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Indonesian Traditional Fermented Fish *Ikan Peda*

Processing, Quality, and Utilization Improvements

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129.1 Introduction

As an archipelagic country, Indonesia is not only abundant with fisheries resources, but also rich in various types of fish-processing methods, including traditional processing practices. One of the traditional fish processing methods is fermentation, and there are many kinds of fermented fish products which can be found in many parts of Indonesia. The most popular fermented fish products in Indonesia are *ikan peda* (moist salted fish), *terasi* (fermented fish or shrimp paste), *kecap ikan* (fish sauce), and *ikan jambal roti* (moist salted split fish). Some other fermented fish products are *bekasang* (fermented fish entrails) from North Sulawesi, *bekasam* (fermented rice-fish) from South Sumatera, *cincalok* (fermented rice shrimp mixture) from West Kalimantan and Riau, and *wadi* (fermented freshwater fish) from South Kalimantan. These products have special consumers in Indonesia, since they provide unique characteristics including specific flavor and texture.

Van Veen (1953) described the history of ikan peda, in which the product was originally salted fish exported from Thailand to Malaysia and Indonesia. That product arrived in Indonesia in very large bamboo crates where it could be held for months. The fermentation process occurred during transportation or shipment and generates changes chemically and microbiologically to salted fish, transforming the product into fermented fish which is then called ikan peda. The product can be kept for a few weeks or a couple of months at most, depending on the quality.

Ikan peda is a very popular product in Java Island, especially in West Java. Physically and in flavor, this product is quite different from other fermented fish products and even from other traditional fish products such as *ikan asin* (dried salted fish), *pindang* (boiled salted fish) or *ikan asap* (smoked fish). For most Indonesians consuming rice, the flavor of ikan peda is able to raise their appetite. Due to the high salt content, ikan peda is normally consumed in limited portions. Consumers of this product come from almost all strata of society, ranging from low to high income.

Ikan peda manufactured through the fermentation process is a way to preserve the fish catch. Ikan peda is produced by processors which can be found along the coast of Sumatera and Java islands with uncomplicated technology and using simple equipment. Basically, the method of ikan peda processing is a salting process with two salting steps, in which each salting step is carried out for a certain period. The first salting is normally performed for

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several days and known as the first fermentation. The second salting takes several weeks to develop flavor and texture, and this step is called the second fermentation (Irianto, 1990). This type of salting process makes ikan peda different from ordinary salted fish, particularly in terms of flavor and texture, making it more suitable to be classified as a fermented fish product than salted fish.

129.2 Processing of Ikan Peda

So far there is no a standard prescribed method of ikan peda processing, but some methods which are employed by traditional processors have been described by Winarno et al. (1973), Sjachri and Nur (1977, 1979), Hedrawan (1981), Irianto (1990), Huda (2012), and Hakim (2016). In fact, processing methods might be different from one place to another or even from one processor to another.

Van Veen (1965) noted that in ikan peda making, the fish are salted, kept for 12–24 hours, washed, and then dried superficially. Sometimes more fresh salt is added and the mixture is carefully packed in large crates, in which it undergoes a maturing or ripening process which takes a number of weeks or months. Sjachri and Nur (1977) said that ikan peda in Central Java and East Java is made to preserve the fish during the peak season to prevent spoilage and to avoid the low price obtainable at that time in the market. Processors make ikan peda by soaking the fish in saturated brine in concrete tanks for an indefinite period until the price in the marketplace rises.

In general, the processing method of ikan peda is divided into two stages: the first and the second fermentation (Winarno et al., 1973; Hanafiah, 1987; and Irianto, 1990). The first fermentation is to develop the characteristic flavor and texture of ikan peda, while the second fermentation is principally a maturation phase (Irianto and Irianto, 1998). The basic method of ikan peda processing is outlined in Figure 129.1. Firstly, the fish are cleaned by washing with fresh water and then drained. Subsequently the fish are soaked for three days in salt (about 25% of the total fish weight) in a salting tank. This process is known as the first fermentation. After this, the fish are washed with fresh water and drained. The drained fish are then put in a wooden box, arranged in

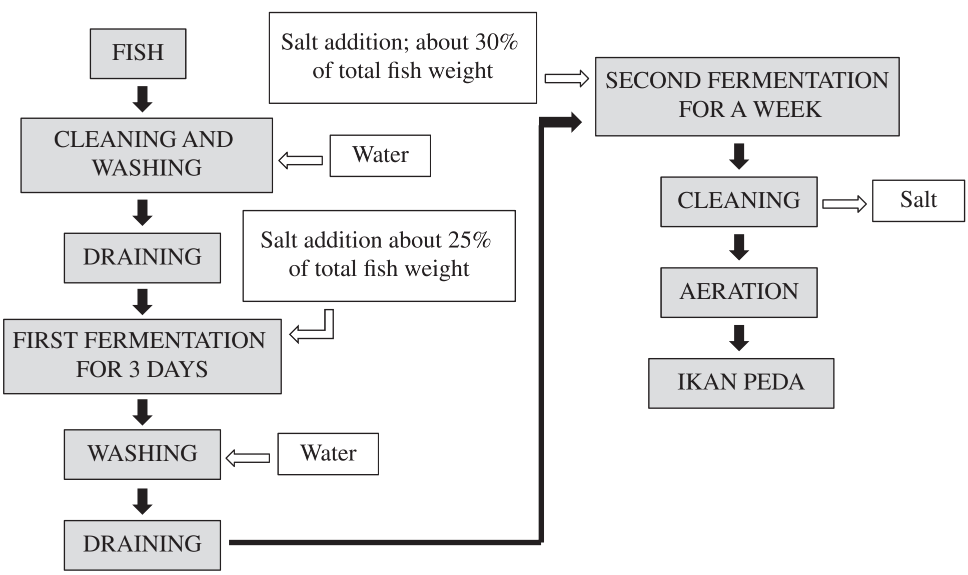

Figure 129.1 Process flow of ikan peda (Adapted from Irianto, 1990).

layers between dry banana leaves. Salt is sprinkled between layers until the total amount of salt is around 30% of the fish weight. The box is then covered with banana leaves and the fish is allowed to ferment for one week or more, until the specific aroma of ikan peda is obtained. This process is called the second fermentation. The last step of the process is to remove the salt from the fish and subsequently the fish are aerated to get the desired moisture content.

Ikan peda is described as a fatty, partly dried salty fish with reddish-brown color, and as being moist and slightly pasty with a flabby texture and a specific flavor which is cheesy, tasty, salty, and often mixed with a mild rancid flavor (Putro, 1993). Texture developments in ikan peda is affected by fat content and the presence of proteolytic enzymes in which their activities contribute to the changes in fish, resulting in the specific unique texture of ikan peda called *masir* (Paparang, 2013).

129.2.1 First Fermentation

The first fermentation is a salting process as employed in the manufacture of dried salted fish. During salting, water from inside the fish is drawn out into the strong salt solution outside the fish. As the water moves out, the salt moves in, penetrating deeply into the flesh of the fish (Tuara, 1997). Therefore, the main feature of salting is basically the removal of some water from the fish flesh and its partial replacement with salt. The salt penetrates the fish flesh because of the osmotic pressure differences in the fish and the salt surrounding the fish and at the same time the water is pushed out to be released from the fish. The water dilutes the coarse salt and forms pickled brine which covers the fish at the end of the first fermentation. The loss of a large portion of water results in the weight loss and shrinkage of the fish and the salt which has passed in can coagulate the protein. The salt concentration outside the fish is an important factor affecting the rate of salt penetration, in which more rapid osmolysis and removal of moisture take place at higher salt concentration. The salt dissolves in the extracted water and forms a highly concentrated solution at the surface of the fish (Irianto, 1990; Horner, 1997). Irianto (1994) found that salt content of fish increased during the first fermentation, while moisture content, water activity (a_W) value, and pH decreased. Those changes occurred rapidly during the first two days of fermentation and significant changes continued until the fifth day of fermentation. A longer fermentation period tended to exhibit insignificant changes. At the end of the first fermentation, a_W of fish achieved 0.764 which was suitable for halophilic bacteria growth.

The salt amount used in the first fermentation affects the success of the fermentation process. Winarno et al. (1973) noted the use of salt at around 25% of the total fish weight for the first fermentation, while Hedrawan (1981) reported the use of salt as 20–25% of fish weight. Sukarsa (1979) and Hanafiah (1987) used about 30% of the total fish weight of salt in the first fermentation for their experiments. On the other hand, Menajang (1988) and Eva and Untari (2014) used 10% salt in ikan peda made from mackerel and failed to produce satisfactory ikan peda, because the fish became rotten.

129.2.2 Second Fermentation

The second fermentation in the processing of ikan peda is also known as the "maturation process" or "ripening process" (Hanafiah, 1987; Menajang, 1988). Theoretically, the ripening process can be described by three hypotheses: (1) microbiological theory; (2) autolytic theory; and (3) enzyme theory. In microbiology theory, the microbes produce the essential active enzymes and these penetrate into the flesh and contribute to its ripening. The autolytic theory explains that ripening is a result of the activity of enzymes of the muscles or other tissues, or of the gastrointestinal tract. The last theory, the enzyme theory, describes the ripening of salted fish as taking place under the influence of certain enzymes, namely those contained in the muscle tissue and in the intestinal body organs of the fish, together with those produced by microorganisms (Voskresensky, 1965). A certain degree of rancidity is both necessary and desirable for sufficient ripening of the product. The rancidity process can be classified into two types, namely the enzymatic process and non-enzymatic process. Enzymatic rancidity can occur in fish, but the levels of lipolytic enzymes in the muscle are low in lean types of fish. The non-enzymatic rancidity is auto-catalytic and is most significant during the storage of fish product (Bjorkevoll et al., 2008).

Basically, the ripening process is the sum of biochemical processes that cause the changes in chemical and physiochemical characteristics of the tissue typical of the product. These changes are induced by enzymes which break down both protein and fats into simpler compounds. The rate of ripening of salted fish depends upon type, quality and original chemical composition of the raw fish; the salt composition, salting method and condition employed; and the amount of salt in the fish tissue (Suwandi, 1988; Irianto, 2012; Bjørkevoll et al., 2008).

Farid et al. (2016) revealed from their study using three different sizes of freshwater fish, namely shol (*Channa striatus*), taki (*Channa punctatus*), and tengra (*Mystus tengra*), that ripening of the dry-salting process had a positive significant role on the biochemical and mineral composition of the fish and reduced bacterial load as well as made them nutritionally suitable for all. After the ripening period, the values of moisture (%) and pH were decreased whereas protein (%), fat (%), ash (%), salt (%), TVB-N, FFA (%) and mineral content (Ca, Mg, Fe, Cu, Zn, Mn) increased significantly in these three fish. The decrease in total bacterial count may be due to the presence of high salt concentration, so the pathogenic microorganism growth can probably be controlled. Irianto and Brooks (1994) reported that changes in salt content, moisture content, aW value, and pH of ikan peda during the second fermentation occurred over an eight-week fermentation period and further fermentation process would give relatively constant values for those parameters.

129.3 Microbiology and Enzymes of Ikan Peda

Bacteria play an important role in the fermentation process of ikan peda. The qualitative microbiological analysis of fish during salting revealed that the genus *Micrococcus* is predominant and that its ratio increases gradually from 40% to approximately 90% of total number. Simultaneously an appreciable reduction is observed in the other genera which are named in the following order of importance: *Flavobacterium, Achromobacter, Pseudomonas, Bacillus*, and *Sarcina* (Dussault, 1958). The salting treatment reduces the water activity of fish from about 0.98 to about 0.70–0.75. At this water activity range, the only possibility is the growth of halophilic bacteria, xerophilic mold, and osmophilic yeast (Smith, 1989). Fortunately, most pathogenic bacteria are not salt tolerant, so they can be destroyed during salting (Weiser and Mountney, 1971). Andriyani (2005) obtained 28 halophilic bacteria isolated from salted fish, and identified them as the genera of *Pseudomonas, Chromohalobacter, Halobacter, Deleya, Bacillus, Salinococcus, Marinococcus*, and *Kurthia*.

The role of microorganisms in the fermentation process of fish is different from that in fermented vegetable products. The high salt content of these products allows only salt-tolerant microorganisms to survive (Rose, 1982); for example, ikan peda has 9–35% salt (Syachri and Nur, 1977).

Fermentation in ikan peda is carried out mainly by halophilic bacteria (Winarno, 1973). Halophilic bacteria in ikan peda have various responses to the salt level as noted by Suwandi (1988), in which isolated halophilic bacteria show optimal growth in media containing

0–15% salt. Hanafiah (1987) reported that Gram-positive bacteria are predominant in the processing of fermented fish ikan peda and some were identified as lactic acid bacteria. Suwandi (1988) isolated halotolerant bacteria from ikan peda purchased from the market and revealed that bacteria growth in ikan peda was characterized as the Gram-positive cocci, which were non-motile, aerobic or facultatively aerobic, catalase positive, non-idole producers, and oxidase negative. They can utilize citrate as the only carbon source, ferment glucose, and show proteolytic activity, and some of them are able to reduce nitrate. These bacteria can be classified as mesophiles and require the pH of the medium to be around 6–8. They show variation in salt tolerance and they can be divided based on salt tolerance as weak, moderate, and halotolerant bacteria.

Idawati (1996) obtained seven isolates of lactic acid bacteria from ikan peda made in the laboratory. Identification showed that those isolates were two isolates heterofermentative *Lactobacillus* sp., one isolate homofermentative *Lactobacillus* sp., three isolates *Leuconostocs* sp., and one isolate *Streptococci* from enterococci group. Those bacteria demonstrated their antibacterial effects of being able to inhibit the growth of *Pediococcus fluorescens*, *Alkaligenes* sp., *Staphylococcus aureus*, *Listeria monocytogenes*, *Vibrio parahaemolyticus*, *Escherichia coli*, and *Salmonella typhii*. Heterofermentative and homofermentative *Lactobacillus* were able to inhibit the growth of those bacteria. Heterofermentative *Lactobacillus* showed higher inhibiting activity to the growth of *P. fluorescens*, but homofermentative *Lactobacillus* had more inhibiting effect on the growth of *Alcaligenes*. H_2O_2 is suspected as a main antimicrobial compound produced by *Lactobacillus* for inhibiting the growth of *P. fluorescens* and *Alcaligenes*.

Savitri (2006) harvested six isolates of halotolerant bacteria from ikan peda made of short-bodied mackerel (*Rastrelliger negletus*). Those isolates were characterized as non-pathogenic *Staphylococcus* sp. The bacteria are suspected of being responsible for the formation of specific flavor in ikan peda. Indriati et al. (2006) obtained four isolates of lactic acid bacteria from commercial ikan peda, in which those isolates were demonstrated to have antibacterial activities against *Escherichia coli, Bacillus cereus, Pseudomonas aeruginosa*, and *Staphylococcus aureus*. In a previous study, Indriati et al. (1999) isolated *Lactobacillus vitulinus* and *Pediococcus damnosus* from ikan peda.

Sarnianto et al. (1984) reported that the number of **total plate count (TPC)**, *Lactobacillus*, and *Staphylococcus* of ikan peda were $3 - 10 \times 10^5$, $0.08 - 0.2 \times 10^2$, and $0 - 2 \times 10^2$ cfu g^{-1} respectively. In addition, Syafii (1988) revealed from commercial ikan peda that the number of TPC, halophilic bacteria, proteolytic bacteria, lipolytic bacteria, acid-forming bacteria, and yeast or mold were present at 4.8 – 4.48, 3.08 – 5.26, 4.11 – 5.50, 3.93 – 5.54, 3.99 – 4.93, and 1.00 – 3.00 log cfu g^{-1}, respectively.

The gut has a significant contribution in the fermentation of ikan peda, since most microbiological and enzymatic activities take place in the gut. Most of the lipolysis and proteolysis activities in the processing of ikan peda occur in the gut, especially at the beginning of the fermentation process (Irianto and Giyatmi, 2002). Hasan (2015) reported that activities of protease and lipase extracted from short-bodied mackerel guts varied with pH value and salt concentration. Protease activity at pH 11 (1.610 μmol ml^{-1}) and salt concentration 6% (0.869 μmol ml^{-1}) showed the highest activity; and pH 10 (0.031 μmol ml^{-1}) and salt concentration 15% (0.073 μmol ml^{-1}) was the lowest activity. Lipase activity at pH 4 (2.428 μmol ml^{-1}) and salt concentration 3% (4.131 μmol ml^{-1}) was the highest activity; and pH 11 (0.042 μmol ml^{-1}) and salt concentration 15% (2.237 μmol ml^{-1}) was the lowest activity. The protease and lipase activity decreased with the increase in salt concentration. This indication was also observed by Irianto (1990) in his study that the enzyme activities in the guts of ikan peda fell rapidly during the process, which may be due to increasing salt content in the gut. The enzyme activity in the flesh was relatively more stable than in the gut, and was probably maintained by the enzyme released by bacteria and enzymes moving from the gut. The proteolytic, lipolytic, and lactic acid bacteria probably contribute significantly only at the beginning of the fermentation, since their number tended to decrease, some disappearing completely after a period. The lipolytic bacteria seemed to predominate in both the flesh and the gut after the sixth day of second fermentation. Both lipolytic enzymes and proteolytic enzymes were still active until the end of the second fermentation. It is suggested that the lipolysis process occurs microbiologically and enzymatically, that the proteolysis is mainly the result of leakage of gut enzymes. This further suggests that probably the lipolysis process plays the main role in developing the flavor of ikan peda. Therefore, leaving the gut is desirable to produce ikan peda with a stronger flavor.

Yeni (2005) has successfully identified histamine-producing bacteria from ikan peda made of short-bodied mackerel; those are 19 types of bacteria which are 8 types of Gram-positive rod bacteria (*Bacillus* spp., *Brevibacterium mcbrellneri*, *Brevibacterium otitidis*, *Clostridium* spp., *Carnobacterium alterfunditum*, *Corynebacterium nitrilophilus*, *Corynebacterium* spp., and *Microbacterium testaceum*), 7 types of Gram-negative rod bacteria (*Aeromonas* spp., *Brevundimonas vesicularis*, *Enterobacter* spp., *Routella terrigena*, *Serratia rubidae*, *Vibrio alginoluticus,* and *Vibrio aestuarium*), and 4 types of Gram-positive cocci bacteria (*Micrococcus diversus*, *Staphylococcus* spp., *Staphylococcus lentus*, and *Streptococcus* spp.). There are more types of histamine-producing bacteria in the flesh than in the stomach contents, namely 15 species and 11 species, respectively. Indriati et al. (2006) reported that the predominant histamine-producing bacteria during the period of intensive histamine production in ikan peda were *Enterobacter* spp and *Staphylococcus* spp. *Enterobacter* spp originated from raw fish, both in the flesh and in the gut, while *Staphylococcus* spp seemed to be contaminant during processing.

129.4 Chemical and Nutritional Properties of Ikan Peda

The proximate composition of ikan peda according to Poernomo et al. (1984) is 50.35% moisture, 26.67% protein, 6.36% fat, 2.9% carbohydrate, and 18.89% ash. Sjachri and Nur (1977) noted that chemical composition of ikan peda obtained from several places in Indonesia is 41.16–61.68% protein, 3.45–8.56% fat, 42.39–52.12% moisture, 14.02–18.41% ash, and 9.13–34.80 % salt. While nutritional composition of ikan peda as described by Soedarmo and Sediaoetama (1984) is 46% moisture, 28% protein, 4% protein, 156 calorie/100 g, 174 mg/100 g calcium, 316 mg/100 g phosphor, 3.1 mg/100 g iron and 110 IU/100g vitamin A.

Syafii (1988) reported that the moisture and salt contents of commercial peda were 44.02%–53.12% and 18.03%–21.95%, respectively. Sarnianto et al. (1984) informed that the moisture and salt contents of ikan peda purchased from the market were 49.42%–56.78% and 10.99%–14.41%, respectively. In addition, the salt content of ikan peda is also informed by Murdinah et al. (1983), Savitri (2006) and Poernomo et al. (1984), i.e. 5.16%, 11.4% and 13.72% respectively. The above data demonstrate that ikan peda found in the market have a very diverse salt content which may induce differences of microorganisms growing in ikan peda from one product to another as well as salty taste levels of the product.

Hanafiah (1987) noted that relative amounts of omega-3 fatty acids C20:5 (eicosapentaenoic acid/EPA) and C22:6 (docosahexaenoic acid/DHA) of ikan peda were 10.51 and 24.81% fatty acids respectively. The fatty acid profile of raw fish seemed to be retained in the ikan peda after the process, although some were significantly changed in terms of percentage. The profile of fresh fish compared to that after salting in the first fermentation, pronouncedly reduced the **polyunsaturated fatty acids (PUFA)**, particularly the omega-3 highly unsaturated fatty acids, namely C22:6 and C22:5. However, C20:5 fatty acid was more stable during the first fermentation than other omega-3 fatty acids. The maturation process in the second fermentation induced reduction of two fatty acids of PUFA group, i.e. C20:4 and C22:5.

129.5 Processing, Quality, and Utilization Improvements

Upgrading of the quality of ikan peda through improvements in the processing method should be carried out with regard to the assumptions of the criteria of good quality ikan peda as follows (Hendrawan, 1981):

1) Tasty taste and aroma are suspected due to the presence of methyl ketone compounds and volatile fatty acids.
2) The taste is not too salty, but if the salt is used in small quantities may lead ikan peda being quickly spoiled. The presence of lactic acid will help to keep the product longer.
3) Besides salty taste, ikan peda also has a slightly sour taste, and the right mixture of sour taste and salty taste will result in delicious taste of ikan peda.
4) The texture of ikan peda is solid but not easily broken and the product has a good enough shelf life.

Efforts which have been made to improve the traditional processing method of ikan peda are aimed at optimizing processing efficiency and obtaining better quality products, especially in terms of product sensory acceptability by consumers. Processing efficiency improvements are concentrated to modify the first and second fermentation steps of the method which were usually applied by processors. Product acceptability improvements of ikan peda can also be conducted through raw material quality improvement, diversification, and evisceration, as well as introduction of suitable packaging materials. More utilization of ikan peda can be performed by developing culinary or new food products which will be able to provide more variety of products to purchase and consume by consumers.

129.5.1 Diversification of Raw Material

Ikan peda is commonly processed from marine fish, particularly mackerel from the species of *Rastrelliger brachisoma* and *Rastrelliger negletus* (Sjachri and Nur, 1979; Tedja and Nur, 1979). In general, ikan peda is better prepared from fatty fish. Fatty fish will produce ikan peda that is better than fish having low fat content. During the fermentation process, fats undergo chemical changes that produce a unique flavor. Therefore, fatty fish will produce ikan peda with strong flavor as the result of chemical reactions involving fat. The surface of ikan peda made from fatty fish is brown, while ikan peda processed from low-fat fish have tangibly less brown color (Irianto, 2012).

Diversification of raw materials from marine fish used for manufacturing ikan peda has been performed by utilizing sardines (*Sardinella* sp.), scads (*Decapterus* sp.), bigeye scads (*Caranx* sp) (Rahayu et al., 1992), mullet (*Aldricetta forsteri*) (Irianto, 1990), and indian scad (*Decapterus russelii*) (Paparang, 2013). Besides the size being similar to mackerel, mullet is also suitable as a raw material in the processing of ikan peda. This is because of mullet has a fairly high fat content, which is 4.47% (Irianto, 1992), while the fat content of short-bodied mackerel was 2.68% (Menajang, 1988). Freshwater fish which have been used as raw materials in the processing of ikan peda are tilapia (*Tilapia mossambica*), common carp (*Cyprinus carpio*), and kissing gourami (*Pontius javanicus*). However the quality of ikan peda produced is not like ikan peda that is processed from marine fish (Sukarsa, 1979).

129.5.2 Use of High-quality Raw Material

Striped mackerel and short-bodied mackerel are raw materials mostly used to produce ikan peda. Those fish are classified in the scromboid fish families, related to scromboid poisoning due to the high amount of free histidine in the fish flesh which usually occurs in fish that have deteriorated or declined in the quality of freshness. Heruwati et al. (2004) reported that delaying processing of the fish kept in ice increased histamine content in fish. The histamine contents of fresh fish, moderately fresh fish, and unfresh fish were 2.4 mg, 4.8 mg, and 6.1 mg% respectively. Ikan peda processed from those fish through the 3-week maturation period had histamine contents of 4.4 mg, 12.4 mg, and 18.7 mg% correspondingly. Therefore, to produce a good-quality ikan peda that is safe for consumers there is no other way except to use fresh raw materials or high-quality fish.

129.5.3 Evisceration of the Fish

The raw materials used in the processing of ikan peda are traditionally uneviscerated. This fact brings the notion that the guts provide a specific role in the formation of the unique flavor of ikan peda. As previously mentioned, the guts are a source of bacteria and proteolytic enzymes which make an important contribution in the process of fermentation, particularly in the formation of this flavor (Irianto. 2012). Menajang (1988) noted that gut removal can decrease total bacterial, halophilic bacterial, and microaerophilic bacterial counts in ikan peda. Irianto (2012) revealed that the presence of stomach contents has a real effect on the ability of the product to retain water, stimulates the formation of carbonyl compounds which give the specific odor and flavor of ikan peda, and increases the pH and microbial population of ikan peda. However, Nur and Sjachri (1979) informed that ikan peda prepared from eviscerated short-bodied mackerel had a better sensory acceptability of color, flavor, and texture compared to those processed from uneviscerated ones. Syafii (1988) also showed that the evisceration treatment improves the quality of ikan peda. Hanafiah (1987) also noted that ikan peda processed using eviscerated fish which have been treated with antioxidants had a better acceptability, particularly in terms of flavor and texture. The product is clean and more attractive. The fried product is described as slightly flaky but moist, salty, and tasty, having a slightly rancid flavor, but without the strong smell of ikan peda. However, Hasan et al. (2013) obtained from their study that the best ikan peda can be processed from uneviscerated fish. In addition, Hasan et al. (2014) introduced ikan peda processed using fillets of short-bodied mackerel, but organoleptically the product was worse than ikan peda made from whole fish and gutted fish.

129.5.4 Use of Better Quality Salt

Salt which is generally used by processors for manufacturing ikan peda is “garam rakyat,” a salt produced traditionally by evaporating seawater. Impurities are still found in that salt. Impurities in the salt affect the quality of ikan peda. Impurities in raw salt also known as “garam krosok” are $CaSO_4$, $MgSO_4$, $MgCl_2$, and others (Rositawati et al., 2013). The use of salt containing impurities will inhibit the penetrating process of salt into fish flesh. Mathias (2015) investigated the effect of salt quality on the quality of ikan peda. This study revealed that the better quality of salt used for the production of ikan peda, the better the quality of the product. The salt level used in this study was 30% of fish weight.

129.5.5 Optimization of the First Fermentation

Efforts to optimize the first fermentation in order to improve the quality of ikan peda have been explored in various ways, namely by optimizing salt amount and fermentation period, as well as carbohydrate usage. The amount of salt used in the fermentation of ikan peda determines the quality of the product and affects the types of microbes that play a role in fermentation. If the amount of salt used is too high, it will result in too salty a product. The salty taste will limit the quantity of ikan peda to be consumed.

Desniar et al. (2009) processed ikan peda by employing various salt amounts, namely 30, 40, and 50%, in which 90% of those salt levels were used in the first fermentation and the remaining was for the second fermentation. Sensory evaluation suggested that the best ikan peda should be processed with 30% salt. Paparang (2013) made ikan peda from indian scad with 10–20% salt, in which the more salt used in the first fermentation the more acceptable taste of the product will be. The best ikan peda was obtained from the first fermentation employing 20% salt.

Determination of the first fermentation duration required for ikan peda processing using mullet as raw material was conducted by comparing the fermentation periods of three days and seven days. Products fermented for three days were organoleptically more acceptable than those fermented for seven days. This may be related to the release of oil during the first fermentation. The end of the first fermentation process found a thin layer of oil on the top of the salt solution. The longer the first fermentation process, the more oil is released from the fish. Consequently, the product produced with seven days of fermentation has a weaker brown color than the one fermented for three days. The high salt content and low moisture content of ikan peda that has undergone 7 days of fermentation resulted in the wrinkling of the fish. This makes the product less acceptable organoleptically (Irianto, 1990). Therefore, the first fermentation is suggested not to exceed three days (Irianto and Brooks, 1994). The first fermentation is actually to prepare the fish for the maturation process in the second fermentation. The performance of the fish after the first fermentation could be characterized as follows: (a) a three-day first fermentation: moisture content 58.28% (w/w), salt content 14.84% (w.b.), water activity 0.83, and pH 6.60; and (b) a seven-day first fermentation: moisture content 53.77% (w/w), salt content 18.66% (w.b.), water activity 0.76, and pH 6.46 (Irianto, 1990). The salt content of the sample fermented for three days in the first fermentation was nearly the same as the result obtained by Hanafiah (1987) from Indian mackerel fermented for seven days, i.e. 14.1% (w.b.). The sample fermented for seven days in the first fermentation had a salt content in the range reported using short-bodied mackerel fermented for seven days by Sjachri and Nur (1977), i.e. 16.98–20.63% (w.b.). The differences of fish performances between the one undergoing the first fermentation for three days and seven days probably selects for differences in the bacterial growth.

Increasing the length of the first fermentation from three- to seven-day fermentation period had undesirable effects on the appearance of ikan peda. The high salt and low moisture contents obtained from a seven-day first fermentation brought about shrinkage of fish and this condition was actually unexpected. The longer first fermentation may have caused more oil separation from the fish and this reduced fat content resulted in ikan peda with a less-intense brown colour (Irianto, 1990). Therefore, this result suggested that the first fermentation should not be run for more than three days. This first fermentation period has been applied by several researchers, such as Winarno et al. (1973), Sjachri and Nur (1979), and Sukarsa (1979).

Eva and Haslina (2012) modified processing method of ikan peda by introducing the use of rice washing water which has been added with 15–25% salt as the fermentation media of short-bodied mackerel. Rice washing water was used as the source of carbohydrate to facilitate the growth of lactic acid bacteria during three-day fermentation. The most preferred product was fermented using rice washing water with 25% salt addition, and the product resulting from this process had 21.03% salt content, 11.67% moisture content, and 21.99% acid content.

Tedja and Nur (1979) conducted a study on ikan peda made from short-bodied mackerel using various salt and glucose concentrations in a five day first fermentation. Faster pH reduction occurred at lower concentration of salt and the fastest reduction was found at 10% salt, while the effect of glucose concentration on ikan peda was not revealed until the end of study.

Employing visceral enzymes prior to salting in the first fermentation of ikan peda was carried out by Hasan et al. (2014). The fish was smeared with visceral enzymes and then underwent first fermentation with 20% salt for a day. After removal of the remaining salt, the fish was kept for four weeks at the second fermentation. Ikan peda made involving enzymes are better than ones processed without enzyme treatment.

129.5.6 Optimization of the Second Fermentation

Modifications have been made to optimize the role of the second fermentation to obtain better quality ikan peda and faster process through optimization of the salt addition level and fermentation period.

Irianto (1990) investigated the effect of the salt addition in the second fermentation compared to the one without salt addition and the optimum second fermentation period. The use of salt in the second fermentation produced a higher salt content, lower moisture content, and lower water activity in ikan peda. This fact suggests that some salt penetration actually still occurs during the second fermentation. However, the salt addition in the second fermentation is actually unnecessary, since the product obtained without salt addition was organoleptically indistinguishable from the product with salt addition. The salt addition could even make the appearance of ikan peda less acceptable, because the remaining salt on the surface of ikan peda was difficult to remove. Sensory evaluation indicated that ikan peda fermented for three days in the first fermentation and without salt addition in second fermentation was the best product. In order to implement this finding, the fish which has been fermented for three days in the first fermentation is just continued into the second fermentation without further salt addition but the brine which has formed on the fish is drained. This recommended processing method can be used as the basic information in the improvement of the process and of the finished product itself. With regard to the fermentation period, Hasan et al. (2013) revealed that maturation at 35°C for a 30-day period produced a better ikan peda compared to one fermented at 30°C, in terms of sensory, microbiological, and chemical parameters.

Based on the sensory evaluation of ikan peda processed using mullet, the second fermentation was recommended not to be conducted for more than four weeks (Irianto and Brooks, 1994), since after this period the appearance and taste of ikan peda got worse.

129.5.7 Use of Bacterial Starter Culture

Bacterial starter cultures are used to accelerate the fermentation process of ikan peda, which normally takes a long time. By employing the starter cultures in several ways, as well as various starter forms, the fermentation process is guaranteed to achieve ikan peda with the desired quality faster.

Eva and Untari (2014) used solution from fermented chicory as the media for the fermentation process of ikan peda, where the fermentation took place for three days. The solution expected as the source of lactic acid bacteria was prepared by placing chicory into rice washing water with 10–20% salt added, then crushed by hand and undergoing the fermentation process for three days. Ikan peda manufactured from the solution of fermented chicory processed by using rice washing water with 15 and 20% salt addition showed better taste compared with a commercial ikan peda.

A solution of fermented shrimp paste, *terasi*, has been used as the source of lactic acid bacteria to be employed in the processing of ikan peda (Fajri et al., 2014). The solution was made by dissolving fermented shrimp paste in 20% salt brine. Mackerel (*Rastrelliger* sp.) were soaked in the solution for 3 hours, followed by the first fermentation with 15–25% salt for 7 days, and a second fermentation with 15–25% salt for 21 days. Organoleptically, ikan peda processed by introducing lactic acid bacteria from fermented shrimp paste was more acceptable, especially the one fermented using 25% salt.

Pediococcus acidilactici F-11 was employed by Rinto (2010) as starter culture in the first fermentation of ikan peda with different salt concentrations, i.e. 20, 25, and 30%. The use of *P. acidilactici* F-11 as a biocontrol of microflora during ikan peda fermentation was effectively employed at a low salt concentration of 20%. This is shown by the inhibition of the growth of coliform and histamine-forming bacteria during the first fermentation process, in which the coliform number decreased up to 2 log cycles from 1.3 x 10^6 to 1.7 x 10^4CFU and histamine-forming bacteria number reduced up to 3 log cycle from 1.2 x 10^6 to 3.8 x 10^3 CFU. However, *P. acidilactici* F-11 was not effectively used to suppress the growth of coliform and histamine-forming bacteria if the salt concentration employed was more than 25%.

The bacterial starter prepared from ikan peda in an anaerobic environment was introduced by Nur and Sjachri (1979) in the second fermentation of ikan peda. The use of starter culture can make the fermentation process more intensive and leads to the quality improvement of ikan peda, especially in the formation of reddish-brown color that signifies a good-quality ikan peda. Starter cultures can be made from the reddish-colored meat of ikan peda by drying at 40°C and pounding into powder.

The process improvement of the second fermentation by introducing microorganisms was also conducted by Kamil et al. (1975) and Irawadi (1979). Kamil et al. (1975) used starter made by mixing ikan peda flesh and mungbean flour. The amount of ikan peda flesh added was around 10% of the formula. Irawadi (1979) processed ikan peda by adding glucose as carbohydrate source and *Lactobacillus* spp. obtained from sauerkraut as starter culture. Eva (2011) inoculated *Lactobacillus plantarum* FNCC 0364 culture isolated from fermented shrimp by soaking the fish into 24 hours old culture for 15 minutes. After that the fish was drained, washed, and underwent second fermentation for 8 weeks. The study exhibited that *L plantarum* was able to inhibit the growth of coliform and accelerated the growth of lactic acid bacteria shown by increasing its total count.

129.5.8 Use of Antimycotic and Antioxidants

Growing mold and oxidation attack are the most common problems encountered in ikan peda during storage and marketing. Sjachri and Nur (1979) investigated the use of sorbic acid as antimycotic and **butylated hydroxyl anisole (BHA)** as antioxidant in the second fermentation and found that they pronouncedly improved the quality of ikan peda with regard to peroxide and total volatile base values. Employing 0.1% sorbic acid and 0.02% BHA can reduce the production of volatile bases, in which total volatile base contents of ikan peda with and without adding those additives were 54.20 mgN% and 61.55 mgN%, respectively, while peroxide values of ikan peda with and without using sorbic acid and BHA were 1.6 meq kg^{-1} and 2.0 meq kg^{-1} correspondingly. Hanafiah (1987) observed that erythrobat used as antioxidant and added as much as 1% did not effectively penetrate or become absorbed by the fish to prevent from oxidation attack, indicated by the ikan peda having higher **non-protein nitrogen (NPN)**, **total volatile bases (TVB)**, and free fatty acids contents.

129.5.9 Use of Packaging

A condition which should be taken into consideration for ikan peda during storage, transportation, and display in the markets is that the fermentation process or maturation process still occurs, inducing microbiological and chemical changes in the product. Ikan peda is normally sold in traditional market unwrapped, but the ones displayed in modern supermarkets are packed in plastic bags. The use of packaging for ikan peda is to facilitate consumers in bringing the products home conveniently and to protect the products from the unfavorable effects of the environment, including providing certain favorable environmental conditions for the products being packed, such as vacuum conditions. The use of polyethylene bags, bamboo baskets lined with banana leaves, and crocks of clay for packing ikan peda did not show any significantly different effect on the product quality (Sjachri and Nur, 1979), thus any types of packaging material can actually be used for packing ikan peda. In order to control the maturation process, vacuum packing is suggested for ikan peda (Hanafiah, 1987). Employing vacuum packing inhibits the production of NPN and TVB as well as retains more water in ikan peda. Due to consumers preferring not to consume ikan peda with very strong flavor, the best ikan peda are suggested to use eviscerated raw material and to conduct second fermentation in vacuum condition, even though the process requires a longer fermentation period.

The results of the study showed that anaerobic fermentation leads to higher production of amine compounds, resulting in products that have higher water holding capacity and better texture. The amines can hold water molecules. Anaerobic fermentation seems to accelerate the formation of reddish brown color from meat, inhibit oxidative rancidity, facilitate the degradation of proteins into carbonyl compounds, and have a marked effect on the water content, pH, and microorganism population of ikan peda (Irianto, 2012).

129.5.10 Use of Proper Storage Methods

Proper storage methods for ikan peda can extend its shelf life and also ensure the safety of the product to be consumed, especially those processed from mackerel due to histamine formation. Indriati et al. (2005) compared three treatments of ikan peda made from short-bodied mackerel for storage study: drying followed by storage at ambient temperature; without drying directly stored at ambient temperature; and without drying directly stored at chilled temperature (5–10°C). In terms of histamine content, chilled temperature is recommended for storage of ikan peda due to the lowest histamine formation, while the highest histamine content was found in ikan peda being directly stored at ambient temperature.

129.5.11 New Developed Products from Ikan Peda

Mahendradatta et al. (2010) introduced a newly developed product of seasoning powder made from ikan peda. Ikan peda was processed through a 6-day first fermentation using 20% salt and clove and cinnamon were added. After fermentation, the fish was then milled into paste, put into a container, closed tightly, and allowed to ferment for 14 days. After that onion and garlic were added to the paste and the mixture was then dried, milled, and sieved into powder. The salt used for the fermentation process was 20% of the fish weight of the material. Drying was carried out at 60°C for about 8 hours (Anas, 2012). The seasoning powder can be stored in aluminum foil wrap for up to 10 weeks at ambient temperature and still accepted organoleptically until 8 weeks, except for its odor. Meanwhile, total microbe as well as histamine and moisture content increased during storage (Mahendradatta et al., 2010).

129.5.12 Culinary Products from Ikan Peda

Strong salty taste limits the amount of ikan peda consumption as a part of the daily diet of Indonesians. In recent years, culinary or food products that use ikan peda as the main ingredients have been widely developed, and there are even products that are claimed as unique culinary products originating from a particular city, province, and ethnicity. Those culinary products include *pepes ikan peda*, *tumis ikan peda*, *tim ikan peda*, and *sambal ikan peda*. Pepes ikan peda is processed firstly by pouring ikan peda with all spices thoroughly, and then arranging on a banana leaf lined with pumpkin leaves, bay leaves, and basil leaves. Green onions are spread over spiced ikan peda and then tomato is added. The banana leaf is folded and wrapped, and the wrapped ikan peda is steamed until cooked for around two hours and then grilled (Anonymous, 2015). Tumis ikan peda is made by cooking without extra salt addition because ikan peda already has salty taste. Tumis ikan peda can be made with extra chili to add spicy flavor and a more delicious taste for those who like spicy foods (Anonymous, 2014). Tim ikan peda is prepared by steaming ikan peda with seasonings consisting of shallot, garlic, chili, tomato, sugar, salt, bay leaf, lemongrass, and lemon for 20 minutes (Permatasari, 2017). Sambal ikan peda is made by steaming ikan peda until cooked and then shredded. Big green chili, green curly chili, green chili pepper, tomatoes, and shallot are steamed together and then pounded. Cooking oil is heated. The pounded cooked ingredients are poured into hot oil until aroma appears, and then shredded ikan peda and sugar are added. That mixture is stirred and heated until cooked (Anonymous, 2017).

129.6 Concluding Remarks

The above facts indicate that there is still room to improve the quality of ikan peda through optimization and modification of existing traditional processing practices, as well as application of new findings and knowledge related directly or indirectly to ikan peda processing. Other things which should still be considered for both consumer satisfaction and consumer protection are to upgrade sanitation and hygiene levels of processing practices and persons involved in production activities, and to provide acceptable quality raw materials of ikan peda.

Mostly, traditional fishery products in Indonesia are produced in processing units which have not implemented sanitary and hygiene practices yet, including ikan peda production. Due to lack of information and knowledge, processors neglect those practices. Therefore, processors have to be made aware of the importance of sanitation and hygiene to be implemented in processing activities of ikan peda. In order to guarantee the safety of the product, the processors of ikan peda have to pay serious attention and to control the environments of processing units and equipments to assure that sanitary and hygiene principles have been applied properly.

Ikan peda should be processed using good-quality fish, especially ones processed using mackerel as raw material. The supply of fresh, quality mackerel is a must to avoid excessive histamine in ikan peda. Sarnianto et al. (1984) reported that the histamine content of ikan peda is the highest among Indonesian fermented fish products. The histamine content of commercial ikan peda noted is approximately 107.32–133.43 mg%, which is over the limit of 50 mg% regulated in Indonesia. This fact indicates that utilization of fresh fish, as well as sanitary and hygienic practices during processing, is necessary to produce ikan peda that is good quality and safe to be consumed.

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