5        | 2.5               | 2.6 |

When dissolving tomato products in gasoline, lycopene passes into the hexane fraction. Thus, the volume occupied by hexane is directly proportional to the amount of lycopene in the product. It was found that the sample with ketchup is superior to others in its content of antioxidant.

4.6. Determination of the forcemeat viscosity

To substantiate the recipe for sausages with ketchup, the effect of filler dosage on the temperature dependence of the ultimate shear stress (PNS) is investigated. According to the value of PNS, you can evaluate the consistency, as well as the quality of the developed product. The determination of the forcemeat viscosity is presented in table 5.
As a result of the study, it was revealed that minced meat without a filler is characterized by lower PNS values. With the advent of the filler in the sample, the ultimate shear stress increased.

**Table 5. Determination of viscosity of meat.**

| Sample                | Forcemeat temperature, t, °C | Stuffing viscosity, \( \eta \), Pa \cdot s |
|-----------------------|-------------------------------|---------------------------------------------|
| Control sample        | 5.0                           | 43.0                                        |
|                       | 7.2                           | 37.0                                        |
|                       | 7.5                           | 35.9                                        |
|                       | 13.0                          | 15.0                                        |
|                       | 16.5                          | 8.9                                         |
| Sample № 2, 1         | 2.0                           | 34.3                                        |
|                       | 4.2                           | 21.2                                        |
|                       | 10.0                          | 23.8                                        |
|                       | 14.4                          | 18.0                                        |
|                       | 18.3                          | 16.5                                        |

Data on the rheological characteristics of minced meat indicate the possibility of adding sausage filler to the minced meat in an amount of 20% by weight of raw materials and does not require the organization of special operating modes of technological equipment.

4.7. **Determination of the mass fraction of sodium chloride in sausages**

The purpose of the experiment is to identify changes in the amount of salt in sausages, with the introduction of a filler already containing sodium chloride. The determination of the mass fraction of sodium chloride is presented in table 6.

**Table 6. Determination of the mass fraction of sodium chloride in the samples.**

| № | Sample          | Weight mass, g | The filtrate mass, mf, g | Titrant volume, \( V \), m\(^3\) | The amount of silver nitrate solution, \( V \), cm\(^3\) | Mass fraction of sodium chloride, \( W_{NaCl} \) % |
|---|-----------------|----------------|--------------------------|-----------------------------------|----------------------------------------------------|-----------------------------------------------|
| 1 | Control sample  | 5              | 10.5                     | 3.08                              | 3.08                                               | 1.8                                           |
| 2 | Sample № 2, 1   | 5              | 10.5                     | 3.25                              | 3.25                                               | 1.9                                           |

Since the maximum permissible proportion of sodium chloride for sausages is 2%, there is no need to reduce the salt mass in the composition of sausage minced meat.

5. **Conclusions**

Thus, as a result of the work, cooked sausages - sausages enriched with lycopene are comprehensively studied. When optimizing the production technology, the advantages of the terstage cutting were revealed.

Ketchup introduced into sausages in the form of jelly incorporates lycopene. When heated, the amount of E160d in tomatoes does not decrease, as it usually happens with various vitamins, but increases. In addition, heat treatment promotes better absorption of the antioxidant by the body. When preparing filler for sausages, carrageenan, ketchup and water are mixed. Then the emulsion is stirred in the mixer for 10 minutes. Heated to 80 °C for 10 minutes with constant stirring. Cooling is carried out by pouring the emulsion into rectangular containers with a layer thickness of not more than 5 cm, at a temperature of 18 °C, for 30 minutes to solidify the carrageenan. After this, the filler freezes at minus 4 °C for 30 minutes. In order to form an attractive appearance of the product in the section, the filler is crushed by a size of 0.5 cm\(^3\). At the third stage of chopping, the filler and the meat component of the minced meat are mixed, the duration of the stage should not exceed two minutes, in order to maintain the integrity of the filler cubes.
The filler used with ketchup positively affects not only organoleptic characteristics, but also increases the nutritional value of the product. In addition, the introduction of filler allows you to increase the yield of the product up to 143%, which will positively affect the price of sausages and make them even more attractive for the consumer.

It was found that sample No. 3.1 with ketchup is superior to others in its lycopene content, as a result of the greatest heat treatment. When determining the PNS, it was established that the introduction of a filler in the composition of the shash would not require special modernization of equipment or technical re-equipment of standard production lines for the production of cooked sausages. In the course of the experimental study, it was concluded that sodium chloride contained in the ketchup will not affect the taste characteristics of the product as a whole.

Based on the above data, it can be concluded that co-sausages with filler are suitable for expanding the diet of the population. They have a natural composition, do not contain dyes, flavors and modified components.

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