Caspian Journal of Environmental Sciences
Online ISSN: 1735-3866
Print ISSN: 1735-3033

Ensuring quality and safety in the production and storage of poultry meat

Raushangul Uazhanova[1], Zamzagul Moldakhmetova[2]*, Ulbala Tungyshbayeva[1], Raushan Izteliyeva[1], Sholpan Amanova[1], Galymbek Baimakhanov[3], Shakhsanam Seksenbay[1], Sultan Sabraly[1]

1. Department of Food Safety and Quality, Faculty of Food Technology, Almaty Technological University, Almaty, Kazakhstan
2. Department of «Food Security and Biotechnology», Faculty of Agricultural Sciences, NAO «Kostanay Regional University named after Akhmet Baitursynuly», Kostanay, Kazakhstan
3. Department of Standardization, Certification and Metrology, Institute of Energy and Mechanical Engineering named after A. Burkitbayev, K.I. Satbayev Kazakh National Research Technical University (Satbayev University), Almaty, Kazakhstan

** Corresponding author's E-mail: Zamza-07@mail.ru*

ABSTRACT
Poultry meat, including chicken, has an important place in human nutrition, but special conditions are required for its storage due to its high perishability. Therefore, this study presents methods for packaging and storing poultry meat to increase food safety and health. Then, using the method of testing microorganisms in poultry meat, the effect of packaging and storage conditions on preserving white meat's health and shelf life is investigated. The results show that packaging should provide the necessary handling, transportation, and storage conditions. Currently, there are packaging systems with different characteristics and applications for poultry packaging. These systems are used for storing poultry in short-term cold storage, retail stores, and long-term cold storage. Poultry packaging should be carried out in packaging factories and under entirely hygienic conditions, and then, while maintaining the cold chain, it is supplied to the consumer market with approved means of transportation.

Keywords: Poultry meat, Packaging, Transportation, Safe food storage.
Article type: Short Communication.

INTRODUCTION
Despite extensive advances in the food industry to increase the safety and shelf life of food products, foodborne diseases, microbial spoilage, and the formation of undesirable compounds resulting from lipid oxidation remain major concerns in the nutrition of society. Microbial growth is one of the main factors in the spoilage of poultry, meat, and fish, which causes undesirable changes in these products and, as a result, causes food poisoning, various diseases, including types of cancer, and also considerable economic losses (Mead 2004). In addition to the adverse consequences that chemical and microbial spoilage of food has on human health, the economic losses caused by it cannot be ignored. One of the most effective and important methods for protecting food from undesirable chemical and microbial changes is packaging. The tendency to use edible coatings and films is expanding due to factors such as environmental concerns, the need for new methods to create new consumption markets for agricultural products, the need of the food industry to increase the shelf life of products, and the increasing desire of consumers to consume natural foods (Mead 2004; Manning *et al.* 2006; Mykhailivna & Grygorivna 2020; Sani *et al.* 2024). Natural compounds with properties to reduce or inhibit the growth of microorganisms in food and using natural biopolymers containing antimicrobial compounds to prevent the growth of microorganisms and oxidation of fats in food products have received much attention today. Edible films are made from natural polymers such as carbohydrates and are biodegradable, making them compatible with the environment,

Caspian Journal of Environmental Sciences, Vol. 22 No. 5 pp. 1271-1277 Received: Feb. 29, 2024 Revised: May 16, 2024 Accepted: July 08, 2024
DOI: 10.22124/CJES.2024.8342

Publisher: University of Guilan

maintaining quality, increasing shelf life, and minimizing moisture loss. As consumers become more aware of the adverse health effects of chemical preservatives, their desire to use natural preservatives, especially plant-based compounds, in food products has increased. Using plant-based compounds in edible films is a practical solution to achieve safer, longer-lasting food products and reduce waste. Given the importance of the issue, it is necessary to investigate further new methods of chicken packaging and their application to hot carcasses, aiming to improve the quality and shelf life of the carcass and reduce environmental risks by increasing the biodegradability of the packaging coating.

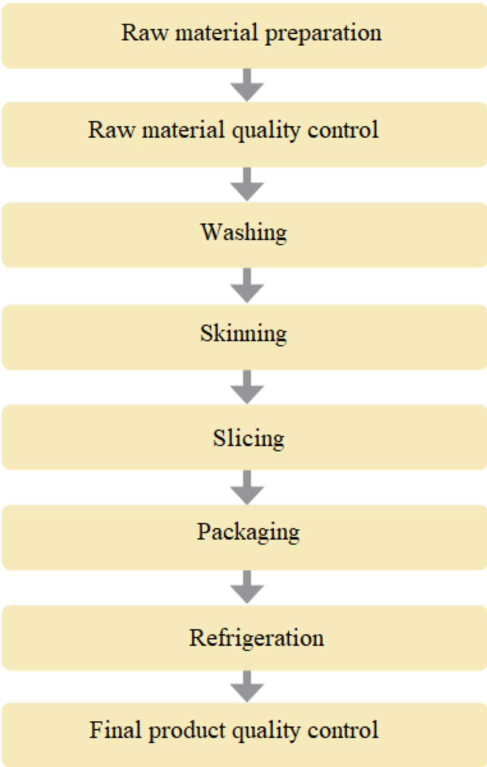

Fig. 1. Poultry meat packaging steps.

Using plant compounds in the formulation of edible films enhances their antioxidant and antimicrobial properties, thus increasing the shelf life of foods. Moro *et al.* (2006), investigated adding garlic oil to alginate films and then the antimicrobial properties of the films on *Escherichia coli*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Salmonella typhimurium*, and *Bacillus cereus* bacteria, as well as the physical and mechanical properties of the films. The results showed that the films' tensile strength changed due to adding garlic oil which significantly reduced the permeability of the films to water vapor. Among bacteria, *S. aureus* and *B. cereus* showed the highest sensitivity to garlic oil (Moro *et al.* 2006). Also, Araújo *et al.* (2013) studied the effect of fennel essence in chitosan film on the shelf life of chicken burgers. This study used fennel essential oil at concentrations of 0.5 to 2% in chitosan film. Then, chicken burgers were packaged in the desired film and stored at 4 ℃ for 12 days. The results showed that adding fennel to the film reduced moisture, solubility, and permeability to water vapor. On the other hand, by elevating the concentration of fennel essential oil, microbial and chemical spoilage in chicken burgers decreased significantly. Recent studies investigated the immersion of chicken meat in an aqueous lupulus extract (Ricke 2017). The results showed that immersion for 18 hours in a solution containing 2 g L^{-1} of the extract before vacuum packaging increased its shelf life by up to 35 days. Also, Cassens (2008), investigated the effect of the stevia, *Nigella stevia* L. seed extract on lipid oxidation and chicken meatball color during 14-day refrigerated storage. The results showed that due to the valuable phenolic compounds present in the extract, its addition reduced the oxidation process in chicken meatballs. The addition of this extract also caused a significant difference in the color of the meatballs during refrigerated storage (Briem *et al*. 2019). In a study conducted by Sofos (2008), the effect of tomato extract in chitosan, as a coating, on the shelf life of chicken meat during storage was investigated. For this purpose, chicken meat samples were immersed in different concentrations of this extract for one minute and then monitored for microbial parameters during storage. The results showed that treatment with

1% tomato extract-chitosan mixture could lead to a suitable increase in the shelf life of meat at refrigerator temperature (Crutchfield *et al*. 1997).

The importance of modern methods in carcass packaging

By definition, a food product's shelf life is when the food remains healthy and, under appropriate conditions and by the nutritional information label, its desirable sensory, chemical, physical, and microbial properties can be preserved. In the case of food, maintaining high quality and desirable properties from production to consumption is very essential. Although chicken meat is one of the most important protein sources, it is also one of the most unstable food products regarding shelf life. Occasional fluctuations in the amount of chicken meat production in the country, on the one hand, and the consumer community's preference for buying unfrozen chicken meat instead of frozen, on the other hand, double the need to provide practical solutions (based on the use of natural preservatives) in order to increase the shelf life of the carcass at refrigerated temperature and control fluctuations in the chicken market. Chicken meat is a very suitable environment for the growth of all microorganisms, and preservatives are used to control oxidative changes and microbial reactions. The presence of natural microbial flora in various foods and secondary contamination during production stages can be one of the causes of food poisoning; therefore, controlling the microbial load of foods during production stages to consumption is very important. Various studies have shown that phenolic and terpenoid compounds extracted from medicinal plants have antimicrobial properties. Their effects have been proven against many bacteria, yeasts, and fungi. These plant-extracted compounds have significant bioactive and antimicrobial properties and are used in various pharmaceutical, chemical, cosmetic, and food industries. Therefore, by using healthy medicinal plants in the food industry, not only can the consumer's health be improved, but also the shelf life and flavor of the food product can be increased, and ultimately, the consumer's satisfaction can be ensured (Indiarto *et al*. 2023).

MATERIALS AND METHODS

Principles and basics of active packaging

Food packaging increases the product's shelf life by applying desirable changes in conditions without causing adverse effects on quality (Yogeswari *et al*. 2024). One of the new concepts in food packaging is active packaging, which has been introduced to the market in response to continuous changes in consumer needs. This method prevents the growth of spoilage bacteria by controlling environmental factors. In conventional packaging, the basis is that at least some interaction between the product and the packaging occurs, but in active packaging, it is not necessary to prevent interaction, since this process is considered beneficial. Modified active packaging has been used in recent years to preserve food, and its various types are expanding daily. This type of packaging is produced in various forms, such as maintaining product freshness, and can have multiple applications. Active ingredients include oxygen absorbers, carbon dioxide, moisture absorbers, ethylene, ethanol release agents, flavoring agents, and antimicrobial agents (Morosini Frazzon *et al*. 2013). To prevent bacterial growth and increase the shelf life of food, a wide range of synthetic preservative compounds such as chlorides, nitrites, sulfites, and organic acids are used. However, their use is restricted in many countries due to the negative effects of these compounds on public health and carcinogenicity. Today, the use of natural substances such as plant bioactive compounds for preserving food in packaging is recommended by experts (Baguio & Naelga 2024).

Types of biodegradable packaging

Extruding starch granules with synthetic polymers obtain biodegradable plastics. In this method, extrusion causes the starch granules to be dispersed in the synthetic polymer matrix without interaction. By the enzymatic degradation of starch, the adjacent interface between the synthetic polymer and the surrounding atmosphere increases, elevating its degradability. Although these compounds are more biodegradable compared to synthetic polymers, they have poor mechanical properties due to the low compatibility of polyethylene and starch. Therefore, the amount of starch used in this method is limited. The hydrophobicity of the surface of the starch granules can be increased by a special process, thereby enhancing their compatibility with synthetic polymers. This way, the amount of starch in the extruded film can increase.

Using edible films and coatings in improving carcass shelf life

Environmental concerns have led to an increased interest in the use of edible films and have created opportunities for the expansion of new consumer markets (Manning *et al*. 2006). Biodegradable packaging that can be eaten and consumed with food is divided into edible films and coatings. Edible films and coatings prevent the transfer of oxygen, moisture, and soluble substances into food products by creating a thin layer around the food. Edible films are produced as thin layers before being used in food packaging and are then used for packaging like synthetic polymers. Films can be produced in the form of wrappers, capsules, and bags, which are molded to a high thickness. Edible coatings, unlike films, are formed on the food. Therefore, the coating is part of the product and remains on the product during use. This is usually done by methods such as vaccination, spraying, and immersion (Fig. 2).

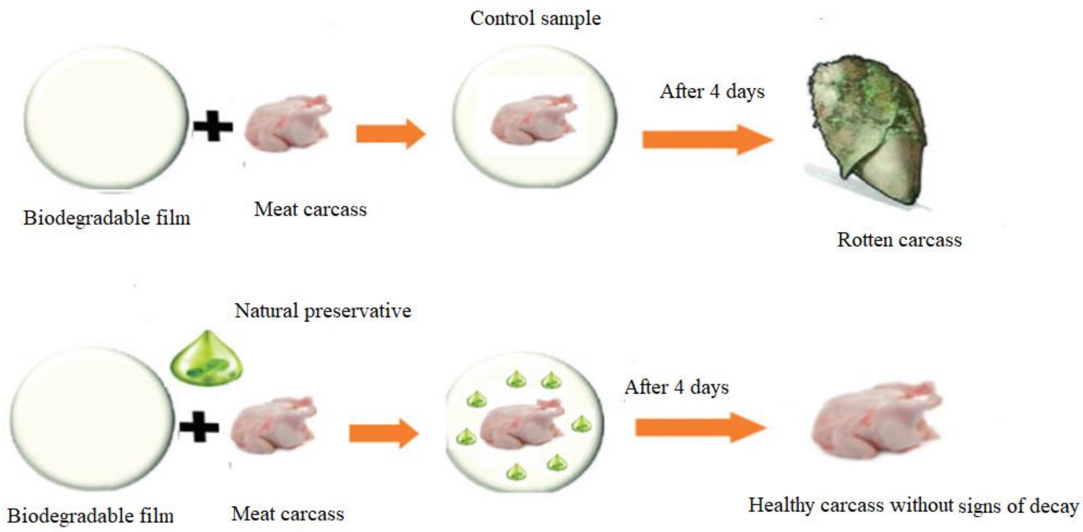

Fig. 2. Comparison of chicken fillet packaging with biodegradable film with and without natural preservatives.

Quality control test for packaged poultry meat

Detection of *Escherichia coli* in chicken meat

Tools and Equipment: Glass container with tight lid, scale with an accuracy of 0.001 g, autoclave, alcohol lamp, incubator, sterile knife, Erlenmeyer flask, test tube, pipette, bacteriological hood, bain-marie, Durham tube, culture ring, gown, gloves, mask, and cap.

Materials: 1/4 Ringer's solution, lauryl sulfate culture medium, EC broth, peptone water without indole as indole reagent.

A) **Sampling**: Randomly separate pieces from several parts of the carcass or cut meat to approximately one kilogram. Then, from this one kilogram of meat, which represents the entire meat or carcass under test, separate pieces to 10 grams.

B) **Preparation of culture medium**:

- An aliquot of 10 mL double-concentration lauryl sulfate containing Durham tube is poured into a test tube 200 cm high and 20 mm in diameter.
- An aliquot of 10 mL lauryl indole peptone water containing Durham tube is poured into a test tube 160 cm high and 16 mm in diameter.
- An aliquot of 10 mL EC broth culture medium is poured into a test tube 160 cm high and 16 mm in diameter.
- C)

Search method

- An amount of 10-g sample is weighed under completely sterile conditions and added to 90-cm Ringer's solution that has been previously sterilized and has reached room temperature (Initial suspension).
- An aliquot of 10 mL of the initial suspension is added to 10-mL double lauryl sulfate culture medium.
- The test tube is placed in an incubator at 37 ℃ for 24 hours.
- If no gas or turbidity is observed after 24 hours, incubation continues for 48 hours.
- If there is no gas or turbidity, *E. coli* is not present, and the test is completed.
- If gas or turbidity is observed, it is removed using a culture ring and inoculated into an EC broth culture medium containing a Durham tube.
- It is placed in a water bath or incubator at a temperature of 44 ℃ for 24 hours.

- If no gas is observed after 24 hours, incubation continues for 48 hours.
- If no gas is formed after 48 hours, *E. coli* is not present, and the test is completed.
- If gas is formed, it is removed using a culture ring and inoculated into a peptone water medium.
- It is placed at a temperature of 44 ℃ for 48 hours. After 48 hours, 0.5-mL reagent is added and shaken.
- It is placed at 44 ℃ for one minute and then analyzed.
- The formation of a red color in the alcoholic phase at the top of the tube indicates the presence of indole and is a sign of *E. coli*.

Given the permissible limit of *E. coli* in poultry meat (maximum 50 units per gram), a counting test should also be performed if the test result is positive.

RESULTS

Principles of packaging and labeling of poultry meat

After leaving the cutting room, chicken parts are washed and placed in special baskets. Then, they enter the packaging room and are placed on a large steel table with a base or placed in special containers by workers while passing on the conveyor belt and packaged. Poultry meat can also be packaged in various ways, including: 1) Fresh or frozen packaging; 2) whole chicken or chicken parts packaging; 3) Conventional packaging, vacuum packaging, modified atmosphere packaging; 4) controlled atmosphere packaging and bioactive packaging. Table 1 lists the storage conditions and shelf life of whole poultry carcasses, chicken parts, and poultry edible impurities in different types of packaging.

Table 1. Poultry meat storage conditions.

Product name	Product delivery form	Storage condition (℃)	Shelf life
Poultry carcass	Fresh (regular packaging)	0-4	3 days
	Vacuum packaging	0-4	6 days
	Modified atmosphere packaging	0-4	8 days
	Frozen (carton packaging)	-18	12 months
Meat pieces	Frozen (carton packaging)	0-4	3 days
	Frozen (carton packaging)	0-4	5 days
	Frozen (carton packaging)	0-4	7 days
	Frozen (carton packaging)	-18	9 months
Minced meat	Fresh (regular packaging)	0-4	2 days
	Frozen (carton packaging)	-18	3 months
Poultry internal organs	Fresh (regular packaging)	0-4	2 days
	Frozen (carton packaging)	-18	3 months

Principles of storage and transportation of packaged poultry meat

The most important points for storing, distributing, and supplying poultry meat are:
- Workers and those who work in the poultry meat storage area must have a health card.
- After unloading the goods from the storage area, the storage area must be disinfected with authorized disinfectants.
- During transportation, precautions must be taken to ensure the packages are not damaged or torn.
- Packages produced earlier should be removed from the storage area and consumed earlier.
- Freshly cooked meat should be stored at 1 to 2 ℃.
-Frozen meat should be stored in a cold room at -18 ℃, and cold air should flow inside the poultry meat storage area.
- There should be no odorous substances following their storage area.
- The maximum storage period for freshly cooked meat is 3 days in a cold room above zero, and for frozen meat, 12 months in a cold room at -18 ℃.
- Frozen poultry meat should be delivered to the buyer completely frozen.

The characteristics of the authorized means of transportation of packaged poultry meat

Obtaining a transportation certificate from the slaughterhouse's technical officer is mandatory for intra-provincial transportation.
- Vehicles transporting fresh products must be equipped with a cooling system and provide a temperature of zero to 4 ℃.
- Vehicles transporting frozen products must have a cooling system of -18 ℃ and below.

- Vehicles transporting frozen products must have a thermograph and an alarm to notify of excessive temperature.
- They must have received a license from the Veterinary Organization to transport packaged chickens.
- The enclosure of these vehicles must be clean and free of contamination.
- The thermoking of the chicken-carrying vehicles must be turned on to provide the temperature of 2 to 4 ℃ required for storing freshly packaged chicken.
- The packaged chickens are transported to consumption and distribution centers after these vehicles load them.

Principles of quality control of packaged poultry meat

Quality control of poultry meat includes examining its appearance and sensory, chemical, and microbial characteristics.

- Sensory and visual characteristics of poultry meat include: texture, skin color, meat color, smell, taste, etc.

In quality control, the following points should be examined for the appearance of packaged poultry meat.

- There should be no blood or frozen water inside the package.
- It should reach the consumer completely frozen.

After defrosting, the muscles should be normal in hardness and consistency and not be slippery or slimy.

- It should be free of traces and signs of burns caused by freezing, as well as signs of mold.
- The weight of water exuded from fresh meat (the sum of water collected in the package and water absorbed by the absorbent material) should not exceed 6% of the weight of the packaged meat.

– Frozen chicken should be free of any abnormal odor, such as sour or rancid.

The skin must be its own natural color, evenly spread over the body, free from tears, swelling, blood, death, signs of freezing burns, discoloration, and scratches, and completely clean and free from feathers, foreign particles, and contamination.

- The chemical characteristics measured in poultry meat include pH, acidity, dry matter, ash, crude protein, and the amount of residual drugs and other chemicals in poultry meat, which must not exceed the maximum allowable amount determined by the legal and competent authorities of the country.
- Microbial tests related to poultry meat include total count, *Salmonella*, *E. coli*, mold, and yeast

Table 2. Microbiological characteristics of fresh and frozen poultry meat.

No	Test	Min	Max
1	Total count of microorganisms (in grams)	10^4	10^6
2	Coagulase-positive staphylococci (in grams)	100	1000
3	*Salmonella* (in 25 grams)	0	0.1
4	*E. coli* (in grams)	45	450

CONCLUSION

The main issue of food preservation is carrying out processes that protect food from spoilage agents. Food spoils by biological agents and chemical and physical reactions. Humanity has always been experimenting and applying preservation approaches to prevent food spoilage. Poultry meat is one of the important parts of people's diets worldwide, especially in Kazakhstan. Poultry meat does not contain trans fatty acids, while beef has about 2-5%, and mutton has about 8% trans acids, which is one of the main priorities of white meat over red meat. Poultry meat is also a source of omega-3 fatty acids. The body's need for vitamin B_3 for adults is met by consuming 100 grams of chicken meat daily and for children with 50 grams. This paper discusses modern methods for preserving poultry meat. The results showed that due to the disadvantages of traditional and old methods in preserving poultry meat due to unsanitary factors and short shelf life, food industry researchers are turning to modern non-thermal methods and advanced packaging, which, compared to thermal methods, causes less damage to the product and preserves the texture and taste of the meat. Also, modern packaging effectively reduces the number of microorganisms during chicken storage, improving packaged poultry meat's preservation and quality. The high nutritional benefits of poultry have led to its increased consumption, so further studies are necessary to understand how the quality of poultry meat products, fresh, cooked, or frozen, changes with the type of storage and packaging. These results indicate a bright future in packaging methods needed to prevent microbial contamination of poultry meat in the market.

REFERENCES

Araújo, M da P, Campos, VBG & Bandeira, RA 2013, An overview of road cargo transport in Brazil. *International Journal of Industrial Engineering and Management*, 4(3): 151-160, DOI: 10.24867/IJIEM-2013-3-119.

Baguio, TKFG & Naelga, SC 2024, The impact of food service attributes on customer satisfaction: the case of cafeteria services at a state university of northern Mindanao. *Cadernos de Educação Tecnologia e Sociedade*, 17: 339-350.

Briem, AK, Betten, T, Held, M, Wehner, D & Baumann, M 2019, Environmental sustainability in the context of mass personalisation – quantification of the carbon footprint with life cycle assessment. *International Journal of Industrial Engineering and Management*, 10(2): 171-180, DOI: 10.24867/IJIEM-2019-2-237.

Cassens, RG 2008, Meat preservation: Preventing losses and assuring safety. John Wiley & Sons.

Crutchfield, SR, Buzby, JC, Roberts, T, Ollinger, M & Lin, CTJ 1997, Economic assessment of food safety regulations: The new approach to meat and poultry inspection. DOI: 10.22004/ag.econ.34009.

Indiarto, R, Irawan, AN & Subroto, E 2023, Meat irradiation: A comprehensive review of its impact on food quality and safety. *Foods*, 12(9). DOI: https://doi.org/10.3390/foods12091845.

Manning, L, Baines, RN & Chadd, SA 2006, Food safety management in broiler meat production. *British Food Journal*, 108(8): 605-621. DOI: https://doi.org/10.1108/00070700610681987.

Mead, GC 2004, Microbiological quality of poultry meat: a review. *Brazilian Journal of Poultry Science*, 6: 135-142.

Mead, GC 2004, Poultry meat processing and quality. Woodhead Publishing, 388 p., https://www.sciencedirect.com/book/9781855737273/poultry-meat-processing-and-quality#book-info.

Moro, GAD & Gisi, ML 2023, FIES, PROUNI and REUNI: unfinished paths for the democratization of access to higher education. *Avaliação: Revista da Avaliação da Educação Superior* (*Campinas*), 32 p. http://dx.doi.org/10.1590/S1414-40772023000100026.

Morosini Frazzon, E Jr, JP & Albrecht, A 2013, Simulation-based Analysis of Integrated Production and Transport Scheduling. *International Journal of Industrial Engineering and Management*, 4: 109-116. DOI: 10.24867/IJIEM-2013-3-114.

Mykhailivna, BN & Grygorivna, MT 2020, Safety and Quality Control of Poultry Meat in the Manufacturing and Storage Enterprise for the Implementation of the HACCP System. In *The 1st International Scientific and Practical Conference—Achievements and Prospects of Modern Scientific Research* (December 6-8, 2020), Editorial EDULCP, Buenos Aires, Argentina, 14 p.

Ricke, SC (Ed.) 2017, Achieving sustainable production of poultry meat Volume 1: Safety, quality and sustainability. Burleigh Dodds Science Publishing.

Sani, MA, Zhang, W, Abedini, A, Khezerlou, A, Shariatifar, N, Assadpour, E & Jafari, SM 2024, Intelligent packaging systems for the quality and safety monitoring of meat products: From lab scale to industrialization. *Food Control*, 110359. DOI: https://doi.org/10.1016/j.foodcont.2024.110359.

Sofos, JN 2008, Challenges to meat safety in the 21st century. *Meat Science*, 78: 3-13, DOI: https://doi.org/10.1016/j.meatsci.2007.07.027.

Yogeswari, MS, Selamat, J, Jambari, NN, Khatib, A, Mohd Amin, MH & Murugesu, S 2024, Metabolomics for quality assessment of poultry meat and eggs. *Food Quality and Safety*, 8, fyae004. DOI: https://doi.org/10.1093/fqsafe/fyae004.

ibliographic information of this paper for citing:

Uazhanova, R, Moldakhmetova, Z, Tungyshbayeva, U, Izteliyeva, R, Amanova, S, Baimakhanov, G, Seksenbay, S, Sabraly, S 2024, Ensuring quality and safety in the production and storage of poultry meat, Caspian Journal of Environmental Sciences, 22: 1271-1277.