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Research Paper

Biogenic Amines Detection by Chromatography and Sensor Methods: A Comparative Review

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Abstract
Biogenic amines (BA) are chemical compounds shaped by amino acids decarboxylation and exist in food and beverages that contain protein. They are categorised as very toxic and some countries have even prohibited their consumption at high level especially histamine. Two major methods have been used and developed well such as chromatography methods and sensors methods. The common method applied for chromatography are liquid chromatography (LC) and gas chromatography (GC) while for sensor methods are optical, chemical and bio-sensor. These methods have advantages and disadvantages. For chromatography methods, derivatization is required in order to improve sensitivity and selectivity, nevertheless these methods are very expensive and time-consuming. Derivatization step is time-consuming and facing the risk of partial detection due to an incomplete derivatization. Thus, sensor method is used to solve these issues, since they do not require derivatization step, generate a direct signal that can be interpreted by anyone, very fast and simple. However, they have disadvantages in several aspects such as sensitivity, accuracy and selectivity compared to chromatography methods. This review is based on studies conducted onto biogenic amines detection related to food and beverage samples. Although biogenic amines commonly found in protein-food for decades, new approaches and technical possibilities are still required in order to increase the sensitivity, selectivity and accuracy of the analytical methods to tackle the complexity by their matrices. The rationale of this study is also to provide data about the comparison of the analytical techniques between conventional and sensor methods. Furthermore, the various approaches of biogenic amines determination and the most applied analytical methods have been reviewed.

Keywords
Biogenic amines, histamine, chromatography, electrochemical sensor, optical sensor

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1. INTRODUCTION

The demand for food supply increases with human population. This will give impact to food security and become challenging to encounter especially prior to market distribution. Fish, meat, cheese and some other variety of foods that contain protein have been extensively studied to identify presence of biogenic amines at various concentration

The accumulation of biogenic amines is caused by several factors related to chemical, biological and physical processes, such as storage conditions of food, inappropriate transportation and processing conditions leading to microbial growth. Furthermore, food and beverages that contain protein have high possibility to biogenic amines accumulation. The biogenic amines concentration are strongly dependence on the food and beverages characteristics and type of bacteria present. The main biogenic amines generally found in food and beverages are histamine, spermidine, spermine, tyramine, putrescine and cadaverine (Liu et al. (2020);Mohammed et al. (2016)). In this review paper, we described and elaborated about biogenic amines, their issues and the methods that have been applied by several researchers to detect biogenic amines in food and beverages that contain protein using chromatography methods such as liquid chromatography and gas chromatography or the application of sensor methods such as electrochemical and optical sensors.

2. Biogenic Amines, Histamine and Their Issues

Biogenic amines (BA) are organic compounds with aliphatic, aromatic and heterocyclic structures of basic nitrogenous and also shaped by amino acids decarboxylation. Biogenic amines present in protein food and beverages such as fish, meat, cheese, vegetables, milk, yoghurt and wines and causing several adverse reaction if excessively consumed (Alizadeh et al. (2017); Gama and Rocha (2020); Gardini et al. (2016)). Figure 1 shows several biogenic amines that can be found in food and beverages.

The alpha-carboxyl group relocated from amino acid com-

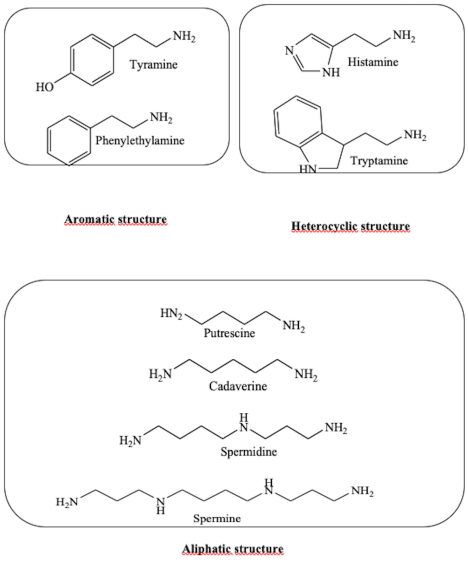

Figure 1. The main biogenic amines chemical structures found in food and beverages (Mohammed et al. (2016) with modifications).

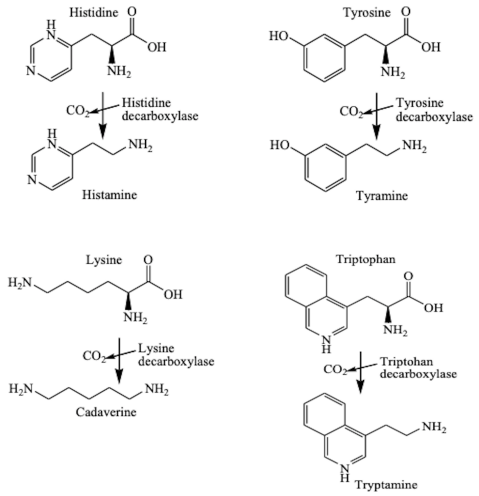

Figure 2. The biogenic amines formation by decarboxylation of the amino-acid through microbial or enzymatic processes (Francisco et al. (2019) with some mofications).

pound causing biogenic amines production. For instance, histidine will generate histamine, lysine generates cadaverine, tyrosine generates tyramine and so on (Hidalgo et al., 2016). Biogenic amines limitation upon consumption by human is linked to the efficiency of detoxification mechanism in individuals (Plakidi et al., 2020). Since biogenic amines can be found easily in food and beverages at various concentrations, the highest concentration of biogenic amines in human body must be maintained at 750 – 900 mg/kg. However, for single amines such as tyramine and phenylethylamine, they should not be consumed more than 100 and 30 mg/kg, respectively, whereas for histamine, it should not be consumed more than 50 mg/kg in foods and 2 mg/L in beverages (Jain et al., 2015). Histamine is the most common biogenic amine exists in protein food or beverages. It has been receiving great attention by some authorities such as FDA and EFSA. Histamine [(2-1H-imidazole—yl)ethanamine] is an amine that can be acquired by decarboxylation of the amino-acid histidine through several factors such as microbial or enzymatic processes. Generally, cooking or heating process destroys some bacteria with the exception of food containing histidine where bacteria inside the foods and beverages causing histidine to be converted to histamine (Biji et al. (2016); Panula et al. (2015)). Histaminolytic bacteria found in food which is histamine oxidizing agent has the ability to exist in food and beverages during destruction process causing the formation of histamine (Naila et al. (2010); Phuvasate and Su (2010)). This occurs not only to histamine but also some other biogenic amines where their formations are influenced by decarboxylation process (Figure 2).

However, the dose of toxicity is different from one individual to another owing to every human beings having different endurance. Histamine intolerance may develop some discomfort symptoms such as burning sensation, sweating, dizziness, nausea, tachycardia, headache and some serious cases can cause death (Wang et al., 2017)). Although many studies have shown the toxicity of histamine, its presence in human body is imperative due to the usability of histamine as a parameter for body temperature, influence appetite and even having physiological functions in nervous system as a neurotransmitter. It also causes increasing permeability in blood capillaries as response to inflammatory. Therefore, existence of histamine in human body is possible to causing immune system disorders and allergies (WHO, 2013). Histamine also plays an important role in human metabolism for the release of hydrochloric acid also known as gastric acid. Zero case was reported if the amount of histamine is in small quantity since low level of histamine has no toxic effect. Humans cannot absorb histamine from gastrointestinal tract but it can be dangerous upon intake of larger quantity of histamine. Human body has a system that can turn histamine into harmless compound by releasing enzymes such as diamine oxidase (DAO) and histamine-N-methyl transferase (HMT) to detoxify histamine. But, cadaverine and putrescine have the ability to inhibit these enzymes and eventually are having potential to increase histamine toxicity (Taylor and Eitenmiller, 1986). Some studies also reported histamine is not toxic at a low level, but with the presence of cadaverine and putrescine at higher level, an increase in toxicity of histamine was observed (Plakidi et al., 2020). According to some studies, putrescine and spermidine can be found in vegetables, whereas cadaverine and putrescine exist in vinegars (Křížek et al. (2014); Qiao et al. (2020)). They also can be found in infant milk products. Although there is no case of poisoning caused by putrescine and cadaverine being reported, yet some studies discovered that they could interact with amine oxidases and increase the toxicity of tyramine and histamine (Alavarez and Moreno – Arribas, 2014; Pereira et al.

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