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Efficiency of Using Plant Antioxidants in the Meat Processing Industry

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Abstract. A decrease in the nutritional value and a reduction in the shelf life of meat and meat products occurs primarily due to lipid peroxidation and microbial contamination of the product during the cold chain. The intensive development of organic animal husbandry requires market operators to ban the use of synthetic preservatives in the food industry and strictly control their use at production facilities. However, although plant extracts look promising as an alternative to antibiotics or chemical preservatives, there is extraordinarily little available information about the effective dose that can be used without the risk of toxic effects in consumers, which determined the relevance of this study. The purpose of this study was to analyse the effectiveness of using plant extracts as natural antioxidants for the meat processing industry. To fulfil the purpose of this study, an analytical method was used. The main factors that reduce the quality and safety of food products during storage were analysed. The paper analyses the effectiveness of using natural, biologically safe antioxidants for the meat processing industry. It was found that the use of bioantioxidants allows minimising oxidative changes and microbial contamination, which can adversely affect the quality of meat and meat-based products. Based on the literature data, it was found that extracts of spicy plants (rosemary, green tea, sage, cloves, mustard, nutmeg, licorice root, ginger, garlic), berries (black currant, cranberry, strawberry, pomegranate, Maki and goji berries, grapes, barberry, plum) and their compositions are effective natural antioxidants that ensure long-term food storage. The intensive development of organic animal husbandry on the territory of Ukraine requires market operators to ban the use of synthetic preservatives in the food industry and strictly control their use at the production facilities of market operators

Keywords: plant extracts, natural antioxidants, meat products, quality and safety, meat storage

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INTRODUCTION

Creating high-quality products and storage stability is one of the key tasks of the meat processing industry. The main factors that reduce food quality and safety indicators are lipid peroxidation and microbial contamination, which lead to changes in sensory properties (colour, texture, smell, and taste), reduced nutritional value and reduced warranty period (Bal-Prylypko *et al*., 2016). That is why the search for effective biopreservants for the food industry and their testing in production conditions is the first urgent task of scientists around the world, which will contribute to the development of organic production and ensure the effective preservation of quality and safety indicators of the finished product during storage with prolonged action.

Lipid peroxidation products can also cause significant harm to the consumer's health. They can directly affect cellular and genomic stability by disrupting gene expression and cellular signalling pathways. The oxidation products of n-3 and n-6 polyunsaturated fatty acids exhibit atherogenic, mutagenic, and carcinogenic effects. Carbonyl and peroxide compounds, formed because of the reaction of oxidised lipids with proteins, can cause atypical cell proliferation and contribute to the development of inflammation and fibrosis (Soletska, 2017).

In their scientific papers, scientists (Qian-Qian *et al*., 2019) note that essential oils of spices are effective natural food preservatives. Most essential oils have a considerable antimicrobial effect against food pathogens that cause food spoilage. It is their use in food production technology that allows the food industry to extend the shelf life of food products, primarily meat and meat-based products, provided that quality and safety indicators are maintained. Thus, delaying lipid peroxidation and preventing cross-bacterial contamination are critical tasks for the food industry.

The purpose of this study was to analyse the effectiveness of using plant extracts as natural antioxidants for the meat processing industry.

LITERATURE REVIEW

One of the ways to improve the quality and safety of perishable products is to use natural, biologically safe preservatives and antioxidants (Ukrainets *et al.,* 2016; Velázquez *et al*., 2021).

With the development of organic production technology and extreme demand in the food industry, namely meat processing, natural plant antioxidants have been acquired (Zheludenko *et al*., 2014; Liebiedieva *et al*., 2016).

The most popular plant antioxidants and preservatives are spicy plants. Presently, there are more than one and a half thousand spices in the world with a unique taste and aroma profile. The most valuable of them grow in tropical countries, where the warm climate contributes to the production of high-quality products due to the rapid accumulation of essential oils. Manual harvesting technology allows preserving the integrity of plant tissues, and therefore the maximum content of active ingredients (Stasyuk, 2018; Atanasova *et al*., 2022).

The world's leading exporters of spices are India, Vietnam, China, Indonesia, Egypt, Brazil, and other countries of southern latitudes. Transportation of natural spices, which ensures the preservation of their quality and safety throughout the transport chain, is a challenging task for logistics companies. Violation of the cold chain, sanitary requirements, hygiene of working personnel, fluctuations in moisture and air speed, integrity of transport containers – all this reduces the quality of spices and leads to secondary contamination by microorganisms. During transportation, they gradually lose their flavour due to evaporation or oxidation of essential oils and other valuable organic compounds that determine their properties (Kovinko, 2016; Khalajji, 2017; Stasyuk, 2018).

Preserving the quality of natural spices and ensuring their stability during storage has become one of the key tasks of modern technologists and engineers. Among the currently developed technologies for processing plant raw materials, the extraction method deserves special attention. Modern production technologies allow obtaining two versions of extracts: dry (powder, complex, granular, encapsulated) and liquid (water-soluble, emulsion, and functional mixtures). Such technologies open wide opportunities for their application (Feng *et al*., 2022).

The use of natural antioxidants of plant origin in the meat processing industry allows regulating the protein, lipid, amino acid, fatty acid, carbohydrate, trace element, and vitamin composition of the final product – meat and meat-based products. An essential factor is that natural antioxidants, unlike synthetic ones, not only do not have a toxic effect on the human body, but also due to the content of several biologically active substances, they can positively affect the health of the consumer (Bilous *et al*., 2019).

RESULTS AND DISCUSSION

Extracts of plant origin (spices, berries, fruits, vegetables) have antimicrobial, antiviral, and anti-inflammatory activity. The antiviral effect is associated with the content of biologically active compounds in the composition of plant components: polyphenols, tocopherols, flavonoids, ubiquinones, vitamins, etc. The antimicrobial activity of plant extracts is determined by the content of phenolic compounds (phytoncides): tannins, flavonoids, simple phenols and their glycosides, phenolic acids, phenol alcohols, anthocyanins (Pasichnyi & Zheludenko, 2014; Valiukh *et al*., 2016).

Polyphenols of plant extracts inhibit the growth of microorganisms (including pathogenic ones) and mould fungi. The mechanism of their action is understudied,

but there is evidence that polyphenols can cause morphological changes in the bacterial cell of microorganisms by damaging its walls and affect the formation of biofilms. They also affect protein biosynthesis, alter metabolic processes in bacterial cells, and inhibit the synthesis of ATP and DNA (by inhibiting DNA gyrase). Thanks to this antibacterial activity of phenolic compounds, plant extracts are an alternative to the use of chemical preservatives in the meat industry, especially sodium nitrite (Efenberger-Szmechtyk *et al*., 2021).

Phenolic compounds have extremely high activity to capture and repair free radicals. Due to this property, natural antioxidants rich in polyphenols can affect lipid oxidation in meat, providing its inhibition. In the meat processing industry, to slow down the oxidation of lipids, plant extracts (berries, fruits, spicy and medicinal plants) with a high content of phenolic compounds are added to meat raw materials: grape seed extract, black currant extract, plum juice concentrate, etc. (Zheludenko *et al*., 2014; Liebiedieva *et al*., 2016).

Recent studies show that due to the high content of polyphenols, certain spices, berries, and their extracts exhibit antimicrobial and antioxidant properties, and therefore they provide a viable alternative to conventional synthetic antioxidants (Bozhko *et al*., 2017). The use of natural additives of plant origin can not only positively affect the shelf life of meat products, but also increase their biological and nutritional value. Sumy's scientists have proved that the antioxidant properties of black currant extract are conditioned upon the high content of anthocyanides in the berry (Bozhko *et al*., 2017; Bozhko *et al*., 2021).

Their research proves (Patent for the invention No. 119078 UA, 2019) that the use of black currant extract (0.01%, 0.02%, 0.03% per 100 kg of minced meat) in the technology of meat-containing boiled sausage based on poultry meat (duck and turkey) can slow down the course of oxidative spoilage of lipids of boiled sausages. Experimentally, the effectiveness of using black currant extract at a concentration of 0.01% was proved: the peroxide number on day 5 was 0.02% J2, while in the control this indicator was 0.13% J2, which is 6.5 times higher.

Furthermore, it was found (Bozhko *et al*., 2021) that the addition of black currant extract doses of 0.1…0.2% to minced meat-containing semifinished products prevents hydrolytic oxidation of fat during long-term storage for 100 days at negative temperatures and, as a result, reduces fat hydrolysis and reduces the peroxidation of free fatty acids.

The use of strawberry extract in the meat processing industry is also effective. Strawberries are a source of antioxidants and hold vitamins, anthocyanins, flavonoids, and phenolic acids (Lorenzo *et al*., 2018). Scientists have proven that adding chopped strawberry extract to minced chicken cutlets in concentrations of 5% and 10% helps to slow down lipid oxidation and ensures their stability during storage at subzero temperatures for 24 days. Furthermore, strawberry extract is thermally stable: during heat treatment, flavonoids are reduced by only 2% and provitamin A, which gives colour to berries (Manessis *et al*., 2020).

Armenteros *et al*. (2013) and Ganhão *et al*. (2013) found that due to the polyphenol content in strawberries (4.3 mg per 1 g of fruit), lipid oxidation in meat and meat-based products slows down. They agreed that the addition of strawberry extract as a natural antioxidant to meat-based products inhibits protein oxidation, as evidenced by the formation of carbon atoms during heat treatment. This ensures the preservation of the quality indicators of Frankfurter sausages for 20 days, provided that they are stored at a temperature of 4°C (Armenteros *et al*., 2013) and pork cutlets for hamburgers (frozen and heat-treated) for 12 days, provided that they are stored in vacuum packaging at 2°C (Ganhão *et al*., 2013).

The use of cranberry extract is also considered promising in the meat processing industry. Cranberry berries hold natural preservatives – organic acids (malic, lemon, chlorogenic, quinic, benzoic) and flavanoids (oxycoric acids, flavones, and anthocyanins). They are characterised by a high content of dietary fibre, sugars (sucrose, glucose, and fructose), essential amino acids (tryptophan, threonine, isoleucine, leucine, lysine, methionine, phenylalanine, valine) and polyunsaturated fatty acids (linoleic and linolenic) (Bozhko *et al*., 2017). Experiments on the use of cranberry extract (concentration of 0.1…0.2% by weight of raw materials) in the recipe of cooked-smoked meat-rich sausage confirmed the property of the extract to slow down the oxidation of lipids and extend the shelf life to 35 days (Bozhko *et al*., 2020).

The method of production of meat-containing boiled sausage "Kachyna" with the addition of cranberry extract to the minced meat for 0.01…0.03% of the mass of the main raw material has been developed. It was found that this amount is best for providing significant inhibition of oxidative processes of the lipid fraction of minced meat, stabilisation of microbiological parameters and high organoleptic parameters of the product (Patent for utility model No. 119891 UA, 2017; Patent for the invention No. 119079 UA, 2019).

Plum fruits also hold phenolic compounds, namely coumarins, flavonoids, and phenolic acid derivatives, as well as substantial amounts of chlorogenic, cryptochlorogenic, and non-chlorogenic acids, which have antioxidant properties (Ahmad *et al*., 2015). Thanks to these compounds, the ingredients obtained from plums exhibit antioxidant and antimicrobial properties. It is proved that when 5% fresh plum juice concentrate, 2.5% or 5% prune juice concentrate are injected into roast beef, protein, and lipid oxidation is inhibited during chilled storage. At the same time, the added ingredients minimally affect the tasting characteristics of meat (Nucez de Gonzalez *et al*., 2008).

Upon studying the antioxidant properties of 10% water infusion of pomegranate (10 ml of infusion was

added to 1 kg of minced meat), Zazharska *et al*. noted the impracticality of its use in the technology of making blood sausage. It was noted that the standard sample of blood sausage according to DSTU 4334:2004 and prototypes with the addition of water infusion of pomegranate (from the membranes and crust) have the same sensory and microbiological indicators during the shelf life regulated by the standard (Zazharska *et al*., 2018).

One of the exotic berries that recently has attracted the attention of scientists as a natural nutraceutical in the food industry has become maqui berry. This is a new Chilean superfruit, the fruit of an evergreen shrub, with high nutraceutical value. Maqui berry (*Aristotelia chilensis*) is also called Chilean blackberries, which are grown in central/southern Chile and southwestern Argentina. It has antioxidant activity due to its high content of biologically active compounds, such as phenolic acids, anthocyanins, and flavonoids (Genskowsky *et al*., 2015; Quispe-Fuentes et al, 2018; Bastías-Montes *et al*., 2020). Furthermore, Maqui berry is a natural antitumour and anti-inflammatory agent that can absorb oxygen radicals, inhibit xanthine oxidase, oxidise lipids, and reduce intracellular oxidative stress (Chen *et al*., 2020).

It is proved that among the proven drying methods (freesing, convective, solar, infrared, and vacuum drying) of Maqui berries, the most effective is the vacuum drying method. It is vacuum-dried fruits that retain the highest content of free flavanols and antioxidant capacity compared to other processing methods (Bastías-Montes, *et al*., 2020). Goji berries hold many nutrients and bioactive compounds, which allowed classifying them as superfruits. They are a source of many biologically active compounds characterised by high antioxidant potential (Kulczyński & Gramza-Michałowska, 2016). Unlike other fruits and fruit extracts, Maqui berries have been tested for use in the meat processing industry as an additive in packaging films (Baek *et al*., 2019).

Scientists from many countries have developed a technology for creating and investigating the effectiveness of using active edible films holding biopolymers (polysaccharides and/or proteins) and active compounds (plant extracts, essential oils, nanofilters, etc.) to reduce losses and extend the shelf life of food products, namely meat-based products. They noted that the inclusion of organic acids, enzymes, antimicrobial proteins, phenolic compounds, or other functional ingredients, such as plant-based nutraceuticals, not only improves the quality of food products, but also extends their shelf life (Benbettaïeb *et al*., 2019).

Two basic statements should be outlined in favour of using active biopolymer films compared to direct administration of antioxidant and/or antimicrobial components in meat products: (1) it is possible to control the diffusion of active compounds to the surface of the finished product and (2) the amount of preservatives added (Jamróz & Kopel, 2020; Smaoui *et al*., 2022).

The authors found that the edible packaging film made of oat starch with the addition of 20% Maqui berry extract for packaging salmon exhibits antioxidant properties by suppressing lipid oxidation under the condition of storage of experimental samples at 4°C (Baek *et al*., 2019).

Analysing the antibacterial ability of edible chitosan films, which include 0.5% or 1% *Maqui berry* extract, it was found that they exhibit a bacteriostatic effect against S. *marcescens*, S. *putrefaciens*, P. *fluorescens*, A.*denitrificans*, A. *hydrophila*, A. *faecalis* and C. *freundii*, L. *innocua*. Furthermore, they exhibit high antioxidant activity (Jamróz & Kopel, 2020; Smaoui *et al*., 2022).

Ginger (Singiber officinale Roscoe) has won the favour of food technologists due to its powerful antibacterial effect and its ability to hydrolyse native collagen (Mao *et al*., 2019; Beristain-Bauza *et al*., 2019). The group of scientists (Hamad *et al*., 2016) proved that ginger essential oil at a concentration of 1250 μg/ml can be used as a natural preservative of fresh chicken meat for 12 days and can extend the shelf life to 6 days at 3-7°C.

Sage extracts (*Salvia officinalis* and *Salvia fruticosa*) hold a wide range of antioxidant compounds (carnosol, carnosic acid, rosmanol, apigenin, luteolin methylcarnosate, rozmadial, Rosmanol-9-ethyl ether, epirosmanol, isorosmanol, and galdozol) that provide its antioxidant, antibacterial, and antifungal effects (Agric, 2013). The literature provides data on the use of sage extract in the technological formulation of meat products (liver pates, meatballs, and sausages) that provides protection against lipid and protein oxidation.

The content of phenols also provides antioxidant properties in barberry leaves, which creates potential for their use in the meat industry. Scientists found that the use of gelatin film with freeze-dried barberry leaves (1 g/kg) for packing meat cutlets considerably inhibits lipid oxidation during 20 days of their storage (Mohd Azman *et al*., 2016).

As a natural antioxidant, green tea extract is used – a source of polyphenols. The use of active packaging made of antioxidant polyamide impregnated with green tea extract for packaging fresh minced meat allows extending its storage period on an industrial scale up to 23 days (Borzi *et al*., 2019).

A source of phytocomponents (gallic acid, catechin, and epicatechin) and phenolic compounds with a high antioxidant effect is grape seed extract (Zheludenko *et al*., 2014). The antioxidant effect of phenolic substances contained in grape seeds is mainly due to two-, three-, oligo-, or polymer proanthocyanidins. Application of a natural preparation made from red grape seeds (in a concentration of 0.5…1.5% by weight of minced meat) in the manufacture of boiled and smoked meat-containing sausages with freshwater aquaculture meat in a natural shell effectively inhibits fat oxidation, which allows preserving the quality of the finished product during storage for 35 days (Bozhko & Tyshchenko, 2020).

I.O. Litvinova (2016) developed a method for obtaining extract from grape seeds and a technology for obtaining an antioxidant additive "Maltovin" on its basis, which contains a phenolic complex and maltodextrin. The use of Maltovin additives in the technological formulation of meat products (meat pate, fried sausage, quick-frozen minced meat semifinished products) (by replacing 2% of the main raw materials) improves rheological parameters, the structure of minced meat, slows down oxidative processes, shows bacteriostatic and fungicidal action, which helps extend their shelf life (Litvinova, 2016).

Among the flavonoid-rich additives, plant-based antioxidants, a special place belongs to rosemary, whose leaves and stems contain more than 12 types of antioxidants, namely rosemarinic, caffeic, carnosic acids, as well as those that can inhibit the oxidation of ascorbic acid and carotenoid fats (Cherednichenko *et al*., 2021).

The most active components of rosemary extracts are carnosic acid and carnosol. They are powerful inhibitors of lipid peroxidation in the microsomal and liposomal systems and absorbers of peroxyl radicals and superoxide anion, thus providing 90% of the antioxidant properties of rosemary. Rosemary extract has a cascading ability to renew vitamin E and is also involved in the carnosic acid cascade. As soon as the antioxidant molecule of carnosic acid "captures" the free radical, it changes its structure turning into carnosine. In the future, carnosol also "captures" the free radical and changes again, transforming into rosmanol. Rosmanol again "captures" radicals and turns into galdozol. Thus, a continuous cascade process is implemented.

Riabovol & Bal-Prylypko (2021) proved that adding 0.15% rosemary extract to minced meat reduces the level of fat peroxide during storage of the finished product for 10 days and slows down the growth rate of fatty acids present in minced meat.

Bozhko *et al.* (2017) developed recipes for meat-rich sausages (Patent for utility model No. 130387 UA, 2018) and meat-rich boiled and smoked sausage (Patent for the invention No. 121263 UA, 2020) made from waterfowl meat, which include the antioxidant of natural origin rosemary extract is injected in a concentration (0.03…0.05% by weight of the raw material). The results obtained by scientists indicate that rosemary extract at a concentration of 0.05% most effectively inhibits the hydrolytic breakdown of acylglycerides (Bozhko *et al*., 2017).

Valiukh *et al.* (2016) found that the use of a 0.02% solution of rosemary extract in minced meat from waterfowl (Peking duck) ensures its microbiological stability for 90 days of storage at -18°C. The amount of mesophilic aerobic and facultative anaerobic microorganisms in prototypes of minced meat at the end of the shelf life is 5.5 times less compared to the control.

Some scientists believe that the use of compositions from plant extracts is more effective. It is the joint mixtures that polygranically increase the biological value of products by introducing essential oils contained in extracts, bioflavonoids (catechins and phenolic acids), and also provide a preventive and restorative effect on the health of the consumer. Furthermore, each of the components of the mixture enhances the effect of the other.

Studies of N.V. Bozhko and L.U. Voytsehivska and others are dedicated to justifying the feasibility of using rosemary and green tea plant extracts and analysing their influence on the physico-chemical parameters of hydrolytic and oxidising processes in minced meat mixtures for meat semifinished products (Bozhko *et al*., 2017)

Scientists of the Institute of Food Resources of the National Academy of Agrarian Sciences (Voitsekhivska *et al*., 2020) found the optimal amounts of addition of biologically active substances to poultry meat of mechanical deboning, which provide the most effective manifestation of their antioxidant properties: dihydroquercetin – 0.025%; fat-soluble and water-soluble green tea extract – 0.05%; water-soluble rosemary extract – 0.07%; fat-soluble rosemary extract – 0.1%. The authors proved the effectiveness of the mentioned extracts in inhibiting oxidation processes during storage for 10…15 days, 3.7…5.2 times compared to the control sample. In addition, Voytsechivska L.U. *et al.* found (Voitsekhivska *et al*., 2020) the effectiveness of the use of these natural antioxidants in stabilising the colour of the meat of mechanically deboned poultry during grinding due to the delay in the oxidation of unsaturated fatty acids, which are catalysed by divalent iron ions present in the pigments of muscle tissue.

The use of natural bioactive substances, such as extracts of rosemary, green tea, and dihydroquercetin, apart from effectively protecting meat lipids from oxidative spoilage, performs the stabilising function of organoleptic parameters – colour and smell (Voitsekhivska *et al*., 2020).

The use of a composition of rosemary and grape seed extracts also reduces the rate of lipid oxidation. The study (Bozhko & Pasichnyi, 2018) investigated the effectiveness of introducing such a composition into minced meat from Peking duck. It was found that the addition of rosemary extract (0.01-0.03%) and grape seeds (0.05-0.15%) helps slow down the hydrolytic lipid oxidation of minced meat by 35.63-57.09%. The results of research prove the prospects of using the composition in the technology of minced meat products with a high fat content.

Zahorui *et al.* (2020) investigated the antioxidant properties of a mixture of spice extracts – cloves, mustard, nutmeg, and garlic (0.5%), when storing melted pork fat under conditions of accelerated kinetic oxidation (102°C). It was found that the use of the mixture extends the duration of fat storage up to 56 days. This mixture of extracts is a promising highly effective bioantioxidant.

CONCLUSIONS

Thus, with the development of organic production in Ukraine, meat industry researchers are focusing on creating new recipes for meat products using natural

and safe ingredients. In this sense, plant extracts are an excellent alternative to synthetic preservatives. Extraction allows protecting the resulting phyto-raw materials from microbiological and mechanical impurities, reducing the volume of industrial storage facilities and, most importantly, extending their shelf life.

Furthermore, this method of processing allows transporting plant extracts over long distances while keeping their quality and safety. With the development of agricultural technologies over the past century, progress has also been made in acclimating spices in temperate countries and matching them with local native plants, which also eases transport logistics. Plant products hold compounds such as flavonoids, vitamins, organic, and phenolic acids, are effective against oxidative processes and have a bacteriostatic effect against bacteria. Extracts of spicy plants (rosemary, green tea, sage, cloves, mustard, nutmeg, licorice root, ginger, garlic), berries (black currant, cranberry, strawberry, pomegranate, Maqui and goji berries, grapes, barberry, plum) and their compositions are promising bioantioxidants with high efficiency. They not only extend the shelf life of meat and meat products, but also positively affect the health of consumers.

The prospects of further studies lie in the development of an effective biopreservative for the meat processing industry based on plant extract of Maqui and goji berries, which will ensure long-term storage of boiled sausages and chilled beef and pork meat.

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Ефективність використання рослинних антиоксидантів у м'ясопереробній промисловості

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Анотація. Зниженння харчової цінності та скорочення терміну придатності м'яса та м'ясопродуктів відбувається, перш за все, внаслідок перекисного окислення ліпідів та мікробної контамінації продукту під час холодового ланцюга. Інтенсивний розвиток органічного тваринництва вимагає від операторів ринку заборону використання синтетичних консервантів у харчовій промисловості та суворий контроль за їх використанням на виробничих потужностях. Однак, незважаючи на те, що рослинні екскракти виглядають багатообіцяючими як альтернатива антибіотикам або хімічним консервантам, доступної інформації про ефективну дозу, яку можна використовувати без ризику токсичних ефектів у споживачів дуже мало, що зумовило актульність даного дослідження. Метою роботи було проаналізувати ефективність використання рослинних екстрактів, як натуральних антиоксидантів для м'ясопереробної промисловості. Для досягнення мети дослідження використано аналітичний метод. Проаналізовано основні фактори, які знижують показники якості та безпечності харчових продуктів під час зберігання. Надано аналіз ефективності використання натуральних біологічно безпечних антиоксидантів для м'ясопереробної промисловості. Встановлено, що використання біоантиоксидантів дає можливість мінімізувати окислювальні зміни та мікробну контамінацію, які можуть негативно впливати на якість м'яса та м'ясопродуктів. На основі літературних даних визначено, шо екстракти пряних рослин (розмарин, зелений чай, шавлія, гвоздика, гірчиця, мускатний горіх, корінь солодки, імбир, часник), ягід (чорна смородина, журавлина, полуниця, гранат, ягода макі та годжи, виноград, барбарис, слива) та їх композиції є ефективними натуральними антиоксидантами, які забезпечують довготривале зберігання харчових продуктів. Інтенсивний розвиток органічного тваринництва на території України вимагає від операторів ринку заборону використання синтетичних консервантів у харчовій промисловості та суворий контроль на виробничих потужностях операторів ринку за їх використанням

Ключові слова: рослинні екстракти, натуральні антиоксиданти, м'ясопродукти, якість та безпечність, зберігання м'яса