

The effect of vitamin E on the quality of geese meat

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During prolonged storage at low temperatures, meat quality deteriorates due to the activation of the oxidation of unsaturated fatty acids. The use of antioxidants in feeding birds to the prefabricated period and during storage of meat significantly inhibits its oxidative damage and prolongs the terms of storage. Vitamin E is traditionally used as one of the most effective fat-soluble antioxidants. The purpose of the work was conducting a comparative analysis of the effects of high content of vitamin E, depending on the technology of its application, on the oxidative damage of geese meat in the course of low temperature storage. The meat of the first experimental sample was obtained from geese that received feed with twice the content of vitamin E in the pre-slaughter period. The meat of the second test sample was obtained by treating geese meat with a vitamin E solution, before low temperature storage. The results of the experiment proved that regardless of the technology of vitamin E application, it contributes to the inhibition of the oxidative damage. An increase of vitamin E dose in the geese dietary is more effective. The content of secondary lipoperoxidation products in the meat of the control sample stored for 210 days increased by 5.3 times, in the first test sample by 2.5 times, and in the second sample by 4.6 times. An additional use of vitamin E in both studied samples contributed to the preservation of unsaturated fatty acids, but the mechanisms of exposure and changes in the content of individual acids in experimental samples are significantly different.

Keywords: geese, meat, storage, oxidation damage, α -tocopherol

INTRODUCTION

Providing the population with high-quality food is one of the most pressing problems of our time. Among all food, poultry meat occupies a spe-

cial place as it is a source of high-grade protein and high-quality fat (Scollan et al., 2017; Schilling et al., 2017). When inhibiting microbiological damage during storage, lipid oxidation is the main cause of meat quality deterioration. Unsaturated fatty acids oxidation products make its nutritional value much worse (Estévez, 2015). In functioning

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muscles, the unsaturated fatty acids, which are most sensitive to peroxide oxidation, are protected from the action of active forms of oxygen by an antioxidant defence system. When the blood circulation stops, irreversible changes occur that create conditions under which lipoperoxidation processes become uncontrolled and the balance between prooxidants and antioxidants shifts in the direction of oxidative processes. A consequence of stopped blood circulation is the accumulation of lactic acid, which leads to a decrease of pH in the environment and a decrease in the activity of antioxidant enzymes (Chan et al., 2011; Estévez, 2011; Zhang et al., 2011; Leygonie et al., 2012; Estévez, 2015). Introduction of poultry antioxidants to the diet in the prefabricated period increases meat resistance to oxidative processes and prolongs its storage period. Vitamin E is traditionally considered one of the most effective fat-soluble antioxidants (Hunchak et al., 2007). Despite the fact that the mechanisms of the antioxidant action are discussed and not finally defined (Traber & Atkinson, 2007; Jiang, 2014), vitamin E is one of the most used substances of antioxidant action in livestock and food technologies.

The purpose of the work was a comparative analysis of the effects of high content of vitamin E, depending on the technology of its application, to the oxidative damage of geese meat in the course of low temperature storage.

MATERIALS AND METHODS

For biochemical studies, three samples of geese meat were used. Meat from the control sample was obtained from the geese of the control group, which was kept on a standard diet balanced by all nutrients and vitamins in accordance with the recommendations (Ryabokon, 2005). The meat of the first experimental sample was obtained from geese the diet of which in the prefabricated period (from the 42nd to the 63rd day) differed from the control group in the double amount (40 mg/kg) of vitamin E. The meat of the second experimental sample was obtained from the geese meat of the control group the sur-

face of which was treated with a vitamin E solution (at a rate of 100 mg/kg) immediately before placing it in low-temperature storage. The geese were slaughtered on the 63rd day of their lives. After slaughtering, the pectoral muscles were isolated from geese carcasses; they were quickly frozen and kept for 210 days at a temperature of -18°C in accordance with the requirements of the State Standard of Ukraine.

The intensity of peroxide oxidation of lipids in geese meat was estimated by the content of peroxidation products that react with 2-thio-barbituric acid, TBARC (Ionov et al., 2011). Their determination was carried out in tissue homogenates (TBARC) and initiated by Fe^{2+} ions peroxide oxidation (TBARCi). For an integrated assessment of the activity of endogenous antioxidants in meat, the antioxidant activity coefficient (K_{AOA}) was used, which was calculated as the ratio of TBARC to TBARCi, since meat contains not only the peroxidation substrate, but also high and low molecular weight compounds that can inhibit lipid peroxidation (Hunchak et al., 2007).

Fatty acid composition of lipids was determined by gas-liquid chromatography on the Italian Carlo Erba chromatograph. As a carrier, Chromosorb W/DP was used with the Silar 5CP (Serva, Germany) phase at a concentration of 10% at a temperature of $140\text{--}250^{\circ}\text{C}$ and a growth rate of $2^{\circ}\text{C}/\text{min}$ (the inlet temperature was 210°C , the temperature of the detector was 240°C). In addition to the total content of unsaturated fatty acids (UFA) (Σ_{C}), calculated the total equivalent concentration of UFAs relatively multiple bonds (unsaturation, Σ_{N}) $\text{mMol}^{\ast}\text{g}^{-1}$ (Danchenko et al., 2012). Lipid extracts for the determination of fatty acid composition were obtained by E. G. Bligh and W. I. Dyer (Bligh, Dyer, 1959) with recommendations by F. B. Palmer (Palmer, 1971). Statistical analysis of the obtained results was undertaken by the known methods, their statistical processing was carried out with Microsoft Office Excel 2013 software package and SPSS v.13, with Student's *t*-test. In comparison with the control sample, the difference is reliable if $p \leq 0.05$.

RESULTS AND DISCUSSION

According to the results of studies, the geese meat of the control group was characterized by a rather low initial content of TBARC (Table). During the first 90 days of storage, there was a gradual decrease of this indicator to a minimum level. According to (Danchenko et al., 2010), this dynamics of secondary peroxide oxidation of lipids products in meat during its storage is due to the fact, that the processes of oxidation in anaerobic conditions that occur in tissues immediately after slaughter of birds, because of the lack of acceptors of Hydrogen cannot penetrate deeply. Therefore, after 90 days of meat storage, a sharp decrease in the TBARC content was observed. Further activation of lipid peroxidation is due to the accumulation of endogenous oxygen. In the control sample meat, these processes intensified from the fourth month: the content of secondary lipid peroxidation products after 120 days of storage increased by 2.1 times compared to the original; subsequently, the change at this rate accelerated and at the end of the experiment, after 210 days of storage, the TBARC content reached a value that exceeded the previous by 41.7% and the corresponding output 5.3 times.

A double dose of vitamin E in the diet contributed to the lengthening of the initial stabilization of the prooxidant-antioxidant balance for the geese of the first sample. During 150 days of storage, the content of the final products of lipoperoxidation in it was maintained

at a constant level, and only from the sixth month the activation of lipids peroxidation processes led to a probable accumulation of TBARC. In general, the content of secondary lipoperoxidation products in meat of the first sample stored for 210 days increased 2.5 times. Surface treatment with vitamin E solution after poultry slaughter (the second test sample) also contributed to lengthening the period of the equilibrium between pro- and antioxidants: only from the 120th day activation of lipoperoxidation processes began and during the fifth month the TBARC content increased by 62.3%, exceeding the level of the corresponding index of the first experimental meat sample. At the end of the experiment, the content of secondary lipid peroxidation products in meat of the second sample was 4.6 times higher than the corresponding initial indicator, but was significantly lower than the control sample of this storage term (12.4%).

Correlation analysis of the TBARC dynamics in the geese meat of the three samples tested shows that, regardless of the method of its application, the additional use of vitamin preparation does not affect the general patterns of accumulation of secondary lipoperoxidation products, which is confirmed by the correlation coefficients of the TBARC dynamics in the studied samples of meat at the level of close ($r = 0.812-0.857$). The specificity of the TBARC dynamics in the control and experimental samples is the duration of the initial period of the prooxidant-antioxidant equilibrium with the TBARC constant level.

Table 1. The content of TBARC and the antioxidant activity coefficient in geese meat ($M \pm m$, $n = 5$)

| Indicator | Sample | Storage term, days | | | | | | |
|------------------|--------|--------------------|-------------|-------------|-------------|-------------|-------------|--------------|
| | | 0 | 60 | 90 | 120 | 150 | 180 | 210 |
| TBARC, nMol/g | K | 32.6 ± 1.1 | 27.3 ± 1.0 | 16.0 ± 0.8 | 69.3 ± 1.4 | 85.5 ± 2.9 | 122.4 ± 2.9 | 173.5 ± 4.1 |
| | I D | 39.5 ± 1.1* | 34.7 ± 0.9* | 19.5 ± 0.4* | 29.8 ± 1.1* | 42.7 ± 2.0* | 75.5 ± 2.8* | 97.3 ± 3.2* |
| | II D | 33.2 ± 1.3 | 67.9 ± 2.3* | 27.3 ± 0.9* | 18.3 ± 0.8* | 69.3 ± 1.9* | 91.5 ± 2.1* | 154.4 ± 5.7* |
| K _{AOA} | K | 0.43 | 0.35 | 0.37 | 0.23 | 0.22 | 0.17 | 0.12 |
| | I D | 0.56 | 0.48 | 0.43 | 0.35 | 0.31 | 0.27 | 0.25 |
| | II D | 0.44 | 0.56 | 0.42 | 0.27 | 0.20 | 0.16 | 0.14 |

Note. The difference is reliable in comparison with control sample where: * $p \leq 0.05$.

At the same time, the antioxidant activity rate, which reflects the processes of decontamination of endogenous antioxidants in the meat of the control sample, steadily decreased during the experiment and decreased by 3.6 times throughout the storage period. K_{AOA} of the first experimental sample of geese meat at the end of the experiment was dominated by the corresponding index of control by 2.08 times, and the second experimental one – by 1.56 times, respectively. Thus, an increase in the content of vitamin E by 2.0 times in the geese diet from the 35th to the 63rd day contributed to the most effective inhibition of the processes of decontamination of endogenous antioxidants in the meat during low temperature storage. The data of correlation analysis indicate that there is a moderate consistency of this indicator within the studied samples of meat, but, compared to TBARC, this connection is weaker ($r = 0.602-0.647$) for the experimental and control samples of the meat, and this is understandable as the ability of peroxidation is determined by the unsaturated lipids on the one hand, and by the level of high and low molecular antioxidants that can counteract the ROS on the other hand.

It is known that the fatty acid composition of the lipids of poultry meat can vary greatly depending on the initial state of the chicks,

technological conditions of their detention and diet (Janovych, 2010; Boschetti, 2015; Puerto, 2017; Untea, 2019). An analysis of the fatty acid composition of geese meat samples indicates that a control sample has the highest content of oleic, linoleic, palmitoleic, arachidonic acids as the unsaturated fatty acids, and the highest mass fraction is represented by palmitic and stearic acids as the saturated ones (Figs. 1–2).

During the first 120 days of storage, the total content of UFAs probably did not change, but slightly increased unsaturation (by 10.7%) due to the increase in the content of linoleic, arachidonic, docosapentaenoic, and docosahexaenoic acids (Fig. 3). However, the second half of the experiment was characterized by a probable decrease in unsaturation against the background of the stable total content of UFA. At the same time, the level of all essential acids (linoleic by 2.1 times, linolenic – by 34.0%, arachidonic acids – by 2.7 times) significantly decreased on the basis of an increase in the content of oleic acid by 27.4%. At the same time, the content of docosapentaenoic and docosahexaenoic acids decreased by 4.6 and 5.2 times, respectively. Consequently, there were negative changes in the fatty acid composition of lipids in the control sample of meat in the second part of the experiment.

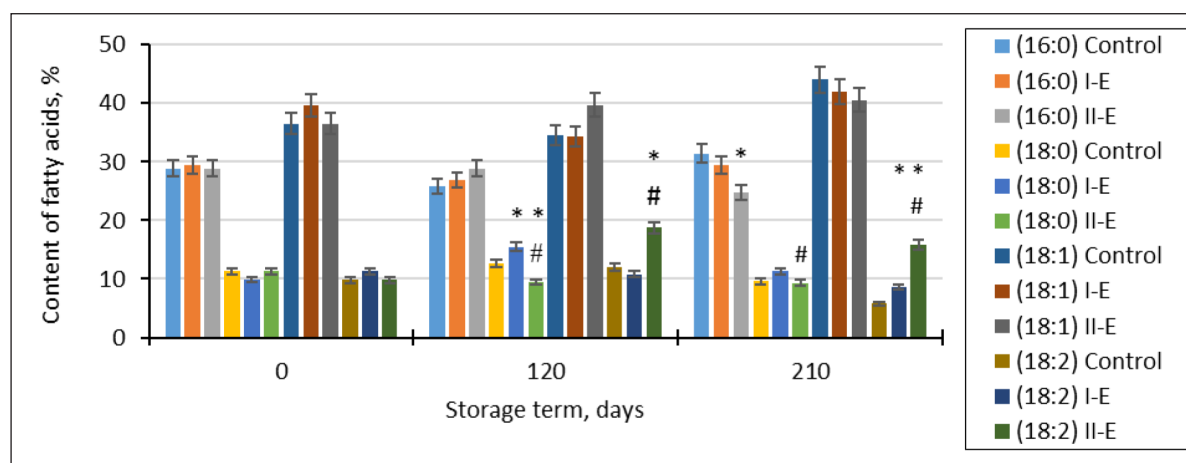


Fig. 1. The content of fatty acids (16:0; 18:0; 18:1; 18:2) in geese meat

Note. Here and further, the difference is reliable in comparison with the control sample when: * $p \leq 0.05$; the difference is significant between the first and the second experimental samples when: # $p \leq 0.05$.

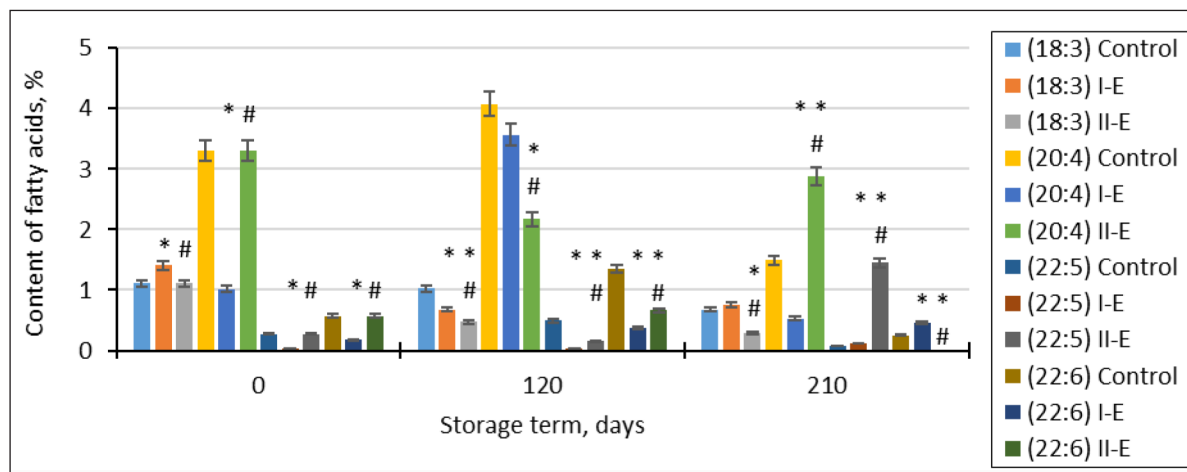


Fig. 2. The content of fatty acids (18:3; 20:4; 22:5; 22:6) in geese meat

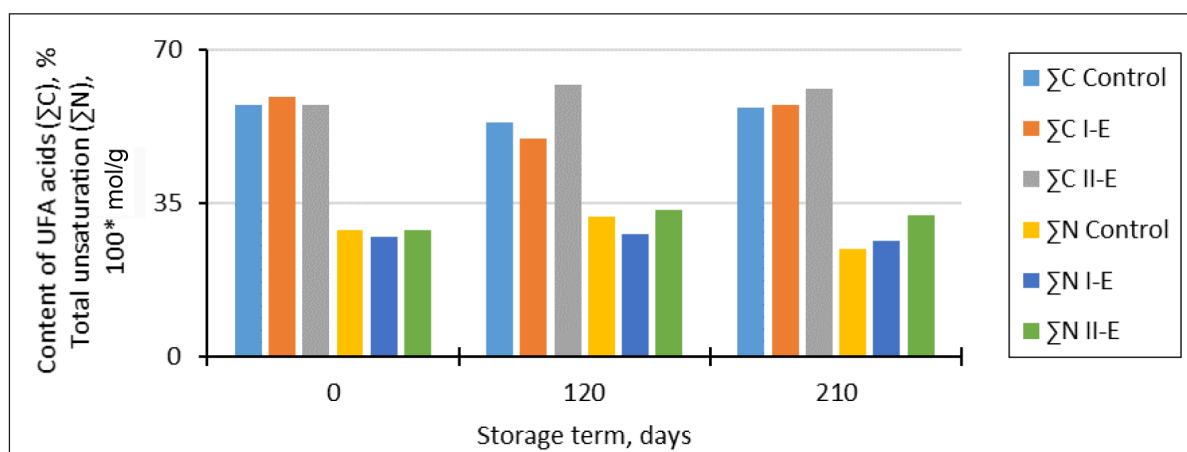


Fig. 3. The total content of unsaturated fatty acids and their unsaturation in geese meat

During the first part of the experiment in the first experimental sample, the general characteristics of fatty acid composition remained at the initial level. Among the significant changes in the fatty acid composition of this sample until the 120th day, there was a decrease the content of linolenic acid by 2.1 times and, conversely, a rise in the level of arachidonic and docosahexaenoic acids (3.5 and 2.1 times, respectively). In the second part of the experiment, significant changes in fatty acid composition were not established. The highest decrease in the content from the 120th to the 210th days was observed for arachidonic acid (2.4 times). Consequently, while storing the meat, a double dose of vitamin E in the geese feed decreases

the loss of unsaturated fatty acids, including indispensable.

The analysis of fatty acid composition of lipids of the second experimental sample shows that due to the treatment with an oil solution of vitamin E, the total unsaturation of fatty acids of lipids on the 120th day of storage of this sample increased by 15.9% compared with the initial value, and the content of linoleic acid increased by 1.9 times. But more importantly, it is likely that at the end of the experiment, the highest level of unsaturation persists in the second experimental sample (31.3% higher than the corresponding index of control). Also, the probable increase in the meat of the second test sample compared to the control was established for

arachidonic and docosapentaenoic acids, while docosahexaenoic acid was not identified in this sample at the end of the experiment.

CONCLUSIONS

Regardless of the technology of application, vitamin E helps to inhibit oxidative damage due to the prolongation of the onset of proximal-antioxidant balance. More effective in inhibiting these processes is an increase in the dose of vitamin E in the diet of geese in the pre-free period. In both studied samples, additional use of vitamin E contributed to the preservation of unsaturated fatty acids, but the mechanisms of influence and changes in the content of certain unsaturated fatty acids in experimental samples are significantly different. The expediency of using the considered technological regimes with the additional use of vitamin E can be determined taking into account the manufacturer's capabilities and requirements for food raw materials.

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VITAMINO E POVEIKIS ŽĄSIENOS KOKYBEI

Santrauka

Ilgai laikant mėsą žemoje temperatūroje, jos kokybė blogėja dėl nesočiųjų riebalų rūgščių oksidacijos. Antioksidantų naudojimas paukščių pašaruose slopina oksidacinę žalą paukštienai ir prailgina mėsos laikymo laikotarpį. Vitaminas E tradiciškai naudojamas kaip vienas efektyviausių riebaluose tirpių antioksidantų. Darbo tikslas – didelės koncentracijos vitamino E poveikio palyginamoji analizė, atsižvelgiant į jo taikymo technologijas žąsienos oksidacinei žalai slopinti, kai mėsa laikoma žemoje temperatūroje. Pirmojo bandinio mėsa buvo žąsies, kuri prieš skerdimą buvo šeriama dviguba vitamino E doze. Antrojo mėginio mėsa iki saugojimo žemoje temperatūroje buvo laikyta vitamino E tirpale. Eksperimento rezultatai patvirtino, kad kokia bebūtų vitamino E panaudojimo technologija, jis prisideda prie oksidacinio pažeidimo slopinimo. Veiksmingesnis yra vitamino E dozės didinimas paukščių pašaruose. Antrinių lipoperoksidacijos produktų kiekis kontrolinėje mėsoje po 210 dienų laikymo padidėjo 5,3 karto, pirmojo mėginio – 2,5 karto, o antrojo – 4,6 karto. Papildomas vitamino E naudojimas abiejuose tirtuose mėginiuose prisidėjo prie nesočiųjų riebalų rūgščių išsaugojimo, tačiau ekspozicijos mechanizmai ir individualūs rūgščių kiekio pokyčiai eksperimentiniuose mėginiuose labai skiriasi.

Raktažodžiai: žąsiena, mėsa, laikymas, oksidacinė žala, α -tokoferolis