ANIMAL SCIENCE AND FOOD TECHNOLOGY

Journal homepage: https://animalscience.com.ua/en
Animal Science and Food Technology, 13(4), 19-29
Received: 15.09.2022 Revised: 13.10.2022 Accepted: 27.10.2022

UDC 006:637.52.04
DOI: 10.31548/animal.13(4).2022.19-29

Analysis of the use of plant components in the production of meat products

Roman Zinchenko*
Postgraduate Student
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0009-0003-1899-1199

Yuliia Slyva
PhD, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0003-2592-6822

Abstract. The inclusion of plant components in meat products plays a substantial role in human nutrition, since such inclusions are a source of biologically active substances, promote digestion, and increase the nutritional composition of food products. The purpose of this paper is to review the latest studies on the use of plant components in the production of meat products and search for new ones that can be used as substitutes for artificial additives and meat raw materials. During the study, methods of analysis, comparison, and synthesis of papers of Ukrainian and foreign researchers located in scientometric databases, such as Web of Science, Scopus, and internet resources, are used. During the study of the literature, the main problems of meat products production are considered: spoilage of products during storage, increased content of nitrates and phosphates, development of pathogenic microflora. It is identified that the main centre of research is oxidative processes during the production and storage of finished meat products. It is identified that due to the high content of vitamins, phenolic compounds, and micro- and microelements, plant inclusions can act as inhibitors in such reactions. In the course of the study, it is determined that the most commonly used: peel, pulp, juices, and extracts of fruits and vegetables as plant inclusions. The main task of such inclusions is to replace synthetic inclusions with natural ones to increase the nutritional value and composition of food products. A comparative analysis of the nutritional value and chemical composition of fruits, vegetables, and their juices is conducted to select the most fitting plant inclusions that are common on the Ukrainian market. The indicators are summarised in the table. Replacing artificial antioxidants, preservatives, and other compounds with their natural counterparts is essential for modern manufacturing, as such technological solutions will help make food more functional, healthy, and increase the level of beneficial compounds in food

Keywords: chemical composition, natural antioxidants, phenolic substances, natural substitutes, plant inclusions

Suggested Citation:
Zinchenko, R., & Slyva, Yu. (2022). Analysis of the use of plant components in the production of meat products. *Animal Science and Food Technology*, 13(4), 19-29.

**Corresponding author*

Introduction

The meat processing industry is one of the most popular industries in Ukraine, which is why the largest number of producers are focused on creating innovative approaches in the processing of meat products. In recent years, when production, formulations, and processing technologies have reached a stable position, manufacturers focused on creating safe products and improving their range (Koval *et al.*, 2021).

Meat and meat products are the main source of high-quality protein, fat, minerals, and vitamins. Due to the growth of the population, and the level of consciousness of consumers, meat consumption per unit of the population increased by 3 times compared to the 1960s (Yarmolenko, 2020), which led to the need for quantity, quality, and safety of these food products.

The segment of meat processing industry occupies a fairly large volume in the food industry of Ukraine, approximately 18% (Ishchuk, 2020), second only to the dairy and grain sectors in terms of output. The high level of competition and an insufficient number of suppliers of raw materials led to an increase in the cost of products, but this did not reduce the demand for them. That is why modern research and production have focused on adding plant inclusions to the production of meat products.

According to classical technologies, the production of meat products provides for the addition of synthetic additives at certain stages of production processes. In particular, phosphates are added at the stage of preparation of minced meat, to increase the emulsifying and moisture-binding properties of meat products, inhibit oxidative processes and colour formation, and stabilise the pH of the product. Along with phosphates, sodium nitrite is added, which is most often used in meat products, as a dye. Antioxidants are added during the preparation of minced meat to inhibit oxidative processes (Klymenko *et al.*, 2021).

Oxidative reactions in meat products are one of the centres of attention of researchers in the field of production and storage of meat products because of their role in the deterioration of safety and quality and the formation of toxic compounds that are directly related to changes in aroma and taste. In addition to causing a change in the colour of meat, which, as a result, leads to rejection of the product by consumers, oxidative reactions lead to the following losses: loss of vitamins, essential amino and fatty acids, which are caused by undesirable lipid oxidation in meat products (Turgut *et al.*, 2017; Zahid *et al.*, 2019). In addition, processed meat products are very susceptible to loss of colour, loss of functionality of lipids, proteins, and the appearance of rancid taste due to highly reactive nitrogen intermediates formed during oxidation. (Reshi *et al.*, 2017; Klymenko *et al.*, 2021). Synthetic food preservatives such as butylated hydroxyanisole and butylated hydroxytoluene, which are used as inhibitors of the fat oxidation process, are effective in stopping spoilage processes in meat and meat products, but simultaneously, these preservatives cause serious health concerns and allergic reactions (Zahid *et al.*, 2019). The use of antioxidants from plant components for storing meat products is an alternative solution to prevent the occurrence of such problems. Organoleptic characteristics of meat products are also improved by introducing plant extracts into meat products (Golub & Horbach, 2018).

The purpose of the study was to analyse the latest studies on the use of juices, zest, and other plant components in the production of meat products.

Analysis of the Use of Vegetable Components in the Production of Meat Products

Given the level of consumer awareness, the trend of healthy eating, and the growing demand for organic products, over the past 20 years, a large number of researchers have been trying to investigate the use of natural substitutes in the production of meat products. Thus, trying to replace artificial or chemical substances in the composition of meat products, while not losing, or even increasing organoleptic, physico-chemical, and microbiological indicators (Krivosheeva *et al.*, 2020). It was due to such studies that the qualitative composition of nutrients and the shelf life of the product increased. The peel, zest, pulp, juices, and seeds of fruits and vegetables are most often used as plant components (Rodriguez-Amava, 2015; Turgut *et al.*, 2017; Mohammed *et al.*, 2022).

In the study (Turgut *et al.*, 2017), 0.5 and 1% pomegranate peel extract was added to beef meatballs and stored at -18±1°C. The results showed that the oxidation of lipids and proteins was suspended, and organoleptic parameters remained constant. This indicates a high antioxidant property of pomegranate. In addition, other parts of the fruit (juice, seeds) have antimicrobial properties. Due to the high content of punicalagin and ellagic acid, pomegranate juice can be used as a natural antibiotic to destroy or suppress pathogenic microorganisms. Antioxidant activity is explained by the high content of phenolic compounds, including anthocyanins (3-glucosides and 3.5-diglucosides delphinidin, cyanidin and pelargonidine), ellagic acid, punicalin, punicalagin, pedunculagin, and various flavonoids (Turgut *et al.*, 2017; Saleh *et al.*, 2017). Ukrainian research focused on the use of pomegranate juice as a vegetable dye that can replace the action of sodium nitrite, according to the results, improved organoleptic parameters with increased content of vitamins in the product were achieved (Verchenko *et al.*, 2019).

In another study, ginger root extract was added to the production of fried sausages from poultry meat. Ginger is one of the traditional medicinal plants. Ginger contains active ingredients that have antibacterial, anti-flatulence, antimicrobial, anti-inflammatory, antidiabetic, antispasmodic, anti-cancer, and antioxidant properties. A 5% solution of ginger root extract was added to the sausage recipe, which led to an increase in the shelf life of sausages, while the pH value remained within the normal range. The action is explained by the high content of phenolic compounds

gingerol, which can inhibit chain reactions during lipid oxidation. In addition, the introduction of ginger extract leads to the saturation of the product with a large amount of vitamins and minerals, which can increase the resistance to infectious diseases and increase the immunity of the human body (Reshi *et al.*, 2017; Rubanka *et al.*, 2017).

An effective antioxidant can be mango juice and its peel. Studies results of a group of authors (Manzoor *et al.*, 2022), showed that when adding mango peel extract to chicken sausages, in concentrations of 2%; 4%; 6%, it will allow not making substantial changes to recipes. In organoleptic parameters, when using an extract concentration of exactly 4%, it had a negative effect on the colour of the product. The study showed that sausages with the addition of the extract show a higher content of thiol and a lower content of carbonyl, which prevents protein oxidation.

From previous studies, it can be stated that the main factor in the replacement of antioxidants is a decrease or complete inhibition of the oxidation of proteins and fats during the life cycle of a meat product. Therefore, (Bozhko, 2015) in his research focused on the search for natural inhibitors and replacing nitrite and its derivatives with natural antioxidants. In the course of his studies, he identified the fact that in case of improper storage of the product, or during violations of technological processing conditions, nitrosamines can form, a substantial part of which has a carcinogenic effect or is toxic to the human body. A drug was used that included β-carotene and vitamin E, which are natural antioxidants to neutralise them. These two vitamins are present in large quantities in juices and vegetables.

A separate issue in the production of meat products is the large amount of phosphates. Excess phosphates in the body cause a violation of the internal intestinal microflora, can lead to the development of allergies. In addition, excess phosphates negatively affect the functioning of the kidneys and liver (Volkova *et al.*, 2021). According to the study by Yu. Krizhova and I. Moskalenko (2021), phosphates were replaced with amylopectin starch, and sodium nitrite – with beet juice during the production of diet cooked sausages. The results of the study showed that organoleptic parameters reached the planned values. Special attention should be paid to the recommendations for a complete replacement of sodium nitrite with beet juice. In addition, beetroot contains substantial amounts of tocopherol, carotene, folic and ascorbic acids, which lead to an antioxidant effect, due to their action as an inhibitor of oxidative reactions. Therefore, beetroot juice can function as a natural substitute for artificial antioxidants (Rodriguez-Amava, 2015; Krizhova & Tkachenko, 2021).

Another group of researchers (Thangavelu *et al.*, 2022) investigated that consumption of processed meat products declined substantially for many reasons. One of the reasons is the likelihood of a negative impact on consumer health, which is associated with the composition of processed meat products, namely high salt and fat content, the presence of synthetic additives, etc. The use of these ingredients can lead to: cardiovascular problems, obesity, kidney problems, and even cancer. Recently, consumers have been demanding the absence of synthetic additives and non-dairy components in meat products. This requirement causes enterprises for the production of meat products to change the recipe, reduce the amount of phosphates, salt, etc. In particular, to reduce the proportion of phosphate use, researchers (Thangavelu *et al.*, 2022) in the production of fresh sausages, added apple pomace as a byproduct in the production of juice and coffee bean husks. In the future, the raw product was subjected to processing by ultrasound and preparation by ultrahigh-frequency radiation. As a result, it was identified that due to such a technological solution and the addition of plant components, it is possible to reduce the use of phosphates by up to 80% without a negative impact on the physico-chemical and technological properties of sausages. In turn, the complete removal of phosphates from the technological stages negatively affected the quality of sausages.

In search of functional food products, some researchers turn to the use of seaweed in their production technologies. So a group of researchers (Mohammed *et al.*, 2022), suggested adding seaweed to pork sausages *Porphyra umbilicalis* – Nori. Seaweed contains biologically active compounds such as: proteins, minerals, vitamins, dietary fibre, polyphenols, carotenoids, and tocopherols. In addition, they are low in lipids, and some types of algae contain high levels of polyunsaturated fatty acids. In addition, studies were conducted on the addition of other types of algae to the recipe of fresh sausages: *Himanthalia elongata* – sea spaghetti, *Alaria esculenta* – Irish wakame and red seaweed – *Palmaria palmata* – dulse. As a result, a disadvantage of the use of seaweed was identified – a change in colour and taste (López-López *et al.*, 2009; Mohammed *et al.*, 2022).

Another main object of research was natural essential oils. They are among the best alternatives to synthetic antioxidants due to their strong antimicrobial action. Essential oils have been widely used in food production due to their antibacterial, antifungal, and antioxidant properties, and as food flavourings. The main advantage of essential oils is that they can be used for any food. Essential oils contain many phytochemicals, including phenol and compounds such as flavonoids, which are sources of natural antioxidants. In studies (Gerges & Asuoty, 2022), basil essential oil and acetic acid were added in various concentrations to chicken sausages. The finished products were stored in the refrigerator at 4°C and freezer at -18°C for 15 days. As a result of the conducted studies, inhibition of pathogenic microflora and suspension of oxidative processes were detected (Viuda-Martos *et al.*, 2010; Gerges & Asuoty, 2022).

In the study (Kotecka-Majchrzak *et al.*, 2021), hemp pulp was used as a byproduct of cold-pressed oil, of various concentrations, in the production of meatballs. According to the technology, meatballs were baked, cooled, and packed in a vacuum. The results showed that such a technological solution allowed to increase the shelf life of the product to 12 days by inhibiting the processes of lipid oxidation.

Materials and Methods

The search used papers placed in scientometric databases in three electronic bibliographic databases: Web of Science, Scopus, and Science Direct, and on the Google Scholar platform published in English, Ukrainian, and Polish.

During the analysis and review of the latest scientific achievements, 323 scientific sources of various types were processed: abstracts and materials of scientific conferences; studies; textbooks; monographs; dissertations; thematic internet sources; technologies for the production of meat products by Ukrainian and foreign authors.

The search was conducted in the following key words and phrases: the meat processing industry; the development trend of the meat industry; plant use; antioxidants; natural antioxidants; meat products; the use of fruits in the production of meat products; the use of fruit juices in meat during production; lipid oxidation in meat products; flavonoids; the use of pomegranate in the production of meat products; the use of ginger in the production of meat products; the use of sea buckthorn in the production of meat products; the use of pumpkin juice in the manufacture of meat products; the use of carrot juice in the manufacture of meat products; the use of mango in the production of meat products; the use of black currant in the production of meat products; the use of sea buckthorn in the production of meat products; the use of elderberry; the use of oil from cannabis; oil from industrial hemp; chemical composition: elderberry, currant, raspberry, carrot, pumpkin, ginger, carrots, beets, pomegranate, hemp oil; chemical composition of juice from elderberries, currants, raspberries, carrots, pumpkins, carrots, beets, pomegranate; study: elderberries, currants, raspberries, carrots, pumpkin, ginger, carrots, beets, pomegranate, hemp oil; nutritional value: elderberry, currant, raspberry, carrot, pumpkin, ginger, carrots, beets, pomegranate, hemp oil; vitamins; trace elements contained in apples, currants, raspberries, carrots, pumpkin, ginger, carrots, beets, pomegranate, hemp oil; macronutrients contained in apples, currants, raspberries, carrots, pumpkin, ginger, carrots, beets, pomegranate, hemp oil; the nutrient composition of food products; bioactive substances in food products; carotenoids; β-carotene; manufacturing technology of chopped semi-finished products; technology for production of natural sausage, and their Ukrainian or Polish translation. All studies and internet sources were summarised in an Excel spreadsheet and checked for duplication. Duplicate studies were deleted (n=86). Studies that passed the first stage of verification (n=237) were reread in detail and those that were clearly irrelevant for information (n=181) were also deleted. Of the remaining 56, internet sources that did not have links to scientific literature (n=13) were removed.

In the further study of the papers, the following methods were used: analysis – when analysing the latest findings on the use of plant substitutes in meat products; comparison – when comparing the effects of the use of plant-based antioxidants with the effects of standard food additives used in the production of meat products; synthesis – to deduce the probability of using natural substitutes or Ukrainian analogues of the investigated ones; generalisation – when searching for common signs of plant inclusions and their effects when used in the production of food products.

After analysing the latest studies of Ukrainian and foreign experts, it is necessary to identify several main areas of research on the use of plant components for partial or complete replacement of synthetic additives in the production of meat products, as natural additives that have antiseptic and antioxidant properties, to increase the level of nutritional value by adding plant inclusions or combinations thereof.

The results of the analysis show that carotenoids, vitamin C, vitamin E, and phenolic compounds are plant-based antioxidants that are used to stabilise and can extend the shelf life of meat products.

Description of Nutrients that Can be Used as Antioxidants

Carotenoids are the most common, numerous, and important group of natural pigments. According to their chemical structure, carotenoids belong to the class of terpenes and are widely distributed in both photosynthetic and non-photosynthetic organisms (Simonova, 2010). Of the carotenoids in the production of meat products, β-carotene (provitamin A) is the most applicable. In nature, β-carotene is a precursor to the fat-soluble vitamin A-retinol. It is used as an antioxidant and food colouring agent E160a. Carotenoids are identified in large quantities in carrots, oranges, persimmons, saffron, tomatoes, spinach, pumpkin, papaya, grapefruit, apricots, pomegranates, mango, watermelon, ginger, melon, avocado, nectarine, and passion fruit (Milne, 2005).

Vitamin E (tocopherol) is a fat-soluble vitamin that is used to prevent the oxidation of fatty acids. It is a group of leaded phenols, labelled as a food additive E306 (a mixture of tocopherols), E307 (α-tocopherol), E308 (γ-tocopherol), and E309 (δ-tocopherol). The antioxidant properties of tocopherols are explained by the ability of the mobile hydroxyl of the chromane core to interact with oxygen free radicals (HO_2, O_2, HO) (Mokrosnop & Zolotareva, 2021). Tocopherols are identified in large quantities in: bananas, almonds, soybeans, carrots, avocado, broccoli, radishes, pomegranates, oatmeal, onions, pumpkin, green leafy vegetables, sea buckthorn, rosehip, black currant and its essential oil (Afanasyeva & Stoychyk, 2015; Kruchanitsya *et al.*, 2019).

Vitamin C (Ascorbic acid) is also a well-known antioxidant, it is identified in many fruits and vegetables and is labelled as a food additive E300. The antioxidant properties of ascorbic acid are due to the reaction with free oxyl and hydroxyl radicals, and it can also reduce α-tocopherol, which enhances the antioxidant effect (Artiushenko, 2021). Most vitamin C in large quantities is identified in: rosehip, sea buckthorn, black currant, kiwi, papaya, grapefruit, lemon, oranges, mango, ginger, celery, raspberry, beetroot,

elderberry, onion, sorrel, tangerine, pumpkin, and apples (Afanasyeva & Stoychyk, 2015; Kruchanitsya *et al.*, 2019).

Phenolic compounds are a group of chemicals based on derivatives of aromatic alcohol – phenol (C6H5-OH), the physiological role of which is associated with antiradical and antioxidant properties. In plant inclusions, the most common are bioflavonoids (vitamin P) – a group of vitamin-like substances that are similar in biological activity to vitamin C. (Afanasyeva & Stoychyk, 2015; Kruchanitsya *et al.*, 2019). Phenolic compounds are identified in large quantities in: raspberries, strawberries, cherries, plums, black currants, elderberries, blackberries, pomegranates, red grapes, and blueberries.

These substances are of natural origin and can be used as a partial or complete substitute for synthetic antioxidants. As a result of the analysis, it can be noted that plants that contain the greatest amount of antioxidants and can be used as additives for partial or complete replacement of synthetic components are: mango, pomegranate, ginger, beetroot, brown and green algae, apples, essential oils. However, a substantial part of these fruits and vegetables are not very common in the Ukrainian market (Rubanka *et al.*, 2017; Simakhina & Naumenko, 2021; Mohammed *et al.*, 2022). The best solution is to select a combination of several fruits, vegetables, and products made from them that could achieve the desired effect during production. Considering the demand on the national market, the following plants, their components, and combinations were selected: pomegranate, ginger, beetroot, carrot, raspberry, pumpkin, elderberry, and sea buckthorn.

Description of Foods Containing Natural Antioxidants

Pomegranate is grown in countries with subtropical climates, present on the market in large quantities. Pomegranate peel and juice contain vitamins B_6, B_{12}, C, H, P, E, fibre, minerals, and trace elements – phosphorus, calcium, manganese, iodine, magnesium, iron, potassium, and sodium. In addition, organic acids – tartaric, succinic, citric, etc. Pomegranate peel contains a lot of tannins, ursolic acid, alkaloids, and it also has good antiseptic properties. In the production of meat products, it can be used as a substitute for meat raw materials, artificial antioxidants, and a partial substitute for antiseptics. (Turgut *et al.*, 2017; Burak, 2012; Kruchanitsya *et al.*, 2019).

Ginger is grown in tropical areas and is available on the market in large volumes. Ginger root juice contains vitamins: B_6, B_1, B_9, B_5, B_2, A, C, E, and K; minerals and trace elements: potassium, calcium, magnesium, sodium, phosphorus, manganese, copper, iron, selenium, zinc, lysine, phenylalanine, threonine, methionine, curcumin, etc.; antiseptic and mucolytic substances: camphene, cineol, bisabolene, resinous substance gingerol forms an astringent and sharp taste; essential acids – oleic, linoleic, and caprylic (Reshi *et al.*, 2017; Rubanka, 2017). In the production of meat products, it can be used as a substitute for meat raw materials, artificial antioxidants, a partial substitute for antiseptics, flavourings, and spices.

Beet is a root vegetable grown in large volumes in Ukraine and is a component of a substantial number of Ukrainian dishes. This root vegetable is rich in vitamins: C, PP, B; amino acids: lysine and arginine; organic acids: pantothenic, folic, sorrel, and malic; phenolic compounds; minerals and trace elements: iron, calcium, magnesium, iodine, zinc, copper, and various carotenoids (Afanasyeva & Stoychyk, 2015). In the production of meat products, it can be used as a substitute for meat raw materials, artificial antioxidants, artificial phosphates, and synthetic food dyes.

Raspberry is a berry that is grown on the territory of Ukraine in large volumes. Berries and their juice are actively used in the food industry. Raspberry berries contain vitamins: C, B_1, B_2, PP, A, and B_9; minerals and trace elements: zinc, cobalt, potassium, iron, and manganese; phenolic compounds (Afanasyeva & Stoychyk, 2015). In the production of meat products, it can be used as a substitute for meat raw materials, artificial antioxidants, and synthetic food dyes.

Carrot is a biennial herbaceous plant that is grown in Ukraine in large volumes. Carrots contain vitamins: B_1, B_2, B_5, B_6, B_9, PP, A, C, E, H, and K; minerals and trace elements: magnesium, iron, zinc, potassium, sodium, phosphorus, copper, calcium, manganese, fluorine, iodine, molybdenum, boron, aluminium, sulfur, chlorine, and nickel. Carrots are rich in fibre and carotenoids (Afanasyeva & Stoychyk, 2015). In the production of meat products, it can be used as a substitute for meat raw materials and artificial antioxidants.

Pumpkin is a melon crop, which is grown on the territory of Ukraine in large volumes. It contains large amounts of carotenoids, pectin, and vitamins: A, E, K, B, PP. The main advantage of pumpkin is the presence of vitamin T and L-carnitine, which are used as substances to control weight and promote digestion in the human body (Afanasyeva and Stoychyk, 2015; Muzychuk *et al.*, 2020). In the production of meat products, it can be used as a substitute for meat raw materials and artificial antioxidants.

Elderberry is a shrub or small tree that grows in many parts of Ukraine, the fruits, flowers, and roots of which are used in the food and pharmaceutical industries. Elderberry berries contain vitamins: A, B, and PP; minerals and trace elements: calcium, potassium, iron, magnesium, phosphorus, sodium, zinc, copper, and selenium; phenolic substances; rutin and β-carotene (Khomich *et al.*, 2012; Burak, 2012). In the production of meat products, it can be used as a substitute for meat raw materials, artificial antioxidants, artificial phosphates, and synthetic food dyes.

Sea buckthorn is a bushy tree that grows in Ukraine and has yellow, orange, or orange-red berries. Sea buckthorn berries contain large amounts of vitamins C, E, B, K1, and carotenoids; minerals and trace elements: potassium, calcium, magnesium, iron, zinc, copper, manganese, bromine, and iodine; organic acids: malic, oxalic, and tartaric; tannins; higher fatty acids; high content of phenolic compounds (Bondarchuk & Kurylenko, 2022; Muzychuk *et al.*,

2020). In the production of meat products, it can be used as a substitute for meat raw materials, artificial antioxidants, and animal fat substitutes.

Black currant is a perennial shrub plant that grows in Ukraine in large volumes. The main active ingredients in black currant fruits are carbohydrates: glucose, fructose, rhamnose, and sucrose; vitamins: C, B_1, B_2, B_6, BC, E, K, minerals and trace elements: potassium, calcium, magnesium, silicium, iron, sodium, manganese, copper, zinc, phosphorus, cobalt, molybdenum, chromium, selenium, boron; carotenoids; pectin substances, organic acids; phenolic compounds; coumarins and flavonols (Afanasyeva & Stoychyk, 2015; Shtonda & Pasichnyi, 2019). In the production of meat products, it can be used as a substitute for meat raw materials, artificial antioxidants, artificial phosphates, and synthetic food dyes.

Hemp oil is made from hemp that does not contain cannabinoids, is made by cold or hot pressing, and is widely used in the pharmaceutical and culinary industries. The main active ingredients in it are fats (omega-3, 6, and 9; oleic, linoleic, palmitic, organic acids.), minerals: zinc, magnesium, iron, calcium, manganese; vitamins: A, E, B, and K; tannins (Oniskiv & Pokotilo, 2014; Kotecka-Majchrzak *et al.*, 2021). In the production of meat products, it can be used as a substitute for meat raw materials, artificial antioxidants, and animal fat substitutes.

Over the past 10 years, the number of papers on the use of plant inclusions in the production of meat products has grown rapidly, demonstrating the interest of researchers and enterprises in developing the production of healthy and safe products. The main task of this study is to identify plant inclusions or combinations of them that can be used in the production of meat products.

During the literature review, it was determined that plant inclusions containing phenolic substances and vitamins can be used as natural substitutes for synthetic anti-oxidants to extend the shelf life of meat products and inhibit lipid oxidation, which is confirmed by studies (Turgut *et al.*, 2017; Burak, 2012; Rubanka, 2017).

Another advantage of using plant inclusions is the achievement of improved organoleptic parameters of the product (Gerges & Asuoty, 2022). However, there are papers that raise doubts about whether they are actually improving. According to the studies (López-López *et al.*, 2009; Mohammed *et al.*, 2022), taste and colour indicators were changed, which did not satisfy all consumers of the product. Also in the study (Manzoor *et al.*, 2022), the colour of the product has changed, which may negatively affect the overall attractiveness for the buyer, but in the other one (Krizhova & Moskalenko, 2021), the colour indicator was achieved as planned. Also in this study, the amount of synthetic phosphates was reduced, which did not affect the quality indicators of the final product. Therewith, in the study (Thangavelu *et al.*, 2022), a decrease in phosphate levels led to a negative impact on the quality of sausages.

A decrease in the level of pathogenic microflora is also accompanied by the replacement of synthetic additives with plant inclusions, which is confirmed by studies (Kotecka-Majchrzak *et al.*, 2021; Gerges & Asuoty, 2022).

In a larger number of papers, there were recommendations for further research on the behaviour of plant inclusions in meat products. Therefore, it is proposed to consider the best plants and their components that can be used in the production of meat products, according to the authors, by their nutritional value and chemical composition, which are presented in Tables 1 and 2.

Table 1. *Comparative characteristics of the chemical composition and nutritional value of fruits and vegetables*

Chemical composition	Carrots	Beetroot	Pumpkin	Pomegranate	Ginger	Elderberry	Sea buckthorn	Currant	Raspberry
Nutritional value per 100g (g)									
Protein	1.1	1	-	2	2	0.66	2	0.5	1
Fats	0.1	-	-	1	0.5	0.5	6	0.27	0.58
Carbohydrates	12.6	14.1	9	19	17	8.4	8	17	13
Water	84.6	83.4	90.8	78	-	79.8	83	81	84
Dietary fibre	1	1	2	4	2	7	3	7	6
Energy value, kcal	56	61	37.5	100	80	74	93	39	73
Macronutrients (mg)									
Calcium	19	19	25	8	16	38	42	40	41
Magnesium	7	17	14	12	43	5	30	35	30
Sodium	26	45	4	3	13	6	4	16	1
Potassium	130	288	204	236	415	280	193	133	200

Chemical composition	Carrots	Beetroot	Pumpkin	Pomegranate	Ginger	Elderberry	Sea buckthorn	Currant	Raspberry
Trace elements (mg)									
Iron	0.6	0.6	0.4	0.3	0.6	1.6	1.4 mg	0.4	1
Zinc	0.18	-	0.24	0.4	0.34	0.11	-	0.3	0.4
Copper	0.046	0.1	0.18	0.2	0.2	0.061	-	0.1	0.1
Vitamins (mcg)									
Vitamin A (provitamin A)	350		250	1	18	30	25	-	30
Vitamin C	3000	3000	8000	10200	5000	36000	200000	85000	45
Vitamin E	1000	1100	-	600	300	-	5000	1000	30
Phenolic compounds	75	-	50	1130	300	80800	200000	200000	400000

Sources: Zubar, 2010; Afanasyeva & Stoychyk, 2015; Simakhina *et al.*, 2016

Table 2. *Comparative characteristics of the nutritional value and chemical composition of fruit and vegetable juices*

Chemical composition	Carrot juice	Beetroot juice	Pumpkin juice	Pomegranate juice	Ginger juice (extract)	Elderberry juice	Sea buckthorn juice	Currant juice	Raspberry juice
Nutritional value per 100 ml (g)									
Protein	0.95	1	1	0.3	1.82	1.1	1.2	0.5	0.75
Carbohydrates	9	9.9	9	14.2	15.5	5.1	5.7	7.3	24.7
Fats	0.15	0	0.09	0.1	0.75	0.2	2.4	-	-
Dietary fibre	1	1	2	0.2	2	7	1.8	1	3.7
Energy value, kcal	40	42	38	56	80	27	82	41	100
Macronutrients (mg)									
Calcium	24	19	25	12	16	30	22	40	40
Magnesium	14	17	14	5	43	3	30	35	22
Sodium	29	45	4	4	13	5	4	16	10
Potassium	292	148	204	102	415	220	193	133	224
Trace elements (mg)									
Iron	0.46	0.6	0.4	1	0.6	1.44	1.4	0.4	1.2
Zinc	0.18	-	0.24	0.1	0.34	0.1	-	0.3	0.2
Copper	0.046	0.1	0.18	0.1	0.2	0.050	-	0.1	0.17
Vitamins (mcg)									
Vitamin A (provitamin A)	350	-	1500	20	18	21	1500	50	30
Vitamin C	3000	3000	8000	4000	5000	27000	200000	85000	45
Vitamin E	1000	100	400	300	300	-	5000	400	30
Phenolic compounds	75	-	10	1000	300	72000	160000	190000	32000

Sources: Zubar, 2010; Afanasyeva & Stoychyk, 2015; Simakhina *et al.*, 2016

According to the latest sources, the loss of biologically active substances (vitamins, micro-, and macro-elements) in the production of juices is on average: for pome fruits is 21%; for light-coloured stone fruits – 17%. Phenolic substances change by 24% when grinding pome fruits, light-coloured stone fruits – 20%, while intensely coloured fruits change by only about 9.5%.

Notably, only a small part of scientific papers considered inclusions in the form of various components of a particular plant, and none considered combinations of inclusions of the plants described above. Therefore, this area of research remains relevant in the future.

Conclusions

The meat processing industry is one of the largest and most promising branches of the food industry in the Ukrainian market, as evidenced by its constant growth over the past decades. When reviewing the latest published studies, it was identified that plant inclusions are actively used in the production of meat products. The most common use of plant components is identified in the production of semi-finished products. Vegetable components in meat products are used as natural antioxidants and antiseptics, nitrosamines, emulsifiers, dyes, substitutes for animal proteins and fats, etc.

Most often, in the Ukrainian production of meat products, the components that are available in large quantities on the Ukrainian market are used, so the most applicable plant inclusions can be: carrots, beets, pomegranate, ginger, elderberry, sea buckthorn, currant, raspberry, and derived products of their processing: juice, peel, zest, pulp, seeds, pomace, extracts. The use of plant components not only allows replacing the technological component but also helps to: increase the level of the biological and nutritional value of finished food products; increase the level of mineral composition; increase the level of vitamin composition; increase the level of dietary content of the product; reduce the level of consumption of artificial nitrates and phosphates. The use of plant inclusions can reduce the level of diseases in the human body due to the additional consumption of biologically active substances, which are included in them, and by changing synthetic analogues that can cause various diseases when used in excessive concentrations. The addition of plant inclusions allows expanding the range of food products, increasing the level of consumer satisfaction, and creating new products with increased standards and functionality.

Negative effects of using plant inclusions can be: a change in the pH level; a change in smell; a change in taste parameters; a change in colour.

It is recommended to examine the possibility of using plant components that are most common on the Ukrainian market for their use in the production of meat products; the possibility of combining various plant inclusions by combining them with each other with subsequent use.

References

[1] Afanasyeva, K.K., & Stoychyk, T.I. (2015). *Culinary terminology guide*. Dnipro: Zhurfond

[2] Artiushenko, T.A. (2021). Ascorbic acid in plants: Metabolism and functions. *Ecological Bulletin of Kryvorizhzhya*, 6, 13-32. https://doi.org/10.31812/eco-bulletin-krd.v6i0.4556.

[3] Bajaj-Zhezherun, S., & Molodid, T. (2019). Hemp processing products are valuable raw materials for the production of functional food products. In *Health foods and dietary supplements: Technology, quality and safety: Materials of the International Scientific and Practical Conference* (pp. 34-36). Kyiv: NUFT.

[4] Bondarchuk, Z., & Kurylenko, Y. (2022). Use of sea buckthorn juice in the technology of non-alcoholic drinks. In *Proceedings of the XIII International scientific-practical conference "Tourist and hotel-restaurant business in Ukraine: Problems of development and regulation"* (pp.133-135). Cherkasy: Ye.I. Hordiienko Publisher.

[5] Bozhko, N. (2015). The use of natural antioxidants in the production of sausages. In *Organic production and food security: Materials of the III International scientific-practical conference* (pp. 390-394). Zhytomyr: Polissia.

[6] Burak, L. (2012). Perspectives of use black elderberry in the food industry. *Food Industry Agroindustrial Complex,* 21(1), 30-33.

[7] Gerges, M.T., & Asuoty, M.S. (2022). Effect of adding essential oils and organic acids on shelf life of chicken sausage. *Alexandria Journal of Veterinary Sciences,* 74(1), 102-115. https://doi.org/10.5455/ajvs.69487.

[8] Golub, A., & Horbach, O. (2018). Development of special meat products for overweight people. In *II International Conference "Modern technologies of food production"* (pp. 9-13). Dnipro: Lira.

[9] Ishchuk, S. (2020). Current situation and key trends of meat procurement and industrial production in regions of Ukraine. *Economic Journal of Lesya Ukrainka Volyn National University*, 1(21), 155-164. https://doi.org/10.29038/2411-4014-2020-01-155-164.

[10] Khomich, G., Tkach, N., & Kaprelyants, L. (2012). Research of technological characteristics of black elderberry berries. In *Equipment and technologies of food production* (pp. 387-392). Kryvyi Rih: DonNUET.

[11] Klymenko, M., Vinnikova, L., Pasichniy, V., Bal-Prylypko, L., Kishenko, I., Busha, O., & Tkachenko, K. (2006). *Technology of meat and meat products*. Kyiv: Vyshcha Osvita. Retrieved from: http://dspace.nuft.edu.ua/jspui/handle/123456789/27193.

[12] Kotecka-Majchrzak, K., Kasałka-Czarna, N., Spychaj, A., Mikołajczak, B., & Montowska, M. (2021). The effect of hemp cake (*Cannabis sativa* L.) on the characteristics of meatballs stored in refrigerated conditions. *Molecules*, 26(17), article number 5284. https://doi.org/10.3390/molecules26175284.

[13] Koval, S., Kornev, R., & Yarmus, A. (2021) Technical aspects of increasing the competitiveness of food products. In *Materials of the X International scientific and practical conference of young scientists and students "Actual problems of modern technologies"* (pp. 53-54). Ternopil: PE V.A. Palianytsia. Retrieved from https://elartu.tntu.edu.ua/bitstream/lib/36580/2/MNPK_2021v2_Koval_S_O-Technical_aspects_of_increasing_53-54.pdf.

[14] Krizhova, Y., & Moskalenko, I. (2021). Sous-vide technology in the production of phosphate-free sausages with using beet juice. In *Innovative technologies and prospects of development of meat processing industry ("Realities and prospects of meat processing"): Program and abstracts of the International scientific and practical conference* (pp. 59). Kyiv: NUFT. Retrieved from http://dspace.nuft.edu.ua/jspui/bitstream/123456789/36838/1/INPRODMASH-2021.pdf.

[15] Kruchanitsya, M., Mironyuk, I., Rozumikova, N., Kruchanitsya, V., Brich, V., & Kish, V. (2019). *The basics of nutrition*. Uzhhorod: "Hoverla".

[16] Kryvosheeva, N., Guzenko, G., & Shcheblykina, T. (2020). Innovative mechanism for implementing a marketing strategy for the promotion of eco-products on the Ukrainian market. *Changes in food legislation in Ukraine in accordance with EU requirements: Abstracts of reports of the International scientific and practical conference* (pp. 11-13). Kharkiv: KhTEK KNTEU.

[17] Kyslychenko, V.S., Zhuravel, I.O., Marchyshyn, S.M., Minarchenko, V.M., Khvorost, O.P. (2015). *Pharmacognosy*. Kharkiv: Zoloti storinky.

[18] López-López, I., Cofrades, S., & Jiménez-Colmenero, F. (2009). Low-fat frankfurters enriched with n–3 PUFA and edible seaweed: Effects of olive oil and chilled storage on physicochemical, sensory and microbial characteristics. *Meat Science*, 83(1), 148-154. https://doi.org/10.1016/j.meatsci.2009.04.014.

[19] Manzoor, A., Ahmad, S., & Yousuf, B. (2022). Effect of bioactive-rich mango peel extract on physicochemical, antioxidant and functional characteristics of chicken sausage. *Applied Food Research,* 2(2), article number 100183. https://doi.org/10.1016/j.afres.2022.100183.

[20] Milne, G.W.A. (Ed.) (2005). *Gardner's commercially important chemicals: Synonyms, trade names, and properties*. New York: Wiley-Interscience.

[21] Mohammed, H.O., O'Grady, M.N., O'Sullivan, M.G., Hamill, R.M., Kilcawley, K.N., & Kerry, J.P. (2022). Acceptable inclusion levels for selected brown and red Irish seaweed species in pork sausages. *Foods*, 11(10), article number 1522. https://doi.org/10.3390/foods11101522.

[22] Mokrosnop, V., & Zolotareva, E. (2021). Accumulation of α-tocopherol in microalgae cells. *Microbiology and Biotechnology*, 2, 6-26. https://doi.org/10.18524/2307-4663.2021.2(52).223991.

[23] Muzychuk, O.S., Matko, S.V., & Levkivska, T.M. (2020). Sea buckthorn as a promising raw material in sauce production technology. In *Step to science: Research in the field of natural and mathematical disciplines and methods of their teaching: Abstracts of the All-Ukrainian scientific and practical conference of students, graduate students and young scientists* (pp. 42-43). Chernihiv: National University "Chernihiv Collegium" named after Taras Shevchenko.

[24] Oniskiv, V., & Pokotilo, O. (2014). Properties and fatty acid composition of unconventional oils. In *Materials of the XVIII scientific conference of Ternopil National Technical University named after Ivan Pulyu* (pp. 171). Ternopil: TNTU.

[25] Reshi, M., Bhat, A.R., Dobi, M.R., Pirzada, R., Beigh, S.A., Ahad, W.A., ul Firdos, W., & Malik, A.H. (2017). Enhancement of shelf life of spent hen meat sausages with incorporation of ginger extract. *International Journal of Current Microbiology and Applied Sciences*, 6(11), 1124-1130. https://doi.org/10.20546/ijcmas.2017.611.133.

[26] Rodriguez-Amava, D.B. (2015). Carotenes and xanthophylls as antioxidants. In *Handbook of antioxidants for food preservation* (pp. 17-50). Sawston: Woodhead Publishing. https://doi.org/10.1016/B978-1-78242-089-7.00002-6.

[27] Rol, N., Nadtochiy, V., Tsebro, A., Vovkohon, A., Merzlova, H., Kalinina, H., & Hrebelnyk, O. (2021). Hemp raw materials: New perspectives for the food industry. *Animal Husbandry Products Production and Processing,* 1, 152-158. https://doi.org/10.33245/2310-9289-2021-164-1-152-158.

[28] Rubanka, K., Terletska, V., & Abramov, A. (2017). Studying of the quality of dry extract ginger root. *Progressive Technology and Technology of Food Production in the Restaurant State and Trade,* 1(25), 301-310.

[29] Saleh, E.A., Morshdy, A.E.M., Hafez, A.E., Hussein, M.A., Elewa E.S., & Mahmoud, A.F.A. (2017). Effect of pomegranate peel powder on the hygienic quality of beef sausage. *Journal of Microbiology, Biotechnology and Food Science,* 6(6), 1300-1304. https://doi.org/10.15414/jmbfs.2017.6.6.1300-1304.

[30] Shtonda, O., & Pasichnyi, V. (2019). Prospects of use of fruit-berry raw materials in the technology of meat natural semi-filled products. *Scientific Works of National University of Food Technologies*, 25(6), 194-200. https://doi.org/10.24263/2225-2924-2019-25-6-25.

[31] Simakhina, G., & Naumenko, N. (2021). Berries as the concentrators of effective antioxidants. *Scientific Works of National University of Food Technologies*, 27(6), 161-168. https://doi.org/10.24263/2225-2924-2021-27-6-18.

[32] Simakhina, G., Stetsenko, N., & Naumenko, N. (2016). *Biologically active substances in food technologies*. Kyiv: NUFT.

[33] Simonova, M. (2010). Carotenoids, their structure, properties and biological action. *Studia Biologica*, 4(2), 159-170. https://doi.org/10.30970/sbi.0402.127.

[34] Tenytska, E., & Nikozyat, Y. (2020). Formation of knowledge about antioxidant properties of polyphenol compounds in the course of bioorganic and biochemical chemistry of medical universities. In *Collection of scientific works of the regional student scientific and practical conference "XIII Mendeleev Readings"* (pp. 112-114). Poltava: Editorial and publishing department of V.G. Korolenko PNPU.

[35] Thangavelu, K.P., Tiwari, B., Kerry, J.P., & Álvarez, C. (2022). A comparative study on the effect of ultrasound-treated apple pomace and coffee silverskin powders as phosphate replacers in irish breakfast sausage formulations. *Foods*, 11(18), article number 2763. https://doi.org/10.3390/foods11182763.

[36] Turgut, S.S., Işıkçı, F., & Soyer, A. (2017). Antioxidant activity of pomegranate peel extract on lipid and protein oxidation in beef meatballs during frozen storage. *Meat Science,* 129, 111-119. https://doi.org/10.1016/j.meatsci.2017.02.019.

[37] Verchenko, M., Kotlyar, Y., & Topchiy, O. (2019). Selection of natural dye at the production of boiled sausages. In *Anniversary International scientific conference of young scientist and students "Youth scientific achievements to the 21st century nutrition problem solution"* (p. 353). Kyiv: NUFT.

[38] Viuda-Martos, M., Ruiz-Navajas, Y., Fernandez-Lopez J., & Pérez-Álvarez, J. (2010). Effect of orange dietary fiber, oregano essential oil and packaging conditions on shelf-life of bologna sausages. *Food Control*, 21(4), 436-443. https://doi.org/10.1016/j.foodcont.2009.07.004.

[39] Viuda-Martos, M., Ruiz-Navajas, Y., Fernandez-Lopez, J., & Pérez-Álvarez, J. (2008). Antifungal activity of lemon (*Citrus lemon* L.), mandarin (*Citrus reticulate* L.), grapefruit (*Citrus paradisi* L.) and orange (*Citrus sinensis* L.) essential oils. *Food Control*, 19(12), 1130-1138. https://doi.org/10.1016/j.foodcont.2007.12.003.

[40] Volkova, S., Havrish, P., & Pylypchuk, L. (2021). *What everyone needs to know about phosphorus and phosphates*. Kherson: Kherson State University Publishing House.

[41] Yarmolenko, A. (2020). Conjuncture-forming factors and their influence on world food market. In *International economic activity in the 21st century: Mechanisms, forms, regulation. Collection of materials of the student scientific and practical Internet conference* (pp. 484-487). Kyiv: KNEU.

[42] Zahid, A., Seo, J.-K., Parvin, R., Ko, J., & Yang, H.-S. (2019). Comparison of butylated hydroxytoluene, ascorbic acid, and clove extract as antioxidants in fresh beef patties at refrigerated storage. *Food Science of Animal Resources*, 39(5), 768-779. https://doi.org/10.5851/kosfa.2019.e67.

[43] Zubar, N.M. (2010). *Basics of physiology and nutrition hygiene*. Kyiv: Publishing house "Condor".

Аналіз використання рослинних компонентів при виробництві м'ясних продуктів

Роман Сергійович Зінченко

Аспірант
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0009-0003-1899-1199

Юлія Володимирівна Слива

Кандидат технічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0003-2592-6822

Анотація. Включення рослинних компонентів в м'ясні продукти відіграють значну роль у харчуванні людей, оскільки такі включення є джерелом біологічно активних речовин, сприяють травленню та підвищують нутрієнтний склад харчових продуктів. Метою цієї статті є огляд останніх досліджень з використання рослинних компонентів при виробництві м'ясних продуктів та пошук нових, що можуть бути використанні в якості замінників штучних добавок та м'ясної сировини. Під час дослідження використовували методи аналізу, порівняння та синтезу наукових праць українських та закордонних вчених, розташованих в наукометричних базах даних, таких як, Web of Science та Scopus; інтернет-ресурсів. Під час опрацювання літератури, були розглянуті основні проблематики виробництва м'ясних продуктів: псування продуктів під час зберігання, підвищений вміст нітратів та фосфатів, розвиток патогенної мікрофлори. Було з'ясовано, що головним центром досліджень є окислювальні процеси під час виробництва та зберігання готових м'ясних продуктів. Встановлено, що через високий вміст вітамінів, фенольних сполук, мікро- та мікроелементів рослинні включення можуть виступати інгібіторами в таких реакціях. В ході досліджень було визначено, що найчастіше використовують: шкірку, м'якоть, соки та екстракти фруктів та овочів у якості рослинних включень. Основним завданням таких включень виступає заміна синтетичних включень на природні з метою збільшення харчової цінності та нутрієнтного складу харчових продуктів. Для підбору найбільш вдалих рослинних включень, що поширені на українському ринку, проведено порівняльний аналіз харчової цінності та хімічного складу, фруктів, овочів та їх соків. Показники зведені в таблиці. Заміна штучних антиоксидантів, консервантів та інших сполук на їх природні аналоги, має важливе значення для сучасних виробництв, оскільки такі технологічні рішення допоможуть зробити їжу більш функціональною, здоровою та підвищити рівень корисних сполук в харчових продуктах

Ключові слова: хімічний склад, природні антиоксиданти, фенольні речовини, природні замінники, рослинні включення