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Mapping Chemical Hazards in Animal Food Origin Product for Food Safety Teaching Materials

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Abstract: Animal origin food product is quite vulnerable to the threat of chemical hazards. Mapping potential chemical hazards is needed to establish good and safe food handling methods. In addition, the mapping can be used as the basis for the preparation of food safety teaching materials that have not been available so far. The purpose of this study is to map various potential chemical hazards in food of animal origin food product to be used as teaching materials for food safety. This research is included as a literature study by collecting various types of scientific references that outline potential chemical hazards that can threaten animal origin food product. The results showed potential chemical hazards in the form of antibiotic residues in beef, chicken, and eggs; excess nitrates and nitrites in beef; scombrotoxin in cob fish; pesticides and heavy metals in honey; and formalin and borax in chicken meat and fish. The results of mapping the potential chemical hazards of animal origin food product can then be used to compile food safety teaching materials.

Keywords: Animal origin food product; Chemical hazards; Food safety; Mapping.

Introduction

Food of animal origin as the main source of protein that must be guaranteed safety. However, the high nutrition of a food ingredient, as long as it is not safe, it cannot be called food. Previously, a case of cob poisoning occurred in Bima City which caused 30 female students to be hospitalized (BPOM, 2020). This case is caused by high levels of histamine in cob fish due to improper fish storage process. Therefore, food safety is a major concern and requirement for public health (Nardi et al., 2020).

The above conditions are further complicated by the level of initial knowledge of students and students towards food safety which is still low (Anggitasari et al., 2014; Tenggana et al., 2020). Good food safety knowledge will have an impact on a person's skill level in handling food hygienically. Educational activities are needed in increasing the knowledge and abilities of students and students related to food safety (Mulyawati et al., 2017). To support food safety education, the availability of teaching materials is very important to make it easier for students and students to understand it well. But unfortunately, these teaching materials are not available until now so they really need to be developed.

For the preparation of food safety teaching materials, the needs analysis step in the form of mapping potential hazards from animal food is the first step that must be done. By knowing the potential hazard, it will make easier to take further preventive action. Hazard mapping is also a basic principle that must be met in the process of good manufacturing practices, good handling practices, and hazard analysis critical control point (HACCP) systems (Wallace et al., 2014; Arévalo et al., 2022). In general, three types of hazards in foodstuffs are known, namely physical, biological and chemical hazards (Panebianco et al., 2019). Chemical hazards are included as hazards can cause illness and even death from contamination of toxins or other harmful substances into food.

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The topic of food safety is taught at the vocational level with a major in culinary management / specialization. As for the higher education level, the results of this mapping can also be used for students of the chemistry education study program through the Food Chemistry course. Meanwhile, for veterinary education students through the Food Hygiene and Environmental Health courses. Therefore, this study aims to map the potential chemical hazards contained in animal food. The results of mapping this potential chemical hazard will then become the basis for the preparation of teaching materials and food safety learning tools.

Method

This research is a literature study with the intention of mapping various potential chemical hazards in animal origin food product from the results of studies by various researchers. This mapping is intended as a step of needs analysis in the form of a literature study for the preparation of animal origin food product teaching materials (Islamiyati et al., 2021). Animal origin food product mapped for potential hazards include beef, chicken meat, eggs, milk, fish, and honey. The detailed step of research method can be seen in the figure 1.

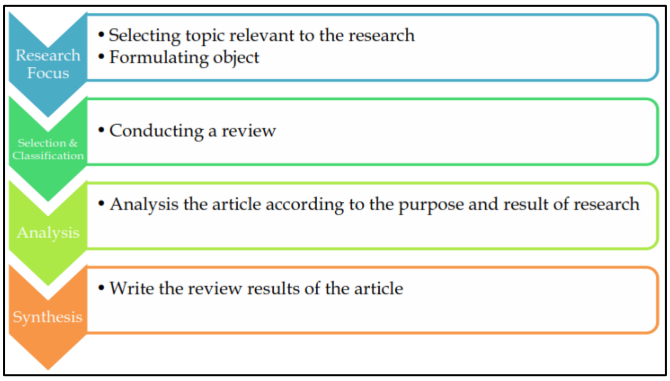

Figure 1. The Detailed Step

Result and Discussion

Mapping of potential chemical hazards in animal origin food product has been carried out by reviewing various scientific articles and other relevant and reputable references. The results of mapping the potential chemical hazards of animal origin food product are shown by Table 1.

Table 1. Mapping the potential chemical hazards of animal origin food product

Chemical hazard potential	Source of animal origin food product
Antibiotics residue (Jahantigh et al., 2020; Ngangguk et al., 2014; Pawestri et al., 2019; Wijaya & Pisestyani, 2011)	beef, chicken
Nitrate and nitrite (Alahakoon et al., 2015; Govari & Fexara, 2015; Habibah et al., 2018; Özbay & Şireli, 2021; Park et al., 2015; Yugatama et al., 2019)	beef
Scombrotoxin (Fatuni et al., 2014; Kung et al., 2016; Visciano et al., 2014)	scombridae fish
Pesticides (Anderson & Maede, 2014; Harwood & Dolezal, 2020; Rodríguez et al., 2016; Sanchez-Bayo & Goka, 2014)	honey
Heavy metal (Boyd, 2009; Gutiérrez et al., 2020)	honey
Formalin and borax (Hardaningsih et al., 2016; Lema dan Jacob, 2020; Wahed et al., 2016)	chicken, fish

Antibiotics Residue

Antiobiotics are very commonly used in animal husbandry as a medium of treatment and feed additives so that farm animals can be free from diseases and their growth processes are not disturbed. Antiobiotics are given to farm animals either through the addition of feed or through injection. Additions to the feed can create residues in the meat of farm animals. One type of antiobiotic commonly used in livestock is tetracycline with a broad spectrum to fight gram-negative and gram-positive bacteria. Tetracycline was reportedly detected in the meat of laying hens (Ngangguk et al., 2014), broiler chickens (Jahantigh et al., 2020), and tilapia (Pawestri et al., 2019). Tetrasiklin can also be in aquatic environments derived from urine and manure (Daghrir & Drogui, 2013).

In addition to tetracycline, macrolide-type antiobiotic residues have also been found in 3 beef samples in Bandung City and Tasikmalaya Regency in quantities that meet the maximum residue limit standards in accordance with the technical guidelines of Standar Nasional Indonesia (SNI) nomor 01-6366-2000 tentang Batas Maksimum Cemaran Mikroba dan Batas Maksimum Residu dalam Bahan Makanan Asal Hewan (Wijaya & Pisestyani, 2011). Macrolides are used to treat infections caused by gram-positive bacteria such as the genus *Streptococcus, Staphylococcus, Enterococcus* and *Trueperella* (*Arcanobacterium*) (Pyörälä et al., 2014). Macrolide antibiotics include erythromycin, kitasamycin, myrosamycin, myrosamycin, and azithromycin. The presence of antibiotic residues in livestock meat can be caused by slaughter times that do not consider the expiration period of these antiobiotics in the body of livestock such as the thighs and liver (Marlina et al., 2015).

Nitrate and Nitrite

Nitrate and nitrite salts have traditionally been used as food additives for the curing process in meat preserved products (Siekmann et al., 2021). The use of nitrate salt and nitrite as preservatives as regulated in Perpu MenKes RI (2012), regarding Food Additives can be in the form of potassium nitrate (KNO_3), sodium nitrate ($NaNO_3$), potassium nitrite (KNO_2) or sodium nitrite ($NaNO_2$). The simultaneous use of nitrate and nitrite in the curing process can be carried out in a ratio of 150 : 150 ppm. The addition of nitrates and nitrites to meat can improve quality in terms of safety from microbial hazards in the form of *Clostridium botulinum* (Park et al., 2015). In addition, nitrates and nitrites play an important role in the formation of flavor and stability of the red color of meat as well as in protecting against lipid oxidation (Alahakoon et al., 2015; Govari & Fexara, 2015).

Excess nitrites can have a negative impact on the health of the body because it produces nitrosamine compounds that can trigger the occurrence of carcinogens. Nitrosamine is a compound produced when processing animal food that has been added nitrate and nitrite through a complex process (Herrmann et al., 2015; Özbay & Şireli, 2021). Nitrosamines belong to a sub-group of N-nitroso compounds with the physical characteristics of being yellow, in the form of an orange yellow liquid, or solid in shape at room temperature. Chemically, nitrosamines are characterized by the presence of a functional group N-N=O (De Mey et al., 2015). In foodstuffs, nitrosamines are formed from the result of the reaction between nitrogen oxides and amines. Nitrites are hydrogenated to hydronitrogenoxide (H_2NO^{2+}) under acidic conditions. Hydronitrogenoxide reacts with other molecules of nitrites to form nitrogen anhydrous. The nitrogen anhyde then contributes the nitroso group to amines in foodstuffs to produce N-nitrosamines.

Regulation of the Perpu MenKes RI (2012) regarding Food Additives has stipulated that the maximum threshold for the content of nitrites and nitrates as preservatives in processed meat products is 30 mg/kg and 50 mg/kg of ingredients, respectively. Several research results found that there are still processed meat foods on the market with nitrite content above the maximum threshold (Habibah et al., 2018; Yugatama et al., 2019). Now, some researchers are starting to try to develop natural preservatives to replace nitrite in processed meats such as with young radish, lettuce, cabbage, celery and red beets (Ko et al., 2016; Riel et al., 2017; Ferysiuk & Wójciak, 2020; Ozaki et al., 2020).

Scombrotoxin

Marine fish of the scombridae family such as cob fish, cob whitefish, tuna, skipjack tuna can produce histamine compounds. Histamine is produced by bacteria in fish that contain high amounts of the amino acid histidine. Normally, with fish storage conditions at 25°C in a span of more than 6 hours, histamine can appear. Histamine poisoning is often also referred to as scombrotoxin fish poisoning (SFP) (Kung et al., 2016).

Fish from the Scombroidae group (including tuna, cobs, skipjack) as well as fish from other groups such as Carangidae (cake, kite, nape) and Clupeidae (lemuru, sardines, tembang) naturally have a higher histidine content than fish from other groups (Visciano et al., 2014). Fatuni et al (2014) reported that histamine in cob fish pindang during 32-hour storage increased from 0.26 mg/100g to 7.54 mg/100 g. Histamine is so stable to heating that various types of processing, be it cooking, canning or freezing will not be able to eliminate the presence of histamine (Visciano et al., 2014).

The formation of histamine in fish from the scombridae family can be prevented through the application of good manufacturing practices, good handling practices and the HACCP system (Visciano et al., 2014). After the fish is caught, the next treatment is to store it immediately in a container with cold or freezing temperatures to avoid the growth of histamine-producing bacteria. Based on the provisions of the Badan Standar Nasional on SNI 01-2729.3-2013, the handling of fresh fish during transportation and storage is carried out at temperatures below 5 °C (BSN, 2013). The fish cooling crate designed by Widianto et al (2014), is able to maintain the temperature of fish below 3 °C at the time of retail sale of fish for 3.8 hours. Histamine can also be inhibited by adding antibacterial compounds such as quercetin (Prasetiawan et al., 2013).

Pesticides

Pesticides are known to be one of the toxic substances released into the environment to kill organisms such as insects (insecticides), fungi (fungicides), weeds (herbicides) and rats (rodenticides) (Kim et al., 2016). In general, pesticides can consist of organosulfur and organochlorine groups. The habit of farmers that is still often done is to use pesticides is still not according to the standards allowed because they have mixed more than 1 type of pesticide and some even exceed 10 active ingredients in one tank (Yuantari et al., 2015).

Sanchez-Bayo & Goka (2014) stated that chemical hazards that have the potential to threaten honey safety can come from exposure to pesticides and residues of agricultural chemicals (agrochemicals) attached to pollen and waters to the process of honey formation by bees. The main pathways of pesticide exposure in humans include through the food, air, water, flora and fauna chains (Anderson & Maede, 2014; Harwood & Dolezal, 2020). The risk of bladder cancer has a strong association with exposure to immidazoline-type herbicides (Kuotros et al., 2015). The same thing was also found in the presence of organochlorine-type pesticide residues in the blood of women who had cervical cancer (Rodríguez et al., 2016).

Heavy Metal

Heavy metals can pose a serious threat to honey carried through bees. This is strengthened by the use of honey bees as bioindicators in monitoring environmental quality (Gutierrez et al., 2020). Heavy metals have the potential to accumulate in honey that passes from the soil to flowers or other parts of the plants inhabited by honey bees. Nectar containing heavy metals is then sucked by bees to be further used as honey (Boyd, 2009). Therefore, what needs to be anticipated if the honey production is in the area around the mine or industrial area. In SNI 8664:2018 tentang Madu, it is stated that heavy metal contamination in the form of lead (Pb), cadmium (Cd), and mercury (Hg) in forest honey, cultivated honey, and trigona honey is a maximum of 1.0 mg kg, 02, mg / kg, and 0.03 mg/kg respectively.

Formalin and borax

Formalin is included as a carcinogenic substance and interferes with public health. Formalin is a colorless solution and has a very piercing smell. Inside formalin is contained about 37% formaldehyde in water. Usually up to 15% methanol is added as a preservative. Formalin is widely known as a pest-killing material (disinfectant), a material for making household products, and furniture upholstery (BPOM RI, 2005; Wahed et al., 2019).

Some of the adverse effects of formalin if consumed regularly by the body include damage to the nervous system, kidneys, liver, and can cause asthma and cancer (Songur et al., 2010). Hardaningsih et al (2017) found the presence of formalin content in milkfish sold in traditional and modern markets in Denpasar. The same result was also reported by Lema and Jacob (2020) who found the addition of formalin to cob and mackerel at the Kupang City Market. This shows that traders' awareness of the non-permissibility of formalin as a food preservative is still very low.

Borax is a compound with the chemical name sodium tetraborate which is in the form of soft crystals of borax when dissolved in water will decompose into sodium hydroxide and boric acid. The actual use of borax is for glassmaking mixtures, wood preservatives, bark ointments, and plant fertilizer mixtures. The misuse of borax in food includes chewing on food such as meatballs, noodles, crackers and chips. Harimurti et al (2020) reported their findings that meatball samples in the Bantul area, Yogyakarta contained the harmful ingredient borax. Borax was also found in meatball samples in the Ciroyom Market area, Bandung (Sari et al., 2021). The danger of borax for health can cause disorders of the central nervous system, kidney and liver function.

Conclusion

Potential chemical hazards that can threaten animal origin food product in the form of antibiotic residues in beef, chicken, eggs and milk; excess nitrates and nitrites in beef; scombrotoxin in cob fish; pesticides and heavy metals in honey; and formalin and borax in chicken meat and fish. The results of this mapping can then be used as a basis for the preparation of food safety teaching materials.

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