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Research and development of a technology for the production of healthy sausages

Maksym Riabovol, Larysa Bal-Prylypko*

National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine

Abstract. Due to the general deterioration of the environmental situation and the associated increase in the negative impact on consumer health, studies have been conducted to develop a healthy sausage recipe. The research aims to develop the composition of minced meat characterized by minimal sensitivity to oxidants and balanced mineral content and implement therapeutic and preventive properties to the product made from it. The research was conducted on minced meat. The Ukrainian state standard 4436:2005 minced meat recipe was used as a sample. The values of the parameters were determined by standardized methods, and the concentration of sodium chloride was determined by the Mohr method. Organoleptic quality indicators of sausages of standardized and experimental composition were determined by the method of expert evaluation. A method of inhibiting the processes of oxidative deterioration of the meat mixture under the influence of oxygen by introducing rosemary extract into the mixture was determined. The possibility of reducing the dosage of sodium cation by replacing rock salt with sea salt enriched with kelp was determined, which also made it possible to reduce the dosage of toxic sodium nitrite. The content of beef in the meat raw materials of the prototype was reduced to 30%, and that of semi-fat pork to 26% due to the inclusion of blood plasma protein (1.0%), orange dietary fiber (0.5%), and water for their hydration (7%). In the composition of spices and auxiliary materials of the prototype, table salt (2.2%) was replaced by sea salt (2.1%), and the content of sodium nitrite was reduced from 0.0075% to 0.0050% due to the introduction of rosemary extract (0.15%) and the bacterial preparation "Iprovit LRR" (0.05%). The possibility of extending the guaranteed shelf life of sausages from 3 to 10 days was shown and the possibility of replacing rock salt with sea salt in minced meat was determined, which, while maintaining a sense of sufficient salinity of the product, allowed the reduction of the dosage of sodium cation by 30% and enrich the minced meat with trace elements – calcium, magnesium and acutely deficient iodine. The developed recipe of "Healthy" sausages can be used for industrial production at meat processing enterprises

Keywords: quality, sausages, antioxidant, rosemary, sea salt, food additives

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*Corresponding author

Introduction

The priority goal of all food industries is to ensure the high quality and safety of their products. The decrease in product safety is primarily due to the accumulation of harmful compounds in the product, which are formed during the oxidation of organic substances under the influence of external and internal ionizing radiation, as well as oxygen and peroxides that arise from its interaction with the components of the meat mixture and free radicals (highly reactive oxygen and nitrogen compounds). Given the significant share of meat products in people's diets and the short shelf life of their guaranteed shelf life, technology developers and manufacturers of innovative products are tasked with slowing down the process of product spoilage and thus extending the guaranteed shelf life without compromising consumer properties.

Literature Overview

Oxidation processes characteristic of meat systems take occur in water-rich environments with the presence of oxygen and peroxides formed with its participation, mainly hydrogen peroxide H_2O_2 . In both cases, due to their instability in slightly acidic environments, atomic oxygen is formed in the product mass. With its participation, oxygen and nitrogen compounds characterized by the presence of an unpaired electron, which is highly active in chemical terms, are also formed in the product mass. Their influence on the components of meat leads to the oxidation of lipids, the main result of which is the deterioration of organoleptic quality indicators, primarily the rancidity of products and, in certain cases, the formation of hazardous substances [1].

To minimize the rate of these processes, the food industry uses several methods, including controlling the storage conditions of finished

products, and careful selection of packaging methods and packaging materials. But most often, this is done by adding ingredients with antioxidant properties to the composition, which primarily interact with free radicals, characterized by the presence of unpaired electrons, and protect the components of the meat raw material from decomposition [2, 3].

To extend the guaranteed shelf life of meat products, plants and plant extracts containing so-called flavonoids (bioflavonoids) are widely used, such as parsley, garlic, buckwheat, blueberries, and other berries, bananas, citrus fruits, as well as red wine, dark chocolate (with a cocoa bean content of more than 70%), black and green tea. In general, a flavonoid molecule (a terpene compound) contains a "skeleton" of 15 carbon atoms, including two phenolic and one heterocyclic ring characterized by the presence of unsaturated chemical bonds sensitive to free radicals [4-6].

Currently, more than 5,000 compounds belonging to this class are known to be characterized by a low level of toxicity, which allows them to be introduced into everyday dietary products, including meat compositions [7-9].

The effectiveness of the combined effect of natural antioxidants and antimicrobial compounds during the cold storage of nitrite-free sausage was determined [10].

There are technologies for meat and fish products using spicy and aromatic plants or their extracts, which not only improve the flavor and aroma characteristics but also improve the quality and safety of the finished product [11].

Scientists have shown the positive effect of using spices (nutmeg, black pepper, fresh garlic, mustard powder) and their oil extracts to increase the resistance of fats to oxidation. Natural antioxidants not only increase the

nutritional and biological value but also serve as a free radical trap for fatty acids [12].

Among the flavonoid-rich antioxidant supplements of plant origin, a special place belongs to rosemary, the leaves, and stems of which contain a sufficiently large amount of acids: rosmarine, caffeic, carnosic, as well as ascorbic acid, and carotenoids that can inhibit the oxidation of fats [13, 14]. The flavonoids present in the plant are also characterized by medicinal properties, in particular, antimutagenic and antitumor effects:

the introduction of 1% rosemary extract into the food of mice reduced the level of breast cancer by 47% [15]. At least 29 substances characterized by antioxidant activity (99.87% of the total extract weight) were found in rosemary processing products, including 95.1% of monoterpenes and 4.77% of sesquiterpenes: 1,8-cineole, camphor, α -pinene, β -pinene, but among these, the extract contains the highest amount of rosmarinic acid, characterized by the presence of a chemically active double bond [4, 15] (Fig. 1).

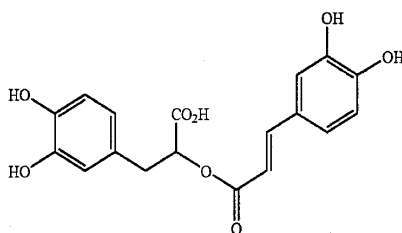


Figure 1. Rosmarinic acid

The result of adding rosemary or rosemary extract to minced meat compositions is a powerful antioxidant effect, which allows products containing lipids to be stored for a long time without spoilage.

The *research goal* is to develop a minced meat recipe with minimal sensitivity to oxidants and a balanced mineral composition and impart therapeutic and prophylactic properties to the product made from it.

To achieve this goal, the following objectives were defined: based on the results of studying the dynamics of changes in the acid and peroxide numbers of fat during storage of control and experimental samples of sausages, to determine the optimal amount of rosemary extract added to minced meat to extend the shelf life; based on the mineral composition of sea and table salt and the results of the organoleptic evaluation of the salinity level of minced meat, to determine the feasibility of replacing

ordinary table salt with sea salt in experimental samples of sausages; to develop a recipe and technological conditions for the production of healthy sausages.

Material and Methods

The research was conducted under comparative conditions using sausage minced meat, the composition of which is normalized by the Ukrainian state standard 4436:2005 “Boiled sausages, sausages, bratwursts, meat bread”. The prototype was additionally supplemented with porcine blood plasma protein, orange dietary fiber, rosemary extract, and a bacterial preparation containing lactic acid bacteria and microorganisms of the *Staphylococcus carnosus* strain. The difference between the experimental sample was also the replacement of ordinary rock salt with sea salt enriched with kelp. The composition of the tested samples is shown in Table 1.

Table 1. Composition of the tested samples of minced meat, %

The main minced meat ingredients	Control	Research
Beef	33	30
Pork half-fat	33	26
Fat pork	34	34
Plasma protein	-	1.0
Water for plasma protein hydration	-	2.0
Orange dietary fiber Citri-Fi 100	-	0.5
Water for the hydration of dietary fiber	-	6.5
Overall	100	100
Spices and materials		
Rock salt	2.2	-
Sea salt with kelp	-	2.1
Sugar	0.16	0.16
Sodium nitrite	0.0075	0.0050
The bacterial drug "Iprovit LRR"	-	0.050
Rosemary extract	-	0.15
Water for the hydration of raw meat	35.0	30.0

The meat raw materials used to make the control and experimental samples of minced meat were cut into pieces and ground in a meat grinder, salt and the calculated amounts of sodium nitrite and sugar were added. The mixtures were stirred in a mixer with a frame stirrer at a speed of 30 rpm for 10 minutes until a homogeneous consistency was achieved. The salted meat was kept for 48 hours in the refrigerator ($t^{\circ}=3-4^{\circ}\text{C}$) for maturation. The calculated amounts of water were added to the dry orange fibers and plasma protein used in the experiment (hydration of the substances was performed separately) and mixed in a mixer with a frame stirrer at a speed of 30 rpm for 10 minutes until a homogeneous consistency was achieved. To determine the optimal dosage in terms of extending the predicted guaranteed shelf life of sausages, rosemary extract was added to the experimental composition in the amount of 0.05, 0.1, 0.15, and 0.20% – by weight of meat raw materials. The rest of the ingredients in the amounts given in Table 1 were added in random

order and mixed in a mixer in the same mode, the minced mixture was ground in a meat grinder repeatedly, and the calculated amount of water was added. The resulting minced meat was filled into the intestinal membranes and kept at room temperature for 3 hours before heat treatment. The casing filled with minced meat was sterilized in a thermal chamber until the temperature in the center of the minced meat reached $40-45^{\circ}\text{C}$, after which the frying temperature was increased until the temperature in the center of the sausage reached about 70°C . The finished product was transferred to a cooling chamber and kept at $2-5^{\circ}\text{C}$ for 5 hours.

After aging, samples were taken from the finished products and analyzed under standard methods. The dynamics of changes in the peroxide and acid numbers of fat of the experimental sausage samples during 10-day storage were monitored in comparison with similar indicators of sausages of the composition normalized by Ukrainian state standard 4436:2005 "Boiled sausages, sausages, bratwursts, meat bread". The

acid number of lipids was determined under the Ukrainian state standard method 4350:2004 (ISO 660:1996), the peroxide number of lipids – under Ukrainian state standard EN ISO 3960:2019, and the mass fraction of table salt - by the Mohr method according to State Standard 9957-2015. The degree of salinity and organoleptic properties of the control and experimental product samples were evaluated on a five-point scale at the Department of Meat, Fish, and Seafood Technology of the National University of Food Science and Technology of Ukraine.

Results and Discussion

The sausages produced under the methodology described above were aged for 10 days. Changes in the peroxide and acid number of fat of the products of the control and rosemary

extract-modified formulations were monitored. In the first stage, the optimal amount of the additive was determined (Fig. 2), according to the results of which it was found that the optimal content of the extract additive was 0.15%. The conclusion was based on the fact that with an increase in dosage from 0% to 0.15%, the peroxide number, which characterizes the number of oxidized lipids, progressively decreased compared to the control. However, with the further addition of the extract, the peroxide number of samples with additions of 0.15% and 0.20% was practically the same. This, in our opinion, is evidence of the sufficiency of the number of flavonoids present in the sample with a concentration of 0.15%, and the inexpediency of further increasing their concentration in additives.

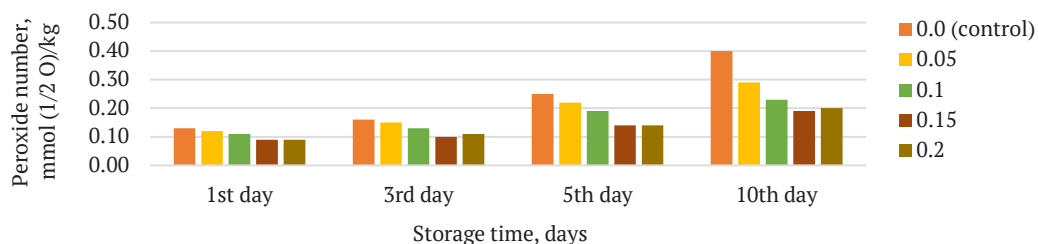


Figure 2. Dynamics of changes in the peroxide number of control and experimental samples of sausages

Considering the sufficient amount of rosemary extract added at 0.15%, the dynamics of the growth of the acid number of minced meat

was studied only in the control and optimal composition according to the preliminary results (Fig. 3).

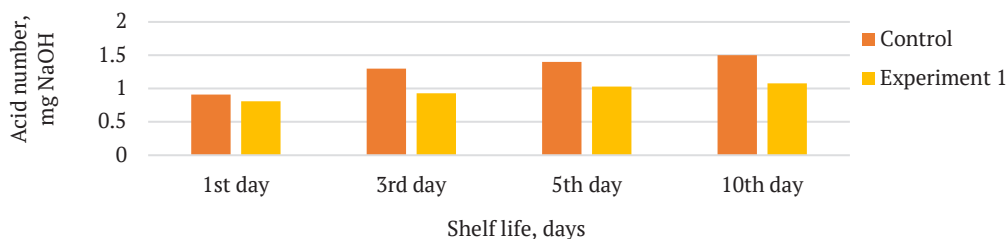


Figure 3. Dynamics of changes in the acid number of fat of control and experimental samples of sausages during storage

Here, as in the previous series of experiments, the positive role of rosemary extract was revealed: the acidity of the samples in the rosemary-modified samples increased more slowly compared to the control. It was also determined that the acidity level of the sample modified by the extract at the end of the study was even lower than that achieved in the control on the 3rd day of aging. Considering that the guaranteed shelf life of sausages with a standardized composition (control) is set at three days, we believe that the proposed modification of the sausage mince recipe allows us to count on extending the warranty period for

the product, which is the subject of further research. The next step in the development of a functional product was to determine the possibility of reducing the intake of excess sodium cation, the content of which in sausage products reaches 2.5% in some cases [16], for which purpose ordinary rock salt was replaced with sea salt in the experiments. A comparison of the chemical composition of the salts used for salting (Table 2) shows that such a replacement not only reduces the amount of sodium cation added to the minced meat by about 30%, but also enriches the product with useful trace elements such as potassium, calcium, magnesium, and iodine.

Table 2. Mineral composition of dry matter of sea and rock salt (%)

Attribute	Sea salt	Rock salt, Ukrainian state standard 3583:2015	
		first grade	“Extra”
Sodium	30.6	38.4	38.7
Calcium	1.2	0.35	0.02
Potassium	1.1	0.1	0.008
Magnesium	3.7	0.05	0.01
Iodine	5×10^{-6}	-	-

An interesting fact was that despite the significantly lower content of sodium chloride in sea salt, the results of the organoleptic evaluation showed that the salinity level of minced

meat prepared using sea salt and first-grade table salt practically did not differ (Fig. 4). On this basis, it was concluded that it is advisable to use sea salt for salting.

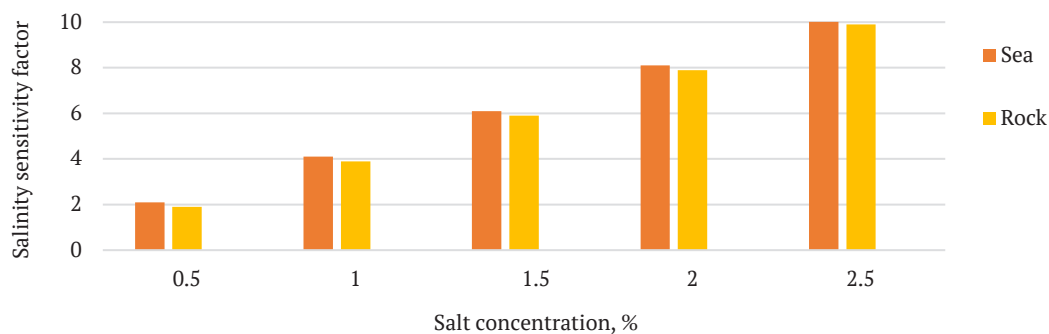


Figure 4. Results of organoleptic evaluation of the degree of salinity of minced meat mixtures

Considering the results of experimental studies, a recipe for healthy sausages and technical specifications for the product 10.1-

00493706-064:2019 “Health sausages” of the Ukrainian technical specifications (UTS) were developed (Table 3).

Table 3. Recipe for sausages “Healthy” UTS 10.1-00493706-064:2019

Ingredient	Amount
Unsalted raw product, kg (per 100 kg)	
Grade 1 lean beef	30
Pork no-fat	26
Pork lean semi-fat	34
Plasma protein	1.0
Water for the hydration of raw ingredients	8.5
Fiber (citrus fibers Citri-Fi 100)	0.5
Total	100
Water, kg	30.0
Spices and materials, g (per 100 kg of unsalted raw materials)	
Rock salt	-
Sea salt	2100
Sugar	160
Sodium nitrite	5.0
Ground black or white pepper	160
Ground allspice pepper	100
Ground nutmeg or cardamom	50.0

The health benefits of the product are associated with several factors: 1) the product has an extended shelf life, which means a reduced amount of substances that can harm health, primarily lipid oxidation products; 2) the product has a significantly lower sodium content due to the use of sea salt and a reduced dosage of sodium nitrite in the minced meat.

Conclusions

Adding 0.15% rosemary extract to minced meat can reduce the peroxide number of fat in the meat

mixture during storage for 10 days and slow down the growth rate of fatty acids in the minced meat.

Replacing rock salt, which is traditionally used for salting, with sea salt allowed us to reduce the amount of sodium cation, enrich the mineral composition, maintain a feeling of sufficient saltiness, and enhance the health benefits of the product.

The direction of further research is on the nutritional value of sausages to recommend their use in diets of therapeutic and preventive orientation.

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Обґрунтування та розроблення технології виробництва сосисок з оздоровчими властивостями

Максим Віталійович Рябовол, Лариса Вацлавівна Баль-Прилипко

Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна

Анотація. У зв'язку із загальним погіршенням екологічної ситуації та пов'язаним з цим посиленням негативного впливу на стан здоров'я споживачів проведені дослідження з розроблення рецептури сосисок, які характеризуються оздоровчими властивостями. Метою виконання роботи було розроблення складу м'ясної фаршевої композиції, що характеризується мінімальною чутливістю до дії окисників та збалансованим мінеральним складом і надає виробленому з неї продукту лікувально-профілактичних властивостей. Дослідження проводили на м'ясних фаршах. За контроль використано рецептуру м'ясного фаршу за ДСТУ 4436:2005. Значення показників визначали стандартизованими методами, а концентрацію хлориду натрію – методом Мора. Органолептичні показники якості сосисок стандартизованого та дослідного складу визначали методом експертної оцінки. В роботі визначено спосіб гальмування процесів окислювального псування м'ясної суміші під дією оксигену шляхом введення в суміш екстракту розмарину. Визначено можливість зменшення дозування катіону натрію заміною кам'яної солі на збагачену ламінарією морську сіль, що дозволило також зменшити дозування токсичного нітриту натрію. У складі м'ясної сировини дослідного зразка вміст яловичини було зменшено до 30 %, свинини напівжирної – до 26 % внаслідок включення до рецептури білку плазми крові (1,0 %), апельсинових харчових волокон (0,5 %), а також води для їх гідратації (7 %). У складі прянощів та допоміжних матеріалів дослідного зразка кухонну сіль (2,2 %) було замінено на сіль морську (2,1 %), а також зменшено вміст нітриту натрію з 0,0075 % до 0,0050 % внаслідок введення екстракту розмарину (0,15 %) та бактеріального препарату «Іпровіт ЛРР» (0,05 %) Контролю підлягали динаміка зміни їх пероксидного і кислотного чисел жиру. Показана можливість подовження гарантованого терміну зберігання сосисок з 3 до 10 діб і визначена можливість заміни у фарші кам'яної солі на морську, що за збереження відчуття достатності солоності продукту дозволило зменшити дозування катіону натрію на 30 % і збагатити фарш мікроелементами – кальцієм, магнієм та гостродефіцитним йодом. Розроблену рецептуру сосисок «Оздоровчі» доцільно використовувати для промислового виробництва на м'ясопереробних підприємствах

Ключові слова: якість, сосиски, антиоксидант, розмарин, морська сіль, харчові добавки