Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.61122

Application of functional ingredients in canned meat production

Sholpan ABZHANOVA[1]*, Gulshat ZHAKSYLYKOVA[1], Talgat KULAZHANOV[2], Lyazzat BAYBOLOVA[2], Zhanar NABIYEVA[1]

Abstract

A comprehensive literature search was conducted. An extended search was performed, including a targeted search on the websites of a number of intergovernmental and non-governmental organisations. All links identified in databases and search engines were uploaded to the Covidence systematic review tool for automatic deduplication and blind screening. The generalised material of the analysis represents a new typological basis of the market strategy for the analysis of the practices used by the dominant producers in the meat canning industry. Only a limited number of papers note the possible benefits of using functional ingredients in canned meat for human health, therefore further studies are required that would provide convincing evidence of the benefits of functional ingredients. As scientific evidence increases, researchers and meat producers should make more efforts to inform and educate consumers about the health benefits of functional ingredients used in meat canning.

Keywords: modern nutrition; food structure; bioactive compounds; scientific strategy; quality improvement; innovative technologies.

Practical Application: The use of functional groups in the production of canned meat can improve their functional properties, improve digestibility, get products that meet basic physiological standards.

1 Introduction

Meat canning is an ancient process developed due to the need to preserve perishable food. Initially, salt was used in the processes of preserving meat. Some types of salt give the meat an attractive reddish-pink colour. Since the middle of the 19th century, the demographic composition of the world's population began to change globally, there was a great need for commercial food preservation. The meat industry has gone the way of evolution, from the industry for slaughtering animals, to the industry for processing and preserving meat (Rodriguez-Amaya & Amaya-Farfan, 2021; Tan et al., 2022). At the turn of the 19th and 20th centuries, chemistry came to the meat industry, and showed that an important stage in the process of preserving meat is the conversion of nitrates into nitrites. The second half of the 20th century led to the rapid development of meat preservation systems, bringing with it new equipment, reducing agents and acidifiers, water-binding ingredients, methods of adding and retaining water in processed meat. Nowadays, the processes of preserving meat have become an extremely complex science (Nile et al., 2020). Meat processing enterprises have come to the need to form a fundamental understanding of the functional properties of all the ingredients to use them with maximum benefit in a highly competitive market.

In recent years, an increasing number of studies have been reported concerning the enrichment of animal food with biologically active compounds. Suppliers manage to produce meat enriched with ingredients such as polyunsaturated fatty acids, vitamins, macro- and microelements (Acosta et al., 2021; McClements & Grossmann, 2021). Due to demographic trends of population ageing, functional ingredients that slow down the effects of ageing and strengthen the structure of bones and joints are becoming popular.

The relevance of the study is related to the global growth of consumer demands and lifestyle changes in the 21st century, which affected the international meat market. Currently, there is a tendency towards increased meat consumption. Current consumers are well aware of the nutritional value of various types of food and their health consequences. Consumers began to demand high standards of product quality and safety (Khajavi et al., 2020; Smagulov et al., 2014). Food manufacturers and technologists face the problem of supplying products without artificial additives, preservatives, or dyes, but at the same time, of high quality and with a long shelf life. To date, many methods have been developed for enriching canned meat products with functional ingredients (Blanco-Gutiérrez et al., 2020), which leads to different approaches of manufacturers and ambiguous interpretations of consumers. The common denominator is minimal processing, a short list of ingredients, and the absence of synthetic additives.

The purpose of the study of the use of functional ingredients in canned meat production is to analyse the use of functional ingredients in meat canning, to analyse technological strategies aimed at reducing health-related risk factors, to promote the

Received 01 June, 2022
Accepted 27 July, 2022
[1] *Department of Food Biotechnology, Almaty Technological University, Almaty, Republic of Kazakhstan*
[2] *Department of Food Technologies, Almaty Technological University, Almaty, Republic of Kazakhstan*
*Corresponding author: abzhanova7254-2-3@uoel.uk

beneficial effects of meat on health. Technological strategies (Etemadzadeh & Emtiazi, 2021; Sun et al., 2021; Yayuan et al., 2022) are mainly associated with an increase in the presence of useful functional ingredients in canned meat products, and with the restriction of those functional ingredients that have negative health effects.

The object of the study are functional ingredients in canned meat production, in conditions of maintaining the stability of demand and consumption, improving living standards and expanding choice (Skotnicka et al., 2021), when consumer preferences shift towards more natural, healthy, and safe meat products with good gustatory characteristics.

The originality of the study of technological strategies for the use of functional ingredients in canned meat production is apparent against the background of market strategies used by canned meat producers. Most of the research on the market strategies of companies in the meat canning industry focuses on the consequences of marketing and labelling of products in the meat canning industry for human health (Wood et al., 2021). However, to understand the methods of profit maximisation in the meat canning industry, it is important to apply tools for monitoring and analysing the entire range of strategies in the field of application of functional ingredients in the meat canning industry.

2 Materials and methods

The systematic review of the use of functional ingredients in meat canning, the results of which are presented in this paper, did not require either the approval of the ethics committee or the informed consent of the study groups, since the data were obtained from open source databases and from the Internet search queries. A comprehensive literature search was conducted in the electronic databases of Scopus, Web of Science, Medline, PubMed, Embase, PsycINFO, Cochrane, CINAHL, Business Source Complete, ABI Inform, Thomas Reuters Westlaw, and Lexis Advance, in the databases of marketing research Euromonitor International (Passport) and IBIS World (Macho-González et al., 2020). Factiva and NewsBank were used to search for news articles on the Internet. An extended search was performed, and a targeted search on the websites of a number of intergovernmental and non-governmental organisations, namely, the Food and Agriculture Organisation of the United Nations (FAO), the Organisation for Economic Cooperation and Development (OECD), the United Nations Conference on Trade and Development (UNCTAD), the International Group of Experts on Sustainable Food Systems (IPES-Food), and the ETC group. Finally, the reverse snowball method was applied, with the help of which the relevant references (Vilas-Boas et al., 2021) to the identified documents were identified.

All links identified in databases and search engines were uploaded to the Covidence systematic review tool for automatic deduplication and blind screening. Research characteristics, including authors, year of publication, country of origin, study design, research tools, were extracted and analysed independently. Original research, reviews, comments, editorials, books and book chapters, working papers, news articles on the Internet, summaries of court cases, market research reports, and web documents of intergovernmental and non-governmental organisations were included in the analysis undertaken if they addressed market strategies for the use of functional ingredients in meat canning (Zhang et al., 2021) used by dominant food companies, other food producers, firms at various functional levels of the food value chain, and consumers. Documents were excluded if they were not published in English. After manually checking the search results, no additional relevant studies were found. The imputation method was applied to the missing information. After applying inclusion and exclusion criteria in the selection of titles and abstracts, 81 publications were admitted to full-text analysis.

To obtain information about the composition of food products, the study used an open database of Open Food Facts about food products sold worldwide, licensed in the Open Database (ODBL). Open Food Facts participants are constantly adding products to this database using crowdsourcing, scanning barcodes, and photographing packages. Information on each food product is automatically processed and includes the commercial name, trademark, list of ingredients, availability of each food additive and food composition. As food formulations develop (Dima et al., 2020), the old products are regularly updated after consumers are re-informed about them. The Global Item Number (GTIN) embedded in the barcode acts as the identifier of each product. The generalised material of the analysis represents a new typological basis of the market strategy for the analysis of the practices used by the dominant producers in the meat canning industry.

3 Results and discussion

For several decades, functional ingredients have been widely used in the meat canning industry to reduce the cost and improve the functionality of products (Almoraie et al., 2021). Functional ingredients include plant proteins, dietary fibres, herbs and spices, and probiotics. Functional ingredients can increase the nutritional value of canned meat products and benefit human health.

Soy proteins are widely used in meat products in the form of soy flour, soy protein concentrate and isolate, to improve the ability to bind water and fat, increase the stability of the emulsion, improve nutrition, and reduce losses in the meat canning industry. Soy protein hydrolysates reduce the number of bacteria and prolong the shelf life of canned meat products without affecting the taste and texture properties of the products. However, soy flour, soy protein concentrates and isolates are characterised by undesirable taste qualities. To overcome the noted taste deficiency, dried soy tofu powder is added to canned meat products. The inclusion of tofu powder leads to a decrease in fat content and an increase in protein content, but does not affect the sensory parameters of canned meat products.

In low-fat meat products, whey proteins demonstrate excellent nutritional and functional properties. Whey proteins improve the stability of the emulsion and provide better colour properties. Preheated whey protein isolates form a gel at low protein concentrations and low temperature, increasing moisture retention, improving rheological properties and reducing losses

during the preparation of canned meat products. In addition, whey proteins can be incorporated into films and coatings for meat products, inhibiting aerobic bacteria and listeria monocytogenes. Wheat proteins can be an excellent functional additive in canned meat products, due to their ability to form a viscoelastic mass of gluten when interacting with water. Wheat gluten hydrolysed with chymotrypsin leads to a decrease in the activity of microbial transglutaminase and an improvement in the gel-forming and emulsifying properties of myofibrillary protein isolates. The addition of wheat proteins to mechanically separated poultry meat increases the hardness of the product, but reduces the elasticity. The addition of wheat protein flour increases the moisture-retaining capacity and reduces losses during the preparation of canned meat products, improving textural and sensory properties, including viscosity, adhesion, and stability.

Fat is an important component of human nutrition, because it serves as a source of vitamins and essential fatty acids, and provides most of the energy in the diet. Fat can also affect the taste, tenderness, juiciness, appearance, and texture of canned meat products. However, excessive fat intake is associated with various diseases, including obesity, cancer, and coronary heart disease. For this reason, the meat canning industry strives to produce meat products with a low-fat content without compromising sensory and textural characteristics. Dietary fibre is one of the functional ingredients that provide canned meat products with low-fat content and high fibre content. Dietary fibres, carbohydrate residues of the edible part of plants, are resistant to digestion and absorption in the human small intestine. Currently, it is recommended (Manessis et al., 2020) to increase dietary fibre intake due to their effect on reducing the risk of colon cancer, diabetes, obesity, and cardiovascular diseases. The addition of suspensions of peach dietary fibres to canned meat products increases the viscosity and lowers the pH, without affecting the loss during cooking, the protein and collagen content, and the sensory evaluation of canned meat products. Dietary fibre leads to changes in pH, water activity, and nitrite residues (Miranda & Schmiele, 2020). The addition of dietary fibres derived from peas and chicory root improves the toughness of canned meat products without affecting texture and colour parameters, causing a feeling of greater satiety, reducing overall fat and energy consumption.

The main reaction that degrades the taste, colour, texture, and nutritional value of canned meat products is lipid oxidation. To prevent oxidative degradation of food, various synthetic antioxidants are used, such as butylated hydroxytoluene, butylated hydroxyanisole, and tertiary butylhydroquinone. However, synthetic antioxidants are not fully accepted by consumers due to health problems. Therefore, some natural ingredients (Kyriakopoulou et al., 2021), including herbs and spices, have been studied as candidates for potential antioxidants of meat and meat products, especially in Asian countries. Compounds from herbs and spices contain many phytochemicals that serve as potential sources of natural antioxidants, including phenolic diterpenes, flavonoids, tannins, and phenolic acids. These compounds have antioxidant, anti-inflammatory, and antitumor activity. In food systems, they can improve taste, slow down the deterioration of food quality caused by lipid oxidation, inhibit the growth of microorganisms, and reduce the risk of certain diseases (Uzakov et al., 2021).

Among spices, cloves have the strongest antioxidant ability, followed by rose petals, cinnamon, nutmeg, and other spices. In addition, due to phenolic compounds, spices have antimicrobial efficacy. Possible mechanisms of antimicrobial action of phenolic compounds include changes in the permeability of microbial cells, interference with membrane function, including electron transport, nutrient absorption, synthesis of proteins and nucleic acids, enzyme activity, interaction with membrane proteins, causing deformation of structure and functionality, the substitution of alkyls in the phenolic nucleus. Rosemary extract is rich in phenolic compounds, which causes its considerable antioxidant activity. Water-soluble rosemary extract effectively slows down lipid oxidation and prevents colour loss, demonstrating a decrease in the concentration of metmyoglobin and an increase in the values of oxymyoglobin during eight days of storage of irradiated ground beef (Stojanović et al., 2021; Kukhtyn et al., 2020). In restructured irradiated pork fillets, the combination of rosemary oleoresin with tocopherol effectively reduces the content of volatile hexanal, without having any effect on the generation of volatile sulphur compounds. Catechins, the predominant group of polyphenols present in green tea leaves, consisting of four compounds, epicatechin, epicatechin gallate, epigallocatechin, and epigallocatechin gallate, improve health by preventing lipid oxidation and provide antibacterial, anticancer, and antiviral protection. Tea polyphenols inhibit the generation of mutagens that are associated with breast and colon cancer. The added tea catechins provide two to four times greater antioxidant capacity than α-tocopherol, depending on different types of animal meat. Green tea powder can partially replace nitrite, which leads to a decrease in the content of volatile nitrogen compared to samples prepared using nitrite only.

Cloves retain antimicrobial efficacy for a long time, thanks to their active ingredient eugenol. Clove oil is effective in suppressing other food-borne pathogens, including E. coli and S. aureus. Among the extracts of spices and herbs, including cinnamon, oregano, pomegranate peel, and grape seeds, cloves are the strongest antioxidant that slows down lipid oxidation. Allicin, the main ingredient of garlic, has antimicrobial activity against both gram-positive and gram-negative bacteria. Allicin is enzymatically obtained from its precursor aliin using an intermediate of allyl sulphonic acid. Garlic extract effectively reduces the growth of many pathogens, including Pseudomonas aeruginosa. The aqueous extract of garlic suppresses the growth of microbial contaminants, including facultative aerobic, mesophilic and faecal E. coli. The extract of sage, a dried leaf of the mint family, alone or in combination with sodium isoascorbate, leads to a decrease in the water activity and pH, a decrease in mesophilic bacteria, improving the taste of canned meat products.

The scientific controversy over the use of biologically active additives in the production of canned meat proceeds from the fact that the use of biologically active additives in the production of canned meat products is justified by the much greater energy efficiency of such biotechnologies as enzymatic modification, bioconservation, and fermentation, compared with heat treatment. The idea of producing meat-canned products that effectively affect

human health is based on the enrichment of original products with healthy ingredients. Meat and canned meat products turn out to be a good matrix for the development and use of biologically active additives. The process of using biologically active additives in the production of canned meat products can occur in two stages, either at the stage of animal nutrition, or at the stage of processing meat carcass. Biologically active additives change the appearance, taste, aroma, and consistency of canned meat products. Bioactive peptides are short polymers consisting of approximately two to twenty amino acids connected by peptide bonds. They are inactive in food, because they are part of the precursor proteins. Bioactive peptides are released as a result of food processing by fermentation or ageing methods, or during digestion.

Bioactive peptides affect various physiological functions of the human body, primarily antioxidant, antihypertensive, antimicrobial, antitumor, antithrombotic, antidiabetic, immunomodulatory, and probiotic. It is necessary to state the correctness of the position of those researchers (Galali, 2021) who are convinced of the safety of bioactive peptides, in the possibility of obtaining them from inexpensive raw materials, often from waste, using relatively cheap technology, which, in general, makes them promising functional food ingredients in the production of canned meat products. One of the most studied examples of bioactive peptides are peptides with the ability to inhibit angiotensin I converting enzymes. This enzyme is responsible for the production of angiotensin II, which narrows the arteries, leading to an increase in blood pressure. Thus, bioactive peptides that inhibit the angiotensin-converting enzyme have antihypertensive properties. Pharmaceutical angiotensin-converting enzyme inhibitors effectively reduce mortality from myocardial infarction in the risk group. However, the use of artificial angiotensin-converting enzyme inhibitors is fraught with numerous side effects, namely skin rash, cough, angioedema, unlike enzymes obtained naturally. Increasing the level of bioactive peptides in the human diet is possible with the help of several strategies. The first strategy is based on the inclusion of some fermented meat products in one of the daily meals. The second strategy is to add certain proteins to the products as peptides that are inhibitors of the angiotensin-converting enzyme. Unfortunately, this strategy is difficult to implement, because it requires the introduction of huge doses of proteins. The third strategy involves the direct addition of bioactive peptides to food. The use of the third method is also not free from some restrictions. The position of those researchers seems fair, in whose opinion (Chazelas et al., 2020) the main obstacle is that bioactive peptides significantly worsen the sensory properties of the product, making it bitter. To overcome this disadvantage, peptides of animal origin are used, in particular, hydrolysates of meat or gelatin, as less bitter, compared with bioactive peptides from other sources. In addition, encapsulations of bioactive peptides with liposomes or water in oil emulsions are used. These methods allow introducing new meat-canned products with functional properties to the market.

In general, there is a growing trend in the global meat canning industry to use functional bioactive compounds in the production of meat canning products (Miguel-Berges et al., 2020). There is no doubt about the prospects of research ideas that dietary supplements can have a significant impact on human health. However, the choice of the type of substance and its quantity depends on the final product that is expected to be obtained. More specifically, an important issue of the use of functional bioactive compounds in the production of canned meat products is the question of whether the product will be processed, and if the answer is yes, what kind of processing will be applied. No less important in the development of functional bioactive compounds in the production of canned meat products is the consideration of dietary deficiencies of specific substances noted in different consumer populations. The process of developing functional bioactive compounds in the production of canned meat products is complex and depends on the influence of the functional ingredients used not only on the nutritional value, but also on the final quality of meat.

Modern approaches to the creation of functional meat-based products are mainly aimed at reducing the risk of cardiovascular diseases, since meat is considered as one of the main causes of cardiovascular health problems. Low-density lipoprotein cholesterol and plasma serve as biological markers of cardiovascular diseases. Strategies and methods for the development of healthy functional meat-based products aimed at increasing the content of useful components and reducing the content of harmful components in meat require agreement with the proposed approaches (Park et al., 2020), since they seem reasonable and deeply thought out. These strategies can include both animal breeding and changing meat recipes. The composition of meat is influenced by the storage conditions and the form of meat consumption. Biologically active compounds contained in meat can be influenced by animal husbandry methods. The composition of animal tissues and the composition of carcasses vary depending on the type of animal and other characteristics. There are approaches to in-vivo modification aimed at changing the profile and composition of fatty acids, minerals, and vitamins, because they have proven effectiveness (Woessner et al., 2021) as biologically active compounds and are easily modified in tissues. By increasing the content of monounsaturated fatty acids in animal feed, it is possible to increase the content of monounsaturated fatty acids in meat. The content of polyunsaturated fatty acids in animal meat can be increased by adding various ingredients of vegetable and marine origin rich in polyunsaturated fatty acids to the feed. In poultry, the cholesterol content in the muscle tissue of a living individual can be selectively reduced by increasing the level of copper in the feed. The risk of peroxidation can be prevented by strengthening the antioxidants in the muscles with an animal diet. The addition of minerals Fe, Mg, and Se, vitamin E to the diet of animals, increases the corresponding concentration in tissues.

In recent decades, breeding methods have been practiced to reduce the fat content of carcasses. Currently, there are methods for manipulating the fat content and fatty acid profiles in carcasses, based on genetic breeding programmes, using genetic markers that identify specific loci that express quantitative characteristics. Biotechnological methods of cloning and transgenesis have proven to be very effective scientific strategies. This refers to the direct manipulation of genes that change the profile of fatty acids to improve the quality and safety of functional meat-based products. The development of functional meat-based food

products by modifying meat transformation systems allow changing the content of various biologically active compounds using a number of methods. The fat content can be improved by changing the fatty acid profile, reducing the fat and cholesterol content. To reduce fat density, water and fat substitutes based on protein or carbohydrates are added. For the manufacture of meat products with a reduced fat content, lean meat is used as a raw material. The fatty acid composition of meat is important for the preparation of healthy foods, because each fatty acid has a different effect on plasma lipids.

There are strategies to change the fatty acid profile of meat by replacing unhealthy fats with healthy ones. Healthy fats contain a smaller proportion of saturated fatty acids and a larger proportion of unsaturated fatty acids, including low cholesterol values. Lipids of vegetable or marine origin can be incorporated directly into functional meat-based products in the form of liquid oils. Plant sources of lipids include corn, soybeans, beans, olives, peanuts, cottonseed, and so on, while marine sources are mainly algae and fish. In recent years, various physicochemical procedures for removing cholesterol from meat raw materials have been developed and practically applied, including fermentation of meat products using bacteria, and methods for diluting fat in meat raw materials.

The development of innovative technologies of canned food for people with a sedentary lifestyle must consider that the interaction of genetic and dietary factors plays an important role in the etiology of many socially significant diseases. The opinion of a number of researchers (Chater et al., 2020) is that discrepancies between the human genome of the Paleolithic era, on the one hand, and modern nutrition and lifestyle, on the other hand, play a significant role in the disease of obesity, hypertension, diabetes, atherosclerosis and other symptoms of a metabolic syndrome caused by the transition from wild and unprocessed foods to a diet high in fat, sugar, and salt, seems to be true and fair. Low levels of physical activity disrupt appetite regulation, while adequate levels of physical activity help to better regulate eating behaviour. Food rich in dietary fibre contributes to the feeling of satiety due to the large volume and low energy density, thereby preventing obesity. The development of innovative technologies of canned food for people with a sedentary lifestyle, including a large amount of dietary fibre, contributes to weight loss, causing a decrease in body fat. Weight loss is associated with the level of dietary fibre intake in cereals, fruits, and vegetables, including whole grains. Canned food for people with a sedentary lifestyle engage mechanisms such as the effects of gastric emptying, the passage time to the small intestine and the production of hormones in the intestine. Each of these mechanisms is affected differently by different types of dietary fibre.

The development of innovative technologies of canned food for people with a sedentary lifestyle involves low levels of fat and carbohydrates in food. Researchers who claim that, recently, consumers have become more interested in products and weight management methods that are aimed at suppressing appetite, promoting satiety, suppressing the digestion and absorption of fats and carbohydrates, and increasing fat oxidation, are certainly not mistaken (D'Amore et al., 2020). This refers to the development of a variety of natural products, such as fat burners, fat and carbohydrate blockers, appetite suppressants, and satiety stimulants. Plant extracts play an important role in the basis of canned food for people with a sedentary lifestyle (Abzhanova et al., 2018).

Summing up the study results, it is necessary to note the importance of scientific controversy on the use of functional ingredients used in meat canning. A comprehensive investigation of the issue has shown the categorical correctness of the idea of producing canned meat products that effectively affect human health. Admittedly, modern methods of manipulating the fat content and fatty acid profiles in carcasses developed by science in cooperation with production are important, based on genetic breeding programmes, using genetic markers that identify specific loci that express quantitative characteristics. In the future, it is necessary to develop a safer and more efficient process for evaluating the functional ingredients used in meat canning, which would allow a strictly scientific approach to be followed with respect to each proposed functional ingredient used in meat canning, and take measures to provide clear information to consumers. Consumer recognition is the key to success in the market of functional ingredients used in canned meat production.

4 Conclusion

The purpose of the study was to analyse the use of functional ingredients in meat canning, contributing to the beneficial effects of meat on health. Scientific methods have established that functional ingredient include vegetable proteins, dietary fibres, herbs and spices, and probiotics, which are able to increase the nutritional value of canned meat products in food systems, improve taste, slow down the deterioration of food quality caused by lipid oxidation, inhibit the growth of microorganisms, reduce the risk of certain diseases, and benefit human health. It was found that when developing functional bioactive compounds in the production of canned meat products, it is extremely important to consider the dietary deficiencies of specific substances noted in different consumer populations.

The limitation of the presented study is the lack of adjustments for other potential environmental and dietary factors that may also affect the quality of canned meat production. The strong point of this paper is the design of the study, which reduces the likelihood of information distortion, and the application of the imputation method for missing information.

In recent years, consumer demand for healthier meat and meat products with reduced fat, cholesterol, reduced sodium chloride and nitrite content, improved fatty acid profile composition, and health-improving ingredients has been growing rapidly worldwide. However, only a limited number of studies indicate the possible benefits of using functional ingredients in canned meat for human health. Therefore, further research is required that would provide convincing evidence of the benefits of functional ingredients in canned meat for human health.

Future research on functional ingredients in the meat canning industry should be devoted to the development of methods for the relative quantitative assessment of the impact of technological innovations on the usefulness of functional ingredients. Within this framework, various strategies are

planned for collecting quantitative information on the content of functional ingredients in meat canning, including special laboratory analyses in specific food matrices, including proactive data collection from manufacturers. Genotyping studies in large populations are required to determine the actual targets for functional ingredients. In future studies of functional ingredients, it is necessary to consider a new trend that emphasises the importance of sensory properties of canned meat products, taste and smell, since they represent the most representative attribute of food.

References

Abzhanova, S. A., Bulambayeva, A. A., Dzhetpisbaeva, B. S., Kozhakhiyeva, M. O., Matibaeva, A. I., Serikkyzy, M. S., & Rskeldiyev, B. A. (2018). Research of the impact of a vegetable protein composition on the functional and technological properties of national meat products. *Asian Journal of Microbiology Biotechnology & Environmental Sciences*, 20(4), 1077-1086.

Acosta, E. V., Ospina-E, J. C., Muñoz, D. A., & Alvarez, H. (2021). Towards a phenomenological based model for predicting the hardness of a processed meat product. *Journal of Food Science and Technology*, 58(2), 701-709. http://dx.doi.org/10.1007/s13197-020-04584-2. PMid:33568864.

Almoraie, N. M., Saqaan, R., Alharthi, R., Alamoudi, A., Badh, L., & Shatwan, I. M. (2021). Snacking patterns throughout the life span: potential implications on health. *Nutrition Research*, 91, 81-94. http://dx.doi.org/10.1016/j.nutres.2021.05.001. PMid:34144310.

Blanco-Gutiérrez, I., Varela-Ortega, C., & Manners, R. (2020). Evaluating animal-based foods and plant-based alternatives using multi-criteria and SWOT analyses. *International Journal of Environmental Research and Public Health*, 17(21), 7969. http://dx.doi.org/10.3390/ijerph17217969. PMid:33138318.

Chater, A. M., Smith, L., Ferrandino, L., Wyld, K., & Bailey, D. P. (2020). Health behaviour change considerations for weight loss and type 2 diabetes: nutrition, physical activity and sedentary behaviour. *Practical Diabetes*, 37(6), 228-231b. http://dx.doi.org/10.1002/pdi.2311.

Chazelas, E., Deschasaux, M., Srour, B., Kesse-Guyot, E., Julia, C., Alles, B., Druesne-Pecollo, N., Galan, P., Hercberg, S., Latino-Martel, P., Esseddik, Y., Szabo, F., Slamich, P., Gigandet, S., & Touvier, M. (2020). Food additives: distribution and co-occurrence in 126,000 food products of the French market. *Scientific Reports*, 10(1), 3980. http://dx.doi.org/10.1038/s41598-020-60948-w. PMid:32132606.

D'Amore, T., Taranto, A., Berardi, G., Vita, V., Marchesani, G., Chiaravalle, A. E., & Iammarino, M. (2020). Sulfites in meat: occurrence, activity, toxicity, regulation, and detection. A comprehensive review. *Comprehensive Reviews in Food Science and Food Safety*, 19(5), 2701-2720. http://dx.doi.org/10.1111/1541-4337.12607. PMid:33336981.

Dima, C., Assadpour, E., Dima, S., & Jafari, S. M. (2020). Bioavailability of nutraceuticals: role of the food matrix, processing conditions, the gastrointestinal tract, and nanodelivery systems. *Comprehensive Reviews in Food Science and Food Safety*, 19(3), 954-994. http://dx.doi.org/10.1111/1541-4337.12547. PMid:33331687.

Etemadzadeh, S. S., & Emtiazi, G. (2021). Generation of non-toxic, chemical functional bio-polymer for desalination, metal removal and antibacterial activities from animal meat by-product. *Journal of Food Science and Technology*, 58(1), 159-165. http://dx.doi.org/10.1007/s13197-020-04525-z. PMid:33505060.

Galali, Y. (2021). The impact of covid-19 confinement on the eating habits and lifestyle changes: a cross sectional study. *Food Science & Nutrition*, 9(4), 2105-2113. http://dx.doi.org/10.1002/fsn3.2179. PMid:33821183.

Khajavi, M. Z., Abhari, K., Barzegar, F., & Hosseini, H. (2020). Functional meat products: the new consumer's demand. *Current Nutrition and Food Science*, 16(3), 260-267. http://dx.doi.org/10.2174/1573401315666190227161051.

Kukhtyn, M., Salata, V., Berhilevych, O., Malimon, Z., Tsvihun, A., Gutyj, B., & Horiuk, Y. (2020). Evaluation of storage methods of beef by microbiological and chemical indicators. *Potravinarstvo Slovak Journal of Food Sciences*, 14, 602-611. https://doi.org/10.5219/1381.<jrn>

Kyriakopoulou, K., Keppler, J. K., & van der Goot, A. J. (2021). Functionality of ingredients and additives in plant-based meat analogues. *Foods*, 10(3), 600. http://dx.doi.org/10.3390/foods10030600. PMid:33809143.

Macho-González, A., Garcimartín, A., López-Oliva, M. E., Bastida, S., Benedí, J., Ros, G., Nieto, G., & Sánchez-Muniz, F. J. (2020). Can meat and meat-products induce oxidative stress? *Antioxidants*, 9(7), 638. http://dx.doi.org/10.3390/antiox9070638. PMid:32698505.

Manessis, G., Kalogianni, A. I., Lazou, T., Moschovas, M., Bossis, I., & Gelasakis, A. I. (2020). Plant-derived natural antioxidants in meat and meat products. *Antioxidants*, 9(12), 1215. http://dx.doi.org/10.3390/antiox9121215. PMid:33276503.

McClements, D. J., & Grossmann, L. (2021). The science of plant-based foods: constructing next-generation meat, fish, milk, and egg analogs. *Comprehensive Reviews in Food Science and Food Safety*, 20(4), 4049-4100. http://dx.doi.org/10.1111/1541-4337.12771. PMid:34056859.

Miguel-Berges, M. L., Barrantes, P. F., Altaba, I. I., Santaliestra-Pasias, A., Samper, P., Moreno, L. A., & Rodriguez, G. (2020). Association of sedentary behaviours with food and beverages consumption and total diet quality in children from a Spanish region. *Child and Adolescent Obesity*, 3(1), 122-135. http://dx.doi.org/10.1080/2574254X.2020.1776054.

Miranda, A. V. S., & Schmiele, M. (2020). Non-digestible carbohydrates as an alternative to improve the technological and nutritional quality of meat products and potential application in fish burgers. *Research, Society and Development*, 9(11), e87691110490. http://dx.doi.org/10.33448/rsd-v9i11.10490.

Nile, S. H., Baskar, V., Selvaraj, D., Nile, A., Xiao, J., & Kai, G. (2020). Nanotechnologies in food science: applications, recent trends, and future perspectives. *Nano-Micro Letters*, 12(1), 45. http://dx.doi.org/10.1007/s40820-020-0383-9. PMid:34138283.

Park, J. H., Moon, J. H., Kim, H. J., Kong, M. H., & Oh, Y. H. (2020). Sedentary lifestyle: overview of updated evidence of potential health risks. *Korean Journal of Family Medicine*, 41(6), 365-373. http://dx.doi.org/10.4082/kjfm.20.0165. PMid:33242381.

Rodriguez-Amaya, D. B., & Amaya-Farfan, J. (2021). *Chemical changes during processing and storage of foods: implications for food quality and human health*. New York: Academic Press.

Skotnicka, M., Karwowska, K., Kłobukowski, F., Wasilewska, E., & Malgorzewicz, S. (2021). Dietary habits before and during the covid-19 epidemic in selected European countries. *Nutrients*, 13(5), 1690. http://dx.doi.org/10.3390/nu13051690. PMid:34065655.

Smagulov, D., Sadykulov, T., Adylkanova, S., & Koishibaev, A. (2014). Features of growth and meat productivity of new factory lines of Saryarka Lambs. *Biology and Medicine*, 6(2), BM-021. <jrn>

Stojanović, B., Janković, S., Đorđević, V., Marjanović, S., Vasilev, D., Stojanović, Z., Balaban, M., & Antić, V. (2021). Determination of toxic elements in meat products from Serbia packaged in tinplate cans. *Environmental Science and Pollution Research International*, 28(35), 48330-48342. http://dx.doi.org/10.1007/s11356-021-14051-w. PMid:33904134.

Sun, C., Ge, J., He, J., Gan, R., & Fang, Y. (2021). Processing, quality, safety, and acceptance of meat analogue products. *Engineering*, 7(5), 674-678. http://dx.doi.org/10.1016/j.eng.2020.10.011.

Tan, W. K., Husin, Z., Yasruddin, M. L., & Ismail, M. A. H. (2022). Recent technology for food and beverage quality assessment: a review. *Journal of Food Science and Technology*, 1-14. http://dx.doi.org/10.1007/s13197-022-05439-8. PMid:35463865.

Uzakov, Y. M., Kaimbayeva, L. A., Dikhanbayeva, F. T., Koshoeva, T. R., & Smailova, Z. Zh. (2021). Physicochemical Parameters of Yak Meat during Massaging and Salt Pickling. *Journal of AOAC International*, 105(3), 822-826. https://doi.org/10.1093/jaoacint/qsab163.

Vilas-Boas, A. A., Pintado, M., & Oliveira, A. L. S. (2021). Natural bioactive compounds from food waste: toxicity and safety concerns. *Foods*, 10(7), 1564. http://dx.doi.org/10.3390/foods10071564. PMid:34359434.

Woessner, M. N., Tacey, A., Levinger-Limor, A., Parker, A. G., Levinger, P., & Levinger, I. (2021). The evolution of technology and physical inactivity: the good, the bad, and the way forward. *Frontiers in Public Health*, 9, 655491. http://dx.doi.org/10.3389/fpubh.2021.655491. PMid:34123989.

Wood, B., Williams, O., Nagarajan, V., & Sacks, G. (2021). Market strategies used by processed food manufacturers to increase and consolidate their power: a systematic review and document analysis. *Globalization and Health*, 17(1), 17. http://dx.doi.org/10.1186/s12992-021-00667-7. PMid:33499883.

Yayuan, Y., Ling, H., Qunli, Y., Yongfang, G., & Hongmei, S. (2022). Effects of caspase activity of yak meat and internal environment changing during aging. *Journal of Food Science and Technology*, 59(4), 1362-1371. http://dx.doi.org/10.1007/s13197-021-05145-x. PMid:35250061.

Zhang, X., Chen, B., Jia, P., & Han, J. (2021). Locked on salt? Excessive consumption of high-sodium foods during covid-19 presents an underappreciated public health risk: a review. *Environmental Chemistry Letters*, 19(5), 3583-3595. http://dx.doi.org/10.1007/s10311-021-01257-0. PMid:34093102.