

INVESTIGATION OF THE INFLUENCE OF THE ROSEMARY EXTRACT ON THE OXIDIZING STABILITY OF FATS OF SEMI-SMOKED SAUSAGES WITH PEKING DUCK MEAT

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Abstract

The work is devoted to studying the fatty-acid composition and biological efficiency of a developed meat-containing semi-smoked sausage, based on duck meat with the balanced fatty-acid composition, investigating the effectiveness of using a rosemary extract in a technology of sausages with a high content of unsaturated fatty acids. It is confirmed, that the fatty-acid composition of meat-containing semi-smoked sausage of Peking duck is characterized by the optimal ratio of PUFA and SFA that is 0.33, at standard 0.2–0.4. The ratio between FA families ω -3/ ω -6 in the developed products is from 1:11 at recommended physiological norms of the ideal composition of lipids in a meat product as 1:10.

Introduction of the rosemary extract in amount 0.02–0.06 % of the forcemeat mass decelerates hydrolytic oxidation of forcemeat lipids, favors deceleration of peroxide oxidation of lipids in a meat-containing semi-smoked sausage, decreasing the amount of peroxides in practically five times. The positive influence of the introduced antioxidant on accumulation of secondary oxidation products is noticed. Their summary amount was the least at the end of the storage term of ready products with the rosemary extract as 0.38–0.80 mg of MA/kg of the product that is 2.54–3.94 times lower than in a control sample. The most stabilizing effect on the process of lipids oxidation is obtained at introducing the rosemary extract in amount 0.06 % that allows to decrease the speed of oxidation processes in the product almost twice.

Keywords: meat-containing semi-smoked sausage, duck meat, unsaturated fatty acids, rosemary extract.

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1. Introduction

Healthy nutrition is impossible without protein of animal origin, which source is meat and meat products [1]. Nutrients of meat products provide humans with necessary means of growth and development, support of healthy condition and effective functioning of the immune system. Deficiency or low content of separate components, for example, such as unsaturated fatty acids may result in the development of internal alimentary diseases, “non-contagious illnesses”, including coronary heart disease [2, 3]. In this connection an urgent task for meat industry is for today to develop and to implement new meat-containing products with a balanced fatty-acid composition.

2. Problem condition review

The fatty-acid composition of most types of meat is mainly presented by saturated fatty acids [4], monounsaturated [5] and polyunsaturated ones that are essential and realize a series of important functions in the human organism [6, 7].

The negative effect of excessive consumption of saturated fatty acids is known [8, 9], and the positive one of polyunsaturated fatty acid consumption on the ratio of blood plasma lipoproteins is proved [10]. In this connection WHO recommends [11] the formula of the ideal lipid nutrition as 10 % of SFA and 6–10 % of USFA a day at 30 % of fat of the total caloric value in the human ration.

At consuming such meat types as pork and beef, it is impossible to achieve the ideal ratio between PUFA and SFA, which optimal diapason is from 0.2 to 0.4 [12, 13]. But the meat of water birds, namely duck, allows to optimize the fatty-acid composition of a meat product [14]. The balance of fatty acids in the composition of a meat-containing product may be achieved either forming the food value of bird meat at the expense of a breeding technology or introducing additional sources of essential fatty acids to the product composition [15, 16].

Connected with an increased risk of oxidation of enriched products, there appears a necessity of using antioxidant systems that would allow to decelerate oxidizing spoilage of complicated meat-containing systems with a prolonged storage term [17–20]. There is an ecological method of meat enrichment with anti-oxidizing inhibitors at breeding through feeding, but its defect is instability of the concentration of active substances in certain forage types [21–23]. Most progressive methods are the use of modified packages, covered with vegetable extracts [24, 25] or special gas mediums [26]. But the most spread way of inhibiting lipids oxidation in meat and meat-containing products is to use antioxidants, both synthetic [27, 28], and natural [29–31]. A technology of using antioxidants with a high concentration of phenol compounds is especially effective [32, 33].

That is why the main aim of our studies is to investigate the fatty-acid composition and biological efficiency of a developed meat-containing semi-smoked sausage, based on duck meat with the balanced fatty-acid composition. One of tasks is also to investigate the effectiveness of using the rosemary extract in a technology of sausages with a high content of unsaturated fatty acids.

3. Materials and methods

A semi-smoked sausage was produced by [34] technology for the research. The recipe included crumbled Peking duck meat, with-free pork heart, side lard, chicken skin, comminuted on a roll with diameter of grating orifices 16–25 mm. Forcemeat was added with dry whey, soya isolate, preliminarily hydrated 1:4 by drinking water, vegetable cellulose preparation fiber 110. All ingredients were mixed, the forcemeat was added with salt and spices. After filling a natural coat with the ready forcemeat, ready sausages were put down at temperature 4–8 °C during 2 hours. Then they were dried and fried at temperature 90 °C during one hour, cooled and boiled at 40...50 min. After cooling at $t < 20$ °C, during 2 hours the sausages were smoked at $t = (43 \pm 7)$ °C, $\tau = 12...24$ hours. After smoking they were dried at $t = 10...12$ °C and relative humidity 76.5 ± 1.5 % during one hour. After finishing the technological process, the sausage was stored at temperature no higher 12 °C during 20 days.

The rosemary extract (Food Ingredients Mega Trade, USA) was used for the experiment with natural antioxidants (**Fig. 1**).

At producing forcemeat of the semi-smoked sausage, the rosemary extract (RE) was added by the following scheme: No. 1 – RE 0,02 %; No. 2 – RE 0,04 %; No. 3 – RE 0.06 % of the raw material mass. A sample without adding antioxidants was used as a control.



Fig. 1. Rosemary extract

Determination of the fatty-acid of the semi-smoked sausages was carried out by the method of gas-liquid chromatography, using the automated gas chromatograph Kupol-55 [35]. For determining the fatty-acid composition of the sausages, a sample was prepared by lipids extraction. The extracts was concentrated on the rotor evaporator at temperature no higher 40 °C. After heating on the water bath during 50 min, the extract was dissolved by water in ratio 1:1. The hexane extracts were obtained. Hexane was steamed on the rotor evaporator, chromatographically pure methyl esters of fatty acids were obtained, solved in hexane and chromatographed on the chromatograph Kupol-55 (Russia) on the column SP 2560 (USA) with length 100 m (**Fig. 2**).



Fig. 2. Chromatograph Kupol-55 (Russia)

The acid number was determined by titration of a batch by sodium hydroxide in the concentration at presence of the phenolphthalein alcohol solution [36]. 3–5 g of the studied forcemeat were weighed in a conic flask of 150–200 cm³ with an error, no more 0.001 g. The batch was heated on the water bath, added with 50 cm³ of the neutralized ester-alcohol mixture and shaken. Then 3–5 drops of the alcohol solution of phenolphthalein with the mass share 1 % were added. The obtained solution at continuous shaking was fast titrated by the potassium hydroxide solution of molar concentration 0.1 mol/dm³ to the clear pink coloration that doesn't disappear during 1 min. The acid number was calculated by the formula:

$$X=(V \times K \times 5.61) / m, \quad (1)$$

where V – volume of potassium hydroxide solution of molar concentration 0.1 mol/dm³, spent for titration; K – correction for the alkaline solution for recalculation for the distinct (0.1 mol/dm³) solution; 5.61 – amount of milligrams of potassium hydroxide, contained in 1 cm³ (0.1 mol/dm³) of the solution; m – mass of the forcemeat batch, g.

The method of PN determination is based on extraction of the batch by the chloroform mixture and ice acetic acid and further titration by the sodium hyposulfite solution with the previously added starch solution [36].

0.8–1 g of the batch, weighted with distinctness no more 0,0002 g were put in a conic flask with a closed cork, melt of the water bath and 10 cm³ of chloroform and 10 cm³ of ice acetic acid were poured by the flask wall. 0.5 cm³ of the saturated new-prepared potassium iodide solution was fast added. The flask was closed by a cork, the content was mixed by rotation movements and put in a dark place for 3 min. After keeping, the flask was added with 100 cm³ of distilled water, previously added with 1 cm³ of the starch solution with mass share 1 %. Then it was titrated by the sodium hyposulfite solution with molar concentration 0.01 mol/dm³ to blue coloration disappearing.

For checking pureness of reagents, the control determination without a batch was conducted. The peroxide number was calculated by the formula:

$$X=(V-V_1)\times K\times 0.00127\times 100/m, \quad (2)$$

where V – volume of the sodium hyposulfite solution of molar concentration 0.01 mol/dm³, spent for titration at conducting the main experiment with the forcemeat batch, cm³; V_1 – volume (0.01 mol/dm³) of the sodium hyposulfite solution, spent for titration at conducting the control experiment (without the forcemeat batch), cm³; K – error coefficient to the hyposulfite sodium solution for recalculation for the distinct (0.01 mol/dm³) solution; 0.00127 – number of iodine grams, equivalent 1 cm³ (0.01 mol/dm³) of the sodium hyposulfite iodine; m – batch mass of the studied forcemeat, g.

TBN determination was conducted by measuring the intensity of distillate mixture coloration of the studied sample with the thiobarbituric acid solution (1:1) after keeping on the water bath during 35 minutes on the spectrophotocolorimeter «Spekol-11» (Germany) at wave length 535 nm [36] (**Fig. 3**).



Fig. 3. Spectrophotocolorimeter «Spekol-11» (Germany)

50 g of the forcemeat batch were added to a porcelain pounder, 50 cm³ of distilled water were measured by a glass cylinder, introduced in the pounder, and the mixture was rubbed by a pestle to the homogenous condition. The prepared test was quantitatively transferred to the Kjeldahl flask, washing residues from the flask by 47.5 cm³ of distilled water, and added with 2.5 cm³ hydrochloric acid. Distillation was conducted in the Kjeldahl apparatus, collecting 50 cm³ of the distillate to the measuring flask. 5 cm³ of the distillate were taken, introduced to the flask with the rubbed cork, 5 cm³ of thiobarbituric acid were added, mixed and put on the boiling water bath for 35 min, fixing time by a stopwatch.

At the same time a control sample was conducted, using 5 cm³ of distilled water instead of distillate. Then the solutions were cooled in running cold water during 10 min, fixing time by the stopwatch, and the optic density was measured at wave length (535±10) nm as to the control solution.

The thiobarbituric number, mg MA (malonic aldehyde)/kg of the product was calculated by the formula:

$$X=D \times 7.8, \quad (3)$$

where D – optic density of the solution; 7.8 – coefficient of proportional dependence of MA density on its concentration in the solution. This coefficient is a constant value.

The absolute error of measurements was determined by Student's criterion, reliable interval $P=0.95$, number of iterations in determinations 3–4, number of parallel tests of experimental samples – 3.

3. Results

As a result of the analysis of the fatty acid composition of the meat-containing semi-smoked sausage, it has been established, that the ratio between saturated and unsaturated fatty acids in the sample of the developed sausage was 0.33 (14.74/44.34) that corresponds to the norm [11]. At that SFA concentration in the sausage was 44.34 % in fat of the product, main of them were palmitic (25.36 g/100 of fat) and stearic (14.61 g/100 g of fat) fatty acids. On the other side, the mass share of PUSA was 14.24 g/100 g of fat and differed by the high content of ω -6 linoleic acid (13.40 g/100 g). In the composition of fat of the sausage there was revealed ω -3 α -linolenic acid, which concentration in the product fat is 1.22 g/100 g.

Among different varieties of birds, just duck differs by the skeleton muscular system with a higher level of lipids and concentration of polyunsaturated fatty acids that, in their turn, influence the intensity and saturation of the meat smell [37–40]. So, the use of duck meat in recipes of meat-containing products is effective in the aspect of creation of a product, balanced by the fatty-acid composition. The study of the individual fatty acids concentration has demonstrated that the product contains not only cis-isomers of separate fatty acids, but also their trans-modifications. Thus, 0.57 % of trans-oleic acid were revealed in the product, but it corresponds to data [41] and is not a risk factor for the human health [42–44].

As a result of using duck meat in the recipe, the biologic effectiveness of lipids of the meat-containing semi-smoked sausage, characterized by the standard ratio of ω -3 and ω -6 SUFA [45], is 1:11.

At studying the effectiveness of using the rosemary extract, it has been established, that the preparation decelerates hydrolysis of fats in systems with the high content of unsaturated fatty acids. It is explained by the high concentration of flavonoids of the extract, confirmed by the studies of the rosemary extract influence on oxidizing processes in a technology of beef cutlets [46–48]. The study of the dynamics of peroxide oxidation in the samples has demonstrated that PN in the control sample of sausage grew at the storage term from 0.15 ± 0.01 to 0.65 ± 0.00 J % . In the experimental samples of semi-smoked sausage, PN at the end of the storage term varied from 0.11 ± 0.001 J % in sample 2 to 0.16 ± 0.002 J % in sample 1.

The rosemary extract had the most effect in concentration 0.06 % of the raw material mass. Thus at the end of the storage term the correspondent sample of semi-smoked sausage had the peroxide number 1.65 ± 0.07 mg KOH, whereas in the control CN was 2.54 ± 0.49 mg KOH that is by 53,94 % higher.

As a result of decelerating peroxide oxidation of sausage lipids, the concentration of secondary products of lipids oxidation (pentanal, hexanal, malonic aldehyde and other) was decreased in average 3 times that is confirmed by the TBN value. At the storage end TBN of the experimental samples varied at level 0.38–0.80 mg of MA/kg of the product that is 2.54–3.94 times lower comparing with the control.

4. Conclusions

It is confirmed, that the fatty-acid composition of meat-containing semi-smoked sausage of Peking duck is characterized by the optimal ratio of PUFA and SFA that is 0.33, at standard 0.2–0.4.

The ratio between FA families ω -3/ ω -6 in the developed products is from 1:11 at recommended physiological norms of the ideal composition of lipids in a meat product as 1:10.

The high effectiveness of the rosemary extract in decelerating the lipids oxidation process in meat-containing products is confirmed. Introduction of the rosemary extract in amount 0.02–0.06 % of the forcemeat mass decreases the concentration of free fatty acids by 53.94 %, favors deceleration of peroxide oxidation of lipids in the meat-containing semi-smoked sausage, decreasing the amount of peroxides in practically five times, comparing with the control. The positive influence of the introduced antioxidant on accumulation of secondary oxidation products is noticed. TBN was the least at the end of the storage term of the ready products with the rosemary extract and was 0.38–0.80 mg of MA/kg of the product that is 2.54–3.94 times lower than in the control sample.

The optimal RE concentration for decelerating oxidizing processes in the semi-smoked sausage of Peking duck meat has been determined. The most stabilizing effect is obtained at introducing the rosemary extract in amount 0.06 % of the raw material mass that allows to decrease the speed of oxidizing processes in the product almost twice.

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