

Proximate composition, amino acid composition and food product application of anchovy: a review

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Abstract

Anchovies are the small pelagic fish that belongs to the family of Engraulidae dominant all over the Indo-Pacific region, which account for human consumption and as feed for other larger fish. Anchovies are rich in macronutrients and micronutrients such as protein, carbohydrate, fat and amino acids. In addition, anchovy is composed of well-balanced amino acid compositions containing eight essential amino acids and eight non-essential amino acids. The nutritive value of anchovies has become the reason for numerous food applications. Proximate analysis is vital in the food industry for the development and quality controls of food products. Knowledge and information regarding the proximate composition of fish are essential in the food processing technology of fish products at commercial and industrial scales. Additionally, this review highlights both conventional and innovative anchovy-based food items. The review demonstrated that anchovies have several possible breakthroughs in the food industry, as shown by their proximate composition and the amino acid profiles used in various food items.

1. Introduction

Pelagic fish refers to fish that live and occupy the upper surface and, in the water, below 200 m in depth. They are among the largest habitat of marine fish, which account for the development of the global economy of marine ecosystems (Barange *et al.*, 2009; Tsighe *et al.*, 2018). In addition, small pelagic fish contribute to the total annual world fisheries catch of approximately 20%-25% (ICES, 2012). Some examples of small pelagic fishes are herring, sprats, pilchards, anchovies, sardine, mackerels, carangids, mullets and ribbon fishes (Rajan, 2018). However, anchovy, sardine and mackerel are the largest species that can be found in the area such as the continental coast (Stephenson and Smedbol, 2019). Anchovies are small pelagic fish dominant all over the Indo-Pacific region, which account for human consumption and feed for other larger fish (Andamari *et al.*, 2013).

Anchovies belong to the order Clupeiformes and the family of Engraulidae which consist of approximately 16 genera and 172 species (Nelson, 2006; Eschmeyer *et al.*, 2021). It is massively distributed in the Indian and Pacific Oceans and can be found in shallow coastal waters (Considine, 2005). The genera that accounted for

the majority of species commonly found are the genera of *Anchoa* which consist of 35 species, *Anchoviella* (15 species), *Stolephorus* (19 species) and *Thryssa* (25 species) (Whitehead *et al.*, 1985; Nelson, 2006). Anchovies are small to moderate-sized fishes with a length that can vary from 8 cm (*Stolephorus banganensis*) to 32 cm (*Setipinna brevifilis*) (Froese and Pauly, 2020). They vary in colour and are usually blue/green or brown on the back, with a silver flank and bright silver lateral stripe (Nizinski and Munroe, 2002).

According to the Food and Agriculture Organization of the United Nations (2017), anchovies and sardines constitute approximately 52% of small pelagic fish landing worldwide. In Malaysia, the landing of marine fish including pelagic fish in 2019 is reported to be 560,879 tonnes. From the amount, the landing of anchovy is reported for 28,894 tonnes (Jabatan Perikanan Malaysia, 2019). The major landing site of anchovy in Malaysia is Kelantan, Sabah and Kedah where Kedah accounted for 40% of the total landing. Meanwhile, anchovies capture is also located at Pulau Pangkor (Perak) and Pulau Perhentian (Terengganu-Kelantan border). The high landing of anchovies was recorded from the beginning of April to June, and from September

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to October (SEAFDEC, 2018). These fish are captured in large numbers in the coastal waters of Malaysia using anchovy's purse seines and lift nets (Jabatan Perikanan Malaysia, 2019).

According to SEAFDEC (2018), two dominant species that are commonly caught in the Southeast Asian region are shorthead anchovy (*Encrasicholina heteroloba*) and Indian anchovy (*Stolephorus indicus*). In addition, the most often found anchovies in Malaysia's coastal waters are from the genera *Encrasicholina* and *Stolephorus* (Jabatan Perikanan Malaysia, 2019) such as *Encrasicholina heteroloba* (*bunga air kepala pendek*), *Encrasicholina punctifer* (*bunga air*), *Stolephorus commersonii* (*bilis tembaga*) and *Stolephorus andhraensis* (*bilis andra*) and *Stolephorus Indicus* (Natalie, 2011; SEAFDEC, 2018).

Fish and other marine animals are some of the major commodities worldwide (Czerner et al., 2011). The consumption of fish would likely maintain health status and prevent diseases such as blood pressure, cancer and coronary heart disease due to its composition of amino acids, omega-3 highly unsaturated fatty acids (HUFA), eicosapentaenoic (EPA), docosahexaenoic (DHA) acids (Abraha et al., 2018). Fish such as anchovies are recommended to be consumed at least twice a week by the World Health Organization (WHO) and the United Nations Food and Agriculture Organization (FAO), according to their tremendous value of nutritional composition, which is beneficial to health (Food and Agriculture Organization of the United Nations, 2010).

Information about the proximate composition of anchovies is crucial to determine and identify the nutritive values, chemical changes and any reaction that could have happened during handling (Nielsen, 2006). It is essential to create information on the proximate composition of fish as it is one of the main protein sources in human nutrition (Mohanty et al., 2014). The composition of fish is influenced by its diet, feed rate, genetic strain and age (Sankar et al., 2013). The whole anchovy contains a potential nutritional value for health. Protein sources from fish are higher than other animal's protein sources and contain almost complete essential amino acids. Fish protein has shown an essential role in studies related to inflammation, metabolic syndrome, osteoporosis, and cancer (Czerner et al., 2011).

In addition, the nutritive value of anchovies has become the reason for numerous food applications. Therefore, understanding the chemical composition of fish is essential in the food processing technology of fish products on a commercial and industrial scale (Hantoush et al., 2015). Moreover, anchovies have been utilized in various food products; either traditionally or highly

processed food development. The overall purpose of this review was to provide a comprehensive overview of the proximate composition, amino acid composition and food application of anchovies.

2. Proximate composition of anchovies

2.1 Proximate composition of fresh anchovy

The quality of fish is evaluated by several factors such as colour, texture and nutritional composition (Anita et al., 2020). Generally, 66-81% moisture content, 16-21% protein, 0.2-15% fat, 1.2-1.5% minerals, and 0-0.5% carbohydrate make up the chemical composition of whole fresh fish (Mazumder et al., 2008). The proximate composition of small pelagic fish such as anchovies and sardines depends on the fishing season (Kudale and Rathod, 2015). In addition, the chemical composition of fish also varies according to age, sex, environment and fish feed and species (Boran et al., 2008; Herawati et al., 2018). Generally, Boran et al. (2008) have stated that anchovies are composed of 65.9–77.9% water, 12.8–19.8% protein, 1.81–15.3% fat and 1.5–2.3% ash. Table 1 shows the proximate composition of anchovies from four different genera of anchovy which is *Stolephorus* sp., *Encrasicholina* sp., *Coilia* sp. and *Engraulis* sp.

Anchovies are one of the perishable foods because of the high moisture content that provides a suitable medium for the growth of micro-organisms after their death. According to Table 1, the moisture content of fresh anchovies ranges from 75.56 to 81.00 g/100 g. Based on Table 1, the highest value of crude protein is shown by *Engraulis anchoita* (22.20 g/100 g), while the lowest value of crude protein is shown by *Stolephorus commersonii* (16.32 g/100 g). The value of protein in these species (>15%) showed that the fish is categorized as high-protein fish as those reported by (Abraha et al., 2018), where the standard proximate composition of fish protein is between 15-23%. The average protein content of the anchovy is comparable to the levels in Indian mackerel, Yellow stripe scad, Fringescale sardinella and Spanish mackerel as reported by Nurnadia et al. (2011).

Besides having an abundant amount of protein, anchovies are high in polyunsaturated fatty acids and phospholipids (Yilmaz and Koca, 2020). The previous study has reported fat content for different species of fresh anchovies, ranging from 1.62 – 3.50 g/100 g (Table 1), with the highest value, being from the species *Engraulis anchoita*. However, this difference may be due to feeding habits and time of catch, the season of capture, sexual maturity and geographical region (Abraha et al., 2018; Tsighe et al., 2018). In the same species, the fat content can also vary according to age variation and sexual maturity (Memon et al., 2010).

Table 1. Nutritional composition of different species of anchovies (fresh and dried form)

Species of anchovies	Nutritional Composition (g/100 g)						Reference
	Category	Moisture	Protein	Fat	Ash	Carbohydrate	
<i>Stolephorus commersonii</i>	Fresh fish	79.32	16.32	2.41	1.31	0.11	Palani Kumar et al. (2014)
	Dried Fish	20.33	63.67	3.73	12.17	0.10	Ahmad et al. (2018)
<i>Stolephorus heterolobus</i>	Fresh fish	81.00	19.32	1.62	1.90	ND	Abraha et al. (2017)
	Dried fish	9.00	60.20	3.08	8.60	ND	Abraha et al. (2017)
<i>Coilia dussumieri</i>	Fresh fish	75.56	17.24	2.57	1.40	ND	Madathil et al. (2017)
	Dried fish	12.45	68.82	7.84	7.98	ND	Madathil et al. (2017)
<i>Encrasicholina devisi</i>	Fresh fish	76.20	19.00	2.40	ND	ND	Reksten et al. (2020)
<i>Encrasicholina punctifer</i>	Dried fish	22.16	63.12	3.04	11.53	0.15	Ahmad et al. (2018)
<i>Encrasicholina heteroloba</i>	Dried fish	19.16	65.45	2.96	12.33	0.10	Ahmad et al. (2018)
<i>Engraulis anchoita</i>	Fresh fish	75.70	22.20	3.50	1.50	ND	Czerner et al. (2011)

ND, not determined

The average ash contents of fish species are between 1.0 to 3.92%. Based on Table 1, the previous study has reported that ash content for different species of anchovies ranges from 1.31 to 1.90 g/100 g, which falls within the range of ash content for fish. Ash is the inorganic residue resulting from the removal of moisture and organic matter by applying heat treatment. Mineral content in food is also represented by ash content (Kurniaty et al., 2018). Higher ash content indicates a higher value of mineral composition for human health (Magara et al., 2020). However, these concentrations of minerals and trace elements may be different due to feeding behaviour, environment ecosystem and migration (Andres et al., 2000).

According to Table 1, anchovy contains a relatively small amount of carbohydrate with the values reported are under 0.10 g/100 g, and almost no study reports the value of carbohydrate content in anchovies (Czerner et al., 2011; Abraha et al., 2017; Madathil et al., 2017; Rojas-De-Los-Santos et al., 2018; Reksten et al., 2020). According to Anthony et al. (2000), the carbohydrate content of fish is reported as significantly low. Hence, the carbohydrate composition in anchovies can be considered insignificant as the estimated value shows a considerable difference from other components.

Moreover, the variation of crude protein content, crude fat content and ash content between the species of the anchovies may be related to the feed intake of the fish. Different geographical locations and seasonal changes influence the chemical composition of fish muscle due to the availability of feeds (Shija et al., 2019). According to Boran et al. (2008), during the seasons of heavy feeding, the protein content of muscle tissue becomes slightly increased and causes a rapid increase in lipid content. On the other hand, starvation periods in which the period where a decrease in the amount of plankton that is consumed by anchovy can occur. As a result, anchovy may have a variation in its

proximate composition.

2.2 Proximate composition of dried anchovy

The drying technique has been applied to preserve the anchovies achieved by lowering water content that retards the growth of microorganisms, causing spoilage (Modibbo et al., 2014). Varying upon species and final desired product, the method of fish drying also varies. There are two common types of drying methods for anchovy, which are sun drying and solar drying. From Table 1, all dried anchovies, *Stolephorus commersonii*, *Stolephorus heterolobus*, *Coilia dussumieri*, *Encrasicholina punctifer* and *Encrasicholina heteroloba* were dried under sun drying technique. According to Abraha et al. (2017), during the drying of anchovy using both sun drying and solar drying technique, moisture content decreased meanwhile other proximate compositions such as crude protein, crude fat and ash increased.

Table 1 shows the value of moisture content of dried anchovies. From the values, the range of moisture content between the samples is between 9.00 g/100 g and 22.16 g/100 g. Jahan et al. (2019) reported that sun-dried fish usually have moisture content with an average of 10 to 20%. The range of moisture content of dried anchovy as reported in the table was included in the range. The difference in these values may be due to the duration and temperature of drying. Generally, the reduced moisture content of dried anchovy is due to the heat application during the drying period, which decreases the water activity in fish tissue (Kumar et al., 2017).

Meanwhile, the value of protein for dried anchovy is higher than the fresh form of anchovies. The data shows that amount of protein increase as the level of moisture content decrease, corresponding with the data reported by Aliya et al. (2012). The dehydration of water molecule that presents between protein leads to aggregation of the protein that causes the protein level to

increase (Ninawe and Rathnakumar, 2008). In addition, the increasing amount of protein as the fish is dried shows that protein nitrogen was not lost during the drying process (Foline *et al.*, 2011). A study by Ojutiku *et al.* (2019) has reported the highest value of protein in fish (62.5%) when dried under a solar tent dryer compared to traditional sun drying which gives a lower protein value (59.8%) on the fifth day of drying. Meanwhile, dried anchovies have a higher crude fat and ash content than the fresh form of anchovies (Table 1). The increase in these values is due to the reduction in moisture through heat processing (Chukwu, 2009; Tenyang *et al.*, 2020).

3. Amino acid composition of anchovies

Low-quality protein does not possess all the essential amino acids that are needed for the synthesis of protein. Meanwhile, high-quality protein is believed to have most of the essential amino acids required for the human body system function (Najafian and Babji, 2019). Amino acid is an important biomolecule that constitutes a building block of proteins and serves as intermediates in many metabolic pathways. It is mainly acquired from proteins in the diet. The amino acid ratio from essential amino acid to non-essential amino acid determines dietary protein quality (Mohanty *et al.*, 2014). Amino acids play a significant role in the synthesis of proteins with various essential functions such as transportation of oxygen, vitamins, carbon dioxide, enzymes and structural proteins (Chalamaiah *et al.*, 2012).

In addition, fish are being incorporated into fishmeal, fish sauce, fertilizer, animal feed and fish silage due to their enormous amino acid composition (Hamid *et al.*, 2002). Fish protein is considered a complete protein as it is only the protein source that contains a well-balanced amino acid composition that has eight essential and eight non-essential amino acids (Petricorena, 2014). Essential and non-essential amino acids are the two types of amino acids. Essential amino acids are those that the body cannot synthesize and must be acquired by diet. The essential amino acids are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine (Reeds, 2000). Meanwhile, non-essential amino acids are alanine, aspartate, asparagine, arginine, cysteine, glutamate, glutamine, glycine, proline, serine and tyrosine (Choi and Coloff, 2019).

Essential amino acids and non-essential amino acids are commonly found in fish species abundantly (Mohanty *et al.*, 2014). Amino acid depicts various physiological roles in the human body such as food intake regulation, gene expression and protein phosphorylation (Chalamaiah *et al.*, 2012; Machado *et al.*, 2020). For instance, a supplement with essential

amino acid methionine can regulate the body's metabolic process and act as intervenes in lipid metabolism in the body (Martínez *et al.*, 2017), histidine contributes to protein interaction and is a precursor of histamine (Mohanty *et al.*, 2014); leucine is the solely amino acid that can stimulate the synthesis of muscle protein (Etzel, 2004); lysine has shown to improve the growth performance in the body (Yang *et al.*, 2017) and threonine is essential in the improvement of nervous system disorder (Hyland, 2007). Meanwhile, the supplement of food with a non-essential amino acid such as alanine is essential in gluconeogenesis and leucocyte metabolism (Kudsk, 2006). In addition, serine plays a significant role in cell signalling, and arginine contributes to wound healing, cell division and maintenance of blood pressure. Glycine contributes to metabolic regulation and promotes the synthesis of protein (Mohanty *et al.*, 2014).

According to Ozden (2005), aspartic acid, glutamic acid and lysine are the major chemical constituent in fish and fisheries products. Dale *et al.* (2019) also reported that fish protein contains a high amount of essential amino acids lysine and leucine. Table 2 shows the amino acid composition of different species of anchovies. Sankar *et al.* (2013) stated that anchovies from species *Stolephorus commersonii* contain the highest composition of essential amino acid leucine, followed by valine and threonine. Glutamic acid, aspartic acid and glycine dominate the concentration of non-essential amino acids in *Stolephorus commersonii*. As reported by Gencbay and Turhan (2016) in Table 2, the most abundant essential amino acid in *Engraulis encrasicolus* are lysine, followed by leucine and threonine.

Ozden (2005) reported that anchovy muscle from species of *Engraulis encrasicolus* from the Marmara Sea contains high essential amino acid which is 44.31%. As mentioned, the nutritional composition may be different due to feeding behaviour, environment ecosystem and migration. For non-essential amino acids, Gencbay and Turhan (2016) reported that glutamic acid, aspartic acid and alanine are the major constituents in *Engraulis encrasicolus*. Among all essential amino acids, leucine, lysine and phenylalanine were found to be higher in *Stolephorus indicus*. Meanwhile, for non-essential amino acids, glycine, glutamic acid and arginine dominate the value (Taheri *et al.*, 2012). In addition, essential amino acids leucine, threonine and lysine and non-essential amino acids glutamic acid, glycine, and serine were found to be higher in *Stolephorus waitei* (Mohanty *et al.*, 2014).

Table 2. Amino acid composition (g/100 g protein) of selected species of anchovies from genus *Stolephorus* spp. and *Engraulis* spp.

Amino Acids	Different species of anchovies			
	<i>Stolephorus commersonii</i>	<i>Engraulis encrasicolus</i>	<i>Stolephorus indicus</i>	<i>Stolephorus waitei</i>
Essential Amino Acids				
Histidine	3.24	2.89	1.83	4.40
Isoleucine	4.64	3.36	2.74	4.20
Leucine	9.73	5.49	5.53	10.40
Lysine	4.55	9.34	4.54	5.70
Methionine	2.90	3.28	3.51	4.00
Phenylalanine	3.85	3.52	4.38	4.30
Threonine	6.37	4.43	3.98	7.90
Tryptophan	1.57	-	0.42	-
Valine	7.37	4.31	3.54	5.60
Non-essential Amino acids				
Alanine	9.05	10.46	7.04	4.10
Arginine	0.91	6.64	7.41	0.80
Aspartic acid	10.41	13.88	6.80	9.90
Cysteine	1.06	-	1.03	-
Glutamic acid	15.12	14.61	10.33	13.00
Glycine	10.73	8.31	17.20	9.80
Proline	1.57	3.25	7.20	1.80
Serine	6.42	4.56	5.64	7.20
Tyrosine	1.24	1.67	1.43	1.10
References	Mohanty <i>et al.</i> (2014)	Gencbay and Turhan (2016)	Taheri <i>et al.</i> (2017)	Mohanty <i>et al.</i> (2014)

-, not available

4. Application of anchovies as a food product

Over the past two decades, the demand for foods that is beneficial to human health has come globally, which is influenced by socioeconomic factors such as increasing population, life expectancy and healthcare cost (Sarojnalini and Hei, 2019). Anchovies are known as one of the essential parts of the human diet due to their essential nutrient provided and are particularly valuable for providing high-quality protein, better than those meat and egg (Balami *et al.*, 2019). Anchovies are as high-priced as food in most Asian countries (Andamari *et al.*, 2013). According to Nizinski and Munroe (2002), selected species of anchovies are valued as food, while other species are used as baits or as fish meals.

4.1 Traditional food products made from anchovies.

Traditional foods are defined as food that has been sustained through generations in diverse communities. It is the food cultures that have been retained in their original form, flavour and taste (Harmayani *et al.*, 2019). The existence of traditional products is mainly through preservation. In many regions of the world, access to refrigeration, ice or cold storage is limited. Thus, the absence of these accesses has led to a deterioration of freshly caught fish (Abraha *et al.*, 2017). Food preservation can increase food product shelf life under various techniques applied such as fermenting, dry salting, curing, smoking, canning, and freezing.

However, these methods stimulated the denaturation of protein, food structure alteration, colour changes, taste alteration and the existence of undesirable substances (Niakousari *et al.*, 2018). These products are in dried, salted, smoked, marinated, fermented, minced and powdered forms (Yeap and Tan, 2002). Common traditionally anchovies-derived foods are in dried form and through fermentation (Niakousari *et al.*, 2018).

4.1.1 Dried anchovy

Traditionally, anchovies have been processed into dried anchovies as it is vulnerable to deterioration after death. It is packed, layered on top of another and dried under sunlight (Karim *et al.*, 2017). Limited marketability of fresh form-anchovies has arisen due to their small size, nature of fishery season and temperature abuses (Xavier *et al.*, 2018). Several regions of the country and throughout the world have used the drying technique to preserve fish such as sun drying and open solar drying (Wang *et al.*, 2011). Drying fish by using solar methods is better than the traditional sun-drying method as it gives better quality of dried fish in terms of nutritional value and is more hygienic due to the reduction in insect infestation (Sablani *et al.*, 2002). In addition, the drying process could reduce the moisture content of fish and subsequently provide a stable protein source to people with limited access to fresh fish (Abraha *et al.*, 2017).

Figure 1 illustrates the basic drying process for anchovies (Paul *et al.*, 2018). The fish are freshly caught, washed, and dried by scattering on a mat laid on the ground or drying racks usually made of bamboo. Then, the fish are sun-dried for 3 to 5 days or until they are thoroughly dried, followed by the packaging. The addition technique involved either fresh washing fish in saltwater, drying or washing, boiling in saltwater, and drying under sunlight or artificial drying. The product shall be prepared by either washing fresh fish in saltwater and drying or washing followed by boiling in saltwater and drying. The drying process shall be utilizing sun-drying or artificial drying (Codex Alimentarius, 2001). Artificial methods involve the usage of mechanical or electrical equipment such as radiation drying that can remove a large amount of moisture efficiently (Maisnam *et al.*, 2017). A few countries in Southeast Asia, such as Thailand, Indonesia, and Malaysia, still traditionally dry anchovies under open sunlight as a technique of preservation (Chotimarkorn, 2014; Karim *et al.*, 2017).

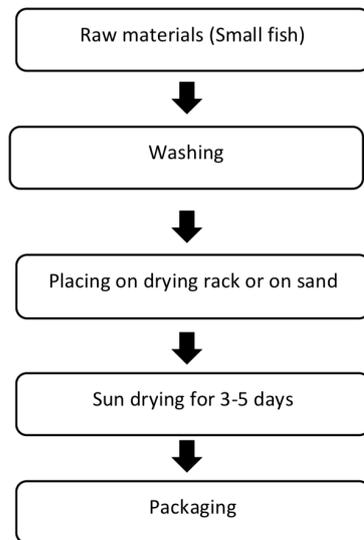


Figure 1. Flow chart for the basic and traditional process of dried small fish. Figure is adapted from Paul *et al.* (2018)

Anchovies are commonly dried and used in various cuisine. In Malaysia, the anchovies are immediately washed and boiled in a 10% brine solution upon landing, which then dried under sunlight (Karim *et al.*, 2017). In Indonesia, dried anchovies were processed by boiling in salt solution (3-4%) and subsequently dried in the open air (Dewi, 2002). Drying of anchovies may reduce nutritional quality, such as degradation of vitamin A, oxidized lipid, and protein degradation (Czerner *et al.*, 2011). Moreover, the product is easily exposed to contaminants during the open-air drying process. Hence, this technique is not adequately hygienic for the consumer (Wang *et al.*, 2011).

4.1.2 Fish sauce

Fermentation has been one of the standard preservation methods for many years in South Asian countries (Killinc and Sahin, 2015). Mohd Khairi *et al.* (2014) reported that fish sauce is a typical product made from the fermentation of anchovies. Fish sauce is a liquid condiment derived from fermented fish commonly consumed by Asian households in some regions and cultures (Tanasupawat and Visessanguan, 2014). It is not directly applied as a physiologically functional food because it contains a high amount of sodium chloride. However, fermented fish sauce is beneficial as a source of biologically active substances, food supplements in the diet, condiments and a replacer for soybean sauce (Watanabe *et al.*, 2004).

Generally, fish sauce is a salty liquid product produced by a combination of fish and salt in containers, which then undergoes a fermentation process that takes not less than six months (Codex Alimentarius, 2013). The primary raw materials used for fish sauce production are fish and salt (Lopetcharat *et al.*, 2001). Factors such as concentration of salt and fermentation time produce different quality of fish sauce as shown in Table 3. Fish sauce provides numerous amounts of protein for human consumption (Ahmad Puat *et al.*, 2015). The high-quality protein of fish sauce has almost all essential amino acids (Najafian and Babji, 2019). There are different processing methods of fish sauce, depending on the place, tradition, availability of raw material and consumer preference that portrays its unique taste and attribute (Dagadkhair *et al.*, 2016; Mohd Khairi *et al.*, 2014). According to Table 3, different world regions have different processing methods and names for fish sauce. In Malaysia, fish sauce is called *budu*, in Thailand, *nampla*, in Indonesia, *bakasang*, in China, *yulu*, in the Philippines, *patis*, in Cambodia, *Nouc-mam*, in Japan, *shotshuru* and Korea, *aekjeot* (Sim *et al.*, 2015).

According to Table 3, *budu* is a brown liquid fish sauce ubiquitous as a condiment in Malaysia, particularly in East Peninsular Malaysia - Kelantan and Terengganu (Mohd Khairi *et al.*, 2014). Anchovies (*Stolephorus* spp.), locally known as *ikan bilis*, are the main constituent of *budu* manufacturing. Primarily, *budu* is made by combining salt and raw anchovies in a ratio of 3:2 to 3:1 (Huda, 2012). The mixture is allowed to ferment for 6 to 12 months at ambient temperature (30-40°C) (Sim *et al.*, 2015). Besides, anchovies are used as the main ingredient of fish sauce in Thailand. *Stolephorus dubiosus* is usually used as the main raw material to produce a fish sauce. Meanwhile, in Indonesia, *Rusip* is a typical food made from fermented anchovy fish. Other ingredients are added in the manufacture of salt *Rusip* such are palm sugar, which then kept for two weeks before it can be served as side

Table 3. Name and processing methods of fish sauce in different regions

Country	Name	Species of anchovies and fish used	Ratio of salt: anchovies/ Duration of fermentation	References
Malaysia	<i>Budu</i>	<i>Stolephorus</i> spp.	3:2 to 3:1/ 6-12 months	Huda (2012); Sim <i>et al.</i> (2015)
Thailand	<i>nampla</i>	<i>Stolephorus dubiosus</i> <i>Ristrelliger</i> spp. <i>Cirrhinus</i> spp.	1-5:1/ 5-12 months	Lopetcharat <i>et al.</i> (2001)
Indonesia	<i>Rusip</i>	<i>Stolephorus</i> spp. <i>Clupea</i> spp. <i>Leiagnathus</i> <i>Osteochilus</i> spp.	6:1/ 6 months	Lopetcharat <i>et al.</i> (2001); Mohd Khairi <i>et al.</i> (2014); Koesoemawardani (2012)
China	<i>yu-lu</i>	<i>Engraulis japonicus</i>	1:3/ 8-12 months	Jiang <i>et al.</i> (2007)
Philippines	<i>patis</i>	<i>Stolephorus</i> spp. <i>Clupea</i> spp. <i>Decapterus</i> spp. <i>Leionathus</i> spp.	3:1/ 9-12 months	Sanceda <i>et al.</i> (1996); Lopetcharat <i>et al.</i> (2001)
Cambodia	<i>Nouc-mam</i>	<i>Stolephorus</i> spp. <i>Ristrelliger</i> spp. <i>Engraulis</i> spp. <i>Decapterus</i> spp.	3:1-3:2/2-3 months	Lopetcharat <i>et al.</i> (2001)
Korea	<i>aekjeot</i>	<i>Engraulis japonicas</i>	3:1/more than 6 months	Jung <i>et al.</i> (2016); Lee <i>et al.</i> (2016);

dishes (Koesoemawardani, 2012).

4.2 Innovative food products made from anchovies.

Innovation is defined by the introduction of something new and beneficial (Fagerberg, 2004). Innovative and exceptionally processed food is outlined as a substitution for traditional and less processed food (Scrinis, 2016). Functional food that is inexpensive has well-balanced nutrition and has an acceptable sensory composition is demanded worldwide, and complements fish and fish products (Petricorena, 2014). According to Paradkar *et al.* (2007), market interest in fish-based innovative food products has skyrocketed due to the growing population, rapid urbanization, and diet behaviour. Despite the continuous demand for fish-based products, only half of the fish catch is used for consumption, and the other 25% is meant for waste (Šilovs, 2018). Thus, fish consumption can be increased by yielding processed and manufactured fish-based products with a high nutritional value (Neiva *et al.*, 2011).

4.2.1 Anchovy cube

A food cube is a cubic form of broth, a mixture of dry ingredients (Adjangba *et al.*, 2020). Bouillon cubes are widely used as a taste enhancer in various cuisine (Akpanyung, 2005), such as condiments, gravies and soup. Commercially available bouillon cubes include chicken, beef, mushroom, pork and seafood cubes (Chiang *et al.*, 2007). Anchovy cube is a bouillon cube product made from anchovies, which has been commercially sold as food seasoning or enhancer. The combination of long-boiled anchovies and spices mixture of anchovies' cube gives a depth flavour to any dishes. Generally, the bouillon cube is composed of salt (NaCl)

and monosodium glutamate (MSG) (RMRDC, 2003). Anchovy cube mainly contains salt and anchovies as the main ingredient.

Producing the cubes started with grinding and mixing the dry ingredients until homogenous before shaping them into cubes using a machine and packed (Gupta and Bongers, 2011). While most bouillon cubes are low in protein content, anchovy cube is the alternative product that supplies generous protein intake through consumption and produces a high value of the anchovies-based product. A study has made a similar product by Ismail and Sahibon (2018), where fish (threadfin bream) hydrolysate is incorporated into bouillon cubes. The addition of the fish hydrolysate in the cubes is acceptable in terms of its physicochemical and functional properties.

4.2.2 Anchovies stock seasoning powder.

Stock is the basic ingredient for sauce and soup, made from the combination of bones, vegetables and herb extracts (Hayter, 1992). The commercial stock is in the powdered form and called the base. Similar to a bouillon cube, powdered seasoning is a food ingredient that is added to cuisine as a flavour enhancer. It is commonly used in food preparation (Ajayi *et al.*, 2013). The available commercial products on markets are beef, chicken, vegetable, fish, lamb and herbs stocks. Anchovies have been employed in stock seasoning powder, which has great value in the market, equivalent to those well-known commercial products. It is in a dried powdered form that has a low moisture content, thus, it stable at room temperature and not vulnerable to oxidative spoilage. Hence, the powder can be stored and used for a longer time (Intipunya and Bhandari, 2010;

Farzana et al., 2017).

The powdered seasoning stock usually includes salt, sugar, dehydrated vegetable, yeast, spices, and any protein-source powder such as chicken, meat and fish. Food powder production generally includes drying (spray drying, freeze-drying) and grinding (Mareta et al., 2019). Most of the readily available soups or sauces do not have enough nutritional value, which can be elevated by adding protein or other mineral and vitamin sources. Incorporating anchovies has augmented the nutritional aspect of powdered seasoning as anchovies contain a high value of protein. A few studies have been using fish protein sources such as silver carp (Islam et al., 2018), a by-product of tilapia (Monteiro et al., 2014), *Sardinella Longiceps* (Udari et al., 2015) as a supplementary in stock seasoning or soup base powdered.

4.2.3 Anchovy bun

Bread is a baked food product made from flour and other ingredients that went through the fermentation and baking process. It is the staple food of most countries due to its high value in carbohydrates. The common types of bread available in the market are high protein white bread, sourdough bread, unleavened bread, French bread, wholemeal wheat bread, soft grain bread etc. (Carocho et al., 2020). A few commercial loaves of bread have been added with anchovies, which have high nutritional value and complement consumer preference. Commercially, a rounded type bun has been added with chillies anchovy or known as *sambal bilis* inside the bun. It is a type of quick meal and ready to eat food product that gives a savoury taste.

4.2.4 Anchovies snack

Snack is a ready-to-eat food popular with consumers and has been a part of a human's diet pattern. Various snacks are commercially available in the market, such as chips, extruded snacks, pretzels, nuts, meat snacks, multigrain chips and more. (Riaz, 2016). One of the popular dish-based snack foods in Malaysia, known as *keropok*, is an example of a snack product made from fish (Taewee, 2011). A few snacks including extruded anchovy snack and snack nut anchovy are types of snack products added with anchovy. Incorporating anchovy into snack products can be an added value to the product in terms of nutritive value because it has an excellent source of protein, omega 3 fatty acids, vitamins and minerals (Shaviklo et al., 2011). A few studies have demonstrated that it is possible to develop snack food fortified with anchovies which are anchovy stick snacks (Kurniaty et al., 2018), cheese stick incorporated with anchovy powder (Assa et al., 2019), tempeh stick added with anchovy (Anna and Nursalim, 2020). Therefore, the

conversion of anchovies to powder form has enabled its use in the production of various other food products.

4.2.5 Anchovies fritter (*cucur bilis*)

Fritter is a flour-based snack that contains wheat flour as the main ingredient. It is a low priced-food that is usually sold in public places. Different types of fritters are produced, such as banana fritter, cassava fritter, sweet potato fritter and vegetable fritter. Common ingredients added to the fritter are wheat flour, water, sugar, salt and spices. The product is made by deep-fried battered mixture at 150-180°C until it reaches golden brown colour (Pratama and Jacxsens, 2019). The product has a distinct taste contributed by its crisp surface, fried flavour and loose texture (Fan et al., 2016).

Anchovy fritter or locally known as *cucur bilis* is the product made with the addition of anchovy that can be in powder or whole forms (dried) that elevated the nutritional value of the product and provided a unique taste. Demands for functional food derived from fish protein sources are gradually escalated worldwide (Sarojnalini and Hei, 2019). Hence, the development of instant anchovy fritter gives convenience to the consumer is available in the Malaysian market. The anchovy fritter can be done by adding water to the flour, followed by deep-frying in oil. Similarly, a past study by Alamu et al. (2018) has incorporated soybean flour into a fritter to increase the added value of the product.

5. Conclusion

Proximate composition and amino acid composition of anchovies are presented in this review in addition to their application in food products. It is highlighted that anchovies from different species contain different values of proximate composition and amino acids. The difference in these values may be due to different factors such as sexual maturity, age, fish feed and environment. From this review, several anchovy-based products are already available in the market that gives a promising application in functional food ingredients. For example, both anchovies powdered and cubes were available in the markets and became very popular as a flavouring or seasoning ingredient in cooking. Anchovy-based products have breakthrough potential in food industries due to their high nutritional value, which gives added value to the products and offers a distinctive taste of anchovies.

Conflict of interest

The authors declare no conflict of interest.

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