WYŻSZA SZKOŁA SPOŁECZNO-PRZYRODNICZA
IM. WINCENTEGO POLA W LUBLINIE

DEVELOPMENT OF NATURAL SCIENCES IN COUNTRIES OF THE EUROPEAN UNION TAKING INTO ACCOUNT THE CHALLENGES OF XXI CENTURY

Collective monograph

The book is compiled by:
prof. dr hab. Witold Kłaczewski,
doc. Henryk Stefanek,
dr n. biol. Małgorzata Gorzel

Lublin, Poland
2018

Recommended for publication
by the Academic Council of Vincent Pol University in Lublin

The authors of articles usually express their own opinion, which is not always comply with the Editorial Board's opinion. The content of the articles is the responsibility of their authors.

Development of natural sciences in countries of the European Union taking into account the challenges of XXI century: Collective monograph. Lublin : Izdevnieciba "Baltija Publishing", 2018. 480 p.

ISBN 978-9934-571-41-1

CONTENTS

Гени контролю темпів розвитку *Glycine max* (L.) Merril
як фактори регуляції процесів калусогенезу та мофогенезу *in vitro*
Авксентьєва О. О.....1

The rare and biotechnologically important mushroom species
in the IBK collection
**Bisko N. A., Mytropolska N. Y., Mykchaylova O. B.,
Lomberg M. L., Al-Maali G. A 21**

The possibility to correct of post-traumatic stress disorder by natural factors
Bobro E. V., Tronko S. P 38

Study on efficiency of natural antioxidant preparations
in the technology of meat and meat-containing products with duck meat
Bozhko N. V., Pasichnyi V. M. 58

Biofilm formation of staphylococci:
modeling of related processes and correction of them
Voronkova O. S., Voronkova Yu. S. 78

Sulfur-reducing bacteria *Desulfuromonas acetoxidans*
IMV B-7384 under the influence of heavy metal ions
Hnatush S. O., Maslovska O. D..... 98

Formation of professionals training system in the field of waste management
Holik Yu. S., Illyash O. E.....123

Hybrid fund of decorative weeping apple trees of the N. N. Gryshko
National Botanical Garden (Kiev): history, morphobiological peculiaryties
and perspectives of use
Goncharovskaya I. V., Klymenko S. V. 145

DNA Barcoding for genotyping of insects listed
in the Red Book of the Republic of Belarus
Dromashko S. E., Balashenko N. A. 165

The fauna of *Rotatoria* and microcrustaceans (*Cladocera, Copepoda*)
of the Ukrainian roztocze and its surroundings
Ivanets O. R.....183

The efficiency of combined use of inoculation and EM-technologies
in the cultivation of legumes
Kononchuk O. B., Pyda S. V. 197

Complex baking improver based on dry milk whey enriched with magnesium and manganese
Kochubei-Lytvynenko O. V., Bilyk O. A. 216

Spontaneous sourdough technology for bakeries and catering establishments
Lebedenko T. Ye., Kozhevnikova V. O. 235

Assessment of the viability and toxicological sustainability of invasive fish species of Zaporizke (Dnipro) reservoir (Ukraine) in contemporary environmental conditions
Marenkov O. M., Holoborodko K. K., Voronkova Yu. S., Kovalchuk Yu. P. 256

Biochemical and histological adaptation of marmorkrebs *Procambarus virginalis* (Lyko, 2017) (Decapoda, Cambaridae) to manganese, nickel and lead ions pollution
Marenkov O. M 299

Emergent properties and propagation pathways of the PEDV field isolate in the model experiment
Masiuk D. M., Sosnitskiy O. I., Nedzvetsky V. S., Kokarev A. V. Koliada S. G. 330

Comprehensive food safety and quality assessment of plasma-chemically activated water usage
Mykolenko S. Yu., Pivovarov O. A., Honcharova O. V. 356

Биохимические защитные реакции злаковых растений
Молодченкова О. О.....397

Catabolites of thiamine: biochemical functions
Petrov S. A., Nikolaienko K. V. 417

Фотопериод как фактор регуляции роста и развития сои (*Glycine max* (L.) Merr.)
Хайдер Набил Хусейн Аль-Хамадени, Жмурко В. В. 435

Bioenergetic potential of swichgrass and sweet sorghum on the reclaimed lands
Kharytonov M. M., Babenko M. G., Martynova N. V., Rula I. V., Klimkina I. I.....453

STUDY ON EFFICIENCY OF NATURAL ANTIOXIDANT PREPARATIONS IN THE TECHNOLOGY OF MEAT AND MEAT-CONTAINING PRODUCTS WITH DUCK MEAT

Bozhko N. V., Pasichnyi V. M.

INTRODUCTION

The length of storage of meat products can be increased by the use of low temperatures, modern packaging materials, nutritional supplements, etc. These technological techniques create a barrier to penetration and development of undesirable microorganisms in the product for a long time. But a significant decrease in the quality and nutritional value of meat products in the process of storage can also occur due to oxidative damage, during which the oxidation of the lipid fraction occurs. Initiating and accelerating this process can disrupt modes during storage, transportation and implementation.

The oxidation of lipids affects the finished product quality, contribute to loss of color, flavour, smell and reduce the shelf life. During the oxidation of fats, various degradation products are formed: free acids, in particular, their transisomers, oxygen-containing derivatives, aldehydes, ketones, peroxides, many of which are toxic substances. Significantly to slow down oxidation is possible only with the addition of antioxidants.

Antioxidants are natural or identical natural functional substances that take part in various metabolic processes, synthesize and convert biologically active metabolites, and, moreover, can either themselves inhibit the oxidation of active chemicals in human body cells or provide the necessary activity of the antioxidant system of the organism – a universal regulatory system that controls the level of free radical oxidation reactions and prevents the accumulation of toxic oxidation products[1].

The most of meat and meat-containing products are emulsified the one, whose structure may differ in the presence of air cavities, which intensify the oxidation within the product under the action of oxygen in the air. Catalysts of oxidation are also metals of variable valence, including iron in the composition of hem pigments of meat. The rate of oxidation also affects the composition of the main raw material in the product.

[1] Shahidi F. Natural Antioxidants. Chemistry, Health Effects and Applications. Illinois, 1997. 414 p.

1. Literature review and problem statement

The most common way of solution for the problem of oxidative deterioration of meat products and, consequently, extending the shelf life, is the use of a variety of antioxidant food additives that can purposefully regulate the oxidation processes in lipid fraction of meat and meat-containing systems.

Antioxidants are divided into two groups of origin: synthetic and natural. The most widely distributed among food artificial individual antioxidants are derivatives of phenols. Butylated hydroxyanisole (E320, BHA) began to be used as one of the first to prevent the oxidation in animal fried fats, salty spokes, dehydrated milk, mixtures for cupcakes and concentrates of soups. Butylated hydroxytoluene (E321, BHT) is allowed to be added to animal fats for prolongation the shelf life. Safety requirements limit the maximum level of individual antioxidants in fat products. This level, for example, for BHA is 200 mg/kg of the fat phase of the product, and for BHT – 100 mg/kg of the fat phase of the product. Also, isoascorbic acid (E 315) is widely used.

However, with the development of modern technology, world society is reorienting to a new level of perception of meat products. That is why the main directions of development and trends of the modern world meat processing industry are the production of environmentally safe products with a minimized content of food additives. For this reason, there is now an intensive search for natural products that not only store the product from various types of spoilage, including oxidative, but also are additional valuable nutritional factors. Particularly perspective components for use as both bioprotectors and preservatives are various biologically active substances and their complexes.

Studies are conducted in several directions. There are many works on extracts of medicinal plants – flour mill, St. John's Wort, oak bark, alder fruits, dihydroquercetin (belongs to the group of vitamin P, isolated from Siberian larch) that slow down hydrolytic and oxidative processes in meat products. The antioxidant efficiency of these extracts is explained by the features of chemical composition and concentration of biologically active substances, namely, the high total content of phenolic compounds, tannins and free organic acids[2].

[2] Толкунова Н.Н. Влияние растительных экстрактов на окислительные процессы в паштете. *Мясная индустрия*. 2002. № 7. С. 26–27.

O.N. Samozvon and others[3] studied the possibility of using vegetable supplements from the fruits of alder and sea buckthorn as antioxidants in the production of meat chopped semi-finished products. It was found that with the addition of additives in the minced meat improves the juiciness by increasing the binding of water, which is associated with the chemical composition of plants. Storage of samples for 6 days resulted in an increase in peroxide value of the control sample by 15,4% compared to the experimental one. The acid value of model samples with the additive was 10,8% less than the control. Thus, the authors have proved the inhibition of lipolytic and oxidative processes with substances that are part of the sea buckthorn and alder fruits.

I.V. Kochieva[4], E.E. Plotnikov[5] studied the effectiveness of thistle for improving the quality and increase the shelf life of sausages and fats. In the conducted studies, the authors found that the shelf life of sausages made from poultry mechanically separated meat was a normative documentation of 15 days at a temperature of 6°C. But after 5 days of storage, the peroxide value of control samples exceeded 0,1% J_2. The use of thistle extract in the maximum allowable dose (40 mg/100 g minced meat) allowed to slow down undesirable processes – the peroxide value in the experimental sausages reached a critical level only after 10 days. The antioxidant effect is explained by the presence in the thistle extract of phenolic compounds, including flavonoids and phenol acids.

Many studies in this area have been conducted by G.V. Gurinovich[6]. In her works she studied the use of dihydroquercetin (DHQ) to increase the shelf life of meat semi-finished products. DHQ belongs to the group of

---

Самозвон О.Н., Бондаренко Н.Г., Пивовар А.К., Никитченко Ю.В. Изучение возможностей применения добавки из плодов ольхи в качестве антиоксиданта при производстве мясных фаршей. *Збірник наукових праць Луганського національного аграрного університету*. Луганськ, 2008. № 87. С. 194–205.

[3] Токаев Е.С., Новаков Р.А., Дегтярев П.С. Использование дигидрокверцетина в качестве натурального антиокислителя. *Мясная индустрия*. 2003. № 10. С. 27–28.

[4] ПАТ. 79879. Україна, МПК (A23L 1/29 (2006.01) u 2012 10153. Спосіб одержання функціональної добавки «Мальтовін» / О.М. Савінок, І.О. Літвінова. Бюл. № 9; Заявлено 27.08.2012; опубл. 13.05.2013. 6 с.

[5] Плотников Е.Е., Глазова Г.В. и др. Растительные антиоксиданты в производстве мясных изделий. *Мясная индустрия*. 2010. № 7. С. 26–28.

Гуринович Г.В., Лисин К.В., Потипаева Н.Н. Препарат для п родления срока годности мясных полуфабрикатов. *Мясная индустрия*. 2005. № 2. С. 31–33.

Гуринович Г.В., Потипаева Н.Н. Натуральный антиокислитель для мясных продуктов. *World meat technologies*. 2009. № 2–3. С. 36–39.

vitamin P, the raw material for obtaining which can be Siberian larch wood, grapes, eucalyptus, rose petals and other plant species. The author found that DHQ promotes the inhibition of oxidation of fat fraction of meat samples, which is confirmed by lower peroxide values during the oxidation period and almost complete absence of secondary oxidation products growth in the first days of storage. Even a comparative assessment of the antioxidant efficiency of various concentrations of DHQ (0,02%, 0,08%, 0,2%) and synthetic phenolic antioxidant BHT (at a recommended concentration of 0,02%) showed that in samples with addition of DHQ in the amount of 0,08% and 0,2% there is complete inhibition of oxidation processes throughout the storage time. The peroxide values of the samples at these concentrations were 97,3 and 98,2% lower than in the control. The obtained data allowed the authors to recommend DHQ as an effective antioxidant supplement in the production of meat products.

I.O. Litvinova with the colleagues developed a polyfunctional additive "Maltovin". It is based on the extract of polyphenolic compounds of grape seeds and maltodextrin, as a carrier of biologically active compounds. The additive was developed for meat semi-finished products. The study of the influence of "Maltovin" on the functional and technological properties of minced meat has shown that the additive "Maltovin" exhibits high functional properties necessary for the production of meat products. Optimum concentration of the adding is 2% to the mass of raw materials. It is this concentration that has a positive effect on minced meat of all the analyzed parameters. In addition to improving the functional characteristics of products, "Maltovin" allows prolonging the shelf life of fat-containing products due to antioxidant properties[7].

Other researchers used extracts of such plants as thistle, sage, Baikal scullcap (these plants contain fatty and essential oils, flavonoids – silybin, silidianin, taxophilin, silichristin, flavolignans, organic acids, alkaloids, etc.). The investigated plant additives had a stabilizing effect on the lipids of

---

Літвінова І.О., Савінок О.М. Дослідження впливу комплексної добавки «Мальтовин» на функціональні властивості заморожених напівфабрикатів. *Scientific Journal "ScienceRise"*. 2014. № 5/2. С. 54–59.

Літвінова І.О. Дослідження впливу комплексної добавки «Мальтовин» на функціональні властивості м'ясних модельних систем. *Харчова наука і технологія*. 2013. 2(23). С. 39–42.

the model meat systems and can be used as natural antioxidants, to increase the shelf life of meat products[8].

The objects of research by Y.G. Bazarnova with the co-authors[9] were selected extracts of the fruits of brier, mountain ash, hawthorn (fresh and frozen), dry St. John's wort and thyme (leaves and flowers), infusions of three compositions of fruits and herbs, made in the laboratory of MC "Adaptogen" (St. Petersburg) according to the proposed formulations. Research was conducted on the antioxidant properties and biological activity of phyto-additives of flavonoid nature when refrigerated storage of foods containing milk fat. It was found that the use of phyto-additives reduces the amount of hydrolysis products and oxidation in milk fat in 1,4–5,0 times, slows the formation of secondary oxidation products by about 2 times and increases the shelf life in 2 or more times.

Of considerable interest are phenolic compounds of grapes, both seeds and peels, due to their antioxidant properties and the ability to absorb free radicals. Clinical studies have proven that antioxidant properties and the ability to absorb free radicals of procyanidine oligomers of grape seeds are 20 times stronger than vitamin C and 50 times that of vitamin E[10]. Also, polyphenols of grape seeds inhibit some enzymes that catalyze the ejection of histamine, proteins serine and threonine, prostaglandins and leukotrienes, it causes inflammation and allergic reactions, play an important role in retarding processes of low density lipoprotein oxidation, prevent platelet aggregation. Phenolic substances of grape seeds protect vitamins from early oxidation and allow vitamins to perform their functions where necessary. It has been proven that procyanidins prevent the growth of cancer cells and have anti-mutagen activity[11].

A technology for obtaining a nutritional supplement on the basis of peel grape seed was developed by M.A. Selimov and a recipe composition of meat products, namely boiled sausage, was introduced. It was found in the study of antioxidant activity on model lipid samples, that the peroxide and

---

[8] Дегтярев П.С., Пикунов А.В., Свергуненко С.Л. Новые данные об антиоксидантной активности шлемника байкальского. *Мясная индустрия*. 2004. № 5. С. 51–52.

[9] Базарнова Ю.Г., Колодязная В.С., Дмитриева И.В. Исследование антиоксидантной активности природных веществ. *Хранение и переработка сельхозсырья*. 2003. № 10. С. 66–71.

[10] Silva R.C., Rigaud J., Cheynier V., Chemina A. Procyanidindimers and trimers from grape seeds. *Phytochemistry*. 1991. № 30. P. 1259–1264.

Ho C.T., Lee C.Y., Huang M.T. Phenolic compounds in food and their effects on health. *Analysis, Occurrence and Chemistry, American Chemical Society*. Washington, 1992. P. 102–117.

acid values are significantly lower in experimental minced meat with the added additive[12].

Y.I. Sharigina conducted research on the possibility of using natural supplements with antioxidant effect in the technology of semi-finished meat frozen products for preserving their quality and increasing biological efficiency and safety, increasing the shelf life. Extracts of medicinal, spice and aromatic plants of imported production: sage, rosemary, fenugreek, green ginger, green tea (produced in Great Britain, Denmark, Belgium, Russia, etc.) were studied as natural antioxidants for meat products.

As a result of studying the antioxidant properties of plant extracts, it was found that the highest content of total fat-soluble and water-soluble antioxidants has extracts of rosemary and green tea. It was shown that using of rosemary and green tea extracts allows reducing the rate of hydrolysis products formation, primary and secondary oxidation of lipids. The use of antioxidants can double the shelf life of meat semi-finished group[13].

Consequently, various research groups have been involved in increasing the shelf life of meat products by protecting the lipid from oxidation processes using natural antioxidants in recent years. However, the generalized material and works on the purposeful use of antioxidants in the production of not only semi-finished products, but also other groups of meat products, especially meat-containing, is very small to solve this problem in a comprehensive manner.

Therefore, the aim of our research was to determine the effectiveness of the use of various natural antioxidants in the meat-containing products with waterfowl meat technology, namely ducks, high in lipids, which will inhibit the oxidative processes and improve the quality of products.

2. Materials and methods

As a model for studying the effects of natural antioxidants on the oxidative processes in meat and meat-containing products, the meat of Peking duck was used (ДСТУ 3143:200), which contains 37–40% lipids,

---

[12] Селимов М.А. Разработка технологии мясопродукта с пищевой антиоксидантной добавкой: дисс. … канд. техн. наук: 05.18.04, 05.18.07. Ставрополь, 2011. 136 с.

[13] Шарыгина Я.И., Байдалинова Л.С. Сравнительная эффективность растительных антиоксидантов на основе экстракта розмарина при производстве мясных замороженных изделий. *Научный журнал «Известия Калининградского государственного технического университета»*. Калининград, 2012. № 18. С. 111–117.

including polyunsaturated fatty acids (PUFA) – 17,5%[14]. Duck meat was prepared according to the standard technological scheme. As experimental samples used:

minced meat from Peking duck[15];

meat-containing sausage with Peking duck meat 33%[16];

meat-containing semi-finished products is with Peking duck meat 30%[17].

As natural antioxidants were used:

– Rosemary extract (RE) (Food Ingredients Mega Trade, USA);

– Grape seeds powder (GSP) and grape seeds extract (GSE), which was made with aqueous-alcoholic extraction (1:4) in a 60% solution of ethyl alcohol of grape seed powder from Isabella Red Grape (Mak-Var, Ukraine);

– Cranberry Extract (CE) (Ukraine);

– Extract of black currant (EBC) (Ukraine).

The effectiveness of natural antioxidants was evaluated in the samples of the products during storage on the following indicators: acid value (AV), peroxide value (PV), thiobarbituric acid reactive substances (TBARS).

The acid value was determined by the batch titration with sodium hydroxide in the concentration in the presence of phenolphtalein alcohol solution[18] 3–5 g of the investigated forcemeat was weighted in the conic retort with the volume of 150–200 cm^3 with the error of no more than 0,001 g. The batch was heated on the water bath and after the addition of 50 cm^3 of neutralized ether-alcohol mixture shaken. Then 3–5 drops of phenolphtalein alcohol solution with the mass share of 1% were added. The received solution while shaking was titrated fast with potassium hydroxide solution

---

[14] Aronal A.P., Huda N., Ahmad R. Amino Acid and Fatty Acid Profiles of Peking and Muscovy Duck Meat. *Int. Journal of Poultry Science*. 2012. № 11(3). P. 229–236.

[15] Bozhko N., Tischenko V., Pasichnyi V., Marynin A., Polumbryk M. Analysis of the influence of rosemary and grape seed extracts on oxidation the lipids of Peking duck meat. *Eastern-European Journal of Enterprise Technologies*. 2017. № 4/11(88). P. 4–9.

Божко Н.В., Пасічний В.М., Бордунова В.В. М'ясо-місткі варені ковбаси з використанням м'яса качки. *Науковий вісник Львівського національного університету ветеринарної медицини та біотехнологій імені С.З. Ґжицького*. Львів, 2016. Т. 18. 2(68). С. 143–146.

Божко Н.В., Тищенко В.И., Пасичный В.Н. Использование порошка виноградных косточек в технологии изготовления мясосодержащих полуфабрикатов с мясом утки . *Пищевая промышленность: наука и технологии*. 2017. № 4. С. 19–24.

Антипова Л.В., Глотова И.А., Рогов И.А. Методы исследования мяса и мясных продуктов. М., 2001. 576 с.

with the molar concentration 0,1 mol/dm^3 till the distinct rose coloration appeared and kept for 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, with the molar concentration 0,1 mol/dm^3, used for titration; K – correction to alkali solution for recalculation on the distinct (0,1 mol/dm^3) one; 5,61 – number of milligrams of potassium hydroxide, contained in 1 cm^3 (0,1 mol/dm^3) of solution; m – forcemeat batch mass, g.

The method of PV determination is based on the batch extraction by the mixture of chloroform and icy acetic acid and further titration by the sodium hyposulfite solution with the previously added starch solution[19].

0,8–1 g of a batch, weighted with accuracy of no more than 0,0002 g were placed in the conic retort with the stopper, melt on the water bath and 10 cm^3 of chloroform and 10 cm^3 of icy acetic acid were gently poured on the retort sides. 0,5 cm^3 of saturated, freshly prepared potassium iodine solution was quickly added. The retort was closed with the stopper; the content was mixed by turning movements and put into the dark place for 3 minutes. Then 100 cm^3 of distilled water with the previously added 1 cm^3 of starch solution with the mass share of 1% was gently poured into the retort. After that it was titrated with sodium hyposulfite solution with the molar concentration of 0,01 mol/dm^3 until the blue coloration disappeared.

To verify the clearness of reagents the control determination without a batch was realized. 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 sodium hyposulfite solution with the molar concentration 0,01 mol/dm^3, used for titration in the main experiment with the forcemeat batch, cm^3; V1 – volume of sodium hyposulfite solution (0,01 mol/dm^3), used for titration in the control experiment without a forcemeat batch, cm^3; K – coefficient of correction to sodium hyposulfite for recalculation on the distinct (0,01 mol/dm^3) solution; 0,00127 – number of grams of iodine, equivalent to 1 cm^3 (0,01 mol/dm^3) of sodium hyposulfite; m – mass of the studied forcemeat batch, g.

Журавская Н.К., Гутник Б.Е., Журавская Н.А. Технохимический контроль производства мяса и мясопродуктов. М., 2001. 476 с.

TBARS was determined by measuring the coloration intensity of the mixture of the studied sample distillate and thiobarbituric acid solution (1:1) after 35 minutes on the water bath on the spectrophotocolorimeter “Spекol - 11” (Germany) at the wave length 535 nm[20].

50 g of forcemeat batch were put into the porcelain mortar, 50 cm^3 of distilled water were measured by the glass cylinder, added to the mortar and ground with the pestle into the uniform mixture. The prepared sample was quantitatively transferred into Kjeldahl retort, remains were washed away from the mortar with 47,5 cm^3 of distilled water and then 2,5 cm^3 of hydrochloric acid were added. The distillation was carried out in Kjeldahl apparatus, collecting 50 cm^3 of distillate in the volumetric flask. 5 cm^3 of distillate were taken, poured into the retort with the fitted stopper. After the addition of 5 cm^3 of thiobaturic acid, the retort was closed with the fitted stopper and heated on the boiling water bath for 35 min.

Simultaneously the control experiment was held, using 5 cm^3 of distilled water instead of the distillate. Then the solutions were cooled in the cold running water for 10 min, and the optic density at the wave length of 535±10 nm as to the control solution was measured.

The thiobarbituric acid reactive species, mg of 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 dependency of MA density on its concentration in the solution. This coefficient is a permanent value.

The absolute error of measurements was determined by Student criterion, the reliable interval P=0,95, the number of repeatitions in calculations – 3–4, the number of parallel tests of studied samples – 3.

3. Results and discussion

To characterize the influence of antioxidants RE and GSE on the hydrolytic processes in the lipid fraction of duck meat, it was determined AV, PV and TBARS, the results of which are presented in Tables 1 and 2.

The decomposition of fats with the formation of fatty acids can contribute to accelerating the oxidation process, because firstly, free, not bound to triglycerides, acids are oxidized. The processes of hydrolysis of fat in

[20] ГОСТ Р 55810–2013. Мясо и мясные продукты. Метод определения тиобарбитурового числа. М., 2014. 21 с.

experimental samples throughout the shelf life were slower than in the control. In the control sample, the AV on the 15th day of storage was 3,30±0,11 mg KOH, and at the end of the storage period it was 2,61±0,14 mg KOH in the experimental samples of RE and GSE for 15 days of storage of AV was 2,05–2,43 mg KOH, and for 90 days – 1,12–1,68 mg KOH, which is 35,63–57,09% below the control, that indicating a direct proportional dependence of the free fatty acids accumulation rate on the concentration of antioxidants.

Table 1

Dynamics of AV and PV minced Peking duck meat with the addition of RE and GSE during storage

Name of sample	Term of storage, days		
	1	15	90
AV, mg KOH			
Control	1,43±0,11	3,30±0,11	2,61±0,14
EP 0,01%	1,47±0,10	2,24±0,13	1,49±0,14
EP 0,02%	1,39±0,09	2,43±0,12	1,30±0,13
EP 0,03%	1,39±0,08	2,05±0,09	1,12±0,13
EBK 0,05%	1,48±0,14	2,05±0,10	1,30±0,08
EBK 0,1%	1,40±0,09	2,43±0,09	1,68±0,14
EBK 0,15%	1,46±0,09	2,24±0,11	1,49±0,12
PV, J %			
Control	0,03±0,002	0,05±0,01	1,35±0,02
EP 0,01%	0,04±0,001	0,051±0,01	0,69±0,01
EP 0,02%	0,03±0,002	0,031±0,002	0,73±0,02
EP 0,03%	0,04±0,005	0,042±0,001	0,79±0,03
EBK 0,05%	0,033±0,005	0,05±0,01	0,65±0,02
EBK 0,1%	0,03±0,005	0,12±0,01	0,75±0,03
EBK 0,15%	0,031±0,005	0,20±0,01	0,64±0,02

Among the experimental samples, the smallest amount of free fatty acids was observed at the application of RE in the concentration of 0,03%: after a month of storage of AV in this sample reached 2,05±0,09 mg KOH, and at the end of the shelf life – 1,12±0,13, which is more than twice as low as the control sample. The obtained results indicate that the introduced complex inhibits the hydrolysis of fat due to the presence of flavonoids in the extract of rosemary and polyphenols in the extract of grape stones. In this case,

increasing the concentration of extracts inhibits the hydrolytic decomposition of acylglycerides.

The study of the peroxide oxidation dynamics in the samples shows that among the experimental samples the minerals of the PV increased more intensively in the sample without an additive, and the introduction of RE and GSE in all three concentrations slowed down the oxidative processes. Practically all concentrations of extracts had a stabilizing effect. The PV at the end of the study period in the experimental samples was 0,64–0,79% J_2, while in control, this index was 1,35±0,02% J_2. The suppression of lipid peroxide oxidation is associated with a high content of carnosine and rosemary acids in rosemary extract, which is twice as high as the activi ty of synthetic antioxidants BHT and BHA[21].

Table 2

Dynamics of TBARS minced Peking duck meat with the addition of RE and GSE during storage

Name of sample	Term of storage, days	
	15	90
Control	3,60±0,14	7,89±0,32
EP 0,01%	1,65±0,05	1,83±0,22
EP 0,02%	2,70±0,05	5,83±0,39
EP 0,03%	2,05±0,03	6,44±0,78
EBK 0,05%	2,35±0,005	4,02±0,42
EBK 0,1%	2,50±0,005	5,15±0,44
EBK 0,15%	3,00±0,005	5,03±0,38

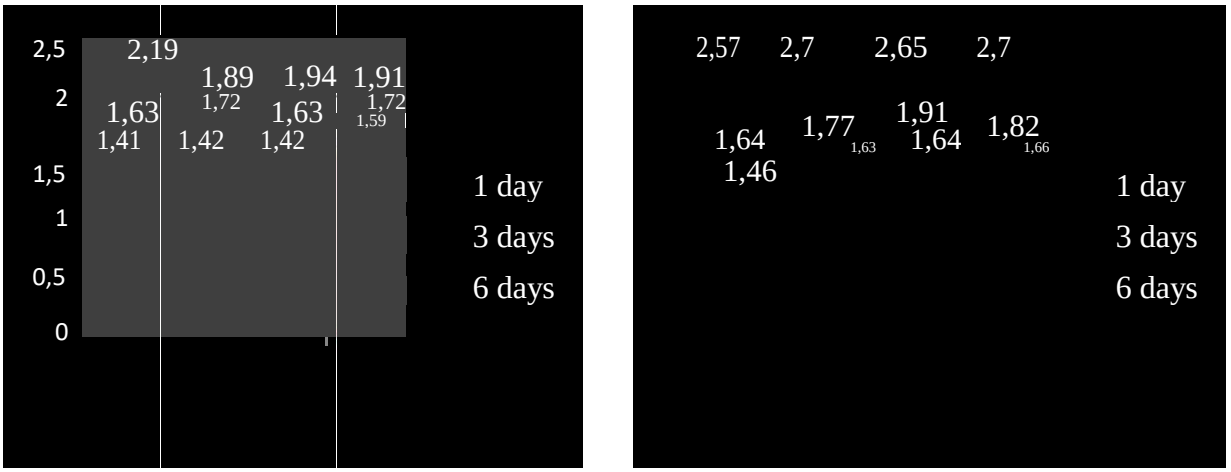
When adding antioxidants, the components of rosemary and grape seed extracts make it impossible to add oxygen to glycerides, thereby inhibiting the oxidizing processes in mincemeat. Carnosic acid and carnosol block peroxide radicals particularly effective in systems based on the high content of lipid components.

The antioxidant effect of additives is also manifested in the accumulation of mono- and di-aldehydes that are reacted with 2-thiobarbituric acid. Secondary oxidation products, namely, peroxides and hydro peroxides, are carriers of unpleasant flavor and taste of oxidized fats. The addition of RE

[21] Makris D., Boskou G., Andrikopoulos N. Polyphenolic content and in vitro antioxidant characteristics of wine industry and other agri-food solid waste extracts. *Journal of Food Composition and Analysis*. 2007. Vol. 20. Issue 2. P. 125–132.

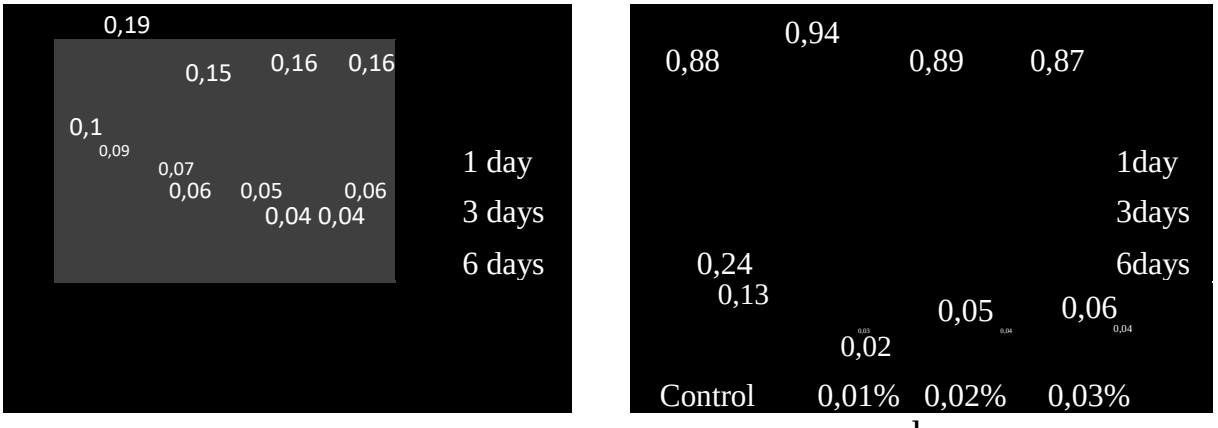
and GSE contributed to the slowdown in the accumulation of secondary oxidation products. At the end of the storage period, the amount of secondary oxidation products in the control sample was 7,89±0,17 mg MA/kg of minced meat, whereas in the experiments this index ranged at 1,83–6,44 mg MA/kg.

In order to inhibit lipid oxidation and extend the shelf life of the products, the effectiveness of cranberry and black currant extracts in the technology of cooked sausages with Peking duck meat was investigated. The results of the study of the AV and the PV are presented in Fig. 1 and 2.



a b

Fig. 1. Dynamics of the AV in samples of cooked sausages: a) with a cranberry extract (CE); b) with extract of black currant (EBC)



a b

Fig. 2. Dynamics of the PV in samples of cooked sausages: a) with a cranberry extract (CE); b) with extract of black currant (EBC)

The analysis of the change in the AV indicates that the addition to the minced meat of the CE suppresses the process of lipid hydrolysis during storage. Thus, the AV for 3 days of storage in experimental samples, respectively, formulations 1, 2 and 3, respectively, 0,1%, 0,2% and 0,3% EBC was lower by an average of 14%. At the end of the experiment, the smallest AV was observed in the sample with a concentration of the antioxidant additive 0,02%, its value was 1,41 mg KOH, while in control this index reached 2,2.

The addition of EBC does not significantly affect the process of lipid hydrolysis during storage. Thus, AV for 5 days of storage in the control and experimental samples was practically the same and ranged within 1,46–1,66. It should be noted that hydrolytic processes in threeglycerides during the investigated period were not intense. The obtained dependences are explained by the ability of bioflavonoids CE and EBC to slow down the hydrolysis of fatty acids of minced meat.

The obtained results showed that in the samples of sausages the PV increased more intensively in the control sample, and CE in all three concentrations slowed down the oxidative processes. The maximum stabilizing effect had an CE of 0,03% concentration: The PV in this sample at the end of the study period was 0,04% J_2, while in control, this index was 0,10% J_2, higher more than twice. The analysis of the results also showed that the EBC in all three concentrations slowed down the oxidative processes. EBC had the highest stabilizing effect at 0,01% concentration: the PV in this sample at the end of the study period was 0,02% J_2, while in control, this value was 0,13% J_2, which is in 6,5 times higher.

The dynamics of the influence of extracts on lipid oxidation in minced meat of cooked sausages with duck meat was different, depending on the type of extract. CE inhibited oxidative processes gradually towards the growth of AV and PV. The dynamics of lipid oxidation in the presence of EBC had an opposite tendency from elevated rates to gradual stabilization and reduction, but both preparations had an inhibitory effect on lipid hydrolysis and their oxidation.

A study was made of the antioxidant efficacy of grape seed grains of red grape varieties when used in the technology of meat-based semi-finished products from duck meat. The object of research was samples of minced meat with powder made from grape stones containing duck meat – 30% and total fat content of 20%. In experimental samples, GSP was added at a

concentration of 0,5, 1,0 and 1,5%. The control served meat-stuffed minced meat without the addition of grape seed powder. The samples were stored at -8°C and observed the accumulation of primary and secondary oxidation products during the shelf life of 90 days.

The dynamics of the change of the PV of the experimental and control samples of semi-finished products during storage at -8°C is shown in Fig. 3.

The resulting curves indicate that the addition of GSP affects the oxidation processes that occur in semi-finished products during storage, reducing the formation of peroxides and hydroperoxides in them.

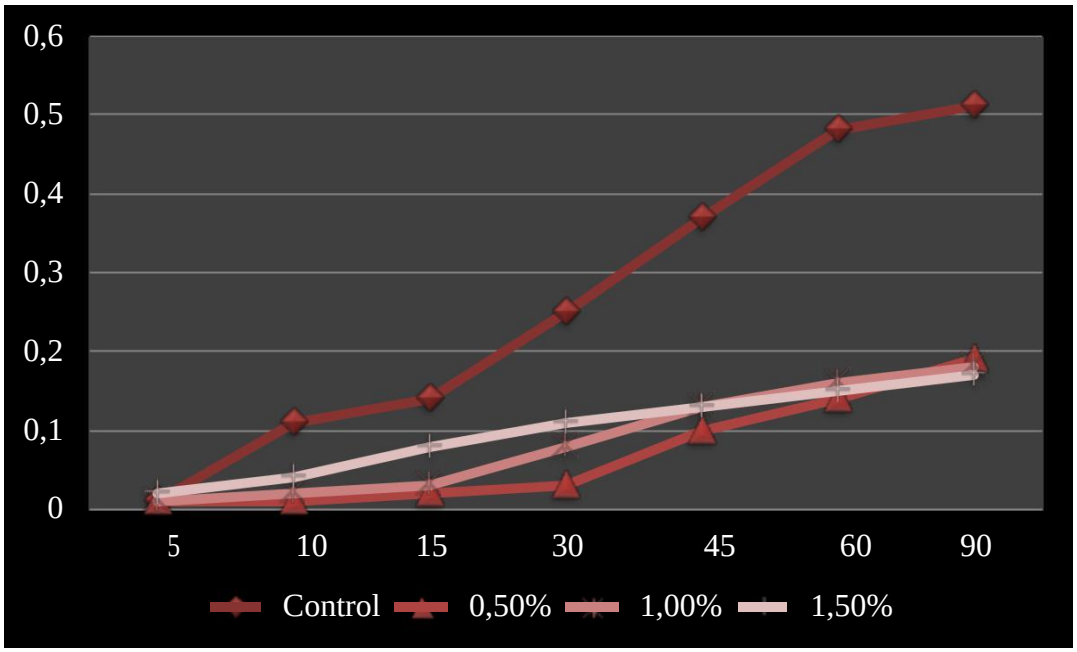


Fig. 3. Dynamics of the PV in samples of semi-finished products with the addition of GSP, % J_2

For 1 day, the PV of samples was 0,01–0,02% J_2, the samples were fresh. On the fifteenth day of storage, the PV of semi-finished products has increased significantly. Thus, the PV in the first sample was 0,02±0,007% J_2, in the second – 0,03±0,006% J_2, in the third – 0,08±0,007% J_2, whereas in the control of the PV was 0,14±0,005% J_2, which is practically three times the current index in experimental samples. Apparently, this is due to the high content of phenol compounds such as pyrohalol in GSP. When the powder is added to the semi-finished products, its components make inaccessible the addition of oxygen to the glyceride, thereby inhibiting the oxidizing processes in the product. At the end of the shelf life, the PV in the

third sample was the smallest and amounted to 0,17±0,02% J_2, which is three times less compared with the control.

The dynamics of the change in the AV of fat of semi-finished products with GSP variety during storage at -8°C is shown in Fig. 4.

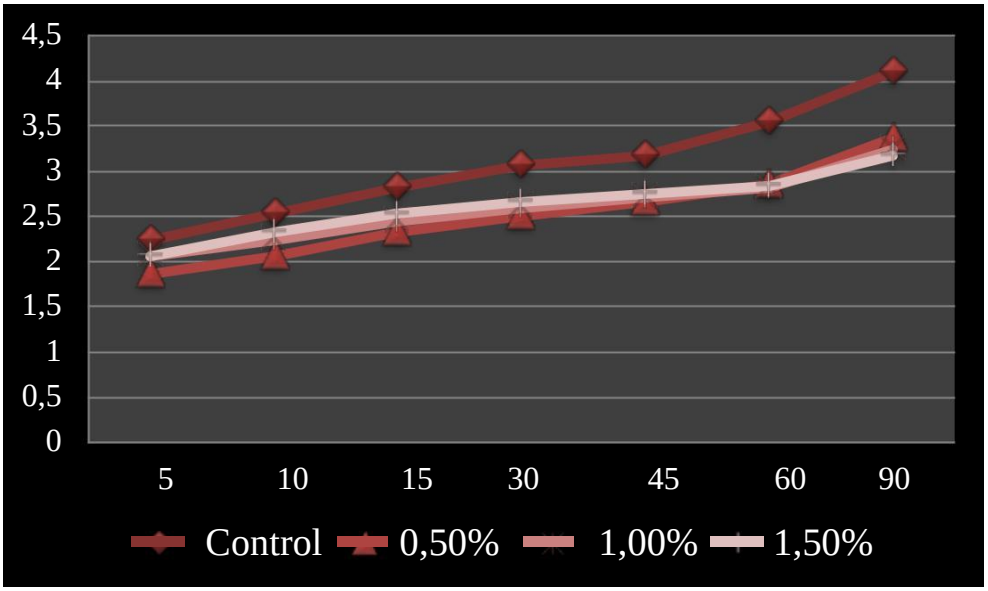


Fig. 4. Dynamics of AV in samples of semi-finished products with the addition of GSP

From the obtained curves it can be seen that the process of fat hydrolyzing in samples of semi-finished products was slower than in the control, but almost at the same speed. AV for 1 day of storage in experimental samples was 1,87–2,06, in control – 2,24±0,02 mg KOH, at 10 days the AV of samples were 2,34–2,52 mg KOH, in control – 2,82±0,01 mg KOH, at 30 days of storage the AV of samples were 2,51–2,66 mg KOH, while in the control – 3,05±0,01 mg KOH, at the end of the storage period the AV of the experimental samples were 3,18–3,37 mg KOH, while in the control – 4,11±0,00 mg KOH. The obtained results testify that the added complex of biologically active substances of GSP does not influence the hydrolysis of fat, but only inhibits the action of lipolytic enzymes. This is due to the fact that antioxidants inhibit the oxidation processes, breaking free-radical chain reactions, and does not affect the hydrolysis of acylglycerides.

The dynamics of the TBARS in the semi-finished products investigated at storage at -8°C for 90 days is presented in Fig. 5. From Fig. 5 it is evident that the introduction of the GSP into the minced meat of semi-finished

products helps to slow down the accumulation of secondary oxidation products.

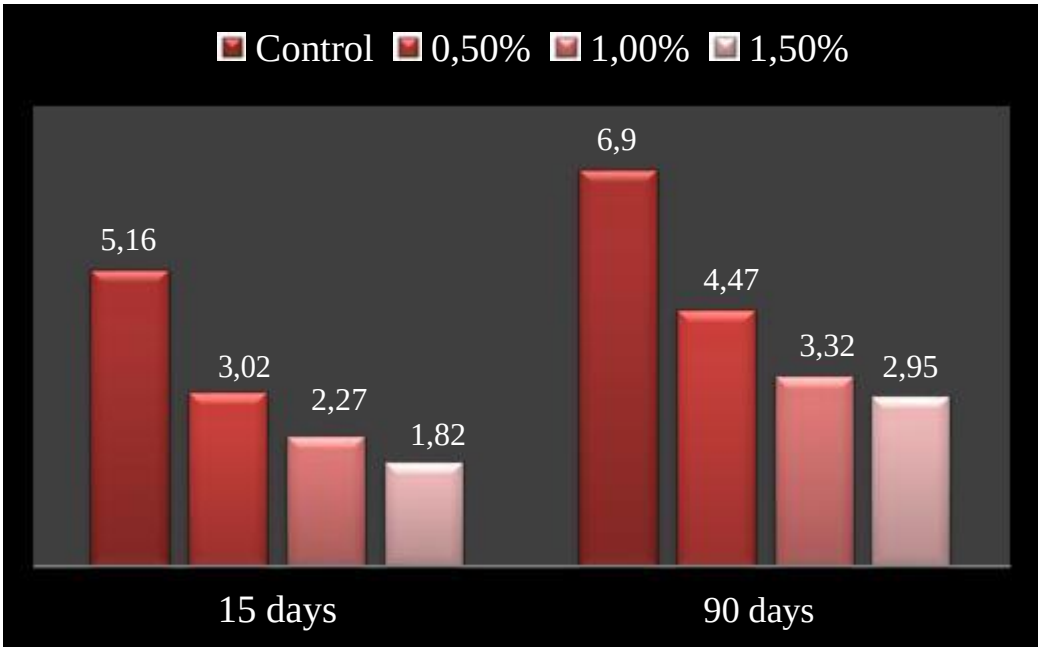


Fig. 5. Dependence of tiobarbitur number of half-finished fat at storage temperature -8°C for 90 days

In 15 days of storage, there is already a noticeable difference in the amount of malonic aldehyde (MA) per unit of product. In the control sample, the amount of MA was 5,16 mg/kg minced meat, in the first sample of semi-finished products – 3,02 mg/kg, which is 41,5% less than the control sample, in the second sample – 2,27 mg/kg and in the third – 1,82 mg/kg, which is respectively 56% and 65% lower than in the control sample. The obtained TBARS indicate the appearance of secondary oxidation products and confirm the data on the definition of the PV, indicating a lower depth of fat oxidation in semi-finished products with the addition of GSP. Reducing the amount of secondary oxidation products is proportional to the amount of antioxidant used. That is, the addition of GSP into semi-finished duck meat products inhibits the accumulation of secondary oxidation products and prolongs their shelf-life. Similar information was obtained on the 90th day of storage of frozen semi-finished products.

CONCLUSIONS

The conducted research has confirmed the high antioxidant activity of rosemary and grape seed extracts, cranberry and black currant extracts, red grape seed powders, and effective inhibition of the oxidation process of duck meat and meat-containing products with Peking duck meat 30–33%.

The addition RE in the amount of 0,01–0,03% and GSE in the amount of 0,05–0,15% helps to slow down the hydrolytic oxidation of the minced duck meat lipids by 35,63–57,09%. Stabilization of lipid peroxide oxidation in minced duck meat as a result of the addition of RE and GSE was 41,48–52,59% lower than control. The number of secondary oxidation products that react with tiobarbituric acid was the lowest at the end of the shelf life of minced meat in a sample with an RE concentration of 0,01% and was 1,83±0,22 mg of MA/kg, which is four times lower than of the control.

The use of CE and EBC in the technology of meat-containing sausage can slow down the oxidative process. The most effective concentration of CE was 0,02%, and EBC – 0,01%.

The addition of the antioxidant complex in the GSP into semi -finished products with Peking duck meat does not significantly affect the hydrolysis of acylglycerides, but only inhibits the action of lipolytic enzymes, slows the accumulation of secondary oxidation products, preserving and improving its quality during storage. Reducing the amount of primary and secondary oxidation products is proportional to the amount of antioxidant used, so the optimal concentration of GSP is 1,5%.

SUMMARY

The most common way of solution for the problem of oxidative deterioration of meat products and, consequently, extending the shelf life, is the use of a variety of antioxidant food additives that can purposefully regulate the oxidation processes in lipid fraction of meat and meat-containing systems. The conducted research has confirmed the high antioxidant activity of rosemary and grape seed extracts, cranberry and black currant extracts, red grape seed powders, and effective inhibition of the oxidation process of duck meat and meat-containing products with Peking duck meat 30–33%. The addition RE in the amount of 0,01–0,03% and GSE in the amount of 0,05–0,15% helps to slow down the hydrolytic oxidation of the minced duck meat lipids by 35,63–57,09%. Stabilization of lipid peroxide oxidation in minced duck meat as a result of the addition of RE and GSE was 41,48–52,59% lower than control. The use of CE and EBC in the

technology of meat-containing sausage can slow down the oxidative process. The most effective concentration of CE was 0,02%, and EBC – 0,01%. The addition of the antioxidant complex in the GSP into semi - finished products with Peking duck meat does not significantly affect the hydrolysis of acylglycerides, but only inhibits the action of lipolytic enzymes, slows the accumulation of secondary oxidation products, preserving and improving its quality during storage.

REFERENCES

Shahidi F. Natural Antioxidants. Chemistry, Health Effects and Applications. Illinois, 1997. 414 p.

Толкунова Н.Н. Влияние растительных экстрактов на окислительные процессы в паштете. *Мясная индустрия*. 2002. № 7. 26–27.

Самозвон О.Н., Бондаренко Н.Г., Пивовар А.К., Никитченко Ю.В. Изучение возможностей применения добавки из плодов ольхи в качестве антиоксиданта при производстве мясных фаршей. *Збірник наукових праць Луганського національного аграрного університету*. Луганськ, 2008. № 87. С. 194–205.

Токаев Е.С., Новаков Р.А., Дегтярев П.С. Использование дигидрокверцетина в качестве натурального антиокислителя. *Мясная индустрия*. 2003. № 10. С. 27–28.

ПАТ. 79879. Україна, МПК (A23L 1/29 (2006.01) u 2012 10153. Спосіб одержання функціональної добавки «Мальтовін» / О.М. Савінок, І.О. Літвінова. Бюл. № 9; Заявлено 27.08.2012; опубл. 13.05.2013. 6 с.

Плотников Е.Е., Глазова Г.В. и др. Растительные антиоксиданты в производстве мясных изделий. *Мясная индустрия*. 2010. № 7. С. 26–28.

Гуринович Г.В., Лисин К.В., Потипаева Н.Н. Препарат для продления срока годности мясных полуфабрикатов. *Мясная индустрия*. 2005. № 2. С. 31–33.

Гуринович Г.В., Потипаева Н.Н. Натуральный антиокислитель для мясных продуктов. *World meat technologies*. 2009. № 2–3. С. 36–39.

Літвінова І.О., Савінок О.М. Дослідження впливу комплексної добавки «Мальтовин» на функціональні властивості заморожених напівфабрикатів. *Scientific Journal "ScienceRise"*. 2014. № 5/2. С. 54–59.

Літвінова І.О. Дослідження впливу комплексної добавки «Мальтовин» на функціональні властивості м'ясних модельних систем. *Харчова наука і технологія*. 2013. № 2(23). С. 39–42.

Дегтярев П.С., Пикунов А.В., Свергуненко С.Л. Новые данные об антиоксидантной активности шлемника байкальского. *Мясная индустрия*. 2004. № 5. С. 51–52.

Базарнова Ю.Г., Колодязная В.С., Дмитриева И.В. Исследование антиоксидантной активности природных веществ. *Хранение и переработка сельхозсырья*. 2003. № 10. С. 66–71.

Silva R.C., Rigaud J., Cheynier V., Chemina A. Procyanidindimers and trimers from grape seeds. *Phytochemistry*. 1991. № 30. P. 1259–1264.

Kandaswami C., Middleton E. Free radical scavenging and antioxidant activity of plant flavonoids. *Adv. Exp. Med. Biol*. 1994. № 366. P. 351–361.

Middleton E., Drzewieki G. Flavonoid inhibition of human basophile histamine release stimulated by various agents. *Biochem. Pharmacol*. 1983. P. 3333–3338.

Ho C.T., Lee C.Y., Huang M.T. Phenolic compounds in food and their effects on health. *Analysis, Occurrence and Chemistry, American Chemical Society*. Washington, 1992. P. 102–117.

Селимов М.А. Разработка технологии мясопродукта с пищевой антиоксидантной добавкой: дисс. … канд. техн. наук: 05.18.04, 05.18.07. Ставрополь, 2011. 136 с.

Шарыгина Я.И., Байдалинова Л.С. Сравнительная эффективность растительных антиоксидантов на основе экстракта розмарина при производстве мясных замороженных изделий. *Научный журнал «Известия Калининградского государственного технического университета»*. Калининград, 2012. № 18. С. 111–117.

Aronal A.P., Huda N., Ahmad R. Amino Acid and Fatty Acid Profiles of Peking and Muscovy Duck Meat. *Int. Journal of Poultry Science*. 2012. 11(3). P. 229–236.

Bozhko N., Tischenko V., Pasichnyi V., Marynin A., Polumbryk M. Analysis of the influence of rosemary and grape seed extracts on oxidation the lipids of Peking duck meat. *Eastern-European Journal of Enterprise Technologies*. 2017. № 4/11(88). P. 4–9.

Божко Н.В., Пасічний В.М., Бордунова В.В. М'ясо-місткі варені ковбаси з використанням м'яса качки. *Науковий вісник Львівського*

національного університету ветеринарної медицини та біотехнологій імені С.З. Ґжицького. Львів, 2016. Т. 18. № 2(68). С. 143–146.

Божко Н.В., Тищенко В.И., Пасичный В.Н. Использование порошка виноградных косточек в технологии изготовления мясосодержащих полуфабрикатов с мясом утки. *Пищевая промышленность: наука и технологии*. 2017. № 4. С. 19–24.

Антипова Л.В., Глотова И.А., Рогов И.А. Методы исследования мяса и мясных продуктов. М., 2001. 576 с.

Журавская Н.К., Гутник Б.Е., Журавская Н.А. Технохимический контроль производства мяса и мясопродуктов. М., 2001. 476 с.

ГОСТ Р 55810–2013. Мясо и мясные продукты. Метод определения тиобарбитурового числа. М., 2014. 21 с.

Makris D., Boskou G., Andrikopoulos N. Polyphenolic content and in vitro antioxidant characteristics of wine industry and other agri - food solid waste extracts. *Journal of Food Composition and Analysis*. 2007. Vol. 20. Issue 2. P. 125–132.

Information about authors:

Bozhko N. V.,
PhD, Senoir Lecturer, Department of Technology of Milk and Meat
Sumy National Agricultural University G. Kondratieva str., 160, Sumy, Ukraine, 40021

Pasichnyi V. M.,
Doctor of Technical Sciences, Professor, Department of Technology of Meat and Meat Products
National University of Food Technologies Volodymyrska, str., 68, Kyiv, Ukraine, 01601