Наведено дослідження бактеріостатичних ефектів, які досягаються при повторній пастеризації за температури 85–90 °С протягом 15–20 хвилин у присутності поглинача кисню. Наведений спосіб обробки дозволяє отримувати на 94 добу зберігання рівень контамінації мікроорганізмів на рівні фонового мікробіологічного забруднення ковбасних виробів, які виробляються без проведення пастеризації.

Підтверджена ефективність захисних бар'єрних властивостей багатошарових полімерних матеріалів виробництва ТОВ «Сіріус Екстружен» (Україна) для зберігання варених ковбасних виробів до 26 діб. На підставі отриманих даних стабільності мікробіологічних показників і відповідності вимог органолептичних показників, встановлено можливість зберігання ковбасних виробів протягом 35 діб.

Наведено способи досягнення удвічі більшого терміну зберігання варених ковбасних виробів, ніж традиційно рекомендований для ковбасних виробів з повторною пастеризацією. Наведені результати отримані для сардельок, підданих повторній пастеризації при температурі 85–90 °С протягом 15–20 хвилин. Досліджувані зразки запаковували на термоформувальних лініях торгівельних марок «Multivac» (Німеччина) та «Webomatic» (Німеччина), пастеризація виробів проводилася в універсальній термокамері ТМ «Fessman» виробництва Німеччини.

Підтверджена можливість комбінування в рецептурах дослідних зразках пастеризованих сардельок яловичини, свинини, м'яса птиці, зокрема м'яса птиці механічного обвалювання, білкових стабілізаторів і тваринних білків на основі шкури свиней, молочних продуктів і прянощів. В результаті досліджень визначено, що сортність ковбасних виробів при використанні повторної пастеризації спільно з використанням поглинача кисню на термін зберігання варених ковбасних виробів суттєвого впливу не дає

Ключові слова: варені ковбасні вироби, ефективність повторної пастеризації, термін зберігання, м'ясо курчат-бройлерів, пакування, безпечність, активність води

UDC 664.8.022.3:633.842
DOI: 10.15587/1729-4061.2018.147768

RESEARCH INTO EFFICIENCY OF PASTERIZATION OF BOILED SAUSAGE PRODUCTS IN ORDER TO IMPROVE THEIR STORAGE TERM

V. Pasichnyi
Doctor of Technical Sciences, Professor
Department of technology of meat and meat products
Educational and Scientific Institute of Food Technologies
Volodymyrska str., 68, Kyiv, Ukraine, 01601
E-mail: Pasww1@ukr.net
A. Ukrainets
Doctor of Technical Sciences, Professor, Rector**
E-mail: a.ukrainez@ukr.net
O. Khrapachov
Regional represantative
SIRIUS EXTRUSION LTD
Pilotska str., 20, Khmelnitskiy, Ukraine, 29000
E-mail: kov.pack@ukr.net
A. Marynin
PhD, Associate professor, Head of Laboratory*
E-mail: andrii_marynin@ukr.net
R. Svyatnenko
Researcher*
E-mail: Svyatnenko@i.ua
O. Moroz
PhD, Lecturer
Lviv College of Meat and Dairy Industry
Bortnianskoho str., 30/32, Lviv, Ukraine, 79039
E-mail: olenaom@ukr.net
*Problem research laboratory**
**National University of Food Technologies
Volodymyrska str., 68, Kyiv, Ukraine, 01601

1. Introduction

The issue of organization and control of effective production, delivery and sale of food products is becoming increasingly important under conditions of globalization of the global market for sale of food products through trade networks.

Today's realities require a solution to the set of issues aimed at retaining the quality of food products and prolonging the terms of their storage.

Production of food products of animal origin limits time possibilities for their sale in trade networks due to the presence of specific contaminating forms of microorganisms that can exhibit viability over a wide range of temperature values [1, 2] in products.

For example, the recommended storage period for boiled sausage products of the highest grade is 72 hours, and it is 48 hours for products of the first grade [1].

Search for effective ways to inactivate or reduce contaminated forms of microorganisms to extend the shelf life of food products requires innovative approaches. The aim of such innovations is to improve production technology, preservation and storage of meat products while maintaining

their quality. Implementation of resource-saving technologies aimed at reducing of losses of full value of food products provides a possibility to meet the needs of general population for high-quality products of animal origin. Solving the issues on minimization of loss of food products quality at the stages of their obtaining along the way to consumer will always be an important task for the food industry.

The ways to extend storage periods of sausage production made with a use of raw materials of animal and vegetable origin are re-pasteurization [3] and active packaging elements [2, 4]. Re-pasteurization makes it possible to achieve 45 days of storage for boiled sausages [3, 4]. It is also effective to use multilayer polymeric materials, which can provide conditions for re-pasteurization and provide high barrier properties [4, 5].

Therefore, studying the possibility of an effective prolongation of terms of storage of sausage products with the use of re-pasteurization is a relevant task.

2. Literature review and problem statement

Important factors for retaining the quality and safety of food products in the meat processing industry, in particular sausage products, are the justification of methods for providing the abiotic processes [2]. Conservation by heating with application of different types of heat treatment [3, 6, 7] ensures that products are ready to use. A number of researchers recommend to use complexes of natural antioxidants [2, 8, 9] in production in addition to reducing of a level of microbiological contamination. There are studies that confirm effectiveness of application of spice extracts [10, 11], oleoresins of spices [11, 12] and extracts with bactericidal properties [12, 13] for obtaining of bacteriostatic effects. However, there is a restriction on the use of these preservatives in production of boiled sausages. It makes impossible to achieve long shelf life without a decrease in the product quality.

Temperature control to provide anabiosis at low plus and minus temperatures at stages of refrigeration and storage is also an important factor in safety of a food chain and a guarantee of product quality in terms of storage [14]. A level of microbiological contamination decreases, but this relates more to the storage of semi-finished products. This factor works only at minus temperatures for sausage products. In addition, it negatively affects organoleptic characteristics of sausages [2].

Application of packaging and storage technologies with active packaging systems [15] are effective in modern food production technologies. Multilayer polymeric materials, which can increase barrier properties of protective films [16], make possible to obtain a high level of product protection. The type of packaging materials takes into account the stages of production. It should provide efficiency of protection of products with different types of heat treatment, in particular with application of high pressure [16, 17], in production of meat products. However, application of innovative methods to bring products to readiness under the influence of high pressure requires introduction of expensive equipment and does not make possible to increase the shelf life significantly. This limits its introduction to the traditional technologies of the production of boiled sausages.

Packing materials create protective barriers to external factors of spoiling, but they have limitations on effectiveness of the action on a number of aerobic and anaerobic forms of microorganisms specific to boiled sausages.

Given the specificity of background microbiological contamination of raw materials of animal origin and the search for ways to minimize it during the production process is one of the important factors to ensure safety of meat products.

Raw materials of animal origin, primarily poultry meat, have a specific characteristic of the chemical composition and composition of the microflora [18, 19]. It necessary to find ways to disinfect it with preservation of functional and technological characteristics of raw materials [16, 19]. Such search research aimed at reducing of the risk of microbiological damage is expedient economically, because of the significant development of resources of this type of meat raw materials [20].

Traditionally widespread use of the boiled group of milk products in formulations of sausage products also requires search for methods for regulation of the microbiological contamination of dairy raw materials [21]. It is not always possible to realize this in production due to high energy consumption of the methods and a need for introduction of complex equipment. It is also important to find ways to improve functional and technological characteristics of these raw materials with various food additives and hydrothermal treatment [22].

Such studies expand possibilities of using secondary animal raw materials in various sectors of food production [23, 24]. However, manifestation of effects of syneresis are possible in heat treated sausage minced meat and during storage in packaged products, due to the specificity of an influence on animal and vegetable proteins and hydrocolloids [25]. Separated moisture is a nutrient medium for the development of microorganisms. It worsens organoleptic parameters of meat products [25].

One of the important factors, which characterizes possibility of storage of food products, is a_w, the water activity index [26, 27]. It gives a possibility to forecast intensity of development of contaminated forms of microorganisms in food products. However, there are difficulties in forecasting of a rational shelf life without conduction of further studies on accumulation of microorganisms in the process of storage for boiled sausages, due to high a_w values.

The way to improve resistance to microbiological damage is also re-pasteurization [2, 28]. The method gives possibility to provide a shelf life of boiled sausages up to 45 days. Producers recommend storage from 20 to 30 days [29] for them traditionally in the case of using of multilayer polymeric materials.

In the case of using of multilayer polymeric materials, there are methods applied to regulate the gas environment or application of vacuuming [29], which reduces possibility of development of aerobic or anaerobic forms of microorganisms.

This principle is a traditional base of possibility of extension of terms of storage of packaged products and ensuring of preservation of their quality.

There is no data on possibility of regulation of the gas environment at the pasteurization stage for sausage products, in particular, performing of re-pasteurization simultaneously with a use of oxygen absorbers, in accessible sources. It is possible to get an effect of synergy of the joint action of thermal heating and a regulator of the gas environment to extend the shelf life of boiled sausage products.

A study into detection of synergistic effects of re-pasteurization simultaneously with the use of active packaging elements on possibility to lengthen the storage period of sausages requires determination of microbiological stability of products during storage.

It is possible to confirm the reliability of these effects only by providing of high barrier characteristics of multilayer polymer films for re-pasteurization in terms of storage.

3. The aim and objectives of the study

The objective of this study was to discover the possibility of obtaining synergistic effects of re-pasteurization and the "active packaging" element – an absorber of oxygen to prolong terms of storage of boiled sausages.

We set the following tasks in accordance with the objective of the study:

– investigation of the possibility of achievement of more than 45 days of storage of boiled sausages with preservation of their quality by means of re-pasteurization;

– determination of effectiveness of simultaneous use of the "active packaging" element – the absorber of oxygen in the process of re-pasteurization on microbiological stability of boiled sausages in the process of storage;

– investigation and assessment of an influence of the grade of boiled sausage products at re-pasteurization and re-pasteurization simultaneously with the oxygen absorber on indicators of their microbiological and organoleptic stability during prolonged storage;

– confirmation of the protective effect of multilayer packaging polymeric materials to ensure re-pasteurization in combination with an oxygen absorber and storage of boiled sausage products using vacuuming.

4. Materials and methods to study the influence of pasteurization on indicators of boiled sausage products in the process of storage

We used samples of "Extra" of the highest grade and "Smachny" sausages of the first grade made at Zhytomyr Meat Processing Plant LLC (Ukraine) in accordance with TU U 15.1-32122069-006: 2008 to study the possibility of prolonging the terms of storage of boiled sausages.

We used different types of meat raw materials (beef, pork, poultry meat, protein stabilizers and animal collagen-based proteins based on skins of pigs) in formulations of experimental samples of sausages (Table 1). We used dairy products and spices traditionally used in production of boiled sausages as non-meat raw materials.

We used a natural sausage shell (pork bowels) for production. Table 1 shows formulations of the sausage products.

After completion of the technological process (cooling to the temperature of 15 °C), we vacuum-packed the experimental samples of sausages with multi-layer polymer materials (films) manufactured by Sirius Extrusion LLC (Ukraine). We packed samples with a use and without a use of sachet packets of oxygen absorber manufactured by LLC "UTAK" (Ukraine) in accordance with TU U 20.5-02070938-143: 2013.

We subjected the packaged samples of sausages to repeated heat treatment – the short pasteurization at a temperature of 85–90 °C for 20 minutes. After re-pasteurization, we cooled the experimental samples of sausages by cold water to a temperature of 15 °C with further additional cooling to a temperature from 0 to 6 °C for further storage.

We carried out the process of packaging of products before pasteurization on "Multivac" (Germany) and "Webomatic"(Germany) thermoforming lines. We carried out the pasteurization in TM "Fessman" universal thermal chamber (Germany).

Table 1

Formulations of experimental samples of sausages

Type of raw materials	"Extra" sausages h/g	"Smachny" sausages 1g
Non-salted raw materials, kg (per 100 kg)		
Sinew free, non-fat pork	50	–
Sinew free, low-fat pork	–	65
Sinew free beef of the first grade	30	–
Side sausage lard	10	–
Poultry meat	–	10
Poultry meat of mechanical boning (PMMB)	–	10
Broiler chicken fillet	–	–
Beef raw fat	7	–
Protein stabilizer of pig skin	–	10
Non-fat dried cow milk	3	1
Mozzarella cheese	–	2
Potato starch	–	2
Spices and materials, g (per 100 kg of not-salted raw materials)		
Cooking salt	2,500	2,300
Nitrite of sodium	5,0	5,0
"Vienna Combi" mixture of spices	1,300	1,300
"Medical" mixture of spices	–	190
Ascorbic acid	100	100
ScanPro T95	–	1,000
ScanGel C-95		750
Natural shell (pork bowels)	+	+

We stored the samples selected for further storage of pasteurized high and first grade sausages and the control sample of sausages without re-pasteurization in industrial refrigerators of LLC Zhytomyr Meat Processing Plant (Ukraine). Storage conditions corresponded to a temperature of 0–6 °C and air humidity of 75–78 % in the storage chamber. In parallel, we stored these product samples under the same conditions at the Problem Research Laboratory of the National University of Food Technologies (Ukraine).

We performed definition of a set of indicators in accordance with regulatory requirements for the given sausage products after completion of the technological process on the first day of storage and on days 35, 65, and 94 of storage.

We carried out investigation of quality and safety indicators by microbiological indicators in accordance with the requirements of TU U 15.1-32122069-006: 2008.

We applied three- and four-time repeatability of indicators control to evaluate the indicators in the course of the study. The confidence probability was P=0.95 for determination of the statistical error.

We determined organoleptic parameters, moisture content, indicators of microbiological safety and the value of water activity (a_w) in sausage products during the storage period.

We determined the moisture content by the method of drying by difference of mass [30] in the samples of sausages.

We monitored microbiological parameters of sausage products in accordance with the normative requirements of TU U 15.1-32122069-006: 2008 by standard methods:

– We determined the amount of MAFAM and CFU (colony-forming unit) in 1g in accordance with DSTU ISO 4833-

2: 2014 Microbiology of a food chain. Horizontal method for counting of microorganisms [31, 32];

– *Sulphitraucuronic clostridia*, in 1 g according to GOST 9958-81;

– *Staphylococcus aureus*, in 1 g according to GOST 10444.2-94;

– *Escherichia coli* group bacteria, in 1 g according to GOST 9958-8;

– Pathogenic microorganisms, including *Salmonella*, in 25 g in accordance with DSTU ISO 6579 Microbiology of food products and animal feed. Method for detection of Salmonella [33];

– *Listeria Monocytogenes*, in 25 g of product according to DSTU ISO 11290-1: 2003 Microbiology of food products and animal feed. Horizontal method for detection and counting of *Listeria monocytogenes*. Part 1. Detection method [34].

We determined a_w water activity at a Hygrolab-2 device (Rotronic, Switzerland) at the room temperature with an accuracy of 1.5 %, 0.3 °C 0.005 units. Aw + 1.5 % of the value.

We performed assessment of the correspondence of organoleptic parameters to requirements of TU U 15.1-32122069-006: 2008 for experimental samples of sausages in terms of storage on a five-point scale [30].

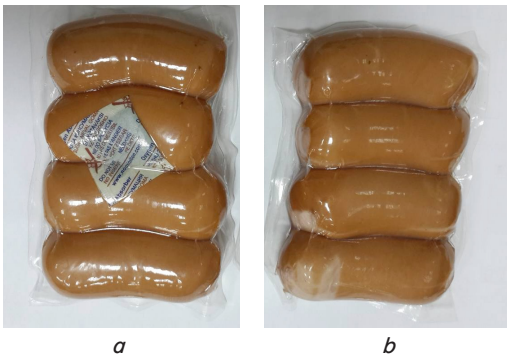
5. Results of studying the effect of pasteurization on the quality of sausage products in the process of storage

According to the conducted research plan for control samples of sausages pasteurized with and without an absorber of oxygen, we determined the following parameters at the stages of storage: a level of microbiological contamination, a value of moisture content, a_w, a change in organoleptic parameters, including the presence of syneresis (separation of moisture) in packed sausages.

Fig. 1, 2 show examples of "Extra" highest grade sausages and "Smachny" first grade sausages at the end of storage for 94 days.

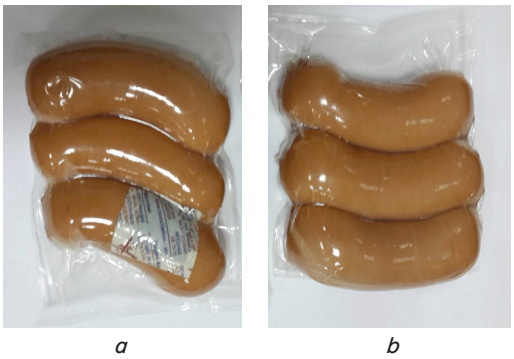
These sausages were made at Zhytomyr Meat Processing Plant (Ukraine) under TU U 15.1- 32122069-006: 2008 and were pasteurized in packaging with and without a sachet of oxygen absorber.

The pasteurized sausages met the requirements of TU U 15.1.-32122069-006: 2008 by organoleptic parameters. The use of multi-layer polymeric materials produced by Sirius Extrusion LLC (Ukraine) ensured hermeticity of the investigated samples (Fig. 1, 2) and absence of the syneresis effect – separation of moisture from sausages into a package. This proves that there were no significant changes in the quality of sausages subjected to re-pasteurization during storage up to 94 days. The stability of organoleptic parameters was consistent with the data on microbiological stability of sausages given below.



a *b*

Fig. 1. Physical appearance of pasteurized first grade sausages: *a* – with oxygen absorber; *b* – without oxygen absorber



a *b*

Fig. 2. Physical appearance of pasteurized highest grade sausages: *a* – with oxygen absorber; *b* – without oxygen absorber

Tables 2–5 show the results of microbiological studies of samples of sausages at storage stages.

We can see from Tables 2, 3 that the control samples of sausages met the requirements of normative documents microbiological indicators until day 35. This indicates the high barrier of used packaging materials.

The control samples (not pasteurized sausages) of both the high and the first grades did not meet the regulatory requirements for boiled sausages by the general content of MAFAM (Table 4) on day 65 day of storage. Therefore, we did not investigate non-pasteurized samples of sausages on day 94 day of storage according to microbiological parameters of Table 5.

Table 6 shows the values of moisture content and a_w water activity index of the samples of pasteurized sausages at the storage stages.

Table 2

Background values of microbiological contamination of sausage products on the first day of storage

Samples of sausages	MAFAM, CFU in 1 g	*Sulphitraucuronic clostridia*, in 1 g	*St.aureus*, in 1 g	*Escherichia coli* group bacteria, in 1 g	Pathogenic m/o, including *Salmonella*, in 25 g	*L. monocytogenes*, in 25 g of product
Sausages without pasteurization						
Sausages 1g	$4.5 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$3.5 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected
Pasteurized sausages without oxygen absorber						
Sausages 1g	$5.0 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$4.5 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected
Sausages pasteurized with oxygen absorber						
Sausages 1g	$3.5 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	<10	not detected	not detected	not detected	not detected	not detected

Table 3

Microbiological indicators of sausage products on day 35 of storage

Samples of sausages	MAFAM, CFU in 1 g	*Sulphitraucuronic clostridia*, in 1 g	*St.aureus*, in 1 g	*Escherichia coli* group bacteria, in 1 g	Pathogenic m/o, including *Salmonella*, in 25 g	*L. monocytogenes*, in 25 g of product
Sausages without pasteurization						
Sausages 1g	$6.4 \cdot 10^2$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$4.5 \cdot 10^2$	not detected	not detected	not detected	not detected	not detected
Pasteurized sausages without oxygen absorber						
Sausages 1g	$1.1 \cdot 10^2$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$9.0 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected
Sausages pasteurized with oxygen absorber						
Sausages 1g	<10	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$5.0 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected

Table 4

Microbiological indicators of sausage products on day 65 of storage

Samples of sausages	MAFAM. CFU in 1 g	*Sulphitraucuronic clostridia*, in 1 g	*St.aureus*, in 1 g	*Escherichia coli* group bacteria, in 1 g	Pathogenic m/o, including *Salmonella*, in 25 g	*L. monocytogenes*, in 25 g of product
Sausages without pasteurization						
Sausages 1g	$8.3 \cdot 10^4$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$2.1 \cdot 10^4$	not detected	not detected	not detected	not detected	not detected
Pasteurized sausages without oxygen absorber						
Sausages 1g	$2.1 \cdot 10^2$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$1.3 \cdot 10^2$	not detected	not detected	not detected	not detected	not detected
Sausages pasteurized with oxygen absorber						
Sausages 1g	$1.5 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$9.5 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected

Table 5

Microbiological indicators of sausage products on day 94 of storage

Samples of sausages	MAFAM, CFU in 1 g	*Sulphitraucuronic clostridia*, in 1 g	*St.aureus*, in 1 g	*Escherichia coli* group bacteria, in 1 g	Pathogenic m/o, including *Salmonella*, in 25 g	*L. monocytogenes*, in 25 g of product
Sausages pasteurized without oxygen absorber						
Sausages 1g	$2.7 \cdot 10^2$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$2.1 \cdot 10^2$	not detected	not detected	not detected	not detected	not detected
Sausages pasteurized with oxygen absorber						
Sausages 1g	$3.5 \cdot 10^1$	not detected	not detected	not detected	not detected	not detected
Sausages h/g	$1.2 \cdot 10^2$	not detected	not detected	not detected	not detected	not detected

Table 6

Indicators of water activity of pasteurized sausage products during storage

Samples of sausages	Day 35		Day 65		Day 94	
	Moisture content, %	a_w value	Moisture content, %	a_w value	Moisture content, %	a_w value
Sausages pasteurized without oxygen absorber						
Sausages 1g	67.60±0.21	0.964	67.70±0.25	0.965	67.68±0.25	0.971
Sausages h/g	72.70±0.27	0.959	72.60±0.021	0.966	72.68±0.24	0.977
Sausages pasteurized with oxygen absorber						
Sausages 1g	67.65±0.23	0.964	67.60±0.22	0.961	67.61±0.23	0.969
Sausages h/g	72.70±0.27	0.963	72.65±0.22	0.970	72.67±0.26	0.973

In the process of storage of packed pasteurized highest quality sausages, the moisture content of the samples varied within the statistical error, which indicates the constancy of the storage conditions of the investigated samples.

The a_w values for the samples of pasteurized sausages without oxygen absorber during storage increased in the range of 0.73 % for the first-grade sausages, and in the range of 1.88 % for the highest-grade sausages.

For pasteurized sausages with oxygen absorber, the increase in a_w value did not exceed 0.6 % for the first-grade sausages and 1.1 % for the highest-grade sausages. This indicates a higher stability of boiled sausage products pasteurized with the oxygen absorber.

Thus, we confirmed the efficiency of the use of the oxygen absorber during pasteurization for sausages pasteurized by a_w value and by the value of MAFAM.

6. Discussion of results of studying the influence of pasteurization modes and compositions of formulations on parameters of boiled sausages products

An analysis of the results of background microbiological contamination of sausage products with different types of heat treatment (Table 2) and the same indicators for day 35 of storage (Table 3) confirms the established feature.

Sausages without pasteurization and sausages pasteurized without oxygen absorber showed synchronous increase in microbiological contamination on day 35. For the control sample, this indicator made up $6.4 \cdot 10^2$ of the amount of MAFAM (the first grade) and $4.5 \cdot 10^2$ (the highest grade). For the sausages pasteurized without oxygen absorber – $9 \cdot 10^1$ and $1.1 \cdot 10^2$, respectively.

For the highest-grade sausages pasteurized with oxygen absorber, the background value was less than 10 of the amount of MAFAM, and it was 50 of the amount of MAFAM for the highest grade sausages and, respectively, 10 of the amount of MAFAM for the first grade sausages (background $3.5 \cdot 10^1$) on day 35.

These data confirm the practical stability of microbiological parameters with the use of pasteurization in combination with an absorber of oxygen up to 35 days.

We can explain this effect by the fact that there is intensification of the reaction of removal of residual oxygen in packaged products in the process of pasteurization with the oxygen absorber during heating. This creates an additional negative impact on existing residual forms of aerobic microorganisms by inhibiting their development. In this way, the effect of actual pasteurization intensifies.

On day 94 of storage, the highest-grade sausages pasteurized without the sachet-packet of oxygen absorber had the same level of microbiological contamination as the first-grade sausages on day 65 (Table 5).

This is consistent with idea of a potentially higher microbiological stability of the sausages of the highest-grade during storage in comparison with the sausages of the first grade, because there is a larger part of meat raw materials from processing of broiler chickens with larger background microbiological contamination.

According to the presented data, the use of the sachet with oxygen absorber in the process of pasteurization ensures preservation of indicators of microbiological contamination, which correspond to the background value, for the sausages on day 94 of storage. This proves the effect of synergy of re-pasteurization in the presence of the oxygen absorber.

We conducted an organoleptic assessment of the compliance of sausage products with the requirements of regulatory documents at stages of samples selection for microbiological analysis under conditions of a certified laboratory, at Zhytomyr Meat Processing Plant LLC (Ukraine).

All samples of the highest and first grade sausages, which were re-pasteurized, including up to 94 days of storage, met the requirements of boiled sausage products by the number of MAFAM (Table 5) according to TU U 15.1-32122069-006: 2008, which guaranteed their microbiological safety for consumption. The sausages also met qualitative requirements related to organoleptic parameters (physical appearance, color, taste, absence of syneresis) in addition to the safety indicator of the sausages, Fig. 1, 2.

On day 94 (Table 5), considering the dynamics of accumulation of microorganisms in the oxygen absorber relative to day 65 (Table 4), the potential time to reach the boundary normalized values of MAFAM could be 150 days. This assumption requires additional research into longer storage times.

However, already obtained results give us possibility to recommend short-term re-pasteurization in combination with the sachet of oxygen absorber to increase the shelf life of sausages. This will give possibility to achieve the microbiological stability of products in the traditional storage of sausage products more effectively.

In general, the effect of combination of re-pasteurization with the use of an oxygen absorber on stability of the fat-acid composition of products needs clarification. In addition, the possible direction of the study may be a search for technological solutions to increase terms of storage of sausage products of other production methods.

The aim of further research could be identification of possible regularities of spoiling of the fat component of boiled sausages and possible changes in their physical-and-chemical parameters when using re-pasteurization with active packaging elements. This will give a possibility to substantiate parameters of optimization modeling of methods for prolonging the terms of storage of sausage products of the emulsion type.

7. Conclusions

1. We proved that it is possible to increase the shelf life of pasteurized sausages up to 72 days, taking into account the stock-taking factor, using re-pasteurization for 15–20 minutes at 85–90 °C.

2. An analysis of the level of microbiological contamination of the sausages of different grades re-pasteurized simultaneously with the use of sachet packets of oxygen absorber confirms the effectiveness of this operation for the prolongation of storage life up to 94 days.

3. The obtained results of microbiological stability of sausages confirm the possibility of lengthening of the shelf life of boiled sausages with different formulation compositions using re-pasteurization.

4. We confirmed that the use of multilayer polymeric materials under traditional storage conditions gives possibility to prolong the shelf life of boiled sausage products with the use of vacuuming up to 35 days. And due to their barrier properties, it is possible to provide re-pasteurization in combination with the use of an oxygen absorber.

References

1. Tekhnolohiya miasa ta miasnykh produktiv / Klymenko M. M., Vinnikova L. H., Bereza I. H., Honcharov H. I. Kyiv, 2006. 640 p.
2. Bal-Prylypko L. V. Tekhnolohiya zberihannia, konservuvannia ta pererobky miasa. Kyiv, 2010. 469 p.
3. Use of repeated pasteurization for the production of boiled sausage products / Pasichnyi V. M., Khrapachov O. V., Ukrainets A. I., Marynin A. I., Lohvynenko N. P., Kapitula E. I. // Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. 2018. Vol. 20, Issue 85. P. 29–34. doi: https://doi.org/10.15421/nvlvet8506
4. Main aspects of using multilayer polymeric materials for pasterization and sterilization of products in the meat processing industry / Pasichnyi V., Ukrainets A., Khrapachov O., Marynin A. // Scientific Works of National University of Food Technologies. 2018. Vol. 24, Issue 4. P. 195–203. doi: https://doi.org/10.24263/2225-2924-2018-24-4-22
5. Robertson G. L. Food Packaging. Principles and Practice. CRC Press, 2012. 733 p.
6. Lee J. J. Sterilization effects of avian influenza virus and newcastle disease virus in chicken muscle and organs dependent on autoclaving time // Korean Journal of Veterinary Public Health. 2011. URL: http://agris.fao.org/agris-search/search.do?recordID=KR2012004468
7. Silva F. V. M., Gibbs P. A. Thermal pasteurization requirements for the inactivation of Salmonella in foods // Food Research International. 2012. Vol. 45, Issue 2. P. 695–699. doi: https://doi.org/10.1016/j.foodres.2011.06.018
8. Bal'-Prilipko L. V., Zadorozhniy V. I., Onishchenko L. V. Vliyanie razlichnyh faktorov na srok i kachestvo hraneniya myasnyh produktov // Myasnoe delo. 2006. Issue 8. P. 53–55.
9. Shahidi F. Natural Antioxidants. Chemistry. Health Effects and Applications. Champaign: AOCS Press, 1997. 432 p.
10. Ukrainets A., Pasichniy V., Zheludenko Yu. Antioxidant plant extracts in the meat processing industry // Biotechnologia Acta. 2016. Vol. 9, Issue 2. P. 19–27. doi: https://doi.org/10.15407/biotech9.02.019
11. Oleoresins effect on cooked poultry sausages microbiological stability / Ukrainets A., Pasichniy V., Zheludenko Yu., Zadkova S. // Ukrainian Food Journal. 2016. Vol. 5, Issue 1. P. 124–134.
12. McBride N. T. M., Hogan S. A., Kerry J. P. Comparative addition of rosemary extract and additives on sensory and antioxidant properties of retail packaged beef // International Journal of Food Science & Technology. 2007. Vol. 47, Issue 10. P. 1201–1207. doi: https://doi.org/10.1111/j.1365-2621.2006.01342.x
13. Analysis of the influence of rosemary and grape seed extracts on oxidation the lipids of peking duck meat / Bozhko N., Tischenko V., Pasichnyi V., Marynin A., Polumbryk M. // Eastern-European Journal of Enterprise Technologies. 2017. Vol. 4, Issue 11 (88). P. 4–9. doi: https://doi.org/10.15587/1729-4061.2017.108851
14. Investigation of the factors of shelf-life prolongation for meat and meat-containing products / Pasichniy V., Geredchuk A., Moroz O., Yastreba Yu. // Scientific Works of National University of Food Technologies. 2015. Vol. 21, Issue 4. P. 224–230.
15. Dixon J. Packaging Materials 9: Multilayer Packaging for Food and Beverages. ILSI, 2011. 48 p. URL: http://ilsi.eu/wp-content/uploads/sites/3/2016/06/ILSI-11-011-9-pack-03.pdf
16. Vinnikova L. G., Prokopenko I. A. The application of high pressure as an alternative to thermal processing of poultry meat // Eastern-European Journal of Enterprise Technologies. 2015. Vol. 3, Issue 10 (75). P. 31–36. doi: https://doi.org/10.15587/1729-4061.2015.44241
17. Vyznachennia terminu zberihannia shynky z miasa ptytsi, vyhotovlenoi atermichnym obroblenniam / Vinnikova L., Shlapak H., Prokopenko I., Hlushkov O. // Scientific Works. 2018. Issue 48. P. 119–123. URL: https://journals.gsjp.eu/index.php/swonaft/article/view/799/723
18. Mohammed H. N. Study of some chemical, physical, sensory and bacteriology characteristics of canned chicken meat imported to Sulaymaniyah markets, Iraq // International Journal of nutrition and Metabolism. 2013. Vol. 5, Issue 7. P. 128–133. URL: http://www.academicjournals.org/app/webroot/article/article1379686298_Mohammed.pdf
19. Development of meat-containing minced semi-finished products based on the locally produced raw materials / Bozhko N., Tischenko V., Pasichnyi V., Polumbryk M., Haschuk O. // Eastern-European Journal of Enterprise Technologies. 2018. Vol. 4, Issue 11 (94). P. 49–54. doi: https://doi.org/10.15587/1729-4061.2018.140052
20. Rynok miasa ptytsi v Ukraini. URL: http://www.poultryukraine.com/data/file/analytics/ptica_yanvar_maj_2017.pdf
21. Impact of pulsed electromagnetic field on escherichia coli vitality in model solution of milk serum / Svyatnenko R., Marynin A., Kochubej-Litvinenko O., Zakharevych V. // Scientific Messenger of LNU of Veterinary Medicine and Biotechnology. 2016. Vol. 18, Issue 2. P. 92–95. doi: https://doi.org/10.15421/nvlvet6818
22. Development of combined protein-fat emulsions for sausage and semifinished products with poultry meat / Pasichnyi V. M., Marynin A. I., Moroz O. O., Heredchuk A. M. // Eastern-European Journal of Enterprise Technologies. 2015. Vol. 1, Issue 6 (73). P. 32–38. doi: https://doi.org/10.15587/1729-4061.2015.36232

23. A study of the effect of enriched whey powder on the quality of a special-purpose bread / Ukrainets A., Kochubei-Lytvynenko O., Bilyk O., Zakharevych V., Vasylchenko T. // Eastern-European Journal of Enterprise Technologies. 2016. Vol. 2, Issue 11 (80). P. 32–41. doi: https://doi.org/10.15587/1729-4061.2016.65778
24. The use of albuminous preparations of animal origin is in technology of hams / Kishenko I. I., Kryzhova Y. P., Linkevich M. V., Krupska A. A. // Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. 2015. Vol. 17, Issue 4. P. 54–59.
25. Shubina G. Vydelenie vlagi v upakovkah gotovyh myasnyh produktov: prichiny i puti resheniya problemy // Myasnoy biznes. 2015. Issue 2. P. 26–28.
26. Usatenko N. F., Kryzhska T. A. Zberihannia ta pererobka produktsiyi. Vykorystannia pokaznyka «aktyvnist vody» v tekhnolohiyi vyrobnytstva miasoproduktiv // Visnyk ahrarnoi nauky. 2012. Issue 5. P. 62–65.
27. Benderska O., Levkivska T., Bessarab A. Technological aspects of «water activity» indicator and its influence on the quality of tomato souss // International scientific journal Internauka. 2018. URL: https://www.inter-nauka.com/uploads/public/15278745764128.pdf
28. TU U 15.1-31923621-002:2010. Vyroby kovbasni vareni, sosysky, sardelky, zapakovani pid vakuumom v polimerni bahatosharovi materialy «Kriovak»(«CRYOVAC») pasteryzovani.
29. TU U 563/46.05407953.60-98. Vyroby kovbasni ta kopchenosti miasni, zapakovani pid vakuumom v polimerni plivkovi bahatosharovi termozsidalni materialy «Kriovak» («CRYOVAC»).
30. Antipova L. V., Glotova I. A., Rogov I. A. Metody issledovaniya myasa i myasnyh produktov. Moscow: Kolos, 2001. 576 p.
31. DSTU 8446:2015. Produkty kharchovi. Metody vyznachennia kilkosti mezofilnykh aerobnykh ta fakultatyvno-anaerobnykh mikroorhanizmiv. Kyiv, 2015. 16 p.
32. DSTU ISO 4833:2006. Horyzontalnyi metod pidrakhunku mikroorhanizmiv. Tekhnika pidrakhuvannia koloniy za temperatury 30 °C (ISO 4833:2003, IDT). Kyiv, 2008. 7 p.
33. DSTU ISO 6579. Mikrobiolohiya kharchovykh produktiv i kormiv dlia tvaryn. Metodyka vyiavlennia Salmonella spp (ISO 6579:2002, IDT).
34. DSTU ISO 11290-1:2003. Mikrobiolohiya kharchovykh produktiv ta kormiv dlia tvaryn. Horyzontalnyi metod vyiavlennia ta pidrakhuvannia Listeria monocytogenes. Chastyna 1. Metod vyiavlennia.