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A comparative study on chemical characteristics of Indonesian *terasies*, traditional salted seafoods

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Terasies are traditional salty seafoods used in almost every food in Indonesia. The production process of *terasi* depends on the available raw materials and resources of the local manufacturer. A comprehensive set of 76 samples from twelve provinces famous for *terasies* were compared for their dry matter (DM) [66.58±8.81 g/100 g fresh weight (FW)], protein (46.32±10.71 g/100 g DM), fat (4.26±1.37 g/100 g DM), ash (41.61±11.88 g/100 g DM), carbohydrate content (7.81±6.74 g/100 g DM) and for their water activity (0.687±0.057). Results showed no particular pattern regarding the province of origin and that chemical characteristics significantly varied within the samples. The total free amino acids (1.21-9.65 g/100 g N), indicated substantial protein hydrolysis. Alanine, glutamic acid, leucine, aspartic acid and lysine were abundantly found. *Terasi* contained prominently putrescine and cadaverine (0.33±0.34 and 0.24±0.26 g/100 g N, respectively), followed by tyramine, β-phenylethylamine and histamine (all <0.05 g/100 g N). Short chain fatty acid analysis revealed the abundant presence of acetic acid (0.52 g/100 g FW), apart from the pungent isovaleric, propionic, isobutyric and butyric acids (0.01-0.12 g/100 g FW). Results indicated inconsistent, unstandardized manufacturing and storage processes which therefore should be improved.

Keywords: Chemical characteristics, Fermentation, Indonesia, *Rebon*, *Terasi*

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As a maritime and the world's largest archipelago in the world[1], Indonesia has a great potential to generate large amounts of fishery products. Unfortunately, many catches remain unprocessed and many non-commercial fish/seafood are unmarketable. One option to valorize these catches is by using salting, with or without fermentation and drying process, which is generally done with the planktonic shrimp (called *rebon*) to produce *terasi*. In Indonesia, *terasi* is added to almost every dish as a flavor enhancer. It is predominantly incorporated into chili sauce, known as *sambal-terasi*. Damanik-Ambarita *et al.*[2,3] evaluated the use of *terasi* in *sambal-terasi*. These authors also indicated that the impact of *terasi* can be noticed with low intensities of fishy and *rebon* notes when added to chili sauce between 3.45-6.90% *terasi* (*terasi* acts as a tastes/flavor enhancer in chili sauce)[2]. Although to reach the optimum taste/flavor of the common *sambal-terasi*, usually between 10.4-13.8% *terasi* is added to the chili sauce[2]. However, sometimes poor people use a higher amount of *terasi* as their source of protein, which will reduce the acceptance of the taste and flavor attributes of *sambal-terasi* especially the umami, sweetness, and sourness, while the saltiness, bitterness, *rebon*, and fishy notes will be much stronger perceived.

Related products to *terasi*, made of shrimp or mysis, can be found in Asia, e.g. *belacan* (Malaysia and Brunei Darussalam); *kapi* (Thailand and Cambodia); *bagoong-alamang* (the Philippines); *mam-ruoc*, *mam-tom* (Vietnam); *jeotgal/jeot* (Korea); *seinsa nga-pi* or *hmyinnga-pi* (Myanmar), *nappi* (Bangladesh) and *shiokara* (Japan)[4]. These products are also made by using various aquatic species and salt concentrations[4,5]. In South Korea, more than 160 different types of *jeotgal* are found differing in major ingredients and the regional preparation methods used[6]. Although also high variations in *terasi* are present in Indonesia which is not well documented, especially many regions and family businesses developed their own traditions, production processes

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or recipes. Sometimes some people prefer *terasi* from certain region than other places.

Terasi is prepared by mixing fresh shrimp (*rebon*) and/or other aquatic animals with salt (usually about 20% w/w), followed by sun-drying and fermentation/ ripening for various time periods, allowing endogenous enzymes, as well as microbial ones to auto-digest the substrate. Sometimes sugars or other carbohydrate sources, spices and colorants are added, which may influence the fermentation conditions and characteristics of the product[7]. After or in between the fermentation/ ripening, the product is kneaded and often sun dried which makes the product easier to storage or to transport. The entire process results in the formation of different metabolites originating from protein and/or lipid degradation and/or oxidation, Maillard and Strecker reactions, which are responsible for the unique and important taste/flavor of fermented seafoods[4,5].

In general, chemical characterization of fermented shrimp products is rarely found. Recently Kim *et al.*[8] characterized and compared the quality characteristics of the Korean fermented and dried *Saewoojeot* shrimp paste to *belacan* from Brunei Darussalam; while Pilapil *et al.*[9] characterized the chemical quality of traditional salt-fermented shrimp paste from Northern Mindanao, Philippines. For *terasi*, as produced in Indonesia, there is no thorough study available in characterizing this product. Damanik-Ambarita *et al.*[2] evaluated six different types of *terasies*. The study revealed that the chemical characteristics of *terasi* could contribute to the sensory profile and acceptance of *sambal-terasi*, especially with respect to the biogenic amines and the short chain fatty acids contents. These compounds contribute to the pungent odor of *terasi* and *sambal-terasi*, although, some products of *terasi* evaluated had also an acceptable odor. That study also showed that protein was the highest component in *terasi* which is an important factor to determine the quality of *terasi*. Therefore, the aim of this study was to have an in-depth characterization (proximate composition, salt content, water activity (a_w), free amino acids (FAAs), short chain fatty acid (SCFA), and biogenic amines (BAs)) of different *terasies* on the market originating from different regions in Indonesia.

Material and Methods

Samples

Terasi samples (76 types) were collected from twelve provinces in Indonesia which are famous for their *terasi* production or consumption of *sambal-terasi* i.e., North Sumatera (17 samples), Riau (4 samples), South Sumatera (14 samples), Lampung (1 sample), DKI Jakarta (10 samples), Banten (4 samples), West Java (9 samples), Central Java (7 samples), East Java (3 samples), Yogyakarta (4 samples), West Kalimantan (2 samples), Bali (1 sample). They were taken either directly from traditional factories or bought from markets. Some of them were purely made from the planktonic shrimp (*rebon*) and some contained fish or other ingredients such as rice bran. Detailed composition data were not shared by the producers. Moreover, on the packaging of many samples obtained in the market, neither information about the ingredients used nor the expiring date was given. All samples were frozen (-20°C) before sending to the laboratory for further analyses.

All standards and chemicals used were of analytical reagent grades and were obtained from Sigma Aldrich, Fluka, Chem Lab and Merck distributors in Belgium.

Chemical analyses

The proximate compositions were analyzed according to the methods described by Damanik-Ambarita[2], i.e., moisture and ash content were determined based on the Official Methods of Analysis, AOAC[10]. The fat content was determined by the Weibull method and the protein content by the Kjeldahl method[11]. The carbohydrate composition was determined by the difference of the mentioned chemical parameters. The a_w was measured using water activity RTD 200 TH-2 RS232 Thermoconstater, Novasina, under isothermal conditions at 20°C. The NaCl (salt) content was measured indirectly by the determination of chloride ions by a precipitation titration using silver nitrate[12]. This analysis was done for 18 samples as the salt content could be represented by the ash content due to their significant Pearson correlation of coefficient determination R^2: 0.967 ($p<0.01$).

Free amino acids (FAAs) were determined using the method of Kerkaert *et al.*[13] with some modifications. Proteins were precipitated by using trichloroacetic acid (TCA) to reach 15% of final concentration and after filtering through a 0.45 µm pore size PTFE syringe filter (Grace, Lokeren, Belgium), their constituent FAAs were obtained. The filtrates were automatically derivatized with OPA and FMOC in the injector of an Agilent 1100 system

(Agilent Technologies, Switzerland) which was operated at 40°C. Derivatized FAAs were then separated on a Zorbax Eclipse AAA Rapid Resolution column (4.6×150 mm, 3.5 µm, Agilent Technologies). The FAAs were detected fluorometrically at excitation and emission wavelengths of 340/450 and 266/305 nm, respectively. Solvent A (45 mM $NaH_2PO_4.H_2O$; 0.02% NaN_3, adjusted at pH 7.8) and solvent B (45% methanol, 45% acetonitrile and 10% H_2O, (vol/vol)), were used as eluents. Eluents were run with the following gradient at a flow of 2 ml/min i.e., from 0 to 1.9 min, 95% solvent A and 5% solvent B, linearly increasing solvent B till 17.9 min at a final gradient of 43% solvent A and 57% solvent B and kept until 18.4 min, followed by a linear increase till 100% solvent B from 18.4 till 22.2 min, kept at 100% solvent B till 23 min and then going back to the original solvent ratio. The FAAs were detected fluorometrically at excitation and emission wavelengths of 340/450 and 266/305 nm, respectively. Norvaline and sarcosine were used as internal standards for quantification of the FAA.

Biogenic amines (BAs) were determined based on the method of Komprda *et al.*[14] with some modifications. *Terasi* was homogenized in 5% TCA together with an internal standard (1,7-diaminoheptane; concentration 1 mg/mL) and filtered through a paper filter (pore size 5–13 µm FN0121P00026, Novolab, Belgium). The pH of the filtrate was adjusted to 9.5 and derivatized with dansyl chloride (5 mg/mL in acetone) for 90 min at 40°C, in the dark. Residual dansyl chloride was removed by adding 100 µL of an aqueous ammonia (25%) solution. The derivate was extracted from the aqueous phase with diethylether (3x1 mL). The extract was evaporated under nitrogen. The dried amines were dissolved in acetonitrile and filtered through 0.45 µm pore size PTFE syringe filter and placed into HPLC-vials. The samples were analyzed using (U) HPLC, using a UV/Vis detector at 254 nm. The BA-derivates were separated using a Dionex bonded silica Acclaim TM RSLC 120 C18 reverse phase column (2.1 mm x 150 mm, particle size 2.2 µm). Separation was carried out by gradient elution with H_2O and acetonitrile i.e., 0-23 min with H_2O (35-0% gradient) and acetonitrile (65-100% gradient) at a flow rate 0.5 mL/min. After calculating the amount of each BA, the biogenic amine index (BAI) was calculated according to Mietz & Karmas[15] i.e., (histamine + putrescine + cadaverine)/ (1 + spermidine + spermine). Based on the BAI values food can be categorized, i.e., 1 and 10 as the nominal cut-offs for class 1 as good; class 2 as borderline (until 10) and values above 10 were considered as class 3 or decomposed[15]. Of all the samples tested, no peak for either spermidine or spermine was observed (LOD < 4 ppm of amines).

The short chain fatty acids (SCFAs) were analyzed based on a method of De Weirdt *et al.*[16]. Samples were homogenized in water and after adding 2-methyl hexanoic acid as an internal standard (concentration 7.5 µL/µL), SCFA were extracted with diethyl ether. Extracts were analyzed using a GC-2014 gas chromatograph (Shimadzu, 's-Hertogenbosch, the Netherlands), equipped with a capillary fatty acid-free EC-1000 Econo-Cap column (dimensions: 25 mm x 0.53 mm, film thickness 1.2 µm; Alltech, Laarne, Belgium), a flame ionization detector and a split injector. The inlets for both dry air and hydrogen gas were set to 50 kPa, which gave a stable flame. The injection volume was 1 µL and the temperature profile was set from 110 to 160°C, with a gradient temperature increase of 6°C per min with nitrogen as carrier gas at a flow rate of 2.49 mL/min and an injector and detector temperature of 100 and 220°C respectively.

Data analysis

The data were subjected to analysis of variance. SPSS 24 (IBM, New York, USA) was used for the statistical analyses and was set to 5% of confidence level. Hierarchical cluster analysis was performed towards protein, fat, ash, moisture, SCFAs, BA contents (on dry matter, DM) and FAA contents (on Nitrogen base), to discover the possible cluster among samples. Ward's method and square Euclidean distance were used to measure the similarity among samples.

Result and Discussion

The chemical characteristics of *terasi* samples are reported in Table 1 (proximate composition, salt content and a_w). Results from cluster analysis also showed that there was no specific pattern to relate the variations of chemical characteristics of *terasi* to the province where samples were collected (Fig. 1). For instance, the samples collected from respectively North Sumatera, South Sumatera, East Java, West Java and Central Java spread in different clusters.

Proximate composition, salt content and a_w-Values

The Indonesian National Standard, SNI 2716.1-2009[17], the standard available during the samples collection, sets that *terasi* should have 30-50%

Table 1 — Proximate composition, water activity (a_w), total free amino acids (FAAs), total biogenic amines (BAs) and total short chain fatty acids (SCFAs) of commercial products of *terasi*

Parameter g/100 g	Mean±SD	Median	Minimum	Maximum
Dry matter*	66.58±8.81	67.05	46.17	93.95
Protein**	46.32±10.71	46.81	25.44	66.46
Fat**	4.26±1.37	4.10	1.62	8.09
Ash**	41.61±11.88	42.36	17.40	67.14
Carbohydrate**	7.81±6.74	6.54	0.03	38.88
a_w***	0.689±0.059	0.690	0.346	0.797
Total FAAs*	8.28±4.46	7.46	2.11	23.39
Total BAs*	1.45±1.33	1.14	≥0.00	6.94
Total SCFAs*	0.79±0.38	0.81	≥0.00	1.71

All data are from two replications (76 samples); * on fresh weight (FW); ** on dry matter (DM) ***no unit;

moisture; ≤15% protein; ≤1.5% ash; ≤2% carbohydrate and ≤10% salt contents (on FW). Results showed that none of *terasi* samples met the SNI 2716.1-2009 in terms of protein and ash contents. Protein content was >18% and ash content was >12%. Most of the samples (60 samples) did not meet the standard for carbohydrate, containing >2%. For the moisture content of *terasi*, 50 samples fitted the SNI 2716.1-2009 and 25 samples were below the range and 1 sample exceeded the range. Out of 18 samples tested for their salt contents, it revealed that only 4 samples had ≤10% salt, the rest of the samples did not meet the SNI 2716.1-2009, which is in line with the high ash contents observed (ranged 4.60 - 38.21%, mean 18.89±10.518 g/100g FW). The Indonesian National Standard SNI 2716:2016, the revised SNI of *terasi*, differentiates the *terasi* into three categories based on its moisture content (on FW based) i.e., ≤10% for powder and granule; ≤35% for solid and blocked and ≤45% for the paste one. According to SNI 2716:2016, two samples were granule, 42 samples were solid and blocked and 24 samples were pastes, and still, eight samples exceeded the ranges. The SNI 2716:2016 that specifies *terasi* to have ≥15% protein, shows that all samples of *terasi* fitted the Indonesian standard. There is no change concerning the ash content of *terasi* in the SNI 2716:2016 (≤1.5%) which none of the samples fit the standard. Both standards seem inconsistent as the salt content which should be also part of the ash content, was already more than that value (≤10% for the SNI 2716:2009 and 12-20% for the SNI 2716:2016). The current SNI 2716:2016 does not include the standard for carbohydrate which should be reconsidered. Although SNI sets a guideline for the production process and standard quality of *terasi*, there is no

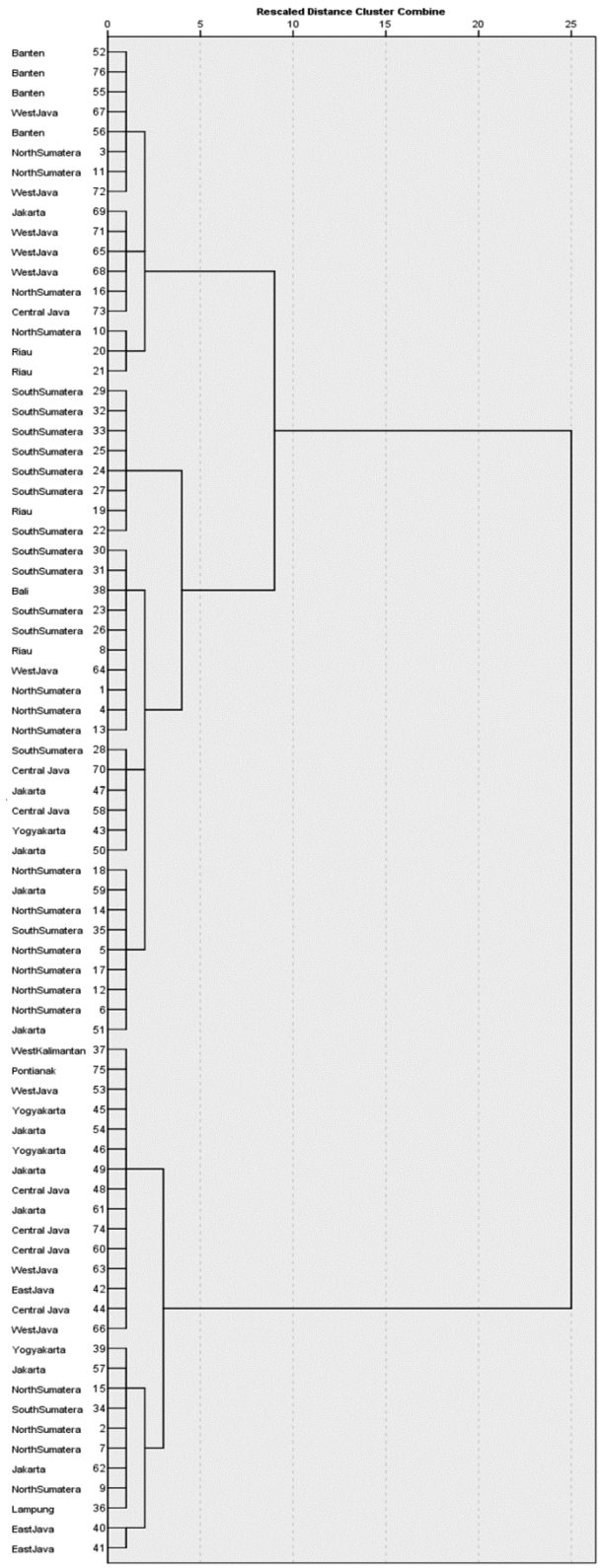

Fig. 1 — Cluster analysis based on province of 76 different *terasi* (Wards method and square Euclidean distance); data from moisture, protein, fat, ash, SCFAs, BAs (g/100 g DM) and free amino acids (FAAs) (g/100 g N) for all

specific supervision or control from the government regarding the implementation of these SNI guidelines. This partly explains the large variations in proximate composition observed in the samples. However, this variation is mainly induced by the different starting quality of the raw materials used[5,6]. The availability of *rebon* and market demands or selling price of the *terasi* might also lead to the inconsistent (non-standardized) quality of *terasi*. The addition of other ingredients during *terasi* production, as described by Campbell-Platt[7], can also influence the non-standardized quality of *terasi*. This for instance was observed during the production of *terasi* found in Cirebon (West Java) where rice bran was added to reduce the production cost.

The drying process is also very challenging to reach the SNI 2716.1-2009 guidelines (50-70% DM), especially during the rainy season, the peak season for catching *rebon. Rebon* contains approximately 80% moisture[18], so water loss is needed to produce *terasi*. In absence of appropriate dryers, producers e.g., in Tegal (Central Java), blended the moist *rebon* mixture with a drier mixture (semi-produced *terasi*) from an older batch, as observed during the period of sample collection (February-March 2011). Producers sometimes also add extra salt when the drying process is interrupted to preserve the mixtures. This also contributes to the variation in salt content as previously explained. Variations of the salt added during production reflecting the variations in the salt content of the products have been reported by Yoshida[4] and Guan[6] and are comparable to those measured in this study for *terasi*.

Considering the a_w of *terasi* samples, according to Belitz *et al*.[19], *terasi* can be considered as intermediate moisture food (IMF). Within this range of a_w values, enzymes, fungi and yeasts (xerophilies/osmophiles) generally are still active, and continuously degrade carbohydrates, proteins, and lipids. These processes result in a variety of compounds over the ripening periods, of which a part is associated with flavor and aroma in the fermented products[20].

Free Amino Acid Contents (FAAs)

As protein is the major compound in seafood, the changes towards this component will be obvious over the fermentation and storage period[5], especially towards its formation to FAAs. Results show that the total FAAs ranged from 1.21 to 9.65 g/100 g N or from 2.11-23.39 g/100 g FW (Table 1). A more detailed overview of the FAA composition is shown in Figure 2. It can be concluded that in most of the samples a substantial degree of proteolysis occurred. FAAs in food are important from a nutritional point of view (e.g., the essential and semi-essential ones) and for their contribution to the flavor[19]. In general, the essential FAAs were abundantly present (Fig. 2). On average alanine, consisting of ≥10% of total FAAs, was the most abundant FAA in the samples, followed by glutamic acid, leucine, aspartic acid and lysine. These FAA contents are comparable to those of

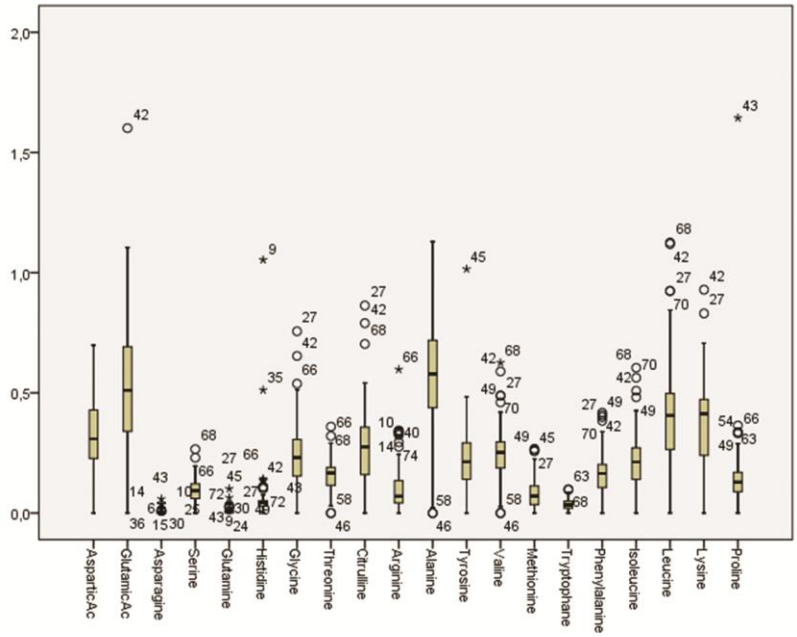

Fig. 2 — Data box plot of the content of 20 free amino acids (FAAs) (g/100 g Nitrogen) of 76 samples of *terasi*, p=0.05

shrimp sauce produced in Southeast and East Asian countries[21] and fish sauces[22]. Asparagine, glutamine, histidine, arginine, tryptophan and serine were found in very small quantities in *terasi*, which is also in line with results observed in shrimp paste from some Asian countries[4]. Remarkably, histidine, arginine and serine (not as FAAs) were abundantly present in the raw materials used[22]. More acidic FAAs than the basic ones were generally found in *terasi*, while hydrophobic FAAs were more dominant than the hydrophilic FAAs.

In general, a large variation in FAA composition was observed (Fig. 2) which is in correspondence with Kleekayai *et al*.[23] who found that the FAAs content differs due to the raw material used and the period of fermentation.

Biogenic Amines (BAs)

Results showed that putrescine, cadaverine and tyramine were the dominant biogenic amines found among all the samples (Fig. 3). Tsai[24] found that tryptamine reached 14 (6.7±3.6) mg/100 g FW, putrescine 0.5-11.8 (4.0±2.7) mg/100 g FW, cadaverine reached 16.2 (8.0±4.5) mg/100 g FW, histamine 2-118 (38.2±4.02) mg/100 g FW, tyramine 1.9 (0.37±0.51) mg/100 g FW, spermidine 9.1 (3.6±2.8) mg/100 g FW, and spermine 13.5 (4.3±3.0) mg/100 g FW in Taiwanese fermented shrimp paste. Comparing these amounts, the BAs in *terasi* from Indonesia are considerably higher than Tsai's findings, i.e., tryptamine reached 417 (17±53) mg/100 g FW, putrescine reached 2542 (609±563) mg/100 g FW, cadaverine reached 1796 (428±401) mg/100 g FW, histamine reached 183 (29±35) mg/100 g FW, tyramine reached 1329 (191±243) mg/100 g FW. High amounts of putrescine, histamine and tyramine were also found in shrimp and fish sauces[25]. Prester[26] noted that putrescine and cadaverine are generally formed in several shrimp products, while histamine formation is generally low in shellfish products.

From Supplementary Fig. S1 it can be concluded that a quite substantial part of biogenic amines is present based on nitrogen basis. These results are in correspondence with the FAA data indicating substantial proteolytic activity in most of the samples studied. The FAAs are converted further to biogenic amines via endogenous or exogenous decarboxylases. There are many factors influencing these conversions such as the manufacturing processes and practices, the microbial population, the raw material quality, the availability of FAAs and the storage conditions[26]. Treatments like salting, fermentation, ripening, or marinating can increase BAs in processed seafood[27]. BAs in fermented products might increase by the storage time and temperature[28]. Storage at non-refrigerated temperatures is the common condition found in Indonesia. As FAAs were abundantly present

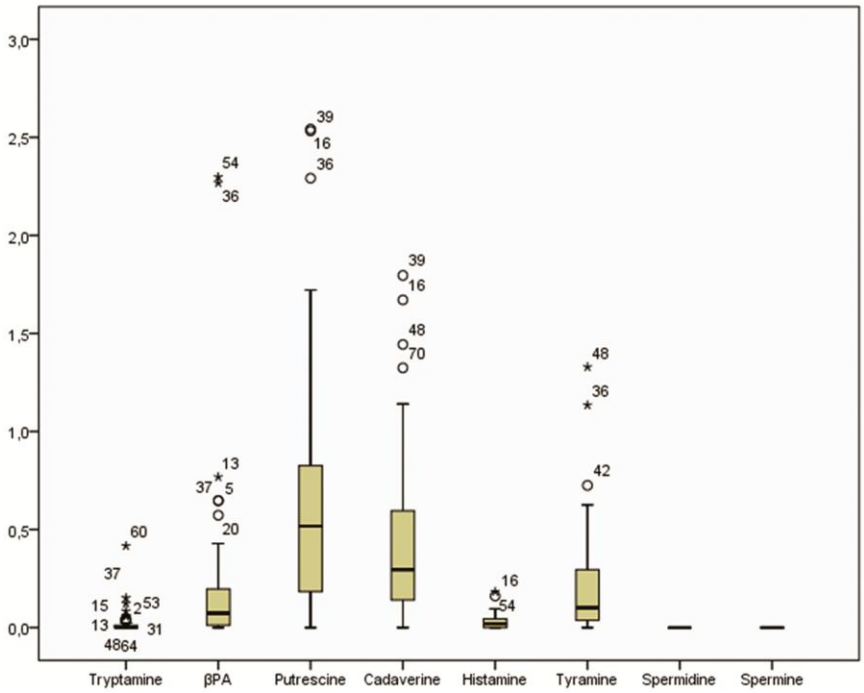

Fig. 3 — Data box plot of the content of biogenic amines (BA) (g/100 g FW) of 76 samples of *terasi*, p=0.05, βPA: β-phenylethylamine

in *terasi* and the aforementioned factors are generally not standardized during *terasi* production, the variation observed in BAs in the *terasi* samples is not unexpected.

The amounts of BAs in *terasi* might be associated with those of their parent free amino acids. The low amount of histamine in *terasi* is probably due to the low amount of free histidine in *terasi* as its source. This observation is in line with the findings of Mizutani[21]. Similarly, the abundant amount of free lysine in *terasi* could originate from cadaverine, also abundantly present in *terasi*. Meanwhile, the high amount of putrescine could be derived from the detected arginine and citrulline as Prester[26] also suggested. The relationship between the amounts of amines and their respective parent of amino acids could not be evaluated during this research, as we could not follow their amounts throughout the production process. Differences in the rate of decarboxylation or deamination reactions converting these amino acids, as well as the entire proteolysis process however has not been studied during *terasi* production, therefore, further research is necessary to explore this issue.

BAs are used as indicators of freshness or spoilage of food[15,26]. BAI in *terasi* was generally very high (ranging from 184 to 43858). Based on this BAI, according to Mietz & Karmas[15], all *terasi* samples were categorized as class 3 (decomposed). Due to long fermentation and ripening, these high BAI indexes can be expected. In seafood, BAs are often associated to food borne intoxication. Probably due to its low histamine content, *terasi* is rarely associated with the cause for BAs poisoning in Indonesia. According to Prester[26], the US Food and Drug Administration (FDA) in 1996 set the acceptable limit of 50 mg/kg for histamine. Histamine gives a risk to intoxication with symptoms of difficult breathing, itching, rash, vomiting, fever and hypertension. Although low in histamine, the cumulative amount of tyramine, putrescine and cadaverine can lead to potential histamine toxicity due to competition with histamine-metabolizing enzymes. Tyramine may cause intoxication that gives similar symptoms to histamine intoxication and may relate to a hypertension crisis[26]. The acute levels of tyramine, putrescine and cadaverine are 2000 mg/kg body weight[29]. Although the levels are high in some samples, it seems unlikely that the acute levels are exceeded because the limited amounts of *terasi* used in the final product as consumed. Usually *terasi* is incorporated into chili sauce (at about 10%) and people consume only about 9 grams of the sauce per serving size. If someone has a body weight of 60 kg then the risk level will not be exceeded (0.71 mg/kg body weight). The presence of putrescine can also contribute to an unpleasant odor at 9.1×10^{-10} mol/L[30]. This odor had been noticed in some of samples during the chemical determinations. Putrescine can be a precursor for the formation of spermidine and spermine[19]. However, spermidine and spermine were undetectable in *terasi*, whilst putrescine, was abundantly present. Preventive methods to control the formation of BAs should be applied by improving the production and storage conditions through good manufacturing practices. This cannot be separated from using high quality raw materials and controlling the enzyme (or microorganisms) involved in the fermentation process[31] so that the formation of biogenic amines can be avoided (reduced). These however, are hardly controlled if fermentation is a spontaneous fermentation without controlling the storage condition, as this is likely to occur in especially traditional *terasi* production places in Indonesia.

Short Chain Fatty Acids (SCFAs)

The SCFAs content of *terasi* are shown in Figure 4. Acetic acid and isovaleric acid are the major SCFAs. The sensorial thresholds of these SCFAs in water are 22 ppm (acetic acid); 20 ppm (propionic acid); 8.1 ppm (isobutyric acid); 0.24 ppm (butyric acid); 0.12-0.7 ppm (isovaleric acid); and 3 ppm (caproic acid), respectively[32]. The SCFAs of *terasi* generally exceeded these thresholds, showing that their presences when dissolved in water should be sensorially detectable e.g. at 10% *terasi* (the *terasi* concentration added for *sambal-terasi* preparation). Moeljohardjo[33] relates the sour tones in the odor of *terasi* to butyric acid, isobutyric acid, valeric acid, isovaleric acids. Although these compounds are generally added into foods as flavoring agent[34], their impacts in a complex matrix containing other compounds like *terasi* are still unclear. For instance, butyric acid may contribute to a cheesy aroma, but it also may cause a defect odor[35].

Sanceda *et al.*[36] discussed many conflicting reports towards factors influencing the formations of SCFAs, but their presences are typically linked to microbial activities, especially the spoilage microbes during proteolysis. If fresh raw materials are used, the rate of

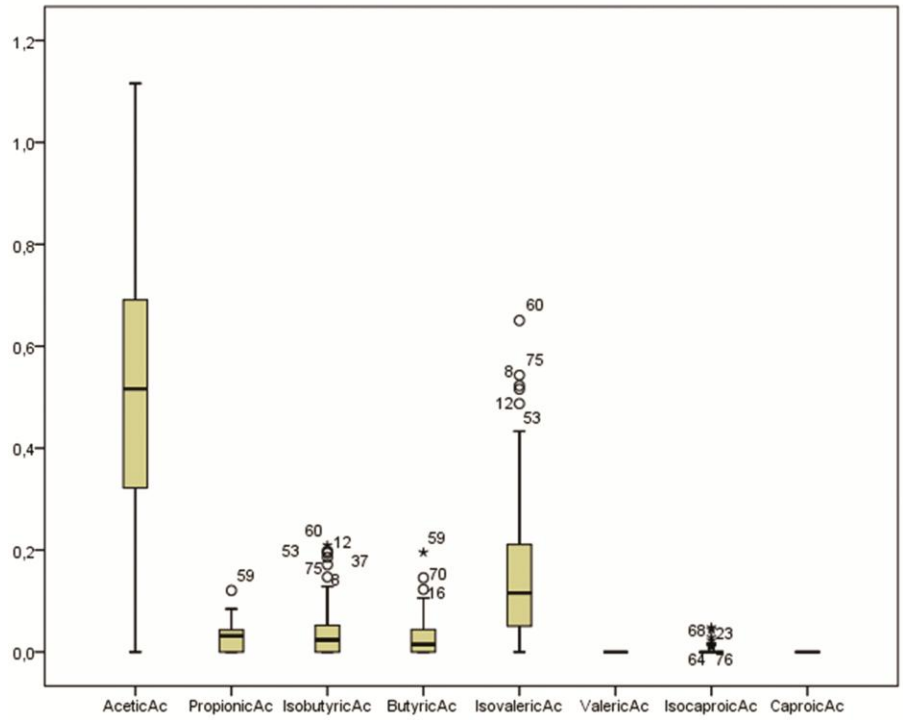

Fig. 4 — Data box plot of the content of short chain fatty acids (SCFA) composition (g/100 g FW) of 76 samples of *terasi*, p=0.05

SCFA formation during the fermentation is reduced. Moreover, the rate of SCFAs formation in fermented salted products was lower than that of non-salted one. Sanceda *et al.*[36] also proposed the use of anaerobic fermentation to reduce the fermentation rate as fat oxidation also contributed to the formation of SCFAs. Therefore, pounding, which is typically applied, will help to reach such anaerobic conditions, because the excess of air is excluded as a result of this process. The delayed production process and the exposure of raw materials to the oxidation process allows the formation of SCFAs. Because of the varying quality of the raw materials and the typical condition (high temperature and humidity) supporting the microbial growth, the presence of SCFAs is unavoidable. In fermented food production, however spoilage microbiotas responsible for SCFAs formation are typically inactive.

Conclusions

Overall, the chemical characteristics of *terasi* vary greatly, probably because of a large variability in influencing factors such as quality of the raw material, production process and storage. From this screening study on 76 different types of *terasi* samples, it can be concluded that these factors are not well controlled or differ extensively between producers. Most of the *terasi* samples did not meet the SNI standards.

Supplementary Data

Supplementary data associated with this article is available in the electronic form at http://nopr.niscair.res.in/jinfo/ijtk/IJTK_20(04) (2021) 1031-1039 Suppl Data.pdf

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