p-ISSN: 1907-8056
e-ISSN: 2527-5410
AGROINTEK
Jurnal Teknologi Industri Pertanian
journal homepage: journal.trunojoyo.ac.id/agrointek

Quality properties of indonesian traditional *terasi*: a review

Askur Rahman[1*], Retno Astuti [2,3], Sucipto Sucipto [2,3]

[1]*Agroindustrial Technology, University of Trunojoyo Madura, Bangkalan, Indonesia.*
[2]*Agroindustrial Technology, Brawijaya University, Malang, Indonesia.*
[3]*Halal-Qualified Industry Development (Hal-Q ID),Brawijaya University, Malang, Indonesia*

Article history
Received:
2 July 2022
Revised:
14 December 2022
Accepted:
29 December 2022

Keyword
Quality;
Intrinsic attributes;
Traditional food;
Terasi.

ABSTRACT

Terasi constitutes an Indonesian traditional fermented product made from shrimp or fish (or a mixture of both) at a high salt concentration with or without incorporating approved additional ingredients. With a distinct flavor and solid texture (paste), terasi is widely consumed as a seasoning ingredient, but it is still produced using a traditional method that lacks quality inspection. Quality properties of terasi, i.e., physical, chemical, and microbiological aspects, are essential since they highly affect consumer acceptance. This article reviews the quality profiles of terasi, covering such aspects as food safety, health, sensory, shelf life, and its use. The safety of biological, chemical, and physical threats can be used to evaluate the quality of terasi from a safety perspective. In addition, the nutritional content, functional qualities, and satiety characteristics of terasi indicate its quality from a health standpoint. Based on taste, texture, aroma, and color, the sensory qualities of terasi are evaluated to determine its quality. From the time the product is developed until consumers utilize it without any modifications, the quality of terasi based on the shelf life aspect is observed. The quality of terasi in terms of usability is determined by items that are user-friendly or, in other words, practical.

* Corresponding author
Email: askurrahman@trunojoyo.ac.id
DOI 10.21107/agrointek.v17i1.15274

INTRODUCTION

Indonesia is endowed with an excellent fishery resource. The Ministry of Marine and Fishery, Republic of Indonesia (2015) reported that production in the fishery sector reached 20.8 million tons. The fishery commodities are then utilized as processed products, yielding 5.3 million tons. *Terasi* is one of the fishery products in Indonesia (Kementerian Kelautan dan Perikanan 2015).

Terasi, also known as belacan, is made from fermented fish or shrimp, consumed as a seasoning ingredient (Ma'ruf et al., 2013). In other countries, *terasi* has numerous name versions, as presented in Table 1.

Terasi is produced at a home industry scale (Hajeb and Jinap 2013, Kim et al. 2014); therefore, this leads to several drawbacks, such as limited technology and management andpoor control. These limitations closely relate to the quality properties of *terasi*.

The escalated understanding of the quality of *terasi* plays a vital role to enhance consumer loyalty and trust. Luning and Marcelis (2011) mentioned that several important aspects need to understand by producers related to the different viewpoints of consumers and producers on the quality of the product. Consumers often prefer abstract product quality, making it difficult to understand by producers. Additionally, consumers also like products due to their excellent appearance (packaging), safety, and health-promoting effects (Luning and Marcelis 2011). Therefore, there is a need to know a comprehensive concept of quality, to understand what consumers want, to determine the required technology, and eventually to generate acceptable thresholds. This review aims to describe the quality attributes of shrimp paste seen from the attributes of food safety, nutrition and health, sensory, shelf life, and Convenience obtained from the results of previous studies

Table 1 Various names of *terasi* in other countries

Country	Local name	Raw material	Reference
Indonesia	*Terasi Udang*	Shrimp, fish	(Ngah and Yahya 2012, Hajeb and Jinap 2013, Kim et al. 2014, Daroonpunt et al. 2016)
Malaysia	*Belacan*	Shrimp	(Ngah and Yahya 2012, Hajeb and Jinap 2013, Kim et al. 2014, Daroonpunt et al. 2016)
Philippines	*Bagoong-alamang, Buronghipon, Dinailan, Lamayo*	Shrimp	(Ngah and Yahya 2012, Hajeb and Jinap 2013, Kim et al. 2014, Daroonpunt et al. 2016)
Myanmar	*Nga-pi, Seinza, Hmyannga pi*	Shrimp	(Hajeb and Jinap 2013, Kim et al. 2014, Daroonpunt et al. 2016)
Vietnam	*Mam ruoc, Mam tom, Mam tep*	Shrimp	(Hajeb and Jinap 2013, Kim et al. 2014, Daroonpunt et al. 2016)
Thailand	*Kapi*	Shrimp	(Hajeb and Jinap 2013, Kim et al. 2014, Kleekayai et al. 2015, Prapasuwannakul and Suwannahong 2015, Daroonpunt et al. 2016, Pongsetkul et al. 2017)
Cambodia	*Kapi, Pra hoc, Mam ruoc*	Shrimp	(Hajeb and Jinap 2013, Kim et al. 2014)
Burma	*Seinsanga-pi, Hmyinnga-pi*	Shrimp	(Hajeb and Jinap 2013)
Bangladesh	*Nappi*	Shrimp	(Kim et al. 2014)
Brunei	*Belacan*	Shrimp	(Kim et al. 2014)
China	*Shajiang*	Shrimp	(Kim et al. 2014)
Korea	*Saewoojeot*	Shrimp	(Kim et al. 2014)
Japan	*Shiokara*	Shrimp	(Daroonpunt et al. 2016)
Laos	*Padoc*	Shrimp	(Ngah and Yahya 2012)
Republic Khmer	*Phahoc*	Shrimp	(Ngah and Yahya 2012)

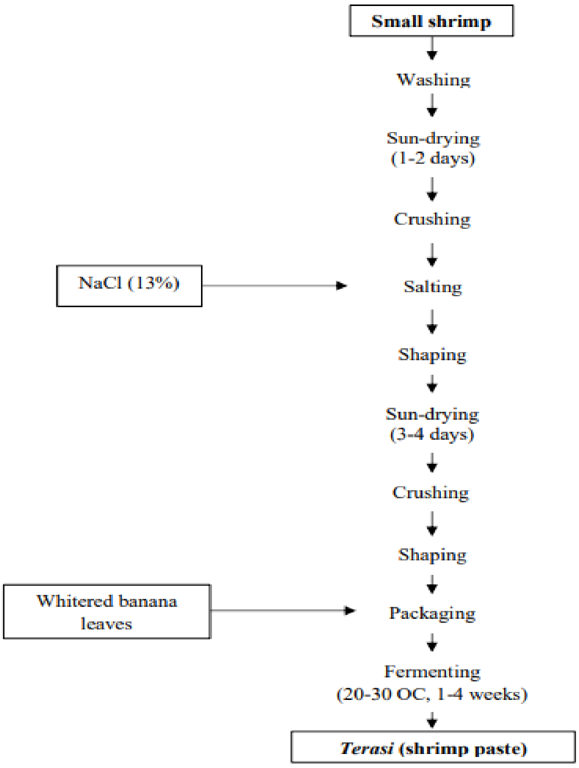

Figure 1 Production of terasi

THE USE OF *TERASI* IN FOODS

Terasi is used in various foods as a seasoning ingredient, including vegetables, sambal, rujak, and others. In addition, *terasi* was also added to various foods for different purposes, such as seasoning (Faithong et al. 2010, Chaijan and Panpipat 2012, Prapasuwannakul and Suwannahong 2015, Pongsetkul et al. 2017), main ingredient, side dish, condiment, flavor, and nutrition source, and umami taste (Hajeb and Jinap 2013), as well as used to produce sambal *terasi* (Indonesian) with the addition of chili and other ingredients (Sobhi et al. 2010, 2012, Cheok et al. 2017). Sambal *terasi* is also named as pazon ng api in Burma, sambal belacan in Malaysia and Singapura, blachan kapi or pherik kapi in Thailand and mam tom in Vietnam (Sobhi et al. 2010).

PRODUCTION OF *TERASI*

The main principle of making *terasi* involves the hydrolysis of shrimp or fish meat induced by proteolytic enzymes in the shrimp and fish (Wibowo 1998). This enzymatic process occurred under high salt concentration, resulting in *terasi* with a very distinct odor, aroma, and taste. *Terasi*, made from shrimp, also called shrimp paste, could be produced by adding salt and other ingredients.

The shrimp paste made from *Schizopodes* or *Mytis* sp was preferable to the fish paste for most Indonesian. The shrimp paste was mixed with 15% salt and fermented for 6-9 months to produce a unique aroma. It appears dark brown, gray, and red and has various tastes and a strong aroma. Regarding chemical composition, shrimp paste is rich in glutamic acid (1508.56mg/100g) and has an umami taste (Hajeb and Jinap 2013). The preparation of shrimp paste is described in Figure 1 and Figure 2.

Belacan is prepared using shrimp *Acetes* (commonly using dried shrimp) under a high concentration of salt (5-20%). The meat tissue of shrimp was enzymatically decomposed during fermentation. *Belacan* displays darker color after a week of fermentation. The most desirable taste and aroma of *belacan* were produced after 1-2 weeks of fermentation. The intense umami taste in *belacan* resulted from the presence of glutamic compounds and 5'-nucleotide in abundant amounts. The concentration of free glutamic acid was found in various Malaysian belacan, ranging from 180 to 530mg/100g. Meanwhile, the concentration of 5'-nucleotide in *belacan* ranged from 0.85 to 42.25 mg/g (Sudaryanto 2013). *Belacan* was also considered one of the significant umami contributors to Malaysian foods (Hajeb and Jinap 2013).

Figure 2 Indonesian shrimp paste. (a) Krill shrimp, the main ingredient of terasi, (b) sun-drying, (c) final appearance of terasi, and (d) terasi covered with withered banana leaves

Kapi was produced from krill shrimp (*Acetes* or *Mesopodopsis* species), mixed with salt at a ratio of 3-5:1. During sun-drying, the water content of the *kapi* was reduced, followed by the addition of other ingredients (such as salt) and mixing to obtain a semi-solid paste. The paste was then fermented for 2 months till gaining the desired taste. *Kapi* was rich in umami and contained a lot of free glutamic acid (647mg/100g) (Hajeb and Jinap 2013).

Seinsanga-pi or *myinnga-pi* constitutes a shrimp paste in Myanmar and appears pale red to red. They are made from *Mysis* or planktonic shrimps. Shrimp paste produced from high-quality shrimp was named *seinsanga-pi,* while the other was *hmyinnga-pi*. To prepare this type of shrimp paste, shrimp was mixed with salt, followed by sun-dried for 3-4 days. The mixture was crushed while added with salt and water to form a paste.

The paste was dried for a day and crushed 3-4 times to obtain a homogenous and fine paste. This paste was fermented for 4-6 months, yielding a strong umami taste. *Hmyinnga-pi* contained free glutamic acid of 10.08 mg/100g (Hajeb and Jinap 2013).

Bagoong-alamang is a shrimp paste from the Philippines prepared by fermentation for 10 days. The free glutamic acid of *Bagoong-alamang* in the Philippines was higher (814.15mg/100g) than in other Southeast Asia countries (Hajeb and Jinap 2013).

QUALITY ATTRIBUTES OF *TERASI*

Quality attributes of *terasi* included intrinsic and extrinsic. The intrinsic attribute considers the natural properties of *terasi*, while the irrelevant attribute covers the indirect aspects affecting *terasi* quality. This paper focuses on intrinsic attributes.

Food safety

Food safety of a product closely relates to aspects causing detrimental effects on health, covering biological, chemical, and physical hazards. Detail of these hazards is described in this section:

Biological hazards

Food infection

Luning and Marcelis (2011) stated that food infection occurred due to microbial infection on the food, which then invaded the gut and grew in the large intestine. Here, living microorganisms could exert toxic compounds capable of deregulating the normal function of the tissues and organs. The infectious diseases symptoms by pathogen included nausea, vomiting, stomachache, headache, and diarrhea. Food infection was caused by pathogenic bacteria such as *Salmonella*, *Shigella* spp., *Escherichia coli*, *Listeria monocytogenes*, and *Campylobacter jejuni*.

Food poisoning in fermented fish and shrimp products (*terasi*) is scarce due to pathogens. This condition is due to a high concentration of salt and cooking at high temperatures during *terasi* preparation, producing unsuitable conditions for the growth of pathogens (Waisundara et al. 2016). However, the traditional method of making *terasi* seems to have poor hygiene and sanitation facilities. Waisundara et al. (2016) did not detect *Salmonella* in the fermented fish product in Ghana.

Norhana et al. (2010) reported that *Salmonella* and *Listeria* had been isolated from shrimp and processed shrimp since the 1980s. The pathogenic bacteria were found in fresh and frozen shrimp and preserved and ready-to-eat shrimp products, suggesting that handling and processing by producers were insufficient to kill the pathogenic bacteria. To minimize the pathogens, physical and chemical treatments are required. The physical treatments included heating, cooling, irradiation, modified atmosphere packaging (MAP), high-pressure processing (HPP), and high-pressure carbon dioxide (CO_2). In contrast, the chemical treatments included the addition of chemicals such as chlorine, ozone, phosphate, and ammonia.

Food poisoning

Food poisoning occurs due to infection of noxious toxins or other harmful chemicals produced by microorganisms that grow in food. The toxin could be generated by bacteria (enterotoxin), mold (mycotoxin), and plants (phytotoxin). These toxins could induce acute stomachache and diarrhea, even promoting cancer and liver dysfunction. Enterotoxin-producing bacteria included *Clostridium botulinum* and *Staphylococcus aureus* (Luning and Marcelis 2011), while mycotoxin-producing mold included *Aspergillus flavus* and *A. parasiticus* (Luning and Marcelis 2011, Waisundara et al. 2016). In the case of *terasi*, microbial contamination that causes food poisoning was scarcely reported, which may be associated with low growth of those pathogens in *terasi* due to high salt levels.

Chemical hazards

Food sensitivities

Food allergy

Food allergy is an immune system response that involves the formation of immunoglobulin E antibodies (IgE), causing reactions such as anaphylaxis, eczema, vomiting, asthma, etc. In sensitive cases, a response to food allergy occurs a few minutes after consuming the food. On the contrary, in an immediate hypersensitivity reaction, the symptoms are recognized about 24 h after consumption (Coeliac disease is the best example in this case) (Luning and Marcelis 2011). Reports and research on food allergy due to *terasi* consumption have not been found, suggesting that *terasi* does not cause food allergy. The allergy-like symptom was found to result from the intake of histamine. However, due to having similar symptoms, such a case was regarded as a food allergy. Syamsir (2013) reported some symptoms, including nausea (with or without vomiting and diarrhea), sore throat, swollen lips, headache, redness on the neck and face, pruritus, and asthenia, which could indicate food poisoning due to histamine, not food allergy. Although both food allergy and histamine poisoning show similar symptoms, they differ.

Food Intolerances

Food intolerance does not involve the immune system, but other compounds (except protein) may promote a disadvantageous effect. A typical reaction occurs through anaphylaxis, metabolic disorder, and idiosyncratic. The anaphylaxis reaction seems to have similar symptoms to the food allergy because of histamine, but the antibody IgE does not mediate it. The metabolic disorder genetically relates to the metabolic pattern resulting in less or more sensitive metabolism, as found in lactose intolerance. The mechanism for many detrimental reactions, in particular, humans, remains unclear, and different reactions may relate to idiosyncratic reactions. Some idiosyncratic reactions were associated with food or ingredients such as sulfites (asthma), aspartame (urticaria), sugar (aggressive behavior), and chocolate (migraine) (Luning and Marcelis 2011). The presence of histamine in fermented fish and shrimp (*terasi*) (Naila et al.

2011, Daroonpunt et al. 2016, Waisundara et al. 2016) is potentially a source of food intolerances, which may show similar symptoms to allergies such as vomiting (with/without nausea or diarrhea), sore throat, swollen lips, headache, redness on the face and neck, pruritus, and asthenia (Syamsir 2013).

Food intoxicants

Food additives

Food additives (both natural and synthetic) are aimed at enhancing food properties. Synthetic chemicals are allowed to use in food without considering their threshold. However, using non-food grade chemicals, such as Rhodamine B, is often found, including in *terasi*. According to the findings of a survey conducted by the Consumers Association of Penang (CAP), samples of belacan (terasi) in Malaysia contained significant amounts of rhodamine-B. Permatasari (2007) also found that *terasi*, made in most home industries in Puger, Indonesia, was added with Rhodamin B as a colorant. Khoirriyah et al. (2014) stated that 2 of 8 *terasi* samples in Bangkalan, Indonesia, were positively added with Rhodamine B. Rhodamine B is a synthetic chemical widely used as a colorant in paper and textile industries, thus causing harmful effects on human health. In the long term, consumption of Rhodamine B could adversely affect the liver and promote cancer. However, a high level of Rhodamine B may cause acute poisoning in a short time.

Residues

Table salt (sodium chloride) is the most used chemical in fermented fish. Nevertheless, in developed countries, other substances such as benzoic acid, borate, sorbic acid, acetic acid, and natrium benzoate are also widely used as a preservative. Sugar and starch were used during fermentation since they are non-toxic and safe for the final product. Yet, African fishermen and producers use organic insecticide to capture and preserve fish (Waisundara et al. 2016). Waisundara et al. (2016) reported that these chemicals (DDT, Gardona, and Shelltox) in the Lake Chad basin were used to prevent insects in preserved fish. Unfortunately, the use of those chemicals was not appropriately controlled, thus potentially causing a health risk for consumers.

Contaminants

Terasi was primarily produced in home industries (Hajeb and Jinap 2013, Kim et al. 2014), using unskilled labor, limited technology, and management. Due to its low monitoring, the product is possibly contaminated by its surrounding. Waisundara et al. (2016) stated that the traditional process of fermented fish and shrimp had elementary tools and techniques, regardless of proper sanitation and hygiene of its waste and packaging aspects. This may relate to unappropriated facilities and practices, service, education, quality standard, and lack of financial support. Such practices included improper clothes, possibly being infected by microorganisms, and poor water quality. The water for washing fish is obtained from a river or lake. These water sources are not under reasonable control; thus, they may be a source of chemical and microbial contaminants. Lack of education and hygiene awareness also contributes to distributing hazardous contaminants in fermented products.

Endogenous substances

Endogenous toxin constitutes a toxic compound present in nature and foods. This harmful substance mostly comes from plants, such as glycoalkaloids (solanine in potatoes), caffeine, and biogenic amine (such as phenylethylamine). Another endogenous toxin was tetrodotoxin, found in puffer fish. In Japan, puffer fish needs to prepare with a high protocol standard since the toxin can cause death and paralysis (Luning and Marcelis 2011).

The toxic substance in *terasi* is histamine (Naila et al. 2011, Syamsir 2013, Daroonpunt et al. 2016, Waisundara et al. 2016). This substance may be present in the following fish, i.e., mackerel, tuna, salted fish, herring fish, whale, sardine fish, and oysters (Waisundara et al. 2016), as well as *Acinetobacter lwoffii*, *Bacillus megaterium*, *B. subtilis*, *B. thuringiensis*, *Brevibacterium casei*, *Enterococcus casseliflavus*, *E. faecalis*, *Staphylococcus hominis* (Naila et al. 2011). The content of histamine can vary depending on the grade of raw materials, the presence of endogenous microflora, handling and production facilities, and free amino acids (histidine) as a precursor (Daroonpunt et al. 2016).

Histamine in food was produced through a histidine decarboxylase-catalyzed reaction (Waisundara et al. 2016). Waisundara et al. (2016) reported that histamine resulted from autolysis. Other studies found that bacteria mostly induced the result of decarboxylation. Thus, the fermented fish product is a strong candidate for histamine source.

In a low concentration, histamine could promote weak side effects, but at a high level, histamine becomes a serious toxin. The hazardous effects of histamine at high dose occurs within a few minutes to hours after consumption (Waisundara et al. 2016). Daroonpunt et al. (2016) reported that histamine content in shrimp paste (collected from local markets and supermarkets) was <20-46.70 and 25.11-53.85 ppm. (Naila et al. 2011) found that histamine in fish paste (*terasi*) reaches 5487 ppm.

The threshold toxic dose (TTD) of histamine is still inconclusive. It is difficult to determine, depending on the degree of fish deterioration. Based on the Australian Standards Standards Code (2001) in (Waisundara et al. 2016), the TTD of histamine was about 60mg/100g. Although the determination of TTD may vary, some countries have decided the maximum level of acceptable histamine. As reported by FDA, the Hazard Action Level (HAL) of histamine was 50mg/100 g in tuna products; this is based on previous findings about histamine poisoning cases and the Defect Action Level (DAL) of 20mg/100g. Based on the health regulation of EEC 1993 for fishery products, DAL for histamine was 10mg/100 g, while the maximum permissible threshold was 20mg/100g (Waisundara et al. 2016). In Japan, no guidance for the threshold of histamine was made, although food poisoning due to histamine occurred in the country.

In addition, another natural chemical toxin was biogenic amine. Naila et al. (2011) reported that fish paste in Rihaakuru was reported to contain biogenic amine groups such as agmatine (161 ppm), cadaver (387 ppm), histamine (5487 ppm), putrescine (290 ppm), phenylethylamine (23 ppm), serotonin (91 ppm), spermin (329 ppm), spermidine (79 ppm), tryptamine (<5 ppm), and tyramine (50 ppm).

Physical Hazards

Physical hazards refer to unwanted or foreign materials present in food, which may cause injury, disease, and psychological trauma to an organism and are regarded as harmful to human health. This hazard can be present in each food chain; thus, a preventive approach must be carried out to minimize its presence in food. The foreign materials in food are divided into 3 groups, i.e. (1) mineral (soil, stone, dust, metal, glass, fiber, plastic, jewelry), (2) plant source (weed, leaves, stalk), and (3) animal source (insects, rats, bird, fish bone) (Luning and Marcelis 2011). For *terasi*, the potential foreign materials are net, oysters, and corals from raw materials (shrimp), stone, and dust (contaminated during the sun-drying process). Also, leaves and packaging materials can contaminate the packaging process.

The foreign materials contaminated food through raw materials, water, floor and building in which the food is produced, and labor. Since physical hazards are from numerous sources and cannot be removed by a particular process (such as heating), the hazard must be controlled through preventive actions, such as using a metal detector to prevent foreign metals from contaminating the foods. Another effort is visual inspection, even though less accurate (Luning and Marcelis 2011).

Nutrition and Health

The health attributes refer to food properties that enhance physiological functions (such as respiration, circulation, physical activities, and protein synthesis) and offer meaningful functions to humans. In this part, the health-related concept consists of 3 parts: nutritional composition, health-enhancing substances, and satiety properties (Luning and Marcelis 2011). These aspects are described in detail as follows:

Nutritional Value

The nutritional value is based on the amount and availability of both macro and micronutrients required for the growth and maintenance of the human body (Luning and Marcelis 2011). The nutritional composition of *terasi* can vary, depending on origins and raw materials (Table 2).

Table 2 demonstrates that the highest moisture content was attributed to Kongsom from Thailand, while the highest protein content was found in dried Saewoojeot from Korea. For ash and fat content, the highest value was found in Bagoong from the Philippines and Saewoojeot from Korea, respectively. In Indonesia, The quality standard of *terasi* was described by Standard Mutu Indonesia (SNI) 01-2716-1992 (Badan Standarisasi Nasional 1992), in which the maximum moisture content was 40%, while the maximum ash content (without salt) and crude fiber calculated was 20% and 8.5% dry base. Heavy metals and hazardous substances (Cu, Hg, Pb, and As) are impermissible.

Health-improving substances

The substances that improve a health condition could be naturally present in food ingredients or intentionally added, aiming to modulate a human metabolic system (Luning and Marcelis 2011). In *terasi*, the potential functional component included antioxidant compound (Peralta et al. 2008, Faithong et al. 2010, Peralta and Jr Serrano 2014, Kleekayai et al. 2015, Prapasuwannakul and Suwannahong 2015, Pongsetkul et al. 2017), essential amino acid, (Kim et al. 2014, Anggo et al. 2015) and polyunsaturated fatty acid (Montano et al. 2001, Peralta et al. 2008, Kim et al. 2014, Anggo et al. 2015).

Peralta et al. (2008) found a free radical and hydrogen peroxide scavenging activity in *terasi*. Higher antioxidant activity was found with a longer fermenting time. The compound responsible for antioxidant activity was α-tocopherol. Faithong et al. (2010) studied Thai traditional fermented shrimp products (*Jaloo*, *Koong-Som*, and *Kapi*) and found that their antioxidant activity was stable against pH and heating. Peralta and Jr Serrano (2014) stated that free radical Diphenyl-1-picrylhydrazyl (DPPH) scavenging activity occurred on the 5th day and increased until the 15th day, even though it demonstrated an insignificant increase. The scavenging activity of free radical DPPH was increased in various heating treatments of *terasi* preparation.

Prapasuwannakul and Suwannahong (2015) reported that *terasi* (Klongkone) from Thailand showed a beneficial effect on human health due to its high nutritional content and natural antioxidant compounds. Kleekayai et al. (2015) also reported that the water extract of Thai traditional *terasi* demonstrated strong antioxidant activity and inhibition of the angiotensin-converting enzyme (ACE). Dipeptide Ser-Val was the principal constituent found in *terasi* that shows ACE inhibition. The report suggests that traditional fermented products contain bioactive peptides with antioxidant activity and ACE inhibition, making *terasi* acceptable as a health-promoting food for consumers.

Table 2 Nutritional value of *terasi* from several countries

Origin countries	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Carbohydrate (%)	Salt (%)	pH	Aw	Reference
Terasi (Indonesia)	33.8	22.3	31.1	2.9	9.9	-	-	-	(Sudaryanto 2013)
Klongkone (Thailand)	37.36-46.85	18.95-25.14	20.95-30.86	0.69-2.05	4.27-17.96	19.78-22.96	7.01-7.71	0.70-0.74	(Prapasuwannakul and Suwannahong 2015)
Ka-pi (Thailand)	33.95-52.19	17.9-42.8	-	-	-	7.00-10.85	-	0.64-0.72	(Daroonpunt et al. 2016)
Belacan (Brunai)	47.92	30.38	19.15	0.63	-	14.94	7.56	0.73	(Kim et al. 2014)
Saewoojeot (Korea)	26.96	21.70	45.83	4.89	-	13.46	7.68	0.68	(Kim et al. 2014)
Dried Saewoojeot (Korea)	21.13	56.59	13.95	0.82	-	12.87	8.50	0.77	(Kim et al. 2014)
Belacan (Malaysia)	31.93-40.27	32.60-34.99	16.44-21.69	0.36-0.70	7.71-11.87	-	-	-	(Mohammad et al. 2016)
Jalo (Thailand)	70.53-77.63	9.82-14.23	7.74-11.28	0.55-0.74	3.22-4.26	4.55-5.43	7.24-7.38	-	(Faithong et al. 2010)
Kong-som (Thailand)	73.35-80.71	6.38-7.21	4.41-5.00	0.11-0.15	6.93-15.75	2.81-3.74	3.71-3.89	-	(Faithong et al. 2010)
Kapi (Thailand)	36.78-49.93	20.14-25.12	24.13-28.99	1.53-2.22	2.84-15.61	19.29-24.73	7.44-7.66	-	(Faithong et al. 2010)
Bagoong (Philipina)	33.2-39.6	-	37.1-46.0	0.60-1.57	-	19.0-24.4	-	-	(Montano et al. 2001)

The mark "-" means no data available

Table 3 Content of essential amino acids in various types of *terasi* (mg/100g)

Amino acids	*Terasi*					
	Fish paste (Indonesia)	Bagoong-alamang (Philippines)	Belacan (Brunei)	Saeoojeot Basah (Korea)	Saeoojeot Kering (Korea)	Kapi (Thailand)
o-Phosphoserine	-	23-40	-	-	-	-
Taurine	-	730-919	-	-	-	-
Urea	-	22-134	-	-	-	-
Aspartic acid	3.08-3.69	33-611	2842.8	2142.9	4741.6	9.65-28.17
Threonine*	1.61-1.85	91-268	1290.3	864.8	1889.4	-
Serine	1.14-1.32	47-181	951.2	606.5	1907.7	-
Asparagine	-	0-52	-	-	-	-
Glutamic acid	4.61-5.52	40-140	5284.6	3133.7	6951.4	7.01-59.39
Glutamine	-	94-823	-	-	-	0.22-4.60
Glycine	1.98-2.36	222-383	1565.2	1239.5	2815.7	8.06-22.03
Alanine	1.97-2.38	254-433	1703.3	992.8	2815.7	9.01-24.50
Citrulline	-	153-760	-	-	-	-
α-Aminobutyric acid	-	0-62	-	-	-	0.07-0.26
Valine*	1.87-2.21	127-499	1417.1	962.7	2071.2	2.95-26.97
Methionine*	1.15-1.29	72-205	923.6	592.2	1209.6	0.82-16.29
Cystathionine	-	9-36	-	-	-	-
Isoleucine*	1.61-1.79	105-448	1259.5	854.7	1845.6	1.85-36.43
Leucine*	2.56-2.80	241-889	2450.4	1457.6	3272.8	2.95-54.49
Tyrosine	1.30	93-173	1011.5	641.1	1513.0	-
Phenylalanine*	1.71-1.84	92-374	1300.3	912.3	1917.4	1.34-25.58
Ornithine	-	1-208	-	-	-	-
Histidine*	0.97-1.26	24-75	491.2	320.8	1049.3	1.11-4.13
Lysine*	2.87-3.12	241-625	2468.1	1385.0	3072.3	11.27-54.67
Tryptophan	-	18-81	-	-	-	-
Anserine	-	0-37	-	-	-	-
Arginine*	2.02-2.49	363-412	1042.6	1382.8	3345.7	1.00-22.44
Proline	1.37-1.71	133-314	1173.0	918.7	1889.6	2.83-13.54
Ammonia	-	6-163	-	-	-	-
Cystine	0.34-0.37	-	-	-	-	-
Total	32.32-37.15	3600-8239	27174.7	18408.1	41957.1	75.35-358.40
Essential amino acid	16.37-18.65	1356-3795	12643.1	8732.9	19673.3	23.29-241.00
Reference	(Anggo et al. 2015)	(Peralta et al. 2008)	(Kim et al. 2014)	(Kim et al. 2014)	(Kim et al. 2014)	(Daroonpunt et al. 2016)

The mark * means essential amino acid

Peralta et al. (2008) observed the content of free amino acid in different fermentation times of *terasi*, extracted using ethanol 80%. The results showed that the free amino acid concentration dramatically increased within 90 days of fermentation (from 3,600mg/100g to 8,239mg/100g w.b). Still, it then showed no significant increase till 180 days of fermentation. The main free amino acids in the extract included taurine, glycine, alanine, lysine, and arginine. Kim et al. (2014) found that the content of free amino acid in a dried Saewoojeot from Korea was 41,957mg /100g, while its essential amino acids reached 16,763 mg/100g. The most abundant amino acid was glutamic acid, followed by aspartic acid and leucine. Anggo et al. (2015) reported that the total content of free amino acids was 32.32 mg/100g (w.b) within 8 days of fermentation and increased by 37.15mg/100g (w.b) within 32 days of fermentation. The study also found that the main amino acids included glutamic acid, Aspartic acid, and arginine. Although the concentration of some amino acids was decreased, the others showed a meaningful increase. The composition of essential amino acids in *terasi* is presented in Table 3.

Montano et al. (2001) stated that *terasi* made from krill (*Acetes* spp.) was reported to have the highest level of DHA (all-cis-4,7,10, l3, l6, l9-docosahexaenoic acid), a member of polyunsaturated fatty acid (PUFA). The results also found that the composition of PUFA in *terasi* was relatively similar to that in fresh shrimp, indicating that there is a mechanism capable of protecting these fatty acids against autooxidation. In addition, the content of DHA in seasoning made from Siganus was quite similar to that made from *Acetes* due to high-fat content. In summary, both seasonings are good sources of DHA. Peralta et al. (2008) found that fatty acids in *terasi* were dominated by PUFA, whose primary fatty acids were 16: 0, 16: 1n-7, 18: 0, 18: 1n-9, 20: 4n-6, 20: 5n-3 (EPA) and 22: 6n-3 (DHA). These fatty acids were found stable during 360-day fermentation, except for DHA, which slightly increased within 180 days. Kim et al. (2014) exhibited that *terasi* was rich in polyunsaturated fatty acids, especially in *Saewoojeot*. Anggo et al. (2015) reported that the primary fatty acids within 8 days of fermentation included palmitic acid, oleic acid, stearic acid, and DHA, while stearic acid, palmitic acid, oleic acid, and DHA seemed to be dominant in 32 days of fermentation. The aforementioned studies suggested that most PUFA (particularly EPA and DHA) was unaltered in the initial phase of fermentation. During fermentation, changes in the content of fatty acids may differ. These fatty acids, i.e., caprylate, lauric acid, myristic acid, palmitic acid, palmitoleic acid, oleic acid, and linolenic acid, were decreased, but others (capric acid, stearic acid, EPA, and DHA) increased. The composition of fatty acids in *terasi* is presented in Table 4.

Satiety characteristic

Satiety refers to a physical feeling of fullness that allows people to stop eating, while satiation considers the end of the desire to eat after a meal. The satiety characteristic of food may be dissimilar due to the physical and chemical properties of ingested food, which induce afferent signals from many organs (stomach, proximal small intestine, distal small intestine, and colon) to the brain (Luning and Marcelis 2011). Holt in Luning and Marcelis (2011) develop the index of fullness for foods according to the capability of foods to satisfy hunger. In general, the high fiber, protein, and water content in a food results in prolonged fullness. This food characteristic is essential considering the elevating prevalence of obesity over the world.

Sensory

The sensory attribute is of foremost concern since it remarkably affects consumer acceptance. The attribute is recognized by specific receptors, i.e., tongue, nose, eyes, skin, and ears. Some physicochemical properties of the product enable to alteration of sensory attributes. For *terasi*, its sensory attributes include taste, texture, aroma, and color.

Taste can be described as sweet, salty, sour, and umami. The correlation between taste and physicochemical properties has been well understood. The main components responsible for sweet, salty, bitter, and sour were sugar, salt, bitter compounds, and acids. However, the taste can be reduced or enhanced by volatile compounds; thus, understanding the correlation between physicochemical properties and taste profile is more complex (Luning and Marcelis 2011). *Terasi* has a strong umami taste resulting from free glutamic acid (Hajeb and Jinap 2013, Kim et al. 2014, Anggo et al. 2015, Daroonpunt et al. 2016). The higher concentration of free amino acid results in a stronger umami taste. Table 3 shows *terasi* in South East Asia contains glutamic acid at different levels. Indonesian *terasi* is reported to have the highest content of free glutamic acid, yielding the strongest umami taste, as described in Table 5.

Texture refers to the mechanical, geometrical, and surface attributes of food. In the case of *terasi*, the texture can be evaluated by observing these parameters, i.e., hardness, compactness, and firmness. The use of sensory analysis for evaluating the texture of *terasi* is considered.

Odor and aroma constitute a quality attribute affected by the presence of volatile and non-volatile compounds, including acid, alcohol, ester, carbonyl, lactone, aromatic compounds, and terpene (Luning and Marcelis 2011). *Kapi* was reported to contain volatile compounds such as aldehyde, ketone, alcohol, Nitrogen, Sulphur, hydrocarbon, and other compounds, reaching 51 volatile compounds (Pongsetkul et al. 2017). *Fish miso* was reported to contain 16 volatile compounds (Giri et al. 2010a, 2010b).

Terasi has a dark appearance. The red color in *terasi* was induced by astaxanthin (Chaijan and Panpipat 2012, Mao et al. 2017), while the brown color could be caused by the Maillard reaction (Peralta et al. 2008, Peralta and Jr Serrano 2014, Pongsetkul et al. 2017).

Consumer acceptance of sensory attributes (taste, texture, aroma, and color) is evaluated using a hedonic test with untrained panelists. Each attribute was scored using a 9-point hedonic scale (1-dislike extremely to 9-like extremely) (Sobhi et al. 2010, 2012, Chaijan and Panpipat 2012).

Shelf Life

The shelf life of the product is defined as a period in which the product is produced, distributed, and consumed by consumers without a significant reduction in quality. The longer shelf life of a product indicates better quality. The presence of *terasi* at high concentrations is responsible for the long shelf life of *terasi*. (Luning and Marcelis 2011) suggested that within the shelf life period, the product needs to ensure (1) food safety, (2) stability on sensory, chemical, physiological, and microbiological properties, and (3) nutritional content in conjunction with the label.

Table 4 The composition of fatty acids in various types of *terasi*

Components	Formula	*Terasi*	*Dalagang bukid*	*Dilis*	*Padas*	*Terong*	*Alamang*	*Belacan*	*Saewoojeot*
Caprylic acid	C8:0	0.58	1.1	1.01	0.07	0.30	0.29	-	-
Capric acid	C10:0	0.43	1.8	1.1	0.20	0.6	1.4	-	-
Lauric acid	C12: 0	1.66	1.3	2.5	0.54	1.09	0.8	-	-
Myristic acid	C14:0	2.45	11.3	7.5	8.2	10.9	4.1	3.31	1.19
Pentadecanoic acid	C15:0	-	-	-	-	-	-	0.72	-
Palmitic acid	C16:0	9.88	38.4	37.2	41.5	40.4	25.0	18.96	16.28
Palmitoleic acid	C16:1	2.20	8.3	5.8	9.9	8.5	6.6	13.90	7.46
Margaric acid	C17:0	-	-	-	-	-	-	1.13	0.88
Margaroleic acid	C17:1	-	-	-	-	-	-	-	0.64
Stearic acid	C18:0	16.57	16.6	17.8	15.3	15.8	11.0	6.15	3.91
Oleic acid	C18:1n9	5.75	12.3	13.5	10.24	12.1	10.8	6.20	7.39
Linoleic acid	C18:2n6	-	0.63	0.9	0.73	0.81	2.9	2.10	1.60
ϒ-Linolenic acid	C18:3n6	-	-	0.08	0.02	0.03	0.16	0.70	-
Linolenic acid	C18:3n3	0.35	0.14	0.22	0.22	0.264	2.15	0.83	0.95
Arachidonic acid	C20:0	-	1.08	0.77	0.6	1.01	1.47	0.44	0.75
Eicosatrienoic acid	C20:3	-	0.11	0.07	0.10	-	0.1	-	0.57
Eicosenoic acid	C20:1	-	1.0	1.0	0.59	0.90	0.4	-	2.11
Eicosedioic acid	C20:2n6	-	0.12	0.18	0.187	0.171	0.44	-	-
Arachidonic acid	C20:4	-	-	0.1	0.12	0.01	0.04	-	3.50
Eicosapentaenoic acid	C20:5n3	1.92	0.5	1.2	1.7	1.2	11.0	21.73	26.92
Behenoic acid	C22:0	-	0.9	0.9	0.61	0.77	2.8	-	-
Erucic acid	C22:1n9	-	0.04	0.04	0.058	0.125	-	0.57	-
Klupanodonoic Acid	C22:5n3	-	0.05	0.3	1.3	0.25	0.3	-	-
Docosahexaenoic acid	C22:6n3	3.91	1.7	3.0	5.4	2.4	11.5	21.84	23.74
Tricosanoic acid	C23:0	-	-	-	-	-	-	0.45	0.73
Lignoseric Acid	C24:0	-	1.0	2.6	0.6	0.78	0.7	-	-
Nervonic acid	C24:1	-	1.3	0.84	0.58	1.08	0.28	0.97	1.39
SFA		31.57	73.4	71.5	67.6	71.6	47.3	31.16	23.74
USFA		14.13	26.6	28.6	32.4	28.5	52.7	68.84	76.26
MUFA		7.95	22.9	21.3	21.3	22.7	18.0	21.63	18.99
PUFA		6.18	3.7	7.3	11.1	5.8	34.7	47.21	57.27
Reference		(Anggo et al. 2015)	(Montano et al. 2001)	(Montano et al. 2001)	(Montano et al. 2001)	(Montano et al. 2001)	(Montano et al. 2001)	(Montano et al. 2001)	(Kim et al. 2014)

Table 5 Content of glutamic acid in *terasi* from various South East Asia countries (Hajeb and Jinap 2013)

Country	*Terasi* (shrimp paste)	Free glutamic acid (mg/100 g)
Indonesia	*Terasi*	1,508.56
Malaysia	Belacan	180-530
Thailand	Kapi	647
Myanmar	Seinsanga or hmyinngapi	10.08
Philippine	Bagoong-alamang	814.15

Convenience

Currently, consumers tend to consider the easy-to-use criteria when choosing products. Producers innovate their products to be more easily used to meet this challenge. For instance, *terasi* is now available in powder, which makes it easier to use. *Terasi* is also packaged in various sizes. Since *terasi* is mainly used as a seasoning in *sambal* (sauce), it is mixed with chili.

CONCLUSION AND FUTURE RESEARCH

Terasi is one of the fermented products made from fish or shrimp (krill), and very popular among South East Asia countries. It is also rich in various nutrients and can be a good source of DHA, EPA and a taste enhancer for umami. Considering its intrinsic attributes (food safety, health, sensory, shelf life, convenience) in the development of *terasi* is a worthwhile endeavor. The intrinsic attributes of *terasi* prepared using modern technology are better than that of traditional *terasi*, thus, requiring the development of proper material handling techniques. The future task is to produce high-quality *terasi* and improve its functional properties.

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