Indonesian Fermented Fish Products

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CONTENTS

42.1 Introduction

Indonesia consists of 17,480 islands and is surrounded with waters that provide a high production of marine fish, for example, approximately 4,701,933 tons of fish in 2008 (Departemen Kelautan dan Perikanan 2010). Approximately 41% of the total marine fish landed is subjected to different preservation and processing methods. Traditional preservation and processing methods, such as salting, boiling, smoking, and fermentation, are responsible for 54.67% of the total preserved and processed fish products. Fermented fish products, categorized as *terasi*, *peda*, and *kecap ikan*, contribute to less than 2% of the total preserved and processed fish products. In addition to *terasi*, *peda*, and *kecap ikan*, other fermented fish products are produced in Indonesia. These include *bakasang*, *bekasem*, *budu*, *cincaluk*, *jambal roti*, *naniura*, *petis*, *picungan*, *pudu*, *rusip*, and *tukai*. This chapter elaborates on the general processing methods of fermented fish products in Indonesia and presents some data related with their chemical composition and microbial characteristics.

42.2 Indonesian Fermented Fish Products

42.2.1 *Bakasang*

Bakasang is a fermented fish product that is mainly produced in the North Sulawesi province and the Moluccas Island. *Bakasang* is a dark brown liquid product with a strong fishy flavor (Figure 42.1). It is

FIGURE 42.1 *Bakasang.*

usually used as a flavoring agent for many dishes or mixed with red chilies, tomato, red onion, and garlic, which are then sautéed with coconut oil and eaten with hot porridge mixtures of rice and vegetables called *tinutuan* (Ijong and Ohta 1995). The main raw materials for *bakasang* processing are the internal organs (viscera and roe) of tuna and tuna-like fish obtained as a waste product from the processing of smoked tuna. Subroto et al. (1984) reported that *bakasang* made from ground viscera showed better quality compared to those from whole viscera. Smoked skipjack tuna (*Katsuwonus pelamis*) is a popular product in the North Sulawesi province and the Moluccas Island. The internal organs of yellowfin tuna (*Thunnus macropterus*) and big eye tuna (*T. obesus*) are also good raw materials for the processing of *bakasang* (Poernomo 1996).

In addition to the internal organs of tuna, *bakasang* is also produced from the whole body of small marine fish. Ijong and Ohta (1996) and Harikedua et al. (2009) reported that some small marine fish, such as sardine (*Sardinella* sp.), anchovy (*Stolepherus* sp. or *Engraulis* sp.), and orange sunkist shrimp (*Caridina wycki*), are also suitable for *bakasang* processing.

The traditional processing of *bakasang* starts with the collection of internal organs, including the viscera and roe of skipjack tuna (Figure 42.2). An appropriate amount of the internal organs is washed with seawater and drained to remove excessive seawater. The cleaned internal organs are mixed with 15%–20% salt and poured into bottles. The bottles are kept for 3–6 weeks to allow fermentation to occur until a dark and sticky liquid is formed. Traditionally, the bottles are stored in a warm place and usually near a source of fire. Subroto et al. (1984) stated that *bakasang* can be made from the visceral parts of bonito by adding 10% salt and allowing the mixture to ferment for 10 days.

As a liquid food product, *bakasang* contains a high moisture content, which is approximately 66%–69% (Ijong and Ohta 1995). Harikedua et al. (2009) reported the moisture content of *bakasang* to be

Fresh internal organ (viscera and roes) of skipjack tuna

Washed with seawater and drained to remove excessive water

Mixed with 15–20% salt

Poured into bottles

Kept at a warm temperature for 3–6 weeks

Bakasang

FIGURE 42.2 General procedure for *bakasang* processing.

TABLE 42.1

Chemical Composition of *Bakasang*

Parameter	Chasanah et al. (1994)	Ijong and Ohta (1995)	Harikedua et al. (2009)
Moisture	73.1	66.3–68.9	59.0–70.9
Protein (% wb)	12.8	14.0–17.4	–
Fat (% wb)	2.6	1.0–3.0	–
Ash (% wb)	8.8	–	–
Salt (% wb)	6.7	8.4–18.0	7.6–9.8
pH	–	5.8–6.3	6.4–6.5
TVN (mg/100 g)	–	–	345.7–351.4
Titratable acid (%)	–	–	1.2–1.9
Free amino acid nitrogen (mg N/mL)	–	–	802.2–921.6

approximately 59%–70%. The salt content will influence the amount of salt used during *bakasang* preparation. Previously, Ijong and Ohta (1995) reported that the salt content of *bakasang* was approximately 84–180 g/kg per sample; however, the report by Harikedua et al. (2009) showed that the salt content decreased to 78–98 g/kg per sample. The chemical composition of *bakasang* is presented in Table 42.1.

A quality *bakasang* product is related to a high moisture content, low viscosity, low titratable acid, low salt content, and low free amino nitrogen content (Harikedua et al. 2009). A longer fermentation process will produce *bakasang* with a higher free amino nitrogen content, which is associated with lower consumer acceptability.

In terms of microbial quality, Ijong and Ohta (1995) reported that *Staphylococcus* sp. and *Lactobacillus* sp. were the predominant bacteria isolated from *bakasang*. Other bacteria isolated in *bakasang* are *Micrococcus* sp., *Streptococcus* sp., *Bacillus* sp., and *Clostridium* sp. *Bakasang* prepared from small sardines (*Engraulis* sp.) contained additional bacteria such as *Enterobacter* sp., *Moraxella* sp., and *Pediococcus* sp. (Ijong and Ohta 1996).

42.2.2 *Bekasem*

Bekasem or *bekasam* is a fermented freshwater fish product popular among people from Central Java and the South Sumatra province. In Central Kalimantan, *bekasem* is referred to as *wadi*. Traditionally, the main raw material used for *bekasem* processing is ikan common carp (*Cyprinus carpio*) (Murtini 1992). However, some other freshwater fish, such as catfish (*Clarias batracus*), java barb (*Puntius javanicus*), tilapia (*Oreochromis mossambica*), and spotted gourami (*Trichogaster trichopterus*), are also suitable raw materials (Murtini et al. 1997). Candra (2006) prepared *bekasem* using milk fish (*Chanos chanos*); meanwhile, Vonistara et al. (2010) used nile tilapia (*O. niloticus*) as a raw material.

A specific part of *bekasem* processing is the addition of cooked rice, roasted rice, or fermented rice as a source of carbohydrate (energy) for the growth of the preferred bacteria. The traditional processing of *bekasem* starts with eviscerating and washing the freshwater fish (Figure 42.3). The eviscerated fish is then split into a butterfly shape (if a larger fish is used) and fully soaked in 15%–16% brine solution for 2–3 days. The soaked fish is drained to remove the excess brine solution and then mixed with a carbohydrate source (cooked rice, roasted rice, or fermented rice) at a ratio of 3:4. The mixed rice and fish are placed into traditional clay or plastic jars and stored for 1–2 weeks (Murtini 1992; Putro 1993).

The chemical composition of *bekasem* is shown in Table 42.2. *Bekasem* is classified as a product with an intermediate moisture content. The moisture content of commercial *bekasem* is approximately 55%–65%. As an effect of soaking in brine solution, the salt content of the product increases to 6%–17% wet base. The protein and fat content will vary depending on the raw material used. Murtini et al. (1991) reported that the protein and fat contents of *bekasem* were around 4.80%–6.91% wb and 5.0%–5.72% wb, respectively.

Eviscerated fresh water fish

Washed and split into a butterfly shape

Soaked into a 15–16% brine solution for 2–3 weeks

Drained

Mixed with a carbohydrate source

Placed in clay or plastic jars and stored for 1–2 weeks

Fermentation process

Bekasem

FIGURE 42.3 General procedure for *bekasem* processing.

TABLE 42.2
Chemical Composition of *Bekasem*

Parameter	Murtini (1992)	Putro (1993)
Moisture	66.95	55–66
Protein (% db)	45.23	41–64
Fat (% db)	17.31	11–23
Ash (% db)	17.42	13–28
Salt (% wb)	15.55	6–17
pH	–	4.46–4.98

As a result of bacterial fermentation, especially from lactic acid bacteria, *bekasem* has a lower pH—approximately 4.57–5.33 according to Murtini et al. (1991) and approximately 4.46–4.98 according to Putro (1993). Sugiyono et al. (1999) reported that *bekasem* contains the lactic acid bacteria *Lactobacillus* sp., *Pediococcus* sp., *Lactobacillus coryneformis*, and *Pediococcus damnosus*. However, Candra (2006) reported that the lactic acid bacteria isolated from commercial bekasem prepared from milk fish (*Cha. chanos*) were *Staphylococcus* sp., *Erysipelothrix* or *Lactobacillus* sp., and *Streptococcus* sp. or *Gemella*. To improve the quality of *bekasem*, the liquid of cabbage and Chinese leaf pickles can be added (Murtini et al. 1997). The results showed that the addition of the pickled liquid had significant effects on the lactic acid bacteria count, aerobic and anaerobic bacteria counts, yeast counts, pH value, total volatile acid and fat content. The *bekasem* used in this study is still accepted by panelists after 8 weeks of storage.

42.2.3 *Budu*

Budu is a fermented fish product produced mainly in the area of Pasaman, approximately 300 km from Padang, the capital city of West Sumatra. *Budu* is also produced in Sorkam, a neighboring area of Pasaman that is part of the province of North Sumatra. The product is different from the Malaysian *budu*, in terms of both the fish used and the processing steps. The *budu* from West Sumatra is normally made from larger marine fish such as Spanish mackerel (*Scomberomorus* sp.) and leatherskin (*Chorinemus* sp.), locally known as *ikan tenggiri* and *ikan talang*, respectively. The Spanish mackerel is more popular for making *budu* than the leatherskin (Figure 42.4).

There are limited reports on West Sumatra *budu* processing and quality characteristics. Huda and Rosma (2006) reported that the traditional processing of West Sumatra *budu* starts with hanging the fresh fish by its caudal fin at room temperature for 4 h (Figure 42.5). The fish is cut into a butterfly style, and all of the intestinal organs and gills are removed. The fish is then washed to ensure that it is free of blood and other intestinal residues. The fish is stacked in a *pasu*, a traditional container, and layered with coarse salt at a ratio of 1:5–1:3. The container is covered and stored at room temperature for a day, after

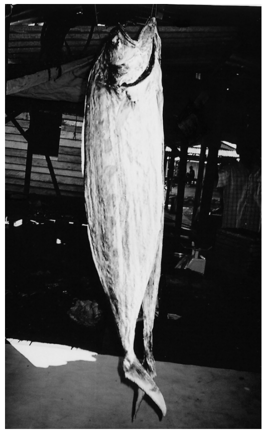

FIGURE 42.4 Spanish mackerel *budu*.

Fresh fish

Hanged at room temperature for 4 hrs

Eviscerated into a butterfly style

Washed and intestinal organs removed

Stacked in a *pasu* and layered with coarse salt at ratio of 1:5–1:3

Allowed to stand overnight

Rinsed

Sun-dried until a moisture content of 50% is reached

Budu

FIGURE 42.5 General procedure for *budu* processing.

which the fish is rinsed to remove the excess salt. The fish is then sun-dried for 5 days. During drying, condiments, such as white paper and garlic, may be sprinkled onto the fish to improve the quality. The product, which has a specific flavor, aroma, and texture, is then ready to be packed and marketed.

The normal shelf life of West Sumatra *budu* at room temperature is approximately 3–4 weeks. Low-temperature storage can prolong the shelf life. The approximate composition of *budu* is as follows—51% moisture content, 33% protein, 0.5% fat, and 14% ash (Huda and Rosma 2006). The higher ash content corresponds to the salt used during fermentation. Because of the strong flavor and higher salt content, *budu* cannot be consumed as a main dish in a daily meal. Normally, it is used as an ingredient during the preparation of fish curry. Some people also roast or fry the *budu* and blend it with ground chilies.

42.2.4 *Cincaluk*

Cincaluk is a traditional fermented shrimp product popular among the Malay tribe people of the Bengkalis Island. Small shrimp-like crustaceans (*Mytis* sp. or *Atya* sp.) called *udang pepai* are used for *cincaluk* production (Maamoen et al. 2003). *Cincaluk* is produced in backyard activities by local people of the Bengkalis Island. The processing of *cincaluk* begins with mixing descaled washed shrimp with tapioca flour, salt, and sugar (Figure 42.6). The tapioca flour is dissolved in water, gelatinized, and allowed to cool. The shrimp are then mixed thoroughly with salt, sugar, and gelatinized tapioca flour.

Fresh small shrimp-like crustaceans

Mixed with tapioca flour, salt and sugar at a ratio of 20:1:1:1 (Method A)
or cooked rice at a ratio of 2:1:1 (Method B)

Stored in a container for the fermentation process for 1–2 weeks (method A)
or 4 days (Method B)

Cincaluk

FIGURE 42.6 General procedure for *cincaluk* processing.

The mixture is poured into bottles that are sealed firmly for the fermentation process (Irianto and Irianto 1998). Another method by which to process cincaluk is by washing small shrimp and mixing them with cooked rice and salt. The mixture is stored in a closed container for the fermentation process. The *cincaluk* produced is poured into glass jars for marketing purposes.

Due to the fermentation process, the pH of *cincaluk* is low. Irianto and Irianto (1998) reported that the pH of *cincaluk* was approximately 4.82, with a lactic acid content of 2.34%. The chemical composition of *cincaluk* shows that the moisture, protein, fat, ash, and salt contents are 69.76%, 16.23%, 1.57%, 12.43%, and 10.11%, respectively. In terms of the microbial characteristics, it has been reported that the bacteria isolated from commercial *cincaluk* are *Lb. coryneformis*, *P. damnosus*, and *Pediococcus* sp.

42.2.5 *Jambal Roti*

Jambal roti is a fermented and dry-salted fish product that is popular in the West Java province and neighboring areas. *Jambal roti* is one of the most highly valued dried fish products in Indonesia (Figure 42.7). It is a fish with a crunchy cracker-like texture, after the frying process. Traditionally, *jambal roti* is prepared from marine catfish (*Arius thalassinus*); however, other fish species with similar characteristics are also suitable as raw materials. Sani (2001) used striped catfish (*Pangasius hypophthalmus*) as the raw material to produce a *jambal roti*-like product.

The processing of *jambal roti* may vary slightly by location, but the basic processing methods applied are similar (Burhanuddin et al. 1987; Putro 1993; Irianto and Irianto 1998). There are two types of *jambal roti*—plain *jambal roti* for larger fish and salty *jambal roti* for smaller fish. Plain *jambal roti* processing begins with the beheading, gutting, and washing of the fresh fish. An appropriate amount of salt is added into the abdominal cavity of the fish, and it is then layered in a concrete tank. Each layer is sprinkled with salt and then left for 24 h. The fish is removed from the tank, and excessive salt from the abdominal cavity is removed. The fish is sprinkled with salt and left in the tank for 48 h before washing to remove the excess salt. The fish is cut into a butterfly shape and dried for 3–5 days. During the drying process, the surface of the fish is wiped with sugar solution. The sugar solution is prepared by mixing 20% palm sugar and 10% garlic in 1 L of water (Suharna et al. 2006).

The processing of salty *jambal roti* begins with eviscerating and washing the fresh fish (Figure 42.8). The cleaned fish is then split into a butterfly shape and soaked in freshwater for 24 h. After draining, the

FIGURE 42.7 *Jambal roti*.

Fresh marine catfish

Beheaded, gutted and washed

25–45% salt added into abdominal cavity, layered in a concrete tank and sprinkled with salt

Allowed to ferment for 24 hours

Remove excess salt from the abdominal cavity, layered in a concrete tank and sprinkled with salt

Allowed to ferment for 2–3 days

Washed and split the fish into butterfly shape

Dried for 3–5 days

Jambal roti

FIGURE 42.8 General procedure for *jambal roti* processing.

fish are arranged in a basin and mixed with 30%–40% salt and then left for 24 h. After the salting process, the fish are washed. The cleaned fish are then dried for 3–5 days. Rochima (2005) reported that using 30% salt and a fermentation period of 24 h produces *jambal roti* with a higher sensory acceptability score.

Marine catfish is known as a fish with a high protein and low fat content. Damayanthi (1991) reported that the protein and fat contents of fresh marine catfish are 16.20% and 1.04% wb, respectively. The higher protein content will remain unchanged during *jambal roti* processing. The protein content of *jambal roti* is approximately 33.76%–46.56% wb. The salt content of *jambal roti* will depend on the amount of ash used. Salamah et al. (1995) reported that the salt content of *jambal roti* was approximately 4.15%–7.25%, whereas Nuraniekmah (1996) reported that the salt content was approximately 7.38%–8.53%. Table 42.3 shows the chemical composition of *jambal roti*.

The specific flavor of *jambal roti* is related to the presence of nitrogen compounds such as creatine, phenylalanine, and tyrosine. Peptides contain glutamic and aspartic, which also contribute to this specific flavor (Dewi 2005). *Staphylococcus* sp. is the dominant bacteria found in a *jambal roti*. Two isolates of *Staphylococcus* sp. were found in the product, one of which hydrolyzes fat, whereas the other does not (Santoso et al. 1995). Previously, Sarnianto et al. (1984) reported that the *Staphylococcus* sp. and *Lactobacillus* sp. contents in *jambal roti* were $0.4–0.9 \times 10^2$ and $0.8–2.9 \times 10^2$ cfu/g, respectively.

The main problem with *jambal roti* processing is insect infestation, especially infestation of *Chrysomya megacephala*, *Musca domestica*, *Phyophila*, and dermestid beetles (Putro 1993). It is estimated that the losses of product due to insect infestation reach 30%. Screening methods, such as placing the fish in closed containers during the fermentation and salting processes followed by covering the fish with a screen during drying, were found to be effective in reducing insect infestation. However, fish processors are reluctant to adopt such practices for their lack of practicality. Hidayat (2000) studied the efficacy of less harmful insecticides and found that theta-cypermethrin and pirimiphos-methyl were similarly

TABLE 42.3

Chemical Composition of *Jambal Roti*

Parameter	Salamah et al. (1995)	Salamah et al. (1997)
Moisture	42.14–43.39	38.40–44.05
Protein (% wb)	33.76–36.81	26.38–33.56
Fat (% wb)	2.76–4.36	1.78–3.29
Ash (% wb)	9.06–13.89	16.26–16.50
Salt (% wb)	4.15–7.25	–

effective in reducing insect infestation. Spraying the raw material with theta-cypermethrin at a concentration of 5 mL/m^2 is the most effective treatment to reduce insect infestation in *jambal roti*.

42.2.6 *Kecap Ikan*

Kecap ikan or fish sauce is a clear yellow to brown liquid with a salty taste and specific aroma (Figure 42.9). In Indonesia, *kecap ikan* is the third largest fermented fish product produced and concentrated along Java Island. The popularity of *kecap ikan* has increased yearly from 9 tons in 2002 to 748 tons in 2007. There is no specific fish species for *kecap ikan* production. Rahayu et al. (1992) reported that the raw material for *kecap ikan* production could be any marine fish, such as anchovy (*Stolephorus* sp.), herring (*Clupea* sp.), or ponyfish (*Leiognathus* sp.). Putro (1993) reported that along the Bali strait, a *kecap ikan* processor is using sardines (*Sardinella* sp.) as the raw material. Desniar et al. (2007) produced *kecap ikan* using jack (*Caranx* sp.) as the raw material. Some freshwater fish, such as java barb (*Puntius* sp.) and bony-lipped barb (*Osteochilus* sp.), are also suitable raw materials (Rahayu et al. 1992). Rachmi et al. (2008) produced *kecap ikan* using nile tilapia (*O. niloticus*) as the raw material. Suptijah (1998) reported that white shrimp (*Penaeus monodon*) were also suitable for producing a *kecap ikan*-like product.

The processing of *kecap ikan* begins by eviscerating, washing, and mincing the fresh fish (Figure 42.10). The cleaned fish are mixed with salt and arranged in the fermentation tank. The fermentation tank must be equipped with an outlet to collect the fermentation product. The fish are arranged in layers, and each layer is covered with salt. The tank is then closed, and fermentation is allowed to take place for 4–12 months. The *kecap ikan* liquid collected from the outlet is then filtered and mixed with brown sugar and spices (Putro 1993). To accelerate the fermentation process, some processors have applied enzymatic or acidic hydrolysis, which reduces the fermentation process to 3 days or 24 h, respectively (Basmal 1992). *Kecap ikan* produced using bromelein and papian showed a higher quality compared to that produced using neutrase (Suparman 1993). However, the quality of accelerated fermentation in *kecap ikan* produced using an enzyme and chemicals is lower compared to *kecap ikan* produced using spontaneous fermentation.

Because *kecap ikan* is a liquid product, the moisture content can reach above 70%. The salt content is influenced by the amount of salt added. Sarnianto et al. (1984) reported that the salt content of *kecap ikan* was 19.70%–22.35%. According to the Indonesian National Standard (Badan Standarisasi Nasional 1996), the salt content of *kecap ikan* should be in the range of 19%–26%. The Indonesian National Standard also stated that the pH value, amino nitrogen content, and total plate count (TPC) values should be 5–6, a minimum of 5%, and a maximum of 10^4 cfu/g, respectively. Table 42.4 shows the chemical composition of *kecap ikan*.

FIGURE 42.9 *Kecap ikan*.

Fresh fish

Washed, drained and minced

Mixed with 20–30% salt

Arranged in layers in a fermentation tank

Fermented for 4–12 months

Collected and filtered the sauce

Added brown sugar and spices (ratio 1:2.5)

Bottled

Kecap ikan

FIGURE 42.10 General procedure for *kecap ikan* processing.

TABLE 42.4

Chemical Composition of *Kecap Ikan*

Parameter	Poernomo et al. (1984)	Desniar et al. (2007)
Moisture	66.67–76.89	64.12–70.88
Protein (% wb)	10.17–10.51	6.11–6.40
N-amine (% wb)	–	5.37–5.84
Fat (% wb)	0.50–0.70	1.68–1.99
Ash (% wb)	21.95–23.50	16.30–21.82
Salt (% wb)	11.60–21.16	–
pH	–	5.01–5.18
TPC (cfu/g)	$8.0–8.5 \times 10^4$	$1.25–4.85 \times 10^3$
LAB (cfu/g)	–	$1.16–1.25 \times 10^3$

Halophilic bacteria are the main bacteria found in *kecap ikan*. Indiyati and Arbianto (1986) reported that *Bacillus* sp. was the dominant bacteria found in *kecap ikan*, although they also isolated *Flavobacterium* sp. Rahayu et al. (1992) reported that the mold species found in *kecap ikan* were *Cladosporium herbarum*, *Aspergillus fumigatus*, and *Penicillium nonatum*, whereas the yeast found in *kecap ikan* is from the species *Caudida claussenii*.

42.2.7 *Naniura*

Naniura is a fermented fish product popular in the Batak tribe community around the area of Toba lake in the North Sumatra provinces and in some parts of the Riau province. *Naniura* in the Batak tribe language means raw fish. *Naniura* is a product that is directly consumed without any further processing. Traditionally, the raw material used for *naniura* processing is freshwater fish such as common carp (*C. carpio*) and tilapia (*O. mossambica*). Silalahi (1994) processed *naniura* using snakehead and nile tilapia (*Ophiocephalus striatus*) as the raw materials. Irianto and Irianto (1998) stated that *naniura* processing is similar to that of bekasam; however, ground rice is used instead of cooked rice. The processing of *naniura* begins with eviscerating and washing the fresh fish (Figure 42.11). The fish is then split into a butterfly shape. The cleaned fish is fully soaked in a local lemon juice (*asam jungga*) solution. To improve the acceptability of the product, some processors mix the lemon juice with condiments including onion, ginger, turmeric, and galangal. The excessive water is removed, and the fish is mixed with ground rice. The fermentation process is allowed to take place for 1–4 days (Irianto and Irianto 1998).

Fresh water fish

Eviscerated and washed

Split into a butterfly shape

Soaked in lemon juice solution for 3–5 hours

Drained

Coated with ground rice

Fermented for 4 days

Naniura

FIGURE 42.11 General procedure for *naniura* processing.

There is limited scientific information on the *naniura* product. Silalahi (1994) processed *naniura* by soaking the fish in 2% acetic acid solution. The product showed lower pH (5.5) and higher water activity (0.8). The product can be kept at room temperature for at least 4 days and still remain acceptable for human consumption.

42.2.8 *Peda*

Peda or *pedah* is the second-largest fermented fish product produced in Indonesia, and its popularity increases yearly. In 2002, *peda* production was 6829 tons, and it increased to 16,556 tons in 2007. *Peda* production is mainly found in Java Island, and mackerel (*Rastrelliger* sp.) is traditionally used as the raw material (Figure 42.12). Some other marine fish, such as sardine (*Sardinella* sp.), scad mackerel (*Decapterus* sp.), and jack (*Caranx* sp.), have also been reported suitable for *peda* processing (Syafii 1988; Rahayu 1992; Rahayu et al. 1992; Desniar et al. 2009). However, freshwater fish are not suitable raw materials for *peda* processing (Sukarsa 1979).

There are two species of mackerel used in *peda* processing—chub mackerel (*Rastrelliger neglectus*) and indian mackerel (*R. kanagurta*). Due to their different fat contents, red *peda* is produced from chub mackerel, and the lighter-color peda is produced from Indian mackerel (Van Veen 1965). The processing methods of *peda* are similar, but each producer has his or her own process, especially in terms of the amount of salt used. The salt used must be more than 10%; otherwise, the fish will spoil (Menajang 1988). The processing of *peda* begins with eviscerating and washing the fresh fish (Figure 42.13). Syafii (1988) showed that the evisceration treatment improves the quality of *peda*. The cleaned fish is mixed with salt and then arranged in layers in the salting container. Saturated brine solution is poured into the container, and the salting process is allowed to take place for 3 days. Excessive salt is removed from the fish, which is washed with brine solution, packed in a bamboo container, and sprinkled with fine salt. A

FIGURE 42.12 *Peda*.

Fresh mackerel fish

Eviscerated and washed

Mixed with 20–50% salt and arranged in a container

Salting process for 3 days

Excessive salt was removed and fish was packed in a bamboo basket

Fermentation process for 1–2 weeks

Peda

FIGURE 42.13 General procedure for *peda* processing.

dried banana leaf is used as a separator if more than one layer of fish is arranged in the basket. The basket is kept at room temperature for 1–2 weeks while the fermentation process takes place. Putro (1993) allowed the fermentation process to continue for 2–3 months.

Syafii (1988) reported that the moisture and salt contents of commercial *peda* were 44.02%–53.12% and 18.03%–21.95%, respectively. Previously, Sarnianto et al. (1984) reported that the moisture and salt contents of commercial *peda* were 49.42%–56.78% and 10.99%–14.41%, respectively. *Peda* prepared from chub mackerel contains more fat compared with *peda* prepared from Indian mackerel. Van Veen (1965) reported that the fat content of chub mackerel *peda* was 7%–14%, whereas for Indian mackerel *peda*, it was 1.5%–7%. Using a larger amount of salt during the salting process and smaller fish will produce *peda* with a higher salt content. The maximum salt content of *peda* suggested by Van Veen (1965) is 18%. Table 42.5 shows the chemical composition of *peda*.

Sarnianto et al. (1984) reported that the number of TPC, *Lactobacillus*, and *Staphylococcus* of *peda* were 3–10 × 10^5, 0.08–0.2 × 10^2, and 0–2 × 10^2 cfu/g, respectively. Studies by Syafii (1988) on commercial *peda* found that the number of TPC, halophilic bacteria, proteolytic bacteria, lipolytic bacteria, acid-forming bacteria, and yeast of 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, respectively. Rahayu et al. (1992) hypothesized that the bacteria responsible for *peda* fermentation were *Acinetobacter* sp., *Flavobacterium* sp., *Cytophaga* sp., *Halobacterium* sp., *Micrococcus* sp., *Staphylococcus* sp., and *Corynebacterium* sp.

Mackerel is one of the scromboid fish families related to scromboid poisoning due to the high amount of free histidine in the fish flesh. Sarnianto et al. (1984) showed that the histamine content of *peda* is the highest among Indonesian fermented fish products. The histamine content reported is approximately 107.32–133.43 mg %, which is over the limit of 50 mg % regulated in Indonesia. Therefore, utilization of fresh fish and hygienic practices during *peda* processing is necessary to produce higher quality *peda*.

TABLE 42.5

Chemical Composition of *Peda*

Parameter	Poernomo et al. (1984)	Desniar et al. (2009)
Moisture	50.35	52.71%–53.94%
Protein (% wb)	26.67	20.15%–21.54%
Fat (% wb)	6.36	1.25%–1.37%
Ash (% wb)	18.89	15.96%–16.90%
Salt (% wb)	13.72	10%–13%
pH	–	6.0
TVB (mg/100 g)	–	16.78–18.42
TMA (mg/100 g)	–	2.23–3.35
aW	0.87	0.73–0.74

42.2.9 *Petis*

Petis is a dark brown to black sticky paste produced from an extract of shrimp or fish, which is used as an appetizer or as an ingredient in some traditional foods. *Petis* is produced and is famous among people in areas of eastern Java such as Sidoarjo, Gresik, Lamongan, Tuban, and Madura (Suprapti 2001; Nisrina 2007). Various raw materials may be used to make *petis*. Leksono and Irasari (1996) used freshwater shrimp *Macrobrachium rosenbergii* as raw materials; Poernomo et al. (2004) used an extract of scad mackerel (*Decapterus* sp.). Fakhrudin (2009) used an extract of bivalve *Corbula faba*, and Pramono et al. (2009) used an extract of beef meat as raw material for *petis* production.

The production of *petis* begins with the preparation of the shrimp/fish/bivalve/meat extract (Figure 42.14). Often, the extract is the liquid waste from the processing of another product such as ebi shrimp, boiled fish, fish balls, shredded fish, meat balls, or shredded meat. The extract is mixed with squid ink as a natural coloring agent and specific spices and then boiled for 1 h (Suprapti 2001). The residue is removed, and the filtered extract is reboiled. After cooling, the extract is added to a solution of tapioca or rice flour and boiled for another hour. After cooling for 24 h, the boiling process is repeated for a better quality of *petis*. The last step is cooling, bottling, and pasteurization for 30 min.

According to the Indonesian National Standard for shrimp *petis*, the moisture content should be in the range of 20%–30%. The protein, carbohydrate, and ash contents should be at least 10%, 40% at most, and 8% at most, respectively (Badan Standarisasi Nasional 2006). Suprapti (2001) reported that the moisture, protein, fat, ash, and carbohydrate contents of marine shrimp *petis* were 39.0%, 15.0%, 0.1%, 40.0%, and 5.9%, respectively. The chemical composition of *petis* is different, depending on the raw material used. Table 42.6 shows the chemical composition of non-shrimp *petis*.

Limited information is available as to the microbial content of *petis*. The Indonesian National Standard states that the maximum TPC for shrimp *petis* is 5×10^2 cfu/g or 5×10^5 cfu/mL (Badan Standarisasi Nasional 2006). Leksono and Irasari (1996) reported that the TPC for *petis* prepared from shrimp waste was in the range of $2.4–2.6 \times 10^4$ cfu/g per sample. Studies by Nisrina (2007) of commercial *petis* marketed in Madura Island found that the range of TPC was 3500–235,500 cfu/mL, and the most probable number (MPN) of coliforms ranged from 0.115 to 1.065 MPN/mL.

Extract of shrimp/fish/bivalve

Mix with spices and squid ink

Boil for 30 minutes

Filter and remove the residue

Reboil the liquid and mix with a solution containing tapioca or rice flour

Continue the boiling process for 1 hour

Cool for 24 hours

Boil again

Cool and bottle

Pasteurize for 30 minutes

Commercial *petis*

FIGURE 42.14 General procedure for *petis* processing.

TABLE 42.6

Chemical Composition of *Petis*

Parameter	Fish (Suprapti 2001)	Bivalve (Fakhrudin 2009)	Shrimp Waste (Leksono and Irasari 1996)
Moisture	56.0	25.2	41.7–43.6
Protein (% wb)	20.0	16.3	2.4–3.1
Fat (% wb)	0.2	0.98	0.2–0.3
Ash (% wb)	23.8	8.9	9.4–11.2
Carbohydrate (% wb)	24.0	48.79	41.9–46.2

42.2.10 *Picungan*

Picungan is a unique fermented fish product that is available only in the Banten province. *Picungan* refers to the fermentation process of fish using the seeds of the picung tree (*Pangium edule*). The picung tree is a tall tree native to the mangrove swamps of Southeast Asia. The raw material for *picungan* processing is a marine fish such as mackerel (*Rastrelliger* sp.), scad (*Decapterus* sp.), anchovy (*Stolephorus* sp.), and hairtail/ribbon fish (*Trichiurus savala*). Irianto (1999) reported that the *picungan* process is similar to the bekasem process. The function of the picung seed is to provide a carbohydrate source for the growth of lactic acid bacteria due to the lower pH of the end product. Widyasari (2006) demonstrated that the antimicrobial substance contained in the picung kernel may be used as a natural preservative for fish products and seems to increase the shelf life of the fish by 6 days, when stored at ambient temperature.

The traditional processing of *picungan* begins with preparation of the picung seeds. Picung seeds contain hydrogen cyanide and are deadly if consumed without prior preparation. To release the toxin, traditionally, the skin of the seeds is divided into two pieces and submerged into flowing water (river) for 2 days or sun-dried for 2 days. The seeds need to be shredded before being mixed with the other material. The fish used as the raw material must be considered fresh fish. The evisceration and washing process is applied to small fish; it is recommended that larger fish be cut to a smaller size or filleted (Figure 42.15). The fish are mixed with the shredded picung seed and salted at a ratio of 4:2:1. The fish are then layered in traditional baskets, and each layer is covered with a banana leaf. The fermentation process is allowed to take place for 3–7 days (Irianto 1999).

The approximate composition of *picungan* is as follows—66.35% moisture content, 21.69% protein content, 3.08% fat content, and 6.79% ash content. The approximate composition will vary depending on the fish used, the amount of *picungan*, and the fermentation period. As a result of the fermentation process, the pH of *picungan* drops to 5.26 and the lactic acid content increases to around 0.36%. *Lactobacillus* sp. and *Lb. murinus* have been successfully isolated from the *picungan* product (Irianto et al. 2003).

Fresh marine fish

Eviscerated and washed

Filleted or cut (for large fish)

Mixed with shredded picung seed and salt

Layered in a traditional basket and covered with a banana leaf

Allowed to ferment for 4–7 days

Picungan

FIGURE 42.15 General procedure for *picungan* processing.

42.2.11 *Pudu*

Pudu is a fermented fish product originally from the Riau province. The raw material of *pudu* is freshwater fish, and it is usually referred to as tilapia (*O. mossambica*). *Pudu* processing is similar to *bekasem* processing, which involves the addition of cooked rice as a carbohydrate source. Maamoen et al. (2003) stated that the processing of *pudu* begins by eviscerating and washing the fresh fish. The cleaned fresh fish is then mixed with a solution that contains 20% salt, 5% cooked rice, and an appropriate amount of *asam kandis*, a fruit of the *Garcinia parvifolia* tree. The formulation is then poured into glass jars and allowed to ferment (Figure 42.16).

There is limited scientific information on the *pudu* product. Maamoen et al. (2003) reported that the pH and salt content of *pudu* were 4.4% and 17%, respectively. There are no significant differences in terms of moisture content, protein, and fat between commercial *pudu* collected from a traditional market and *pudu* prepared in a laboratory. The moisture, protein, and fat contents are within the range of 58%–59%, 13.5%–15.7%, and 1.1%–1.2% wb, respectively.

42.2.12 *Rusip*

Rusip is a fermented fish product that originated in the Bangka–Belitung province. Physically, *rusip* is a dark brown liquid product with a strong fishy flavor (Figure 42.17). It is usually used as a flavoring agent in many dishes made by the local people of the Bangka–Belitung province. Madani et al. (2010) reported that the number of backyard processors of *rusip* in the Bangka–Belitung province is around 68. The main raw material for *rusip* processing is anchovy (*Stolephorus* sp.). Some of the processors also produce *rusip* prepared from Spanish mackerel (*Scomberomorus* sp.) and frigate mackerel (*Katsuwonus* sp.).

The traditional processing of *rusip* begins with removing the head of the fresh anchovy and washing with seawater (Figure 42.18). The cleaned, beheaded anchovy is then mixed with 20%–30% salt and kept

Fresh tilapia

Eviscerated and washed

Mixed with salt, cooked rice and *asam kandis*

Poured into glass jars

Allowed to ferment for 2 days

Pudu

FIGURE 42.16 General procedure for *pudu* processing.

FIGURE 42.17 *Rusip.*

Anchovy is beheaded and washed

Mixed with 20–30% salt

Kept in a closed container for one day

Mixed with 10% palm sugar and vinegar

Poured into bottles and kept sealed for 2–3 weeks

Rusip

FIGURE 42.18 General procedure for *rusip* processing.

TABLE 42.7

Chemical Composition of *Rusip*

Parameter	Ibrahim et al. (2009)	Madani et al. (2010)
Moisture	62.49–66.62	62.2–83.7
Protein (% wb)	16.43–16.71	10.5–14.5
Fat (% wb)	0.71–0.90	1.8–3.1
Ash (% wb)	9.23–14.41	–
Salt (% wb)	6.35–10.30	17.0–30.0
pH	4.33–4.56	5.1–6.1
TVN (mg/100 g)	–	165.0–2384.5
TMA (m/100 g)	–	11.6–94.6

in a closed container for 1 day. The container is opened, and 10% palm sugar and vinegar are added. The mixture is then poured into bottles. The mixture in the bottles is allowed to ferment for 2 weeks until a gray sticky liquid with a specific fishy aroma is produced.

Madani et al. (2010) reported that the moisture content of commercial *rusip* was 62.2%–83.7%. The moisture content of *rusip* depends on the fermentation period and the amount of salt added. Nurulita et al. (2010) reported that the moisture content of *rusip* fermented for 16 days was 50.6%, whereas Ibrahim et al. (2009) reported that a 14-day fermentation period produced *rusip* with a moisture content of 66.49%. As a result of the higher amount of salt added during *rusip* preparation, the salt content of *rusip* can reach 30% (Madani et al. 2010). Table 42.7 shows the chemical composition of *rusip*.

As a result of the fermentation process, *rusip* contains a higher amount of total lactic acid bacteria, in the range of 7.6–10.2 log cfu/g (Madani et al. 2010). Nurulita et al. (2010) reported that the total lactic acid bacteria of *rusip* were 10.5 log cfu/g. Kurniati et al. (2010) reported that the main bacteria isolated from rusip were *Leuconostoc* sp., *Streptococcus* sp., and *Lactococcus* sp. Early on in the *rusip* fermentation process, the main bacteria found are *Streptococcus* sp., while at the end of the fermentation process, the main bacteria found are *Lactococcus* sp. *Leuconostoc* sp. is more likely to be present in the middle of the fermentation process. Kusmarwati et al. (2001) reported that the *Staphylococcus aureus* count of the *rusip* product ranged from 6.0×10^2 to 1.6×10^5 cfu/g.

42.2.13 *Terasi*

Terasi is the largest fermented fish product produced in Indonesia. However, the production of *terasi* has decreased yearly, from 29.884 tons in 2002 to 19.915 tons in 2007. *Terasi* is popular as an appetizer in the daily diet of Indonesian families and is usually served along with chili, garlic acid, and salt in a mixture called *sambal terasi* (Figure 42.19). There are two types of *terasi*—*terasi udang* or shrimp paste and *terasi ikan* or fish paste. *Terasi udang* is more popular than *terasi ikan*. The raw materials for *terasi*

FIGURE 42.19 *Terasi udang.*

udang processing are small shrimp-like crustaceans (*Mytis* sp. or *Atya* sp.) called *udang rebon*, whereas the raw materials for *terasi ikan* are small anchovies (*Stolephorus* sp. or *Engraulis* sp.) (Putro 1993; Rahayu et al. 1992). In addition to being produced in a pasta form, *terasi* is also produced in a powder form. This is accomplished by applying an additional sun-drying process and fine grinding (Suparno and Murtini 1992).

The production of *terasi* is spread along Sumatra and Java Island. Although the actual processing is slightly different among producers and places, the basic methods applied for *terasi* processing are similar. Normally, shrimp-like crustaceans caught in the sea are first salted with 10% salt in the fishing boat. *Terasi udang* processing begins with washing the small shrimp-like crustaceans, draining, and sun-drying them until a half-dried product is obtained (Figure 42.20). The shrimp are then mixed with salt, pounded and sun-dried, and stored in a container at ambient temperature for 2–3 days. The shrimp are pounded again and at the same time mixed with salt. During the second pounding process, some processors also mix in a coloring agent such as rhodamine B or carthamine D to produce red *terasi* (Putro 1993). The pounded shrimp are sun-dried and stored at ambient temperature for the next 2–3 days until soft. The shrimp are then ground through a grinder until fine and formed into cubes or cylinders. The cubes or cylinders are fermented for a week or more at ambient temperature until the desired *terasi udang* aroma has developed (Yunizal 1998; Irianto and Irianto 1998). *Terasi ikan* is produced following similar procedures and more often colored with synthetic dye. The fish paste smell is more repulsive in this product than in the shrimp paste, which is the reason why this product is the less popular of the two (Putro 1993).

Shrimp-like crustaceans

Washed, drained and sun-dried until half-dried

Left overnight

Pounded and mixed with 2–3% salt

Sun-dried and stored at ambient temperature for 2–3 days

Pounded a second time and mixed with 2–3% salt

Sun-dried a second time and stored at ambient temperature for 2–3 days

Grounded and formed into cubes or cylinders

Fermented for 1–2 weeks

Terasi udang

FIGURE 42.20 General procedure for *terasi udang* processing.

TABLE 42.8

Chemical Composition of *Terasi Udang*

Parameter	Nio (1992)	Surono and Hosono (1994a)
Moisture	40.0	37.4
Protein (% wb)	30.0	25.4
Fat (% wb)	3.5	6.1
Ash (% wb)	23.0	29.2
Salt (% wb)	–	16.8
Carbohydrate (% wb)	3.5	1.9
pH	–	7.5

Terasi is also produced by mixing with other ingredients such as coconut sugar and tamarind. These ingredients are mixed during the second pounding, with the objective of accelerating the fermentation process. *Terasi* mixed with other ingredients showed a higher carbohydrate content, in the range of 20.50%–21.52% (Poernomo et al. 1984). The salt content is influenced by the amount of salt added during *terasi* preparation. Sarnianto et al. (1984) reported that the salt content of *terasi* was approximately 8.85%–17.24%. Table 42.8 shows the chemical composition of *terasi udang*.

Aerobic bacteriological analyses showed that *terasi udang* had a total viable bacterial count of 4.0×10^5 cfu/g and a halophilic count of 1.1×10^5 cfu/g. The predominant microbial flora in *terasi* were *Bacillus* sp. (65.7%), *Pseudomonas* sp. (21.4%), *Micrococcus* sp. (7.2%), *Kurthia* sp. (4.3%), and *Sporolactobacillus* sp. (1.4%) (Surono and Hosono 1994a). Moreover, the *terasi* starter was composed of *Bacillus brevis*, *B. pumilus*, *B. megaterium*, *B. coagulans*, *B. substilis*, and *Micrococcus kristinae*. *Pseudomonas* sp., *Kurthia* sp., and *Sporolactobacillus* sp. were not detectable in the *terasi*, starter and the lack of these bacteria is due to contamination during the *terasi udang* processing (Surono and Hosono 1994b). Studies by Kobayashi et al. (2003) found lactic acid bacteria in *terasi udang*, which consist of *Tetragenococcus halophilus* and *Tet. muriaticus*.

42.2.14 *Tukai*

Tukai is a fermented fish product produced in the Painan area, approximately 60 km from Padang, the capital city of the West Sumatra province. Normally, *tukai* is processed from a marine fish called sea-pike or barracuda (*Sphyraena* sp.), locally known as *tete* or *alu-alu* (Figure 42.21). The processing of *tukai* is closely related to that of another Indonesian fermented product, *peda*, except for the fermentation process, which is performed by burying the fish underground (Efendi 1995; Huda and Rosma 2006).

The traditional processing of *tukai* starts with removal of the scales, gills, and intestinal organs (Figure 42.22). The fish are then rinsed with water and submerged in 20% coarse salt solution for 2 h. The fish are drained to remove excess salt solution and sun-dried for 2 days. The fish are then wrapped individually in taro leaves and buried underground for 3 days. After that, they are unpacked and sun-dried for two additional days until the moisture content reaches 50%. The product, which has a specific flavor, aroma, and texture, is then ready to be packed, distributed, and marketed. Like *budu*, *tukai* cannot be consumed as a main dish. The product is normally mixed with ground chili and fried before being served.

The normal shelf life of *tukai* is about 3–4 weeks. Low-temperature storage can prolong the shelf life. The approximate composition of *tukai* is as follows—50% moisture content, 40% protein, 2% fat, and

FIGURE 42.21 *Tukai*.

Fresh barracuda

Washed and eviscerated

Dipped into 20% brine solution for 2 hrs

Drained and sun-dried for 2 days

Individual fish wrapped with taro leaves and buried underground for 3 days

Taro leaf is removed and fish is sun-dried for 2 days

Tukai

FIGURE 42.22 General procedure for *tukai* processing.

TABLE 42.9

Chemical Composition of *Tukai*

Parameter	Efendi (1995)	Huda and Rosma (2006)
Moisture	51.0	50.0
Protein (% wb)	–	40.0
Fat (% wb)	–	2.0
Ash (% wb)	–	7.0
Salt (% wb)	5.0	–
pH	6.9	–
TVN (mg/100 g)	113.2	–
VRS (meq/g)	40.9	–

7% ash. The higher ash content is correlated with the amount of salt used during salt soaking (Huda and Rosma 2006). The chemical composition of *tukai* is presented in Table 42.9.

In terms of microbial quality, Efendi (1995) reported that the main bacteria isolated in *tukai* are *Micrococcus* sp., *Staphylococcus* sp., *Pediococcus* sp., *Lactobacillus* sp., and *Pseudomonas* sp. Other bacteria isolated from the *tukai* sample include *Streptococcus* sp., *Bacillus* sp., *Corynebacterium* sp., *Clostridium* sp., and *Escherichia coli*.

42.3 Conclusions

There are many different fermented fish products available in Indonesia. The processing method of each product varies slightly among producers and production areas. The scientific information available about some products is limited and, therefore, provides an opportunity for Indonesian and international researchers to contribute to the development of fish fermentation technology in Indonesia.

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