

INFLUENCE OF MODERN VACUUM PACKAGING ON QUALITY AND SAFETY OF SAUSAGE PRODUCTS

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Summary. The necessity to provide the quality and safety of the product during storage, transportation and sale is determined not only strict observance to veterinary and sanitary measures, but has also forced manufacturers to look for modern packaging methods that meet the claimed requirements. The system of vacuum packaging into the food gas is widely used modern type of packaging — 'Modified Atmosphere Packaging' (MAP). The special feature of MPA is to substitute the air in the package with a mixture of gases (oxygen, carbon dioxide and nitrogen), the ratio of which, especially O₂, depends on the type of packaged product. Low oxygen level prevents the development and reproduction of fungus, bacterium and other microorganisms. The use of a modified gas atmosphere allows you to maintain the quality, taste and the product's appearance, increase shelf life.

The aim of this work has been to carry out the influence of modern vacuum packaging on quality and safety of the sausage products and to install the shelf life term of the ready product in the conditions of packaging into modified gas mixture (carbon dioxide, nitrogen and oxygen) and shrink wrap under vacuum.

The automatic line 'Multivak' has been used for packing of sausage products in the modified gas mixture. Experimental studies have been carried out during the use a gas mixture, which has been consisted of carbon dioxide (30%), nitrogen (40%) and oxygen (30%).

The use of vacuum packaging machines 'Cryovac' and 'Supervak' has provided the reliable sealing of sausage products in a shrink-wrap under vacuum (vacuum depth 9 mbar).

In article terms of realization of sausage products in the natural coating, that are packed in a modified gas mixture (carbon dioxide, nitrogen and oxygen) and the shrink wrap under vacuum with the storage conditions at the temperature 4 ± 1 °C and the relative humidity $85 \pm 2\%$ have been detected. It has been defined that the use of the modified gas mixture extends the implementation terms of sausage products in the natural coating from 7 to 20 days. The use of the automatic packing line 'CrioVac' and 'Supervak' for the packaging of products in the shrink-wrap at vacuum (9 mbar) allows prolonging shelf life of sausage products in the natural coating from 7 to 15 days.

Keywords: sausage products, packaging, vacuuming, modified gas mixture

Introduction. The meat industry has a great economic importance, because it is designed to provide the population with high quality and safe products: meat, sausage, meat-canned food, products for children and dietary foods, semi-finished products, etc. (Agulnik and Teternik, 1971; Karmas, 1981).

One of the main reasons of the extreme decreasing of the quality and food value of sausage products is the violation of optimal temperature regimes during the storage period, transportation and sale (Münch et al., 1985; Marmuzova, 2006). The storage condition violation for meat and meat products tends to quick microbiological spoilage. Even the short-term presence of products in the air, which contains pathogenic or conditionally pathogenic bacteria, is completely enough to contaminate them (Shmarina, Ryaskova and Rodionova, 2016; Rodionova and Paliy, 2017). Microorganisms, that contaminate products, worsen the product's appearance, reduce its taste, because of changes in proteins and fats, but provoke food poisoning, dysbacteriosis, allergic reactions, and metabolic disorders in humans due to the ability to produce various toxins. In addition, many types of mold, even at low storage temperature, form mycotoxins that

intrude into the product. In this case, the removal of mold from the product surface does not exclude the presence of dangerous metabolites (Protchenko, 2002; Agul'nik and Korneyev, 1972; Hultman et al., 2015).

The necessity to provide the quality and safety of the product during storage, transportation and sale is determined not only strict observance to veterinary and sanitary measures (Rodionova and Paliy, 2016; Paliy and Rodionova, 2017), but has also forced manufacturers to look for modern packaging methods that meet the claimed requirements. The system of vacuum packaging into the food gas is widely used modern type of packaging (Shuba, 2008; Kostenko, Gutnik, and Iskakov, 2009; Kainash, Ofilenko and Burbak, 2014).

The technology of product preserving with the help of modified gas atmosphere has received the common English name 'Modified Atmosphere Packaging (MAP)'. The special feature of MPA is to substitute the air in the package with a mixture of gases (oxygen, carbon dioxide and nitrogen), the ratio of which, especially O₂, depends on the type of packaged product. Low oxygen level prevents the development and reproduction of fungus, bacterium and other microorganisms. MPA is the natural

and environmentally friendly technology of product preservation. The use of a modified gas atmosphere allows you to maintain the quality, taste and the product's appearance, increase shelf life (Cachaldora et al., 2013; Hur et al., 2013).

Therefore, using of modern vacuum technologies to vacuum sausage and meat is the promising technology in the food industry all over the world (Potekha, Potekha and Kurilo, 2016; Buzoverov and Postnikova, 2013; Semyenova et al., 2013).

The aim of the work has been to carry out the influence of modern vacuum packaging on quality and safety of the sausage products and to install the shelf life term of the ready product in the conditions of packaging into modified gas mixture (carbon dioxide, nitrogen and oxygen) and shrink wrap under vacuum.

Materials and methods. Experimental studies has been carried out in the Laboratory of Veterinary Sanitation and Parasitology of the National Scientific Center 'Institute of Experimental and Clinical Veterinary Medicine' (Kharkiv, Ukraine), Meat Processing Enterprise 'X' and the Department of Infectology, Quality and Safety of Agricultural Products of the Luhansk National Agrarian University (Kharkiv, Ukraine), respectively to the existing standard documents in accordance to generally accepted methods applied on the state level in Ukraine (DSTU 4436:2005).

The objects of the study have been sausages in the edible coating, which have been packed in a modern shrink-wrap in vacuum and modified gas mixture.

The automatic line 'Multivak' has been used for packing of sausage products in the modified gas mixture. Experimental studies have been carried out during the use a gas mixture, which has been consisted of carbon dioxide (30%), nitrogen (40%) and oxygen (30%).

The use of vacuum packaging machines 'Cryovak' and 'Supervak' has provided the reliable sealing of sausage products in a shrink-wrap under vacuum (vacuum depth 9 mbar).

Results and discussion. In order to study the influence of modern vacuum packaging on the quality and safety of sausage products and to install the shelf life term for the ready products in the conditions of packing into modified gas mixture (carbon dioxide, nitrogen and oxygen) and shrink wrap under vacuum, all experimental sausages have been divided into three groups:

1st group (packed in a modified gas mixture (carbon dioxide, nitrogen and oxygen) — 'Varena z molokom' 1st class, 'Dytiachia' highest class, 'Sosysky bavarsky' highest class, 'Sosysky molochni' 1st class;

2nd group (packed in a shrink wrap under vacuum) — 'Varena s molokom' 1st class, 'Doctorska' highest class, 'Dytiachia' highest class;

3rd group (control) — 'Varena z molokom' 1st class, 'Doctorska' highest class, 'Dytiachia' highest class,

'Sosysky molochni' 1st class, 'Sosysky bavarsky' highest class.

The samples have been saved in the refrigerator at the 4 ± 1 °C temperature and $85 \pm 2\%$ relative humidity.

Microbiological, organoleptic, physical and chemical studies of sausages have been carried out for 25 days to establish the optimal terms, storage conditions and temperature regimes.

Before making the experiment, microbiological studies have been carried out to determine the accordance of the experimental samples with the requirements of DSTU 4436:2005.

In accordance with DSTU 4436:2005 according to microbiological parameters, sausage products must meet the requirements that are given in Table 1.

It has been established that the number of mesophilic aerobic and facultative-anaerobic microorganisms (MAFAnM) in 1 g of experimental sausage products at the time of the end of the technological process was:

'Varena z molokom' — 1.15×10^2 CFU/g,

'Doctorska' — 1.1×10^2 CFU/g,

'Dytiachia' — 1.3×10^2 CFU/g,

'Sosysky molochni' — 1.1×10^2 CFU/g,

'Sosysky bavarsky' — 9.0×10^2 CFU/g.

In the microbiological study of the first group of sausages (Fig. 1), the microbial composition of experimental product has remained at the original level for 5 days. The moisture mass concentration of the researched samples decreased in average in 3% on the 5th day, which is in 6 times less compared with the control.

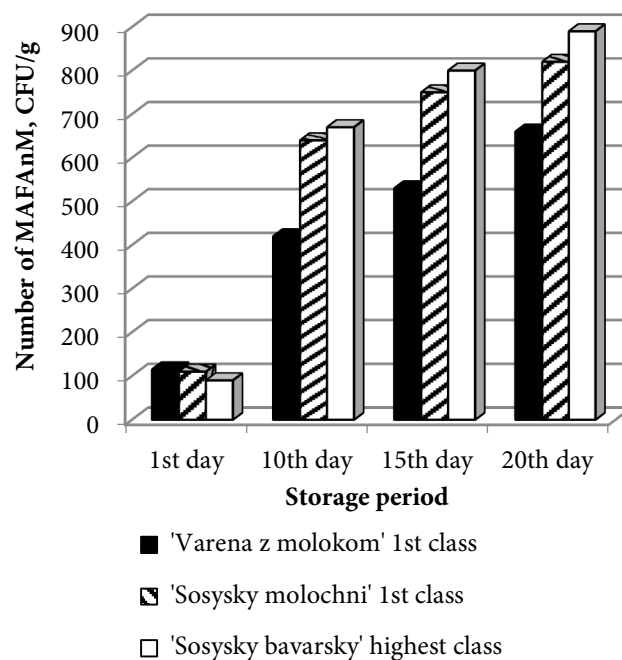


Figure 1. Dynamics of the development of MAFAnM in sausage products packed in modified gas mixture (carbon dioxide, nitrogen and oxygen)

Table 1 —Microbiological indicators of sausage products

Name of the index	Standard			Method of control
	Boiled sausages of the highest, 1 st and 2 nd classes, frankfurters, sardellas, meat loaves	Boiled sausages of the 2 nd class with the use of cereals, meatmass, meat by-products	Boiled sausages of the 3 rd class	
Number of mesophilic aerobic and extra-anaerobic microorganisms, CFU/g of product, not more	1.0×10^3	2.5×10^3	5.0×10^3	According to GOST 9958-81
Pathogenic microorganisms, in particular bacteria of the genus <i>Salmonella</i> , in 25 g of product	Not allowed			According to GOST 9958-81 or DSTU 12824:2004
Bacteria of the group of intestinal sticks (BGKP), in 1 g of product				According to GOST 9958-81
Sulphide reductant <i>Clostridia</i> : in 0.01 g of product or in 1 g of product for vacuum packed				
Coagulase-positive <i>Staphylococci</i> in 1 g of product for children and dietary foods				
<i>Staphylococcus aureus</i> in 1 g of product				According to GOST 10444.2-94 or DSTU 6888-1 or DSTU 6888-2
<i>Listeria monocytogenes</i> , in 25 g of product				According to DSTU 11290-1 or DSTU 11290-2

On the 10th days from the beginning of the study, in accordance with the results of microbiological studies, it has been found that the amount of MAFAnM in the experimental samples is:

‘Varena z molokom’ — $4.2 \pm 0.46 \times 10^2$ CFU/g,

‘Sosysky molochni’ — $6.4 \pm 0.26 \times 10^2$ CFU/g,

‘Bavarsky sosysky’ — $6.7 \pm 0.32 \times 10^2$ CFU/g.

Pathogenic microorganisms have not been detected. According to the results of organoleptic studies, the smell and taste are up to quality of these types of product. The experimental rolls of sausage products have the clean lightly damp surface. Consistency is elastic. The specific smell of the gas mixture disappears within 3–5 seconds. The moisture mass concentration of the researched samples has dropped in general in 3.4%.

According to the results of microbiological research on the 15th day of storage of this experimental group samples, it has been determined that the amount of MAFAnM in the experimental samples is:

‘Varena z molokom’ — $5.3 \pm 0.25 \times 10^2$ CFU/g,

‘Sosysky molochni’ — $7.5 \pm 0.31 \times 10^2$ CFU/g,

‘Bavarsky sosysky’ — $8.0 \pm 0.22 \times 10^2$ CFU/g,

which is in 4.6, 6.8, and 8.9 times more than at the beginning of the experiment. The analysis of the MAFAnM amount, which has been made on the 10th day

and 15th day of storage, concluded that the MAFAnM amount in the experimental samples increased in average in 18.2% during the 5-days period. Pathogenic microorganisms have not been detected. As the result of organoleptic studies, all the experimental samples meet the requirements of DSTU 4436:2005. The moisture mass concentration of experimental samples decreased more in 0.3%.

At the 20th day, the number of MAFAnM has been increased in average in 7.5 times.

Pathogenic microorganisms have not been detected. According to the results of organoleptic studies the deviations from standard indicators (DSTU 4436:2005) are not detected. The specific smell of the gas mixture disappears within 5–10 seconds. On the packing surface there it appeared single evaporations droplets. The moisture mass concentration of the experimental samples decreased in 4.1%.

At 22nd day of the research on the packing surface there were droplets of dew, as a result of the interaction of the residual amount of oxygen with a food gas mixture. The surface of sausage products had an extraneous smell.

Therefore, as a result of the carried out research it has been established that during the packaging of sausage products in the modified gas mixture at the automatic

packing line 'Multivak', the realization terms of sausages in the natural coating could be extended up to 20 days under provided preserve condition at 4 ± 1 °C temperature and $85 \pm 2\%$ relative humidity.

The microbial composition also has remained at the original level in the second group of sausages in a vacuum package during 5-days storage (Fig. 2).

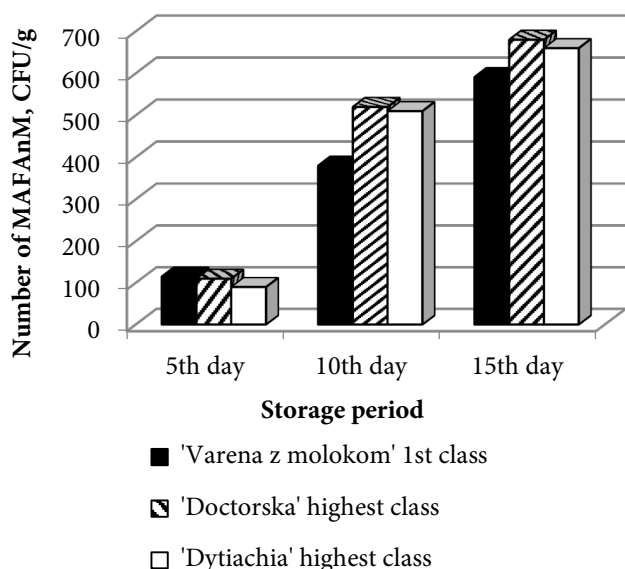


Figure 2. Dynamics of development of MAFAnM in sausages during storage in vacuum packaging

On the 10th days after the beginning of the study, according to the results of microbiological studies, it has been found that the amount of MAFAnM in the experimental samples is:

'Varena z molokom' — $3.8 \pm 0.16 \times 10^2$ CFU/g,

'Doktorska' — $5.2 \pm 0.41 \times 10^2$ CFU/g,

'Dytiacha' — $5.1 \pm 0.15 \times 10^2$ CFU/g.

Pathogenic microorganisms have not been detected. According to the results of organoleptic studies, the smell and taste are up to quality of these types. Shrink wrap sticks tightly to the rolls. The structural integrity of the seal is not damaged. The content of the broth under the wrap is absent. The consistency of sausage rolls is elastic. The specific smell of the gas mixture disappears within 3–5 seconds. The moisture mass concentration of the experimental samples decreased for 3.4%.

At the 15th day, the number of MAFAnM is increased in sausages: 'Varena z molokom' and 'Dytiacha' in 5.1 times, and 'Doktorska' in 6.2 times respectively. Pathogenic microorganisms have not been detected. According to the results of organoleptic studies, it has been found that the color of the sausage rolls 'Doktorska' has changed from pink to pale-pink that indicates about the decomposition of sodium nitrite.

The moisture mass concentration of the experimental samples decreased in 5.4%, which is in 1.8 times more than the first experimental group, but 3.3 times less than the control one.

According to the results of the organoleptic study of sausages of the second group at the 17th day of storage, it has been found that the sausage 'Doctorska' highest class a greenish tinge on the cut surface due to the decomposition of sodium nitrite under the light influence during the storage. In all experimental samples there is the separation of the broth under the shrink-wrap, due to the product losses the vacuum and, consequently, it losses of the commercial appearance of the test specimens.

Making the analysis of the obtained results presented in Fig. 2 it was established that the packaging sausages in a shrink wrap under vacuum, thanks to the automatic packing line 'Criovak' and 'Supervak', allows extend the shelf life of sausage products in natural coating for up to 15 days provided preserved condition at 4 ± 1 °C temperature and $85 \pm 2\%$ relative humidity.

As a result of the microbiological study of sausage products in the natural coating (Fig. 3) in storage conditions at 4 ± 1 °C and $85 \pm 2\%$ of relative humidity, it has been found that during 3 days in the given temperature, the total amount of bacteria in 1 g of sausages 'Varena z molokom' 1st class, 'Doctorska' highest class, 'Dytiacha' highest class has remained at the original level.

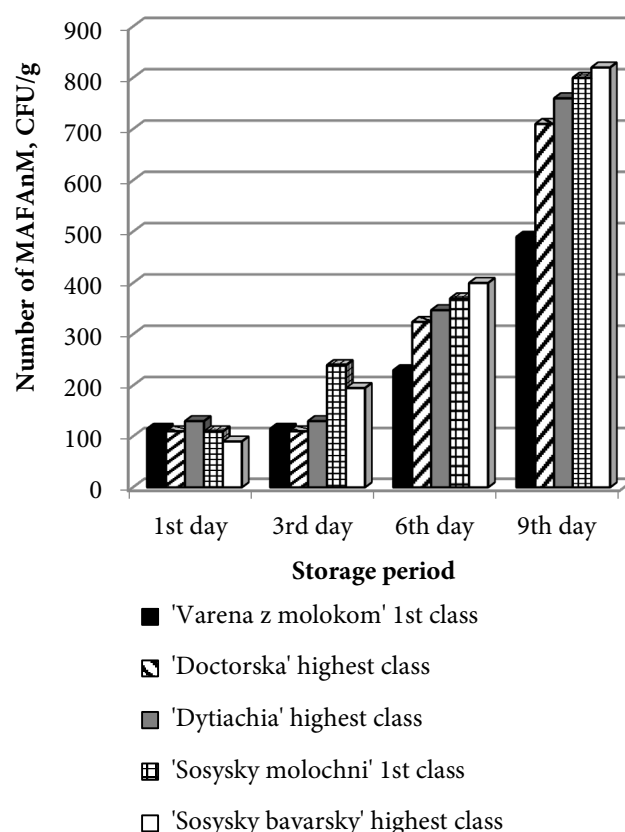


Figure 3. Dynamics of development of MAFAnM in sausage products without packaging

In the sausage products 'Molochni sosysky' and 'Sosysky bavarski' at 3rd day the total amount of MAFAnM has been $2.4 \pm 0.12 \times 10^2$ and $1.95 \pm 0.27 \times 10^2$ CFU/g,

respectively. According to the results of organoleptic studies the deviations from standard parameters (DSTU 4436:2005) were not detected. The moisture mass concentration has in average decreased in 3%.

Making the analysis of the microbiological data which were obtained at 6th day of storage at the given temperature, it was determined that the number of MAFAnM is in average in 3 times higher than at the beginning of the experiment. Pathogenic microorganisms have not been detected. During the organoleptic studies has found that the smoked smell is light, the surface of sausage rolls is slightly wrinkled. The moisture mass concentration of the researched sausages has in average decreased in 18%.

In accordance with the results of bacteriological research the amount of MAFAnM increased in sausages 'Varena z molokom' — in 4.2 times, 'Doktorska' — in 6.4 times, 'Dytiacha' — in 5.8 times, 'Sosysky bavorski' and 'Sosysky molochni' — in 9.0 and 7.2 times respectively at the 9th day. Bacteria of the *Escherichia coli* group (BGKP) have been detected during the analysis on presence of pathogenic microorganisms in the experimental samples of sausages.

During the organoleptic study of control group sausages the extraneous smell has been detected at the 9th day. The sausages surface is sticky. Molds and BGKP has been found during the study of the swabs from the sausages surface.

The moisture mass concentration of the researched sausages has in average decreased in 22%, at the 9th day which is almost in 6 times more than in the first and second control groups.

As a result of the study which were carried out in the control group of sausages, it was found that during the storage of sausages in the natural coating at 4 ± 1 °C temperature and $85 \pm 2\%$ of relative humidity, its shelf life period is 7 days.

According to the results of scientific research the Ukrainian patent for utility model No. 119865 'Method of food packaging' (Rodionova, Paliy and Brahinet, 2017) were received.

Conclusions. Nowadays vacuum packaging and modified atmosphere packaging are the most up-to-date ways to maintain the quality and food freshness.

The packaging of sausages in the natural coating in modified atmosphere mixture (carbon dioxide, nitrogen and oxygen) by the automatic packaging 'Multivak' extends its shelf life from 7 to 20 days at storage conditions of 4 ± 1 °C temperature and $85 \pm 2\%$ of relative humidity.

The packaging of sausages in vacuum shrink wrap thanks to the automatic packing line 'Criovak' and 'Supervak' allows extend the shelf life of sausage products in the natural coating from 7 to 15 days at 4 ± 1 °C storage temperature and $85 \pm 2\%$ of relative humidity.

It has been established that the use of modern vacuum packaging could prevent the losses of the finished product's weight in 6 times compared with the control group.

Using of the modern vacuum packaging, allows to create the high barrier for oxygen, that prevents from microbial contamination, saves the casings protect against breakage, punctures and other mechanical damages, which in reduces the possibility of contaminating products with pathogenic microflora.

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