International Journal of Healthcare Sciences ISSN 2348-5728 (Online)
Vol. 11, Issue 1, pp: (228-236), Month: April 2023 - September 2023, Available at: www.researchpublish.com

DETERMINATION OF HISTAMINE LEVELS IN COMMERCIAL CANNED TUNA

Desak Gde Diah Dharma Santhi[1]

[1]Department of Clinical Pathology, Faculty of Medicine, Udayana University, Denpasar, Bali

DOI: https://doi.org/10.5281/zenodo.8282875

Published Date: 25-August-2023

Abstract: **Tuna species are the large group of important fishes that belong to the Scombridae family, covers more than 50 different species, are significant in supplying a global market. Tuna widely consumed worldwide as fresh or canned. Considering that tuna fish, like other scombroid fish, is commonly associated with cases and outbreaks Histamine Food Poisoning (HFP). Histamine is identified by the Food and Drug Administration (FDA) as a major chemical hazard of seafood products. The aim of the present study was to search and review the findings from the scientific published literature studies focusing on determination of histamine levels in commercial canned tuna. The results of the data search, remaining 11 articles were suitable in this review. The histamine levels in canned tuna were determined in this study by using ELISA, HPLC or a rapid test method. Samples of commercial canned tuna from different countries were analysed and found to have histamine levels that were within the acceptable range. Histamine level that is considered to be permissible in fish and fishery products differs by country. In the United States (US), a histamine level of 50 mg/ kg is considered indicative of fish spoilage, while the European Union (EU) has established an acceptable histamine level of 200 mg/ kg for fish belonging to the Scombridae, Clupeidae, Engraulidae, Coryphaenidae, Pomatomidae, and Scomberesocidae families.**

Keywords: **Determination, histamine levels, commercial, canned tuna.**

I. INTRODUCTION

Canned tuna was first produced in France and Italy in the late 19th century in small quantities. Halfhill started a large-scale canned tuna production in California, United States in 1908. Subsequently, canned tuna has been industrially produced worldwide, particularly in Italy, Japan, Thailand, and Spain, then has since become one of the most popular foods in the world. The world consumption remained between 500,000 and 600,000 t in the 1970s, while it increased to 1 million t in the 1990s and nearly doubled at 1.9 million t in 2018. Global catch of tropical tuna, namely *Thunnus albacares* (yellowfin), *Thunnus obesus* (bigeye), *Thunnus thynnus* (bluefin), *Thunnus alalunga* (albacore) and *Katsuwonus pelamis* (skipjack) in 2019 was 5,443,000 t. Most of those catches were used as raw materials for canned tuna industry, in addition to other food products such as sashimi, cooked directly and others. Canned tuna is considered to be one of the most traded seafood products globally, due to its long shelf life, transporting benefits, ready-to-eat form, as well as due to the variety of meals that can be prepared with it.[1, 2] The overall demand for canned tuna products has increased remarkably over the past four decades because it is a good nutritional source of high dietary proteins and high content of healthy lipids, and preferred in the human diet.[3]

Despite all of the benefits, the consumption of fish meals cause approximately 90% of total life-threatening allergic reactions, gastrointestinal problems, and respiratory symptoms. Therefore, the occurrence of fish allergies among consumers is one of the main concerns among seafood producers.[4,5] Tuna species, as an umbrella species, are the large group of important fishes that belong to the Scombridae family. Fishes belonging to the Scombridae family are characterized by high levels of amino acid histidine which can be easily converted to histamine by thermal processing during the canning process. The presence of histamine in these foods can indicate spoilage or poor manufacturing processes. Histamine is identified by the Food and Drug Administration (FDA) as a major chemical hazard of seafood products. Therefore, the

consumption of canned tuna with high levels of histamine (5 mg/ g) can cause vomiting, diarrhoea, abdominal cramps, perspiration, flushing, headaches and burning sensations in the mouth.[6,7,8]

The aim of the present study was to search and review the findings from the scientific published literature studies focusing on determination of histamine levels in commercial canned tuna.

II. MATERIALS AND METHODS

Search strategy. The data used in this research is secondary data obtained not from direct observation, but obtained from the results of research that has been conducted by researchers earlier. A comprehensive literature search conducted during January 2023 to June 2023 in the form of national and international articles using the database such as PubMed, (https://www.ncbi.nlm.nih.gov/pubmed/advanced), Web Science, and Google Scholar. Search words/ MESH terms used in PubMed, Web science and Google Scholar can be listed as Search (determined) OR (histamine level) OR (histamine concentration) OR (commercial) OR (canned tuna).

Articles identified were exported and duplicate articles were subsequently removed. The titles and abstracts of all articles identified independently were reviewed, and studies that did not meet our inclusion criteria were excluded. The information was taken from each study using a collection form that consisted of author, the publication year, title, method, and results.The full texts of the remaining articles were then reviewed to determine whether these articles still met the inclusion criteria.

Data extraction and synthesis of the results. Inclusion criteria in the present study were (i) full text available; (ii) report of concentration of histamine in canned tuna; (iii) published full article or abstract; (iv) original (experimental new data) research; and (v) published between 2018 and 2023. To avoid any mistake in the translation process and for the clarity of the reports, only those articles published in the ‘‘English language’’ were included. Some of the unpublished citations such as reports from federal agencies, foundations, and research institutes and proceedings of relevant conferences were not included because of the lack of peer review.

Data from each study included the year of study and publication; total sample size; number of positive samples (samples in which histamine was detected); mean, standard deviation, and range of the histamine concentration; and method of histamine detection.

This literature review is synthesized using the narrative method, did not use any other additional analysis techniques. The author only summarized the results in the literature then analyzed descriptively with a description in the form of a narrative explanation.

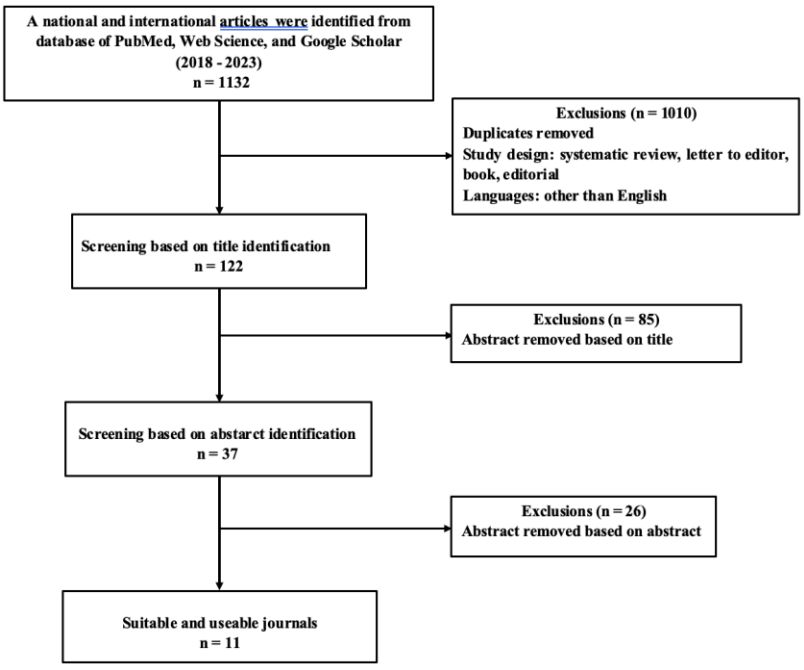

Figure 1. Flow diagram of the search and selection articles process

III. RESULTS

The results of the data search, identified 1132 relevant studies through the database that was previously mentioned using keywords and filters. A 1010 full text articles excluded after the duplicated study, study design and language analysis. A 85 articles excluded after the screening title, therefore 37 articles assess for eligility. In the final stage of the eligibility assessment, 26 articles were excluded and the remaining 11 studies were suitable in this review.

Table 1. The main characteristics of included studies

No.	Author	Year of Publication	Journal, Volume	Title
1.	Lo Magro S, Summa S, Iammarino M, D'Antini P, Giuliana M, Chiaravalle A.E and Muscarella M	2020	Applied Science. 2020, 10, 8693; doi:10.3390/app10238693	A 5-Years (2015–2019) Control Activity of an EU Laboratory: Contamination of Histamine in Fish Products and Exposure Assessment
2.	Sadeghi N, Behzad M, Jannat B, Oveisi MR, Hajimahmoodi M, Mozafari M	2019	J Food Safe & Hyg. 2019 Vol 5 No. 1 Winter	Determination of histamine in canned tuna fish available in Tehran market by ELISA method
3.	Pavlović M.S, Ivanovic S.D, Pavlović I.N, Roković1 N.I, Radosavljević V.I, Vasilev D.D	2018	Food and Feed Research, 2019 Vol. 46 (1), pp.37-43	Histamine levels in fish samples collected from Serbian market in 2018
4.	ElbarbaryN.K and Abdelmotilib N.M	2023	Egyptian Journal of Aquatic Biology &Fisheries. 2023. Vol. 27(4): 421 – 438	Monitoring the Bacteriological Contamination and Histamine Formation in Canned Tuna
5.	Weremfo A, Eduafo M.K, Gyimah H.A, and Oppong S.A	2020	Journal of Food Quality Volume 2020 https://doi.org/10.1155/2020/2684235	Monitoring the Levels of Biogenic Amines in Canned Fish Products Marketed in Ghana
6.	Elbayoumi Z.H, Dawod E.E, Shawish R.R	2023	Journal of Advanced Veterinary Research. 2023 Vol. 13, Issue 6, pp. 936-940	Occurrence and Control of Biogenic Amines in Fresh Fish and Products of Fish
7.	Roudsari L.P, Rahmani A, Shariatifar N, Oranj B.T, Mazaheri M, Sadighara P, Khaneghah A.M	2019	Journal of Food Protection. 2020, Vol. 83, No. 1, pp. 136–141	Occurrence of Histamine in Canned Fish Samples (Tuna, Sardine, Kilka, and Mackerel) from Markets in Tehran
8.	Crobu L, Mudadu A.G, Melillo R, Pais G.L, Meloni D	2021	Italian Journal of Food Safety. 2021; 10:9379	Qualitative determination of histamine in canned yellowfin tuna (Thunnus albacares) marketed in Sardinia (Italy) by rapid screening methods
9.	Nagy N, Kirrella G.A.K, Moustafa N.Y, Abdallah R	2023	Journal of Advanced Veterinary Research. 2023 Vol. 13, Issue 3, pp. 377-383	Quality Assessment of Some Imported and Local Canned Tuna Sold in Kafrelsheikh, Egypt
10.	Karami M, Eghbaljoo gharehgheshlaghi H, Alizadeh-sani M, Sadighara P, Tajdar-oranj B, Shariatifar N, Molaee-Aghaee E, Peivasteh-roudsari L	2020	Journal of Food Safety and Hygiene. 2020 Vol 6 No. 4 Autumn	Rapid determination of histamine levels in canned tuna by a novel spectrophotometric method
11.	Charlie Li, Vrdoljak G, Moezzi B	2018	Food Nutr J: 2018. Volume 2018; Issue 06 DOI: 10.29011/2575-7091. 100089	Sampling and Analysis of Histamine in Fish Products from Local Northern California Markets

Histamine contamination was evaluated by Lo Magro S, *et. al* (2020) on 474 batches of fish products collected in Puglia and Basilicata (southern part of Italy) during the years 2015–2019. The screening technique used was the ELISA test, while confirmation was performed by HPLC/FLD with o-phthalaldehyde derivatisation. The samples were subdivided into three categories: 294 fresh/frozen and defrosted fish products, 119 canned products (mainly tuna and mackerel), and 61 ripened products (mainly anchovies and sardines). Canned tuna samples (101 samples) made with skipjack tuna or yellowfin tuna. A total of 119 batches of canned samples, 98% of the samples contained histamine levels below 50 mg/ kg, with 92% of the samples below 10 mg/ kg. Mean histamine levels for canned tuna was 4.9 mg/ kg with range 2.6 – 38 mg/ kg. Based on the present study, Lo Magro S *et al*., (2020) concluded that the canned tuna observed was of good quality.[9]

Sadeghi *et al.*, (2019) carried out a study analyzing the histamine content of 56 canned tuna fish and fresh fish samples produced from 22 manufactures. The samples were analyzed by ELISA method. Canned tuna bought randomly of random stores in Tehran, Iran. The results revealed that the mean histamine levels in canned tuna available in the Tehran market were high, at 5.78 ± 6.14 mg/ 100g, with a range of 2.14 - 21.69 mg/ 100g. According to FDA data, safety limits of histamine content of food determined as < 5 mg/ 100g as safe, 5 - 20 mg/ 100g presumably toxic, 20 - 100 mg/ 100g likely toxic and > 100 mg/ 100g as toxic levels. So, FDA introduces the limit of 50 mg/ 100g. Average concentration of histamine in canned tuna fishes available in Iran Market, is slightly higher than the level considered safe but such amount seems to be tolerable for healthy consumers without excessive sensitivity to histamine, although, efforts should be done to improve storing and preparing methods to decrease histamine production to minimum.[10]

Marija S. Pavlović *et al* (2019) determined the level of histamine in canned fish and frozen fish of different species, commercialy on Serbian market, and compare the results with regulatory standards. A total of 167 samples of frozen fish species and 1030 samples of canned fish were collected during the period of six months from the January 2018 to June 2018, as a part of official control. Histamine determination was performed by ELISA method. In the 544 samples of canned tuna, histamine levels were 15.03 ± 1.73 mg/ kg, the level of histamine varied between 2.90 – 68 mg/ kg.[11] The EU has established an acceptable level of histamine of 200 mg/kg for fish belonging to Scombridae, Clupeidae, Engraulidae, Coryphaenidae, Pomatomidae and Scomberesocidae families (Commission Regulation (EU) No. 2073/2005/EC). In Serbia,

the current regulation regarding histamine content in fish meat has been harmonized with EU recommendations, an acceptable level of histamine of 200 mg/kg for fish belonging to Scombridae.[12, 13] Most of the tested samples exhibited low histamine levels, which confirms adequate implementation of control protocols and efficant surveillance of products placed on the Serbian market.

Elbarbary and Abdelmotilib assessed the quality of canned tuna by determining its bacterial load, histamine and cholesterol levels. The aim of study was to ensure its safety for public consumption. A total 150 canned tuna brands (50 of each solid tuna, chunk tuna and crumbled tuna) were randomly selected from several supermarkets in the governorate of Elfaiyoum, Egyp during January 2023. Histamine determination was performed by HPLC method. The histamine concentrations "ppm" were 48.33 ± 1.12, 56.00 ± 1.86 and 62.66 ± 1.59 in solid, chunks, and crumbled tuna, respectively. The maximum acceptable histamine limit for tuna with respect to FDA (2011) and EOS (804/2005) regulation must not exceed 100 ppm; therefore, all examined products are accepted according to EOS measures.[14]

An ion-pair HPLC method with postcolumn o-phthalaldehyde (OPA) derivatization and fluorescence detection was validated for quantitative determination of of five biogenic amines (histamine, tyramine, putrescine, cadaverine, and agmatine) in canned fish products (mackerel, sardine, and tuna) marketed in Ghana. A canned tuna (8 samples) from different manufacturers were purchased from retail markets in Accra, Ghana, in February 2017. Alexander Weremfo *et al.*, (2020) detected histamine level ranged from ND – 26.12 mg/ kg in canned tuna products. None of the samples analyzed containe histamine levels higher than 100mg/ kg, which is the limit established by the European Union. Overall, the levels of histamine and tyramine found in canned fish products were within acceptable limits, therefore relatively safe for human consumption.[15]

Zakaria H. Elbayoumi *et al.*, (2023) collected a total of 120 random samples of fresh fish (Lates niloticus), canned tuna, smoked herring, and salted sardine (30 for each samples) during October 2022 to February 2023 from different markets in Shibin Elkom, Menoufia, Egypt. The collected samples were analysed to quantify their biogenic amine content (histamine, putrescine, cadaverine and tyramine). Biogenic amine detection was carried out using the HPLC approach. According to EOS (2010), the maximum tolerable level for histamine was 20mg/ 100g. Values for the mean histamine concentrations in canned tuna from 2.3 to 31.2 with average 15.08 ± 0.76 mg%.[16]

Roudsari L.P *et.al*., 2019 conducted a study to measure the concentration of histamine in canned fish samples, including tuna in oil (n= 18), tuna in oil with vegetables (n = 15), tuna in brine (n = 9), kilka in oil (n = 9), sardine in oil (n = 3), and mackerel in oil (n = 6) collected from markets in Tehran, Iran. Histamine concentrations were determined with a High Performance Liquid Chromatography (HPLC) device equipped with a UV detector. For canned tuna in oil, the average histamine concentration was 31.57 ± 27.03 mg/ kg, and there was no histamine was found in canned tuna in brine. The mean histamine concentrations was 34.4 ± 29.92 mg/ kg for canned tuna in oil with vegetables.[17] According to the FAO/WHO guideline, a dose of 50 mg of histamine, which is the no observed adverse effect level, is the appropriate hazard limit.[18] The study reveals high histamine concentrations detected in some brands of Iranian canned tuna. Therefore, it is necessary to implement precise control programs, hazard analysis critical control point systems, and good hygiene practices should be implemented.

A rapid screening method was used to determine the presence of histamine in canned tuna marketed in Sardinia (Italy) by Crobu L *et al.*, (2021). A total of 165 samples of canned tuna were screened for the qualitative determination of histamine by HistaSure™ Fish Rapid Test. The results were consistently in agreement with the food safety criteria (<100 mg/ kg of histamine) laid down in EC Regulation 2073/2005 (as amended). The HistaSure™ kit was confirmed as a rapid screening method for the presence of histamine in canned tuna.[19]

A study conducted by Nancy Nagy *et al.*, (2023) aimed to evaluate and compare local and imported canned tuna products available in supermarkets within Kafr El Sheikh Governorate. Product safety was assessed through the evaluation of physicochemical, bacteriological, and sensory parameters, as well as the determination of mercury and histamine levels. Histamine levels were quantified by the ELISA method according to the protocol of Leszczyocha and Pytasz (2004) in conjunction with a complementary kit. For the histamine level, the mean ± SD values for imported chunks and shredded tuna were 4.6 ± 2.8 mg/ kg and 8.2 ± 2.7 mg/ kg, respectively. The values for local chunks and shredded tuna were 9.4 ± 4.3 mg/ kg and 10.8 ± 3.63mg/ kg, respectively. Although the histamine levels of the canned tuna samples were found within the Egyptian Standards according to ES (2010), which recommended that the maximal permissible limits for histamine be (20 mg/ 100g), there was a significant difference between local and imported canned tuna samples.[20]

In a study conducted by Karami M *et al.*, (2020), a novel spectrophotometric method was used to screen commercial canned tuna purchased from Tehran market, Iran, for histamine levels. A total of 30 canned tuna were purchased from different supermarkets located in Tehran in July 2020. Histamine concentration was measured using a UV-Vis spectrophotometer (Hach DR5000, USA) at 600nm wavelength. The mean of histamine concentration was 98.104 ± 5.18 mg/ kg with a range of 85.04 - 125.08 mg/ kg. Regarding the Iranian National Standard (INS) maximum limit 100 mg/ kg, 40% of the samples have shown exceeding values of histamine. However, the amount of histamine in all the samples was less than the limit set by the Codex Alimentarius (200 mg/kg).[21]

Histamine levels were observed in fish and fish products obtained from local supermarkets in the Northern California San Francisco Bay Area by Charlie Li, Vrdoljak G, and Moezzi B. Histamine was extracted and analyzed by HPLC post-column derivatization with fluorescence detection. No histamine was detacted in canned tuna samples.[22] It should be noted that although the histamine levels in those canned foods are low, histamine levels can increase quickly if the canned tuna is not handled properly after it has been opened. Histamine begins to accumulate when the free amino acid histidine and bacteria found in the tuna interact. The canning process kills bacteria, but once the can is opened, the tuna must be kept in a refrigerator if not consumed in a reasonable time to reduce spoilage from bacteria reintroduced from the environment.[23] The inhibition of histamine formation in canned and pouched samples could be due to the effect of phosphate and sodium chloride. Phosphate acts as an inhibitor for histamine formation.[24]

Table 2. Comparison of histamin levels in commercial canned tuna worldwide

Study Yr	Published Yr	Samples			Method	Histamine Level			Standard	Ref.
		Samples origin	Kind of Tuna	Number of Samples		Mean	SD	Range		
2015 - 2019	2020	Fish product commercialized in Puglia and Basilicata, Italy	– Skipjack Tuna – Yellowfin Tuna	101	Screening: ELISA Neogen Veratox® Histamine kit Confirmatory method: HPLC/ FLD with *o-phthalaldehyde* derivatization	4.9 (mg/ kg)	-	2.6 – 38 (mg/ kg)	US FDA limit of 50 mg/ kg	9
2019	2019	Canned tuna purchased from Tehran markets, Iran	-	56	ELISA	5.78 (mg / 100g)	6.14	2.14 - 21.69 (mg / 100g)	FDA limit of 50 mg/100 g	10
2018	2018	Canned tuna purchased from Serbian markets	-	544	ELISA	15.03 (mg/ kg)	1.73	2.90 – 68.00 (mg/ kg)	The current regulation an acceptable level of histamine of 200 mg/ kg for fish belonging to Scombridae	11
2023	2023	Canned tuna collected from supermarkets in Elfaiyoum, Egypt	– Solid tuna – Chunk tuna – Crumbled tuna	150	HPLC	48.33 (mg/ kg) 56.00 (mg/ kg) 62.66 (mg/ kg)	1.12 1.86 1.59	30 – 60 (mg/ kg) 41 – 70 (mg/ kg) 44 – 83 (mg/ kg)	FDA (2011) and EOS (804/2005) regulation must not exceed 100 mg/ kg	12
2017	2020	Canned tuna purchased from retail market in Acra, Ghana	-	8	HPLC	5.22 (mg/ kg)	-	ND – 26.12 (mg/ kg)	Codex standard, which Ghana subscribes to, 100 mg/ kg of histamine in fish and fish products	13
2022 - 2023	2023	Canned tuna collected from different markets in Shibin Elkom, Menoufia, Egypt		30	HPLC	15.08 (mg/ kg)	0.76	2.3 – 31.2 (mg/ kg)	The maximum acceptable value for histamine was 20 mg/100 g according to EOS (2010)	14
2018	2019	Canned tuna purchased from supermarkets in Tehran, Iran	– Tuna in oil – Tuna in oil with vegetables – Tuna in brine	42	HPLC	31.57 (mg/ kg) 34.40 (mg/ kg) ND	27.03 29.92 ND	7.2 – 62.33 (mg/ kg)	US FDA limit of 50 mg/ kg	15
2018 - 2019	2021	Canned tuna collected from large retail stores located in the town of Sassari, Italy	Yelowfin tuna (*Thunnus albacares*)	165	HistaSure™ Fish Rapid Test (LDN)	< 100 (mg/ kg)	-	-	Safety criteria (<100 mg/kg of histamine) laid down in EC Regulation 2073/2005	17
2021 - 2022	2023	Imported and local canned tuna collected from different shops and markets in Kafr El Sheikh Governorate, Egypt	– Imported Chunk tuna – Local chunk tuna – Imported shredded tuna – Local shredded tuna	36	ELISA	4.6 (mg/ kg) 9.4 (mg/ kg) 8.2 (mg/ kg) 10.8 (mg/ kg)	2.8 4.3 2.7 3.63	- - - -	The maximum acceptable value for histamine was 20 mg/100 g according to EOS (2010)	18
2020	2020	Canned tuna (n=30) were purchased from different supermarkets located in Tehran	-	30	UV-Vis spectrophotometry	98.104 (mg/ kg)	5.18	85.04 – 125.08 (mg/ kg)	Histamine level limit set by Codex Alimentarius (200 mg/ kg)	19
2014 - 2015	2018	Seafood and seafood products obtained from local supermarkets in the Northern California Bay Area	-	12	HPLC	ND	-	-	US FDA limit of 50 mg/ kg	20

IV. DISCUSSION

Fish is an important source of dietary proteins, minerals, and vitamins and has become a necessity in many households globally. It provides a unique and well-balanced source of nutrients for persons of all ages.[13] These nutrients are essential for human nutrition and have been shown to play a role in several metabolic processes.[12, 23] Fish also forms an integral part of regular and therapeutic diets due to their low caloric value, ease of digestibility, moderate cost, and high nutritional content. Tuna fish has high economic and nutritional value and is an important fishing target.[24] Tuna is a pelagic and predatory fish that colonizes most of the planet's seas and ocean.[25] Tuna belonging to the tribe Thunnini, part of the family Scombridae.[26] The term 'tuna' usually covers more than 50 different species, but only *Thunnus albacares* (yellowfin), *Thunnus obesus* (bigeye), *Thunnus thynnus* (bluefin), *Thunnus alalunga* (albacore) and *Katsuwonus pelamis* (skipjack) are significant in terms of supplying a global market in which the European Union represents the primary market.[27] Tuna widely consumed worldwide as fresh or canned.[28]

The presence of histamine in fish and fish products has been used as an indicator of the good manufacturing practice and of the preservation state of seafood, for instance canned fish.[17] Quality control measures designed to minimize the occurrence of scombrotoxic fish require the determination of histamine levels in the range of approximately 10 to 200 mg/ kg.[29] Good quality fish contains less than 10 mg/kg histamine, a level of 30 mg/kg indicates significant deterioration and 50 mg/kg is evidence of definite decomposition. In the United States of America (USA), the defect action level (DAL), the level at which regulatory actions are taken by Food and Drug Administration (FDA) for histamine, is 50 mg/ kg.[30] Canning is a well-established and traditional means of providing food which is stable at ambient temperatures, has long shelf life and in consequence is eminently suitable for world-wide distribution. Canned fish is therefore exported from countries all over the world into the consumer markets. The major steps in canning process include cooking, cooling, packing with a covering oil or tomato sauce in sealed cans and sterilized to achieve commercial sterilization by the heat. During canning process, the bacteria and enzymes inactivated by heat treatment, so the canned fish products have a very long shelf lifetime. Some undesirable effects were occurred during canning process such as loss of essential nutrients, formation of undesirable compounds, browning development and lipid and protein damage which can influence the shelf life of canned products.[31] A study conducted by Roudsari L.P *et.al.,* 2019 to measure the concentration of histamine in canned tuna collected from markets in Tehran, Iran showed there was no histamine was found in canned tuna in brine, but histamine was detected in samples of tuna in oil from the same brand and the same production date.[15] Incorporation of salt is an important factor for preventing bacterial growth and providing food safety; the important histamine-forming bacteria are not capable of growing under high-salt conditions.[32] According to Koral *et al.,* (2013), when good hygienic and manufacturing practices are used, brining is an effective strategy for preventing the formation of histamine in fish products. However, halophilic and halotolerant histamine-producing bacteria such as Vibrio, Pseudomonas, and staphylococci can grow in broth with 12% salt. Bedia Erim (2013) found that salting is a promising technique for preventing histamine formation in salt-cured products unless biogenic amines are produced before the salting process.[33] However, the contamination of sea or rock salt with impurities such as nitrate and nitrite can encourage the production of carcinogenic nitrosamines due to the reaction of biogenic amines with these impurities, mainly nitrite.

Considering that tuna fish, like other scombroid fish, is commonly associated with cases and outbreaks of scombroid fish poisoning. Histamine Food Poisoning (HFP), formelly called "scromboid fish poisoning".[14] A histamine intake of 70-1000 mg per single meal may be associated with many instances of a major health problem referred to as "scombroid fish poisoning".[17,34,35] The time of onset of this poisoning ranges from several minutes to 3 h after ingestion of fish containing high levels of histamine.[36] Symptoms of scombroid poisoning include flushing, rash, urticarial, palpitations, headache, dizziness, sweating, burning of mouth and throat, abdominal cramps, nausea, vomiting, diarrhea, bronchospasm, respiratory distress and vasodilatory shock.[10] Though very rare, death by scombroid poisoning has been reported once, cause death related with the amount of histamine ingested and the individual's sensitivity to histamine.[36, 37]

Histamine is a bioactive amine, which consist of imidazole ring with two nitrogen atoms and the aliphatic amino group. Histamine is synthetized in decarboxylation of the amino acid histidine, and reaction is catalyzed by the enzyme L-histidine decarboxylase.[11] The ability to produce the enzyme have certain bacteria, and the most common are *Escherichia coli*, *Morganella morganii*, *Proteus* spp., *Klebsiella pneumoniae*, *Hafnia alvei*.[38, 39] Histamine-forming bacteria are capable of growing and producing histamine over a wide temperature range, but high temperature promotes the histamine synthesis. Once present in fish meat the enzyme remains active even if the bacteria are not active.

Histamine level that is considered to be permissible in fish and fishery products differs by country. In USA, histamine level of 50 mg/kg is an indicator of fish decomposition (FDA, 1995). The EU has established an acceptable level of histamine of 200 mg/kg for fish belonging to Scombridae, Clupeidae, Engraulidae, Coryphaenidae, Pomatomidae and Scomberesocidae families (Commission Regulation (EU) No. 2073/2005/EC).[11] Various analytical techniques are used for the concentration of histamine, including Gas chromatography (GC), High-Performance Liquid Chromatography (HPLC), Thin Layer Chromatography (TLC), fluorometric assay, colorimetric assay, ultrasensitive flow injection electrochemical analysis, immunoassay methods, and spectrophotometry. Because the use of complicated methods such as chromatography is costly and time-consuming, thus the use of spectrophotometry is especially suitable for rapid monitoring of finished products in factories before releasing them to the markets, with good applicability and feasibility. Alizarin Red S easily forms complex colors with organic and metallic substances such as copper.[19]

V. CONCLUSION AND SUGGESTIONS

A. Conclusion

The results of the data search, remaining 11 articles were suitable in this review. The histamine levels in canned tuna were determined in this study by using ELISA, HPLC or a rapid test method. Samples of commercial canned tuna from different

countries were analysed and found to have histamine levels that were within the acceptable range. Histamine level that is considered to be permissible in fish and fishery products differs by country. In the United States, a histamine level of 50 mg/ kg is considered indicative of fish spoilage, while the European Union has established an acceptable histamine level of 200 mg/kg for fish belonging to the Scombridae, Clupeidae, Engraulidae, Coryphaenidae, Pomatomidae, and Scomberesocidae families (European Union (EU) Commission Regulation No. 2073/2005/EC).

B. Suggestion

For future researchers, it is hoped that the results of this review will be data resources and research references related to determination of histamine level in canned tuna.

REFERENCES

[1] Kawamoto., Taro. A challenge to estimate global canned tuna demand and its impact on future tuna resource management using the gamma model. Marine Policy. 2022 May; Vol. 139, 105016 https://doi.org/10.1016/j.marpol. 2022.105016

[2] Tugce, Elif.; Tumerkan, Aksun. Detection of Parvalbumin Fish Allergen in Canned Tuna by Real-Time PCR Driven by Tuna Species and Can-Filling Medium. Molecules. 2022; 27, 5674 https://doi.org/10.3390/molecules27175674

[3] Lasekan, A. Attenuating the Antibody Reactivity of the Shrimp Major Allergen (Tropomyosin) using Food Processing Methods. Ph.D. Thesis, The University of Maine, Orono, ME, USA. 2017

[4] Ruethers, T.; Taki, A.C.; Khangurha, J.; Roberts, J.; Buddhadasa, S.; Clarke, D.; Hedges, C.E.; Campbell, D.E.; Kamath, S.D.; Lopata, A.L.; et al. Commercial fish ELISA kits have a limited capacity to detect different fish species and their products. J. Sci. Food Agric. 2020; 100, pp.4353 - 4363.

[5] Saptarshi, S.R.; Sharp, M.F.; Kamath, S.; Lopata, A.L. Antibody reactivity to the major fish allergen parvalbumin is determined by isoforms and impact of thermal processing. Food Chem. 2014; 148, pp.321 - 328

[6] Klueber, J.; Schrama, D.; Rodrigues, P.; Dickel, H.; Kuehn, A. Fish Allergy Management: From Component-Resolved Diagnosis to Unmet Diagnostic Needs. Curr. Treat. Options Allergy. 2019; 6, pp.322 - 337

[7] Food and Drug Administration. Scombrotoxin (histamine) formation. In: Fish and fisheries products hazards and controls guidance. Center for Food Safety and applied Nutrition, Office of Seafood, Food and Drug and Administration, Washington, DC. 2001; pp.83 - 102

[8] Rahimi E., Nayebpour F. and Alian F. Determination of histamine in canned tuna fish using ELISA method. American Eurasian Journal Toxicology Science. 2012; 4(2):pp.64 - 66

[9] Lo Magro S, Summa S, Iammarino M, D'Antini P, Giuliana M, Chiaravalle A.E and Muscarella M. A 5-Years (2015–2019) Control Activity of an EU Laboratory: Contamination of Histamine in Fish Products and Exposure Assessment. Applied Science. 2020; 10, 8693 DOI:10.3390/app10238693

[10] Sadeghi N, Behzad M, Jannat B, Oveisi MR, Hajimahmoodi M, Mozafari M. Determination of histamine in canned tuna fish available in Tehran market by ELISA method. J Food Safe & Hyg. 2019; Vol 5 No. 1 Winter

[11] Pavlović M.S, Ivanovic S.D, Pavlović I.N, Roković1 N.I, Radosavljević V.I, Vasilev D.D. Histamine levels in fish samples collected from Serbian market in 2018. Food and Feed Research. 2019; Vol. 46 (1), pp.37- 43

[12] Elbarbary N.K and Abdelmotilib N.M. Monitoring the Bacteriological Contamination and Histamine Formation in Canned Tuna. Egyptian Journal of Aquatic Biology &Fisheries. 2023; Vol. 27(4): pp.421 - 438

[13] Weremfo A, Eduafo M.K, Gyimah H.A, and Oppong S.A. Monitoring the Levels of Biogenic Amines in Canned Fish Products Marketed in Ghana. Journal of Food Quality Volume 2020 https://doi.org/10.1155/2020/2684235

[14] Elbayoumi Z.H, Dawod E.E, Shawish R.R. Occurrence and Control of Biogenic Amines in Fresh Fish and Products of Fish. Journal of Advanced Veterinary Research. 2023; Vol. 13, Issue 6, pp.936 - 940

[15] Roudsari L.P, Rahmani A, Shariatifar N, Oranj B.T, Mazaheri M, Sadighara P, Khaneghah A.M. Occurrence of Histamine in Canned Fish Samples (Tuna, Sardine, Kilka, and Mackerel) from Markets in Tehran. Journal of Food Protection. 2020; Vol. 83, No. 1, pp. 136 – 141

[16] Food and Agriculture Organization of the United Nations, World Health Organization. Joint FAO/WHO expert meeting on the public health risks of histamine and other biogenic amines from fish and fishery products. Meeting report. Food and Agriculture Organization of the United Nations and World Health Organization, Rome. 2013

[17] Crobu L, Mudadu A.G, Melillo R, Pais G.L, Meloni D. Qualitative determination of histamine in canned yellowfin tuna (Thunnus albacares) marketed in Sardinia (Italy) by rapid screening methods. Italian Journal of Food Safety. 2021; 10:9379

[18] Nagy N, Kirrella G.A.K, Moustafa N.Y, Abdallah R. Quality Assessment of Some Imported and Local Canned Tuna Sold in Kafrelsheikh, Egypt. Journal of Advanced Veterinary Research. 2023; Vol. 13, Issue 3, pp.377 – 383

[19] Karami M, Eghbaljoo gharehgheshlaghi H, Alizadeh-sani M, Sadighara P, Tajdar-oranj B, Shariatifar N, Molaee-Aghaee E, Peivasteh-roudsari L. Rapid determination of histamine levels in canned tuna by a novel spectrophotometric method. Journal of Food Safety and Hygiene. 2020 Vol 6 No. 4 Autumn

[20] Charlie Li, Vrdoljak G, Moezzi B. Sampling and Analysis of Histamine in Fish Products from Local Northern California Markets. Food Nutr J: 2018; Volume 2018; Issue 06 DOI: 10.29011/2575-7091. 100089

[21] Canned tuna FAQ: Question and Aswered

[22] Bjornsdottir-Butler K, Green DP, Bolton GE, McClellan-Green PD. Control of Histamine-Producing Bacteria and Histamine Formation in Fish Muscle by Trisodium Phosphate. J Food Sci 80. 2015; pp.1253 – 1258

[23] Chandravanshi, N.K.; Dhruw, P. and Bharti, R. K. Nutritional quality of fish food. 2019 pp.82 – 86

[24] Rahimi E, Nayebpour F , AlianF. Determination of Histamine in canned Tuna fish using ELISA method. Americ-Eurasia J Toxicol Sci. 2012; 4:pp.64 – 66

[25] Gabriela Popa, Roxane. Toxicity of canned tuna. Annals of the Constantin Brancusi, University of Targu Jiu, Engineering Series , No. 4/2020

[26] Casalinuovo F., Brindisi D., Rippa P., Ceniti C., Ciambrone L., Musarella R., Costanzo N. Microbial quality and safety of skipjack Tuna Loins (*Katsuwonus pelamis*) intented for canning. Macedonian Veterinary Review. 2018; 41 (1): pp.33 – 37

[27] Hamilton, A., Lewis, A., McCoy, M. A., Havice, E., Campling, L. Market and industry dynamics in the global tuna supply chain. 2011. Forum Fisheries Agency Honiara (Solomon Islands)

[28] Catarci, C. The world tuna industry—ananalysis of imports and prices, and of their combined impact on catches and tuna fishing capacity. In: W. Bayliff, J. I. Leiva Moreno, J. Majkowski (Eds.), Management of tuna fishing capacity: Conservation and socio-economics. 2005; pp.235 – 278

[29] Kose S, Kaklikkaya N, Koral S, Tufan B,Buruk KC, Aydin F. Commercial test kits and the determination of histamine in traditional (ethnic) fish products-evaluation against an EU accepted HPLC method. Food Chem. 2005; 125: pp.1490 – 7.

[30] Bajpai VK, Oh C, Khan I, Haldorai Y, Gandhi S, Lee H, Song X, Kim M, Upadhyay A, Chen L, Huh YS, Han YK, Shukla S.. Fluorescent immunoliposomal nanovesicles for rapid multi-well immuno-biosensing of histamine in fish samples. 2020. Chemosphere 243: 125404.

[31] El Lahamy, A.A and Hassan R Mohamed, H.R. Changes in Fish Quality During Canning Process and Storage Period of Canned Fish Products: Review Article. Global Journal of Nutrition & Food Science. 2020 Volume 3-Issue 1 DOI: 10.33552/GJNFS.2020.03.000553

[32] Koral, S., B. Tufan, A. Scavnicar, D. Kocar, M. Pompe, and S. Kose. Investigation of the contents of biogenic amines and some food safety parameters of various commercially salted fish products. Food Control. 2013 32:pp.597–606

[33] Bedia Erim, F. Recent analytical approaches to the analysis of biogenic amines in food samples. Trends Anal. Chem. 2013; 52:239–247.

[34] Altieri I, Semeraro A, Scalise F, Calderari I, Stacchini P,. 2016. European official control of food: Determination of histamine in fish products by a HPLC–UV-DAD method. Food Chem. 2016; 211:pp.694-9.

[35] Nei D, Nakamura N, Ishihara K, Kimura M, Satomi M. A rapid screening of histamine concentration in fish fillet by direct analysis in real time mass spectrometry (DART-MS). Food Control.2017; 75: pp.181-6

[36] Silva TM, Sabaini PS, Evangelista WP, Gloria MBA. Occurrence of histamine in Brazilian fresh and canned tuna. Food Control. 2011; 22: 323-7.

[37] Khan S, Carneiro LSA, Vianna MS, Romani EC, Aucelio RQ. Determination of histamine in tuna fish by photoluminescence sensing using hioglycolicacid modified Cd Te quantum dots and cationic solid phase extraction. J Luminescence. 2017; 182: pp.71-8

[38] Lehanea, L., Olleyb, J. Histamine fish poisoning revisited. International Journal of Food Microbiology. 2000; 58, pp.1–37.

[39] Ozogul, F., Oztekin, R., Kulawik, P. Biogenic amine formation and microbiological quality of anchovy (Engraulis encrasicolus) treated with lavender and lemon balm ethanol extracts. Journal of Food Science. 2017; 82 (5), 1278-1284 DOI: 10.1111/1750-3841.13704