Scientific Papers. Series D. Animal Science. Vol. LXVIII, No. 1, 2025
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

CHEMICAL COMPOSITION AND BIOGENIC AMINES IN WILD BOAR MEAT DEPENDING ON STORAGE PERIOD: A REVIEW

Adina Florina CIOATA[1], Aurel DAMIAN[1], Oana-Andreea PECE[1], Adina SABOU[1], Anca BECZE[2], Aurelia COROIAN[1]

[1]University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, 3-5 Calea Mănăştur Street, 400372, Cluj-Napoca, Romania
[2]INCDO INOE 2000, Research Institute for Analytical Instrumentation Subsidiary, 67 Donath Street, 400293, Cluj-Napoca, Romania

Corresponding author email: aurelia.coroian@usamvcluj.ro

Abstract

The quality of boar meat also depends a lot on the food ingested during the fattening period. Boar meat, compared to domestic pig meat, is richer in protein, lower in lipids and richer in mineral salts. Studies have shown a reduced calorie content of wild boar meat compared to domestically raised pork, a large amount of essential amino acids, vitamin B12, D and mineral salts (iron, zinc, selenium). Since the meat of young boar is more difficult to digest, it is recommended to prepare meat from mature boar. A peculiarity of the biochemical processes in venison is represented by connective tissue proteins, which have a high degree of densification and polymerization, myofibrillar proteins being abundantly represented. The proteins in game meat are resistant to enzymatic denaturation, and that is why it is difficult to mature game meat. The purpose of this study is to characterize the composition of wild boar meat and the biogenic amine content depending on the storage period.

Key words*: biogenic amines, boar meat, fat, protein, quality.*

INTRODUCTION

Food security is currently being addressed more and more intensively both internationally and nationally, being a major concern regarding the quality of food (Feddern et al., 2019).
Game meat is a meat that is increasingly appreciated and sought after by many consumers lately, due to its good chemical composition, the saturated fatty acids present in game meat, the high protein content, low amounts of fat and due to its special organoleptic characteristics (the specific taste and aroma of game meat) (Tomasevic et al., 2018).
Numerous international studies have been conducted over time on the quality of game meat, namely its advantages, disadvantages, storage methods and preparation for consumption (Font-i-Furnols & Guerrero, 2014; Bodnar et al., 2014; Pickering & Lawrence, 2012).
According to data from the specialized literature, biogenic amines (BA) that are taken up through food consumption have no effects on the body if the quantities ingested are small, but if the quantities are larger they can cause various reactions or disorders in the body (Șoimușan et al., 2024; EFSA, 2011).
Biogenic amines can be found in various fermented or matured products, for example: cheeses, fish, meat or in wine products (Barry et al., 2009; Santos et al., 2003; Novella-Rodriguez et al., 2002).
Studies in the specialized literature confirm the existence of these biogenic amines in both animal and plant-based foods intended for human consumption (Capillas-Ruiz & Herrero 2019).
According to their chemical structure, biogenic amines are divided as follows: heterocyclic amines (histamine, tryptamine), aliphatic amines (putrescine, cadaverine) or aromatic amines (tyramine, phenylethyl amine), (Feddern et al., 2019; EFSA, 2011).
According to Ladero et al., 2010, the main source of contamination with biogenic amines is contaminated foods and fermented beverages.
The main biogenic amines that lead to acute toxicity are histamine and tyramine (Halász et al., 1994).
The main reactions produced by the ingestion of high quantities of biogenic amines are the following: headache, emesis, nausea, skin rashes, allergies, fluctuations in blood pressure (Jae-Hyung et al., 2002).

To prevent contamination with biogenic amines, it is necessary to meet the standards for high-quality raw materials for obtaining food products, monitor temperature and humidity parameters and of course comply with good manufacturing process practices (Doeun et al., 2017).

According to Șoimușan et al., 2024, the human body can be affected by the consumption of cheeses that have uneven amounts of biogenic amines inside them, and a much more careful control of the food production stages is recommended.

The process of formation of biogenic amines in food is influenced by a series of intrinsic factors (pH, water activity, microorganisms) and extrinsic factors (storage method and time, storage temperature) (Benkerroum, 2016).

Putrescine, spermidine, spermine and polyamines are commonly found in the cells of living organisms and play physiological roles according to Kalač & Krausová, 2005.

MATERIALS AND METHODS

As part of this review, we conducted a systematic search of scientific publications in the following online databases: Google Academic, Google Scholar, ScienceDirect, PubMed, Scopus, Elsevier, Springer Nature, Web of Science, and Wiley databases.

In this review, we have followed the essential characteristics of biogenic amines and their formation, including the microorganisms involved in the formation of biogenic amines, respectively the effect of storage conditions on the content of biogenic amines and their control methods.

RESULTS AND DISCUSSIONS

THE EXISTENCE OF BIOGENIC AMINES IN FOODS

According to studies, there is a wide range of foods in which biogenic amines may be present, namely: meat, fish, milk, cheese, fruits, vegetables, beer, wine and other products obtained from fish meat (Krizek et al., 2004; Kim et al., 2003; Simon-Sarkadi, 2002; Halász et al., 1994).

Biogenic amines present in different types of food (fish and fish products, meat products, dairy products, vegetables and other plant products) are represented in Table 1 and the daily dose (mg) is reported.

The quality of game meat, according to (Barendse, 2014) is determined by the general quality of the animal, the state of health, the welfare of the game animals as well as the age, breed, anatomy and physiology from the point of view of lifestyle, in addition to all these aspects, the technology of processing game meat also intervenes. In order to prevent high levels of biogenic amines, special attention should be paid to the temperature conditions of the storage process of food intended for human consumption, their handling practices, and the presence of microbial populations (Visciano et al., 2012).

Of course, the specialized literature also touches on some food technological treatments that are essential to avoid contamination with BA, for example, in the case of meat we have the salting process, the baking process, the fermentation process, the maturation process and the marinating process (Chong et al., 2011).

In the case of a study conducted by Hutařová et al., 2014a, biogenic amines in game meat (pheasant, rabbit and deer) were evaluated. Following the study, the sum of biogenic amines for each animal species did not exceed the value allowed by legislation, so the authors conclude the importance of the quality of hygiene and storage measures regarding game meat foods.

One of the potential indicators regarding the safety and quality of a food, in our case game meat, is the level of biogenic amines, so an increased level of BA is automatically associated with an increased level of microbial contamination followed by spoilage processes (Ruiz-Capillas & Jiménez-Colmenero, 2004).

Other measures to prevent food contamination with biogenic amines in food are represented by the cooling and freezing process (Paulsen et al., 2008a).

Limiting microbial growth may include hydrostatic pressures, irradiation processes, controlled atmosphere packaging processes or even the use of food additives (Hutařová et al., 2013).

Biogenic amines are involved in the deterioration of amino acids under high concentrations of microorganisms, with consequences for the human body (Yang et al., 2025).

According to studies a significant increase in the concentration of biogenic amines was observed inside the meat compared to its outside. Histamine and tyramine, present an increased toxic level, compared to spermine, spermidine, putrescein and cadaverine which are not as toxic (Doeun et al., 2017).

MICROORGANISMS INVOLVED IN THE FORMATION OF BIOGENIC AMINES

According to EFSA, 2011, the process of producing biogenic amines requires available amino acids and decarboxylating amino acids synthesized by specialized bacteria.

Strong activity in fermented food can lead to high levels of biogenic amines (Gonzalez et al., 2003).

Regarding the amount of biogenic amines produced, this depends directly on the level of free amino acids present, which in turn depend on the species and on the amount and activity of decarboxylating enzymes (Hutařová et al., 2014a).

The production process of biogenic amines is influenced by several factors, including, according to data from the specialized literature: food storage temperature, duration and method of food storage, food storage conditions, food pH, food salt content, amount of available oxygen, and last but not least, amount of free amino acids (Ruiz-Capillas & Jimenez-Colmenero, 2004). Together, all of these factors mentioned can lead to variable levels of contamination, in terms of biogenic amines (Ruiz-Capillas & Jimenez-Colmenero, 2004). The toxicological effects of biogenic amines through food consumption are mentioned in numerous specialized studies, such as respiratory, digestive, cardiovascular effects and including neurological disorders (Gardini et al., 2016; Lehane & Olley, 2000).

The bacterial colonies present can influence the production of biogenic amines as fermentation increases (Wang et al., 2025). High levels of certain biogenic amines cause adverse effects on the body, including: migraines, hypertension, tachycardia, acute respiratory failure, heart palpitations, hot flashes, sweating, nausea, skin rashes and other allergies (Capillas-Ruiz et al., 2019; Tofalo et al., 2016).

In a study carried out in Austria on batches of fermented sausages, fish meat, cheese and sauerkraut, the authors suggest tolerable levels of biogenic amines, namely: 6.8 mg per person in the case of adult women and 8.8 mg per person in the case of adult men, the estimated dose per day (Rauscher-Gabernig et al., 2012).

Regarding the exact toxicity limits for biogenic amines, they are very difficult to establish, because the toxic dose is dependent on the effectiveness of the activity of the detoxification mechanism, which can fluctuate depending on the individual (Brink et al., 1990).

Biogenic amines, especially histamine commonly found in foods, are the major cause of skin problems and body allergies (Silla-Santos (1996).

According to Gill (2007), it specifies that the incidence of enteric pathogens in meat from farmed game is positively better than that of field-hunted animals, due to the location of the bullet in the body, the time of evisceration and the temperatures, all of which factors under certain conditions can trigger the development of biogenic amines.

In Table 1, the main biogenic amines are specified with the physiological effects and toxicological effects produced.

Table 1. The main biogenic amines

Biogenic amines	Physiological effects	Toxicological effects
Histamine	neurotransmitter, body temperature regulation, food intake, learning, memory, allergic reactions, immune response, gastric acid secretion, local hormones, cell growth and differentiation	headache, flushing, sweating, nasal discharge, skin rash, dizziness, itching, edema, hives, difficulty swallowing, diarrhea, increased cardiac output, extrasystoles
Tyramine	neurotransmitter, peripheral vasoconstriction, increased cardiac output, increased respiration, increased blood glucose, release of noradrenaline	headaches, migraines, neurological disorders, nausea, vomiting, respiratory disorders, high blood pressure
Putrescine	regulation of gene expression, cell growth and differentiation	increased cardiac output, tachycardia, hypotension, carcinogenic effects

Source: Ladero et al., 2010

EFFECT OF STORAGE CONDITIONS ON THE CONTENT OF BIOGENIC AMINES IN WILD BOAR MEAT

There are numerous factors that influence wild boar meat according to data from the literature, these factors can be triggered during the hunting

process but also after the hunt (Naila et al., 2010).
The concentration of biogenic amines influences the freshness of game meat, in our case wild boar meat (Paulsen et al., 2008b).
According to the study conducted by Hutařová et al., 2014b, good hygienic quality was maintained when wild boar carcasses were stored for a maximum of 14 days at a temperature of 0°C. The authors of the study also confirm a content of biogenic amines in the case of three wild boar samples taken into the study, which exceeded the limit of 5 mg/kg on day 21 of storage of wild boar meat (Hutařová et al., 2014b).
Regarding the temperature of 15°C, it is considered, according to the study conducted by Hutařová et al., 2014b, an inappropriate storage temperature for wild boar meat, because the content of biogenic amines in 2 samples of game meat exceeds the limit of 5 mg/kg on day 7 of storage (Hutařová et al., 2014b). In the case of small game (pheasants or hares), which are hunted with a hunting gun, and the bullets reaching the various tissues and organs of the digestive system, can raise an alarm signal when the game is not eviscerated immediately after the hunting process, but only a few days later, which leads to a major concern regarding the hygienic quality of the game meat (Paulsen et al., 2008b).
In a study, the authors stored tuna meat at two different temperatures and for a storage period of 9 days, as follows: at a temperature of 0°C, tuna meat showed an increase in histamine of 15 ppm, while at a temperature of 22°C, the increase in histamine was 4500 ppm (Du et al., 2002).
In a study Barnes et al., 1973, they showed that the process of storing uneviscerated small game at a temperature of 10°C, for several days, results in a negative impact on carcass quality only when certain organs of the digestive system are perforated, releasing the contents.
In a study, variations in the levels of pathogens (*Escherichia coli,* staphylococci*, Clostridium perfringens, Listeria monocytogenes*) were evaluated for meat from deer, roe deer and wild boar, with a total of 2919 samples collected from commercial units. The results of the study showed that *Clostridium perfringens* was the most common pathogen, and *Listeria monocytogenes* was the least common pathogen in these game samples. The authors also mention that there were no significant differences in contamination between the types of meat and their refrigerated or frozen storage method (Membré et al., 2011).

CONTROL OF BIOGENIC AMINES

The main way to control the concentration of biogenic amines is temperature, and according to data from the specialized literature, emerging methods are also confirmed, including: modified atmosphere packaging, the irradiation process, high hydrostatic pressure, control of microorganisms and the use of food preservatives (Naila et al., 2010).
The process of reducing biogenic amines can be achieved through adequate temperature control, slowing down microbial growth and of course reducing enzymatic activity in meat, data confirmed by numerous studies (Naila et al., 2010; Emborg & Dalgaard, 2008; Balamatsia et al., 2006; Du et al., 2002).
Data from the literature confirm that the formation of biogenic amines can also occur at temperatures below 5°C, so the authors draw attention to the fact that the control of the production and level of biogenic amines should not be based only on temperature control (Emborg & Dalgaard, 2008).
When the presence of biogenic amines is detected in a food product, it is automatically characterized as having poor hygienic quality and as having been obtained through improper food safety practices, so it is important to remember that in order to control the level of biogenic amines, it is necessary to know with certainty what the triggering factors are that lead to the formation of biogenic amines (Hernandez-Jover et al., 1997).
Many studies specify the use of food additives and preservatives that lead to a decrease in the production of biogenic amines, for example, in one study it was shown that sodium sorbate helps extend the shelf life of seafood (Shalini et al., 2001) or meat-based preparations that contain potassium and ascorbic acid showed better values in terms of biogenic amines (Bozkurt & Erkmen, 2004).
Other inhibitory substances with an impact on biogenic amines are: curcumin, capsaicin and piperine, but the effect of these substances

decreases during the cooking process (Shishodia et al., 2005) or as it is also specified ginger, garlic, onion, red pepper or cinnamon (Mah et al., 2009).

Bover-Cid et al., 2000, state that starter cultures used for the fermentation process can delay the formation of biogenic amines, these starter cultures being represented by bacteria that need optimal conditions to have control over preventing the development of biogenic amines. Mbarki et al., 2009, mention that the preservation process using packaging may be an option for delaying the formation of biogenic amines in meat, mainly due to the fact that it restricts the development of microorganisms and enzymes that are the main triggering factors for the production of biogenic amines.

Regarding foods susceptible to containing biogenic amines, we can mention: meat, fish, milk, vegetables, beer, wine, as well as other fish-derived products (Table 2). Among the most frequently encountered and relevant biogenic amines from a food point of view are histamine, tyramine, putrescein, cadaverine and phenylethylamine (Pickering & Lawrence, 2012).

The process of formation of these compounds in food products is significantly influenced by certain intrinsic factors (pH, water activity, type of microorganisms present), as well as by extrinsic factors (storage time and temperature). According to the specialized data obtained to date, histamine and tyramine are considered the most toxic of the biogenic amines (Naila et al., 2010).

Table 2. Biogenic amines in various foods (mg/day)

		Biogenic amines in food categories (mg/day)					
		Histamine	Tyramine	Putrescine	Cadaverine	Phenylethylamine	Tryptamine
Alcoholic beverages	Beer	3.6 - 24.2	18.5 - 124.6	6.2 - 41.9	4 - 26.7	0.6 - 4.3	1.3 - 8.6
	Red wine	2.5 - 12.4	1.6 - 8.5	1.9 - 11.5	0.1 - 1.6	<0.1 – 5	-
	White wine	0.1 - 3.9	0.2 - 6.8	0.2 - 6.5	<0.1 - 0.6	<0.1 - 2.3	-
Fish and fish products	Fermented fish	0.3 - 12.6	2 - 90.4	0.6 – 27	0.3 - 12.4	<0.1 - 3.3	0.1 - 2.3
	Fish and other fish products	8.8 - 41.4	4.8 - 13.8	3.8 - 10.9	18.9 - 53.8	1.8 – 5	2.2 - 6.4
Meat products	Fermented sausages	6.4 - 37.1	17.2 - 99.3	14.5 - 83.6	6.7 - 38.5	1.5 - 8.7	1.9 - 10.7
	Other matured meat products	1.4 - 9.9	5.8 - 42.1	5.3 - 38.6	3.3 - 23.9	0.1 - 2.8	<0.1 - 0.3
	Other meat products	0.8 - 1.4	11.4 - 20.1	20.9 - 36.9	4.3 - 7.5	0.2 - 0.3	0.2 - 0.3
Dairy products	Cheese	13 - 32.1	44 - 108.7	14.3 - 35.3	47 - 116.1	1.9 - 4.6	0 - 12.3
	Yogurt	0.3 - 0.8	1.3 - 4.1	0.3 - 0.9	2.6 - 8.2	-	-
	Other dairy products	0.2 - 0.6	0.1 - 0.4	0.3 - 0.9	0.9 - 2.9	-	-
Vegetables and other plant products	Fermented vegetables	0.8 - 27.6	0.8 - 27.3	4.9 - 164.7	0.8 - 28.2	<0.1 - 1.5	-
	Other vegetables	<0.1 - 0.2	1.1 - 7.6	13.4 - 93.6	3.7 - 25.6	<0.1 - 2.8	-

Source: EFSA, 2011

Table 3. Microorganisms involved in the production of biogenic amines

Target food	Amine Biogena	Microorganism
Cheese	Histamina	*Lactobacillus buchneri*
	Tiramina	*Enterococcus faecalis, Enterococcus faecium, Enterococcus durans, Entererocccus hirae, Lactobacillus brevis, Lactobacillus curvatus*
	Putresceina	*Enterobacteriaceae (Enterobacter, Serratia, Escherichia, Salmonella, Hafnia, Citrobacter, Klebsiella) Lactobacillus brevis*
	Cadaverina	*Enterobacteriaceae*
Meat	Histamina	*Enterobacteriaceae, Stphylococcus capitis*
	Tiramina	*Staphylococccus carnosus, Staphylococccus xylosus, Staphylococccus epidermidis, Staphylococccus saprophyticus, Lactobacillus brevis, Lactobacillus curvatus, Lactobacillus sakei, Lactobacillus bavaricus, Carnobacterium divergens, Carnobacterium pisicola*
	Putresceina	*Enterobacteriaceae, M. morganii, S. liquefaciens, Pseudomonas, Lb. curvatus, Enterococcus*
	Cadaverina	*Enterobacteriaceae*
Fish	Histamina	*Morganella morganii, Klebsiella pneumonia, Hafnia alvei, Proteus vulgaris, Proteus mirabilis, Enterobacter cloacae, Enterobacter aerogenes, Serratia fonticola, Serratia liquefaciens, Citobacter freundii, Clostridium* spp., *Pseudomonas fluorescens, Pseudomonas putida, Aeromonas* spp., *Pleisomonas shigelloides, Photobacterium* spp.
Wine	Histamina	*Oenococcus oeni, Lactobacillus hilgardii, Pediococcus parvulus*
	Tiramina	*Lactobacillus brevis, Lactobacillus hilgardii, Leuconostoc mesenteroides, Lactobacillus plantarum, Enterococcus faecium*
	Putresceina	*Lactobacillus brevis, Lactobacillus hilgardii, Leuconostoc mesenteroides, Lactobacillus plantarum, O. Oeni, Lb. buchneri, Lactobacillus zeae*
	Cadaverina	*Enterobacteriaceae*

Source: Ladero et al., 2010

Several species susceptible to producing histamine are reported in the literature, for example: *Psychrotolerans morganella, Photobacterium damselae, Photobacterium phosphoreum, Raoultella planticola and Hafnia alvei* (EFSA, 2011; Hoffman & Wiklund, 2006; Bover-Cid & Holzapfel, 1999), (Table 3).

CONCLUSIONS

Game meat is becoming increasingly sought after by consumers due to its compositional and organoleptic characteristics.

Game meat is susceptible, along with other types of meat, to contamination with biogenic amines, given the levels of microorganisms present at different stages of the food chain. Elevated levels of BA can be prevented by following hygiene standards, good handling practices, and observing temperature parameters during the meat handling, delivery, or storage process.

The existence and application of correct verification measures is essential to ensure the correct quality of game meat, with direct responsibility on the personnel involved along the technological chain of handling and processing.

The existence of biogenic amines in game meat has a major role for two reasons: toxicologically and as a quality indicator.

Therefore, we cannot control biogenic amines by simply refrigerating meat, because it is not enough, as we have stated in this review, so other alternative methods must be used.

REFERENCES

Balamatsia, C. C., Paleologos, E. K., Kontominas, M. G., & Savvaidis, I. N., (2006). Correlation between microbial flora, sensory changes and biogenic amines formation in fresh chicken meat stored aerobically or under modified atmosphere packaging at 4 degrees C: possible role of biogenic amines as spoilage indicators. *Antonie van Leeuwenhoek*, 89(1), 90-17.

Barendse, W. (2014). Should animal fats be back on the table? A critical review of the human health effects of animal fat. *Animal Production Science*, 54, 831-855.

Barnes, E. M., Mead, G. C., & Griffiths, N. M., (1973). The microbiology and sensory evaluation of pheasants hung at 5, 10 and 15°C. *British Poultry Science*. *14*(3), 229-240.

Barry, C., Kelly, F., Gobas, A. P., Michael, S., & McLachlan. (2009). Intestinal absorption and biomagnification of organic contaminants in fish, wildlife, and humans. *Environmental Toxicology and Chemistry*, 23(10), 2324-2336.

Benkerroum, N. (2016). Biogenic Amines in Dairy Products: Origin, Incidence, and Control Means. Comphrehensive Reviews. *Food Science and Food Safety*, (15), 801-826.

Bodnar, K., Hodi, S. M., & Bodnar, E. S., (2014). Acceptance of the meat of wild ungulates among the hungarian consumers. *Agron. Ser. Sci. Res. Stiint. Ser. Agron*., 57(1), 35-38.

Bover-Cid, S., & Holzapfel, W. (1999). Improved screening procedure for biogenic amine production by lactic acid bacteria. *Interantional Journal of Food Microbiology*, 53(1), 33-41.

Bover-Cid, S., Izquierdo-Pulido, M., & Vidal-Carou, M. C. (2000). Mixed starter cultures to control biogenic amine production in dry fermented sausages. *Journal of Food Protection*, 63(11), 1556-1562.

Bozkurt, H., & Erkmen, O., (2004). Effects of temperature, humidity and additives on the formation of biogenic amines in sucuk during ripening and storage periods. *Food Science and Technology International*, 10(1), 21-28.

Brink, B., Damink, C., Joosten, H.M.L.J., Huis In 't Veld, J.H.J. (1990). Occurrence and formation of biologically active amines in foods. *International Journal of Food Microbiology*, 11(1), 73-84.

Capillas-Ruiz, C., & Herrero, M. A. (2019). Impact of Biogenic Amines on Food Quality and Safety. *Foods*, 8(2), 62.

Chong, C. Y., Abu Bakar, F., Russly, A. R., Jamilah, B., & Mahyudin, N. A. (2011). The effects of food process-ing on biogenic amines formation. *Interantional Food Research Journal*, 18, 867-876.

Csomos, E., & Simon-Sarkadi, L. (2002). Characterisation of tokaj wines based on free amino acid and biogenic amine using ion-exchange chromatography. *Chromatographia Supplement*, 56, 185-188.

Doeun, D., Davaatseren, M., & Chung, M.-S. (2017). Biogenic amines in foods, *Food Science and Biotechnology*, 26, 1463-1474.

Du, W. X., Lin, C. M., Phu, A.T., Cornell, J. A., Marshall, M. R., & Wei, C. I. (2002). Development of bio-genic amines in yellowfin tuna (Thunnus albacares): effect of storage and correlation with decarboxylase-positive bacterial flora. *Journal of Food Science*, *67*(1), 292-301.

EFSA; EFSA Panel on Biological Hazards (BIOHAZ). (2011). Scientific Opinion on Scientific Opinion on riskbased control of biogenic amine formation in fermented foods. *EFSA Journal*, 9, 2393.

Emborg, J., Dalgaard, P., (2008). Modelling the effect of temperature, carbon dioxide, water activity and pH on growth and histamine formation by Morganella psychrotolerans. *Interantional Journal of Food Microbiology*, *128*(2), 226-33.

Feddern, V., Mazzuco, H., Noe Da Fonseca, F., & De Lima G. J. M. M. (2019). A review on biogenic amines in food and feed toxicological aspects,impact on health and control measures. *Animal Production Science*, *59*(4), 608-618.

Font-i-Furnols, M., & Guerrero, L., (2014). Consumer preference, behavior and perception about meat and meat products: An overview. *Meat Science*, 98(3), 361-371.

Gardini, F., Ozogul, Y., Suzzi, G., Tabanelli, G., Ozogul, F. (2016). Technological factors affecting biogenic amine content in foods: a review. *Frontiers in Microbiology*, 7, 1-18.

Gill, C. O., (2007). Microbiological conditions of meats from large game animals and birds. *Meat Science*, *77*(2), 149-160.

Gonzalez, F. C., Santos, E. M., Jaime, I., & Rovira, J. (2003). Influence of starter cultures and sugar concentrations on biogenic amine contents in chorizodry sausage. *Food Microbiology*, 20, 275-284.

Halász, A., Barath, A., Simon-Sarkadi, L., & Holzapfel, W. (1994). Biogenic amines and their production by micro-organisms in food – Review. *Trends in Food Science and Technology*, 5, 42-49.

Hernandez-Jover, T., Izquierdo-Pulido, M., Veciana-Nogues, M. T., Marine-Font, A., & Vidal-Carou, M. C. (1997). Biogenic amine and polyamine contents in meat and meat products. *Journal of Agricultural and Food Chemistry*, *45*(6), 2098-2102.

Hoffman, L. C., & Wiklund, E. (2006). Game and venison-Meat for the modern consumer. *Meat Science*, 74, 197–208.

Hutařová, Z., Bořilová, G., Svobodová, I., Večerek, V., Forejtek, P., Hulánková, R., & Maršálek, P. (2014a). Effect of storage conditions on the biogenic amine content in wild boar meat. *Acta Vet. Brno*, 83, 61- 65.

Hutařová, Z., Večerek, V., & Maršálek, P. (2014b). Biogenic amines in the meat of hunted pheasant and hare during the course of storage. *Acta Vet. Brno*, 83: S45-S50.

Hutařová, Z., Večerek, V., Steinhauserová, I., Maršálek, P., Bořilová, G., & Forejtek, P. (2013). The effect of treating method of pithed pheasant on the content of biogenic amines in the meat during the course of storage. *Poultry Science, 92*(8), 2182-2187.

Jae-Hyung, M., Hyung-Kee, H., Young-Jun, O., Man-Goo, K., & Han-Joon, H. (2002). Biogenic amines in Jeotkals, Korean salted and fermented fish products. *Food Chemistry*, 79, 239-243.

Kalač, P., & Krausová, P. (2005). A review of dietary polyamines: Formation, implications for growth and health and occurrence in foods. *Food Chemistry*, 90(1-2), 219-230.

Kim, C. D. H., Shin, M. G., Kang, I. J., & Byun, M. W. (2003). Irradiation effect of bulgogi sauce for manufacturing Korean traditional meat product, bulgogi. *Radiation Physics and Chemistry*, 68(5), 851-856.

Krizek, M., Vachá, F., Vorlová, L., Lukásová, J., & Cupáková, S. (2004). Biogenic amines in vacuum-packed and non-vacuum-packed flesh of carp (*Cyprinus carpio*) stored at different temperatures. *Journal of Food Chemistry*, 88, 185-191.

Ladero, V, Cruzz M.M., Fernández. M., & Alvarez, M. A., (2010). Toxicological Effects of Dietary Biogenic Amines. *Current Nutrition & Food Science*, 6, 145-156.

Lehane, L., & Olley, J. (2000). Histamine fish poisoning revisited. *Int. J. Food Microbiol.*, *58*(1-2), 1-37.

Mah, J. H., Kim, Y. J., & Hwang, H. J., (2009). Inhibitory effects of garlic and other spices on biogenic amine production in Myeolchi-jeot, Korean salted and fermented anchovy product. *Food Control*, *20*(5), 449-454.

Mbarki, R., Miloud, N. B., Selmi, S., Dhib, S., & Sadok, S., (2009). Effect of vacuum packaging and low-dose irradiation on the microbial, chemical and sensory characteristics of chub mackerel (Scomber japonicus). *Food Microbiolology*, 26(8), 821–826.

Membré. J. M., Laroche, M., & Magras. C. (2011). Assessment of levels of bacterial contamination of large wild game meat in Europe. *Food Microbiology,* 28(5), 1072-1079.

Naila, A., Flint, S., Fletcher, G., Phil Bremer, P., & Gerrit, M., (2010). Control of Biogenic Amines in Food-Existing and Emerging Approaches. *Food Science*, 75(7), R139-R150.

Novella-Rodrıguez, S., Veciana-Nogues, M. T., Trujillo-Mesa, A., & Vidal-Carou, M. C. (2002). Profile of biogenic amines in goat cheese made from pasteurized and pressurized milks. *Journal of Food Science*, 67, 2940-2944.

Paulsen, P., Dičáková, Z., & Bauer, F., (2008a). Biogenic amines and polyamines in liver, kidney and spleen of roe deer and European brown hare. *European Food Research and Technology*, *227*(1), 209-213.

Paulsen, P., Nagy, J., Popelka, P., Ledecky, V., Marcincak, S., Pipova, M., Smuldlers, F. J. M., Hofbauer, P., Lazar, P., & Dicakova, Z., (2008b). Influence of storage conditions and shotshell wounding on the hygienic condition of hunted, uneviscerated pheasant (*Phasianus colchicus*). *Poultry Science*, 87, 191-195.

Pickering, M., & Lawrence, J., (2012). Habits and Behaviours of High-Level Consumers of Lead-Shot Wild-Game Meat in Scotland. *Food Standards Agency in Scotland Project number FS421005*, 1-73.

Rauscher-Gabernig, E., Gabernig, R., Brueller, W., Grossgut, R., Bauer, F., Paulsen, P. (2012). Dietary exposure assessment of putrescine and cadaverine and derivation of tolerable levels in selected foods consumed in Austria. *Eur. Food Res. Technol.*, *235*(2), 209-220.

Ruiz-Capillas C, & Jiménez-Colmenero F. (2004). Biogenic amines in meat and meat products. *Critical reviews in food science*, 44, 489-499.

Santos, W. C., Souza, M. R., Cerqueira, M. M. O. P., & Gloria, M. B. A. (2003). Bioactive amines formation in milk by Lactococcus in the presence or not of rennet and NaCl at 20 and 32 °C. *Food Chem.,* (81), 595-606.

Shalini, R., Jasmine, G. I., Shanmugam, S. A., & Ramkumar K., (2001). Effect of potassium sorbate dip-treatment in vacuum packaged Lethrinus lentjan fillets under refrigerated storage. *Journal of Food Science Technology -Mysore*, 38, 12-6.

Shishodia, S., Sethi, G., & Aggarwal, B. B., (2005). Curcumin: getting back to the roots. *Annals of the New York Academy of Sciences*, 1056(1), 206-17.

Silla-Santos, M. H., (1996). Biogenic amines: Their importance in foods. *International Journal of Food Microbiology*, 29(2-3), 213-231.

Șoimușan, I. R., Mastan, O. A., Ladoși, I., Longodor, A. L., & Coroian, A. (2024). A review on biogenic amines in cheese. *Scientific Papers. Series D. Animal Science, LXVII* (1), 566-575.

Tofalo, R., Perpetuini, G., Schirone, M., Suzzi, G. (2016). Biogenic amines: toxicology and health effect, in: Encyclopedia of Food and Health. *Elsevier*, 424-429.

Tomasevic, I., Novakovic, S., Solowiej, B., Zdolec, N., Skunca, D., Krocko, M., Nedomova, S., Kolaj, R., Georgi Aleksiev, G., & Djekic, I. (2018). Consumers' perceptions, attitudes and perceived quality of game meat in ten European countries. *Meat Science*, 142, 5-13.

Visciano, P., Schirone, M., Tofalo, R., & Suzzi, G. (2012). Biogenic amines in raw and processed seafood. *Microbiology.* 3(188), 1-10.

Wang, H., Liu, S., & Kong, B. (2025). Analysis of biogenic amines in salt-reduced Harbin Dry sausages. *Food Science and Technology*, 216(11), 117327.

Yang, M., Xie, Y., Zhu, L., Wang, R., Zheng, J., & Xu, W. (2025). Aptamer – based biosensors for biogenic amines detection, *Advanced Sensor and Energy Materials Elsevier*, 100135.