

Poultry Meat Spoilage and Biogenic Amine Content

Subjects: [Food Science & Technology](#)

Contributor: Wojciech Wójcik , Monika Łukasiewicz-Mierzejewska , Krzysztof Damaziak , Damian Bień

Meat is a key element of a balanced diet. Meat consumption has played a significant role in evolution, affecting the development of the human brain. Poultry meat is a source of many important nutrients, micro- and macro-elements, and biologically active substances. During meat storage, many physicochemical changes take place, also affecting the content of biologically active substances, including biogenic amines.

poultry meat

food

quality

1. Introduction

The chemical composition of meat depends on the animal species, age, genotype, nutrition, pre-slaughter treatment, and post-slaughter storage ^{[1][2][3]}. What is more, meat is one of the food types that undergo rapid spoilage. This process occurs at a faster rate for white meat than for red meat. This stems from the higher number of short fibres present in white poultry meat, which affects increased proteolysis. It is estimated that these changes occur between 4 and 10 days after slaughter ^{[4][5][6]}. The high protein content in poultry meat results in increased proteolysis and autolysis, which affects amino acid release (AA). Presence of AA and bacteria exhibiting decarboxylation capacity accelerates the process of meat spoilage and results in increased content of microorganism metabolites, including biogenic amines ^{[7][8][9][10]}.

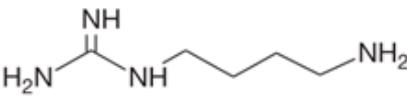
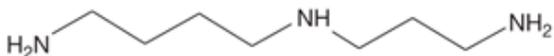
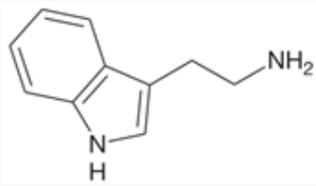
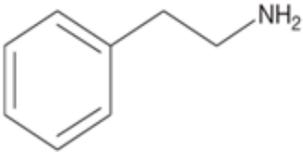
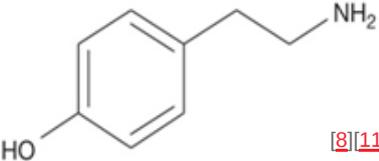
Meat spoilage or ageing also occurs in refrigeration conditions by microflora contamination during slaughter. It has been determined that poultry has a high slaughter contamination level, which further affects the processes that deteriorate the product shelf-life ^{[7][11][12]}. Early symptoms of meat spoilage are difficult to observe. Sensory assessment is insufficient due to its subjective nature. However, determination of microbial contamination is time-intensive and can be determined with the use of changes that occur in meat due to bacterial activity ^{[11][13][14]}. The changes determining meat ageing include: microbiological techniques, microscopic techniques, ionic changes, application of fluorescent spectroscopy, ion-mobility spectrometry (IMS), determination of changes in the basic composition of meat with near-infrared analysers (NIR), chemical changes (pH, total volatile basic nitrogen (TVBN), ATP, glucose, BA content), and modern techniques of electronic tongue or nose ^{[3][7][14][15]}.

2. Biogenic Amines: Characteristics

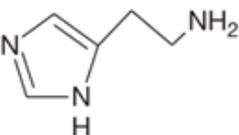
Biogenic amines (BA) are compounds with a low molecular weight below 200 Da. They are formed through three processes: decarboxylation of amino acids by decarboxylation-capable microorganisms, reductive amination and

transamination of aldehydes and ketones, or as a result of the activity of tissues in the organism. Furthermore, they can be accumulated in tissues throughout the life of the organism [16][17][18]. Biogenic amines can be divided (Table 1) in terms of the structure of the amino acid (precursor) into: aliphatic (putrescine, cadaverine, agmatine, spermine, spermidine), aromatic (tyramine, β -phenylethylamine), and heterocyclic (serotonin, histamine, and tryptamine), and for the number of amine groups: monoamines (tyramine, histamine, tryptamine), diamines (putrescine, cadaverine), and polyamines (agmatine, spermine, spermidine) [17][18][19]. What is more, endogenous and exogenous amines can be distinguished. Endogenous amines are mainly catecholamines, indoleamines, histamines, and BA of endogenous origin (spermine, spermidine, and low levels of putrescine and histamine), whereas exogenous amines are those formed mainly by the activity of microorganisms (cadaverine, putrescine, tyramine, histamine, β -phenylethylamine) [20][21].

Table 1. Classification of biogenic amines [19].

Biogenic Amine	Structural Formula	Classification	Precursor
Putrescine		Diamine Aliphatic	Ornithine
Cadaverine		Diamine Aliphatic	Lysine
Agmatine		Polyamine Aliphatic	Arginine
Spermine		Polyamine Aliphatic	Arginine Ornithine
Spermidine		Polyamine Aliphatic	Arginine Ornithine
Tryptamine		Monoamine Heterocyclic	Tryptophane
β -phenylethylamine		Monoamine Aromatic	Phenylalanine
Tyramine		Monoamine Aromatic	Tyrosine

Bacillus, and Gram- strains of bacteria isolated from poultry skin and their decarboxylase activity. It was shown that numerous strains of *Enterobacteriaceae* and *Aeromonas* are characterized by decarboxylase-positive activity. Furthermore,

Biogenic Amine	Structural Formula	Classification	Precursor
Histamine		Monoamine Heterocyclic	Histidine [24]

Biogenic amines are mainly found in protein-rich products (meat, fish, cheese) and in fermenting products. Amines most commonly found in poultry are: histamine (HIS), tyramine (TYR), cadaverine (CAD), and putrescine (PUT). Also present are β -phenylethylamine (PHM), spermine (SPM), and spermidine (SPD) [\[12\]\[14\]\[25\]\[26\]](#).

3. Role of Biogenic Amines

Biogenic amines fulfil a range of important functions in live organisms, including human organisms [\[25\]](#). They have been identified in both animal and plant tissues, as well as in eukaryotic organisms (bacteria, fungi) [\[19\]](#).

Biogenic amines are precursors for hormones, alkaloids, proteins, and nucleic acids, and are a source of nitrogen for the organism. Polyamines such as spermine, spermidine, and putrescine contribute to the natural growth of cells. These polyamines are also present in mammal sperm, fulfilling the role of gene expression modulators (binding with the locus in the DNA, activating genes or cell growth), supporting cellular growth of differential as well as initial embryologic development [\[17\]\[19\]\[27\]\[28\]](#). Excess of the aforementioned polyamines intensifies neoplastic degeneration, and their high contents were found in tumours [\[5\]](#). Despite their positive action, an excess of BA exhibits toxic properties, and biogenic amines are known as toxic biomolecules [\[29\]](#). Histamine is a widespread amine found in such organs as muscles, brain, intestines, stomach, uterus, or ovaries. Its action is related to H receptors (H1–H4) and it acts as a neurotransmitter and local hormone, modulating the activity of the stomach, work of the heart, smooth-muscle contraction, circadian rhythm, and maintaining body heat [\[17\]\[19\]](#). However, it exhibits a toxic effect when consumed in excess. Symptoms of the toxic effect of histamine include dilation and increased permeability of blood vessels, which results in ecchymosis, hives, itching, tingling, burning, headache, blood pressure drop, tachycardic responses, and breathing difficulties (airway constriction and hypoxemia). It further results in smooth-muscle contraction, resulting in diarrhoea, vomiting, and stomach-ache [\[5\]\[30\]\[31\]](#). Histamine is strictly related to fish and fish product poisoning, but it also occurs in poultry meat, particularly during poultry meat processing in high temperatures and meat with skin processing [\[30\]\[32\]](#)

On the other hand, tyramine is responsible for the reaction related to the consumption of excessive amounts of cheese, and its symptoms are referred to as “cheese reaction.” Its action resembles neurotransmitters, and it is characterized by the capacity for increased sympathetic activity of the cardiovascular system by releasing catecholamine (noradrenaline), which results in peripheral constriction of blood vessels and acceleration of the heart action (tachycardia), a blood pressure drop, and a blood glucose concentration increase. The influence on the formation of microhaemorrhages during blood vessel dilation results in inflammatory state formation [\[17\]\[19\]\[31\]](#). In an organism, its presence can be detected in brain, spinal cord, heart, spleen, lungs, or kidneys [\[19\]](#).

Histamine and tyramine are referred to as psychoactive and vasoactive amines. Excessive intake of both histamine and tyramine results in acute allergic-like reactions, particularly from the nervous and cardiovascular system [17][31][33]. They are heterocyclic amines, which are linked to the neoplastic degeneration process. They are easily absorbable in the gastrointestinal tract, and an arilnitrenium ion is formed as a result of the reaction with cytochrome P450monoaminooxidase, which intensifies neoplastic-increasing processes during DNA replication. As presented by Plevaet et al. [32] in experiments of animals, they contributed to the formation of benign neoplastic lesions of liver and malignant ones in the large intestine.

Cadaverine and putrescine have a considerable impact on cell proliferation, including neoplastic cells. They accelerate neoplastic degeneration, producing changes within the oral cavity and tumour growth. Putrescine is an electrostatic amine, fulfilling many physiological roles, but it also exhibits the capacity to react with nitrites, forming heterocyclic nitroso-pyrrolidine with carcinogenic activity. They further intensify the toxic effect of the excess of heterocyclic amines (histamine and tyramine), which also exhibit the properties for reaction with nitrates, forming carcinogenic nitrosamines [4][17][22][34].

β -phenylethylamine acts as a neurotransmitter, which induces the release of dopamine, serotonin, and noradrenaline. It affects perception, memory, and behaviour. It was mainly found in the brain and spinal cord, but its excess, as with tyramine, affects the incidence of migraines and pressure drops [17][19][34]. When blood levels of β -phenylethylamine and tyrosine increase, an increase of other BA and type 2 diabetes may occur [35].

4. Biogenic Amines Index (BAI)

Amine content in meat is considered a meat freshness determinant. To this end, the quality index (QI) was developed—the sum of histamine, putrescine, and cadaverine divided by the sum of spermine and spermidine plus 1; subsequently, the biogenic amines index (BAI) was developed, which is the sum of histamine, tyramine, cadaverine, and putrescine [27]. The content of these amines increases with meat storage and their excessive consumption exhibits toxic effects, and thus the determination of amine content is important not only from the standpoint of meat freshness, but also for maintaining the health status of society (meat consumers) [18][20]. BAI is of high significance for the determination of amine content in cheese and meat because it includes the content of tyramine. BAI in fresh meat should not exceed 5 mg/kg, whereas the acceptable range with initial symptoms of spoilage is between 5 and 20 mg/kg. Meat with low hygienic quality is classified in the range 20–50 mg/kg, and spoiled meat has a BAI above 50 mg/kg [18].

5. Systemic Defensive Mechanisms

Natural defensive mechanisms of the organism, protecting against negative effects of consuming excessive levels of BA, are monoamine oxidase (MAO), diamine oxidase (DAO), and polyamine oxidase (PAO). However, this system is often disturbed by gastric problems of consumers, antidepressant intake, alcohol consumption, disruption of natural defensive mechanisms of the organism, or consumption of spoiled food containing high levels of BA.

Additionally, the synergistic effect of these factors influences increased toxicity of biogenic amines. The main problem consists of MAO and DAO inhibitors, which include antidepressant drugs. It is estimated that 20% of the European population uses antidepressants, and the intake of this type of agent exhibits a growth tendency [18][36].

6. Monitoring and Recommended BA Consumption Standards

To care for the consumer health and to reduce the negative impact of consuming excessive amounts of BA, whose toxicity mechanism has not been fully understood, it is recommended to restrict consumption of BA-rich products [17]. International permissible limits of biogenic amine consumption are absent [19]. This issue has thus far been covered by numerous consumer organizations and food safety agencies. These include the European Food Safety Authority (EFSA), the Food and Drug Administration (FDA), the Food Safety Commission of Japan (FSCJ), and the World Health Organization (WHO). As a result of cooperation with the aforementioned entities and based on the Regulation EC/178/2002, the Rapid Alert System for Food and Feed (RASFF) database was created. However, the above organizations and the mentioned system mainly focus on the toxicity of histamine from fish and fish products [17][18][30][34]. Based on the FDA report, as provided by Rabieet et al. [22], the maximum level of tolerated histamine content in meat was determined as 100 mg/kg, whereas daily histamine consumption should not exceed 50 mg and 600 mg for tyramine. Danchuket et al. [34] reported that the permissible histamine level in healthy food should not exceed 50 mg/kg, the level between 50 and 200 mg/kg may have a harmful effect on consumer health, and the level above 200 mg/kg exhibits toxic properties. In turn, Feddern et al. [5] report that histamine and tyramine content above 100 mg/kg and β -phenylethylamine above 30 mg/kg show toxic effects on consumer health status. According to the EFSA Report, the daily recommended histamine intake is below 50 mg for healthy people, but below detection limits for people with a histamine intolerance, and 600 mg of tyramine for healthy people who do not take drugs from the group of monoamine oxidase inhibitors (MAOI), but 50 mg for people taking third-generation MAOI drugs or 6 mg for people taking classic MAOI drugs. However, information on putrescine and cadaverine have proven insufficient in this scope [37].

References

1. Ahmad, R.S.; Imran, A.; Hussain, M.B. Nutritional Composition of Meat. *Meat Sci. Nutr.* 2018, 61–77.
2. Lázaro, C.A.; Junior, C.A.C.; Canto, A.C.; Monteiro, M.L.G.; Franco, R.M. Biogenic amines as bacterial quality indicators in different poultry meat species. *LWT Food Sci. Technol.* 2015, 60, 15–21.
3. Rodriguez, M.; Conte-Junior, C.; Carneiro, C.; Lázaro, C.; Mano, S.; Conte-Junior, C. Biogenic Amines as a Quality Index in Shredded Cooked Chicken Breast Fillet Stored Under Refrigeration and Modified Atmosphere. *J. Food Process. Preserv.* 2015, 39, 2043–2048.

4. Gallas, L.; Standarová, E.; Steinhäuserová, I.; Steinhäuser, L.; Vorlová, L. Formation of Biogenic Amines in Chicken Meat Stored under Modified Atmosphere. *Acta Vet. Brno* 2010, 79, S107–S116.
5. Feddern, V.; Mazzuco, H.; Fonseca, F.N.; De Lima, G.J.M.M. A review on biogenic amines in food and feed: Toxicological aspects, impact on health and control measures. *Anim. Prod. Sci.* 2019, 59, 608.
6. Ntzimani, A.G.; Paleologos, E.K.; Savvaidis, I.N.; Kontominas, M.G. Formation of biogenic amines and relation to microbial flora and sensory changes in smoked turkey breast fillets stored under various packaging conditions at 4°C. *Food Microbiol.* 2008, 25, 509–517.
7. Salinas, Y.; Ros-Lis, J.V.; Vivancos, J.-L.; Martínez-Máñez, R.; Marcos, M.D.; Aucejo, S.; Herranz, N.; Lorente, I. Monitoring of chicken meat freshness by means of a colorimetric sensor array. *Analyst* 2012, 137, 3635–3643.
8. Buňková, L.; Buňka, F.; Klčovská, P.; Mrkvička, V.; Doležalová, M.; Kráčmar, S. Formation of biogenic amines by Gram-negative bacteria isolated from poultry skin. *Food Chem.* 2009, 121, 203–206.
9. Min, J.S.; Lee, S.O.; Jang, A.; Jo, C.; Lee, M. Control of Microorganisms and Reduction of Biogenic Amines in Chicken Breast and Thigh by Irradiation and Organic Acids. *Poult. Sci.* 2007, 86, 2034–2041.
10. Ibrahim, H.M.; Amin, R.A.; Eleiwa, N.Z.; Ahmed, N.M. Estimation of some biogenic amines on chicken meat products. *Benha Vet. Med. J.* 2017, 32, 23–28.
11. Höll, L.; Hilgarth, M.; Geissler, A.J.; Behr, J.; Vogel, R.F. Prediction of in situ metabolism of photobacteria in modified atmosphere packaged poultry meat using metatranscriptomic data. *Microbiol. Res.* 2019, 222, 52–59.
12. Fraqueza, M.J.; Alfaia, C.M.; Barreto, A.S. Biogenic amine formation in turkey meat under modified atmosphere packaging with extended shelf life: Index of freshness. *Poult. Sci.* 2012, 91, 1465–1472.
13. Balamatsia, C.; Paleologos, E.; Kontominas, M.; Savvaidis, I. Correlation between microbial flora, sensory changes and biogenic amines formation in fresh chicken meat stored aerobically or under modified atmosphere packaging at 4 °C: Possible role of biogenic amines as spoilage indicators. *Antonie Leeuwenhoek* 2006, 89, 9–17.
14. Ivanov, G.; Ivanova, I.; Slavchev, A.; Vassilev, K. Biogenic Amines and Their Role as Index of Freshness in Chicken Meat. *J. Appl. Life Sci. Int.* 2015, 3, 55–62.
15. Wojnowski, W.; Kalinowska, K.; Majchrzak, T.; Płotka-Wasyłka, J.; Namieśnik, J. Prediction of the Biogenic Amines Index of Poultry Meat Using an Electronic Nose. *Sensors* 2019, 19, 1580.

16. Sirocchi, V.; Caprioli, G.; Cecchini, C.; Coman, M.M.; Cresci, A.; Maggi, F.; Papa, F.; Ricciutelli, M.; Vittori, S.; Sagratini, G. Biogenic amines as freshness index of meat wrapped in a new active packaging system formulated with essential oils of *Rosmarinus officinalis*. *Int. J. Food Sci. Nutr.* 2013, 64, 921–928.
17. Ahmad, W.; Mohammed, G.I.; Al-Eryani, D.A.; Saigl, Z.M.; Alyoubi, A.O.; Alwael, H.; Bashammakh, A.S.; O'Sullivan, C.K.; El-Shahawi, M.S. Biogenic Amines Formation Mechanism and Determination Strategies: Future Challenges and Limitations. *Crit. Rev. Anal. Chem.* 2019, 50, 485–500.
18. Ruiz-Capillas, C.; Herrero, A. Impact of Biogenic Amines on Food Quality and Safety. *Foods* 2019, 8, 62.
19. Nuñez, M.; del Olmo, A.; Calzada, J. Biogenic Amines. *Encycl. Food Health* 2016, 416–423.
20. Jairath, G.; Singh, P.K.; Dabur, R.S.; Rani, M.; Chaudhari, M. Biogenic amines in meat and meat products and its public health significance: A review. *J. Food Sci. Technol.* 2015, 52, 6835–6846.
21. Bover-Cid, S.; Latorre-Moratalla, M.; Veciana-Nogués, M.; Vidal-Carou, M. Processing Contaminants: Biogenic Amines. *Encycl. Food Saf.* 2014, 381–391.
22. Rabie, M.A.; Peres, C.; Malcata, F. Evolution of amino acids and biogenic amines throughout storage in sausages made of horse, beef and turkey meats. *Meat Sci.* 2014, 96, 82–87.
23. Rokka, M.; Eerola, S.; Smolander, M.; Alakomi, H.-L.; Ahvenainen, R. Monitoring of the quality of modified atmosphere packaged broiler chicken cuts stored in different temperature conditions: B. Biogenic amines as quality-indicating metabolites. *Food Control* 2004, 15, 601–607.
24. Hassan, M.A.; El-Shater, M.A.; Heikal, I.G.; Waly, H.A. Biogenic Amines in Chicken Cut-Up Meat Products. *BVMJ* 2013, 24, 70–81.
25. Bennato, F.; Di Luca, A.; Martino, C.; Ianni, A.; Marone, E.; Grotta, L.; Ramazzotti, S.; Cichelli, A.; Martino, G. Influence of Grape Pomace Intake on Nutritional Value, Lipid Oxidation and Volatile Profile of Poultry Meat. *Foods* 2020, 9, 508.
26. Min, J.S.; Lee, S.O.; Jang, A.; Jo, C.; Park, C.S.; Lee, M. Relationship between the Concentration of Biogenic Amines and Volatile Basic Nitrogen in Fresh Beef, Pork, and Chicken Meat. *Asian-Australas. J. Anim. Sci.* 2007, 20, 1278–1284.
27. Silva, C.M.; Glória, M.A. Bioactive amines in chicken breast and thigh after slaughter and during storage at 4±1 °C and in chicken-based meat products. *Food Chem.* 2002, 78, 241–248.
28. Goes, E.C.; Pont, G.C.D.; Oliveira, P.R.; da Rocha, C.; Maiorka, A. Effects of putrescine injection in broiler breeder eggs. *J. Anim. Physiol. Anim. Nutr.* 2020, 105, 294–304.
29. Stadnik, J. Aminybiogenne w wyrobachmięsnychsurowodojrzewających. *Zywn-Nauk. Technol Ja* 2013, 3, 5–15.

30. Leuschner, R.G.; Hristova, A.; Robinson, T.; Hugas, M. The Rapid Alert System for Food and Feed (RASFF) database in support of risk analysis of biogenic amines in food. *J. Food Compos. Anal.* 2013, 29, 37–42.
31. Özogul, Y.; Özogul, F. Chapter 1. Biogenic Amines Formation, Toxicity, Regulations in Food. *Biog. Amines Food Anal. Occur. Toxic.* 2019, 1–17.
32. Pleva, D.; Lányi, K.; Monori, K.D.; Laczay, P. Heterocyclic Amine Formation in Grilled Chicken Depending on Body Parts and Treatment Conditions. *Molecules* 2020, 25, 1547.
33. Sarkadi, L.S. Amino acids and biogenic amines as food quality factors. *Pure Appl. Chem.* 2019, 91, 289–300.
34. Danchuk, A.; Komova, N.S.; Mobarez, S.N.; Doronin, S.Y.; Burmistrova, N.A.; Markin, A.V.; Duerkop, A. Optical sensors for determination of biogenic amines in food. *Anal. Bioanal. Chem.* 2020, 412, 4023–4036.
35. Nie, C.; He, T.; Zhang, W.; Zhang, G.; Ma, X. Branched Chain Amino Acids: Beyond Nutrition Metabolism. *Int. J. Mol. Sci.* 2018, 19, 954.
36. Estrela, M.; Herdeiro, M.T.; Ferreira, P.L.; Roque, F. The Use of Antidepressants, Anxiolytics, Sedatives and Hypnotics in Europe: Focusing on Mental Health Care in Portugal and Prescribing in Older Patients. *Int. J. Environ. Res. Public Health* 2020, 17, 8612.
37. EFSA. Scientific opinion on risk based control of biogenic amine formation in fermented foods. *EFSA J.* 2011, 9, 2393–2486.

Retrieved from <https://encyclopedia.pub/entry/history/show/59801>