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Mini Review

The Evolution of Sensing Device for the Detection of Histamine and other Biogenic Amines

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Abstract

This paper reviewed the progressive trend in the sensing of biogenic amine such as histamine. A sensor was developed where this sensor is using palm-based polyurethane as an electro-sensor substrate. Palm based polyurethane (PU) was produced via condensation polymerization between palm kernel oil-based monoester polyol (PKOp)and 4,4'-diphenylmethane diisocyanate (MDI). PU is used in this study due to its porosity and its capability to attach onto screen – printed electrode (SPE) sturdily without disintegrate. PU – SPE absorbed histamine inside its pores so histamine can undergo the oxidation process. The oxidation process was detected using cyclic voltammetry (CV) and differential pulse voltammetry (DPV).

Biogenic Amines

Biogenic amines (BA) are basic nitrogenous compounds shaped by decarboxylation of amino acids. Biogenic amines can be present in food and can cause several adverse reactions in the consumers [1-3]. Relocation of the alpha-carboxyl group from a proteinogenous amino acid leads to corresponding biogenic amines such as histamine originates from histidine, cadaverine from lysine, tyramine from tyrosine and so on [4]. All kinds of foodstuffs that contain proteins or free amino acids represent important task to be subjected to conditions enabling microbial or biochemical activity of biogenic amines. The total amount of different amines formed strongly depends on the nature of food and the microorganisms present. Food likely to contain high levels of these compounds are dairy products, fish and fish products, meat and meat products, fermented vegetables and soy products and fermented beverages such as milk, wine and beer. The main biogenic amines encountered in food and beverages are histamine, tyramine, putrescine and cadaverine [5,6]. The factors that influence biogenic amines accumulation in food are distribution and storage conditions, food physicochemical parameters (pH, NaCl and ripening temperature), raw material quality, manufacturing processes, presence of decarboxylase-positive microorganisms and free amino acids [7].

Biogenic amines and polyamines have been reported in variety of food, such as fish, meat, cheese, vegetables and wines. They are also described as organic bases with aliphatic, aromatic and heterocyclic structures [8]. Histamine is the most common biogenic amine and can be found in food or beverages. Histamine [(2-1H-imizazol—yl)ethanamine] is a biogenic amine that can be produced in organisms by decarboxylation of the amino-acid histidine through microbial or enzymatic processes. Histamine is involved in several physiological functions in the central nervous system (CNS) as a neurotransmitter, in sleep-wake regulation and body temperature control, and it affects appetite, mood, endocrinal processes, learning, and memory. It is also implicated in inflammatory and immune responses by increasing the permeability of blood capil-

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laries. In addition, histamine is partly responsible for gastric acid release, stimulatory effects, erection and sexual functions, schizophrenia and multiple sclerosis. Therefore, it is not surprising that elevated levels of histamine may cause immune system disorders and allergies. One of the major sources of health problems caused by histamine is Scombroid food poisoning that is a common type of seafood poisoning caused by eating spoiled fish, mainly mackerel, tuna, sardines and anchovies [9]. At temperatures above 16oC, the enzyme histidine decarboxylase, produced by enteric bacteria, converts histidine to histamine. Unlike food spoiled by bacteria that can be suitable for consumption after cooking, the histamine content in food is not normally destroyed by cooking. It should be noted that histamine is present in a variety of food like wine cheese, fermented sausages and fish, and most members of the public are not affected by moderate consumption of these products. However, people with histamine allergy may develop symptoms that typically include sweating, burning sensation, dizziness, nausea, headache, tachycardia and other symptoms. The National Institutes of Health (NIH) recently published a popular article about food poisoning by seafood products describing these effects [10].

Histamine has an important role in human metabolism, such as the release of stomach acid. In small dosage it has little effect, but in larger dosage is has toxic effects. The intestinal tract of human contains the enzymes diamine oxidase (DAO) and histamine-N-methyl transferase (HMT) which convert histamine to harmless degradation products. Putrescine and cadaverine can inhibit these enzymic reactions and also have potentiate to increase histamine toxicity. The presence of low levels of histamine, in the diet normally has no toxic effect as humans do not absorb histamine efficiently from gastrointestinal tract. If a high level of histamine is present in the diet, then the capacity of DAO and HMT to detoxify histamine will be limited and histamine will enter into the bloodstream resulting in histamine poisoning [11].

Histamine generally comes from the Scombridae family such as mackerel and tuna, sardine, blue fish and mahi-mahi. Histamine has been connected with Scombroid poisoning in several studies. The time of onset of Scombroid poisoning ranges from several minutes to 3 h after ingestion of food containing histamine at concentration higher than 100 mg/100 g fish. The most general symptoms of this toxicity after consumed by human are itching, faintness, a burning sensation in the mouth, dizziness and the inability to swallow, but the victims usually recover within 8 h [12]. Furthermore, histaminolytic (histamine oxidizing) bacteria may allow an equilibrium to develop between histamine production and destruction in food containing high amounts of histamine [13].

Food and Drug Administration (FDA) has allowed to consume 5 mg/100 g fish (FDA, 1998), but in several studies showed histamine at 67 and 180 mg has been given orally to volunteers without any sign of toxicity [14]. Thus, the efficiency of detoxification system in the body influences the histamine toxicity [10]. Histamine poisoning (Scombroid poisoning) is a worldwide problem that occurs after consuming food that containing biogenic amines, particularly histamine at concentrations higher than 500 ppm [15]. Histamine poisoning manifest itself as an allergen-type reaction characterized by difficulty in breathing, itching, rash, vomiting, fever and hypertension. People having deficient natural mechanisms for detoxifying biogenic amines through genetic reasons or through inhibition due to the intake of anti-depression medicines, such as monoamine oxidase inhibitors (MAOIs) are more susceptible to histamine poisoning [13]. Histamine alone may not cause toxicity at a low level, but the presence of other biogenic such as putrescine and cadaverine, at concentrations 5 times higher than histamine, enhance the toxicity of histamine [14].

Histamine fish poisoning is among the most common food borne diseases related to fish consumption. Fifty-six of the 71 food borne disease outbreaks (78.9%) that have been notified in Europe in 2011 were due to histamine fish poisoning (EFSA 2013). The risk is correlated with the number and the histidine decarboxylase activity of the contaminating bacteria that grow in the flesh of fishes that are rich of free histidine, such as tuna, mackerel and bonito [15]. Bacteria of the genus Photobacterium, i.e., P. damselae subsp. Damselae (Pdd) and P. phosphoreum, are strong histamine producers [16-18]. Photobacterium damselae subsp. damselae is considered to be an emerging pathogen of marine fish of importance in aquaculture, with a notable increase in its geographical distribution during the last several years [19].

[16] demonstrated that Pdd inoculated on tuna can produce toxic levels of histamine even at 4oC. These authors observed the Pdd displayed the highest performance in accumulating histamine in fish samples stored at refrigeration temperature in comparison with other psychrotolerant marine bacteria, namely P. phosphoreum and Raoultella planticola. The demonstrated that Pdd (strain JCM 8968) can produce more than 500 mg/kg histamine at 4oC in 24h and maintain 60% and 50% of the initial activity in tuna and dried saury for up to 12 weeks at -20oC, respectively. The presence of Pdd in the fish that are stored in melting ice or at chilling temperature and even in the de-frozen and processed seafood can thus pose a significant hazard if the contamination is carried on fish species which are rich in free histidine.

Biogenic amine levels in processed fish products are strongly affected by the quality of raw material and conditions and handling techniques during processing [20]. Therefore, the monitoring of Bas in fish and fish products in considered for two reasons: as a quality index and prevention of potential toxicity to human health [21]. Due to toxicological effects of Bas on human health, 50 ppm of histamine and 100 ppm of tyramine [22] have been suggested by the Food and Drug Administration (FDA) as tolerance levels in fish. Histamine in the causative agent of Scombroid poisoning, a food borne chemical hazard. Scombroid poisoning is usually a mild illness with a variety of symptoms including rash, urticarial, nausea, vomiting,