Identification of Key Sensory Attributes of *Sambal-Terasi,* Impact of Different Type of *Terasi,* Chemical Characteristics and Salt Addition

(Pengenalpastian Sifat Sensori Utama Sambal Terasi, Impak Jenis Terasi Berbeza, Pencirian Kimia serta Penambahan Garam)

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ABSTRACT

This research studied the identification of key sensory attributes of sambal-terasi *as caused by the use of different types of* terasi *and by the chemical characteristics of* terasies*, including the addition of salt.* Sambal-terasi *is a chili sauce containing* terasi*, a fermented salty seafood from Indonesia. Six different types of* terasi*, with varying chemical characteristics, including proximate compositions, salt content, free amino acids, biogenic amines, and short chain fatty acids, were prepared as* sambal-terasi *(at 6%, fresh weight of* terasi*). To five* sambal-terasies *table salt was added, aiming to reach a comparable salt content as the* sambal-terasi *with the highest salt content among the six mentioned* sambal-terasies*. Eighty-seven un-trained panelists assessed the* sambal-terasies' *acceptability in a hedonic test and nine trained panelists rated their intensities towards the attributes sweet, bitter, salty, sour, umami, fishy and* rebon*. The addition of different types of* terasies *significantly affected the sensory characteristics of* sambal-terasies*. The undesirable compounds formed during production of* terasi *(biogenic amines and short chain fatty acids) could still be perceived in* sambal-terasi*, therefore their presences should be controlled. Salty, umami and* rebon *were identified as desirable taste/ flavor attributes which were enhanced by the addition of salt. Bitterness was identified as an undesirable taste attribute, which could be reduced by the addition of salt. A salt content of 2-2.5% in* sambal-terasi *was tentatively proposed as a good compromise with respect to the sensorial aspects and salt intake.*

Keywords: Salt; sambal-terasi*; sensory analysis; taste;* terasi

ABSTRAK

Kajian ini mengkaji pengenalpastian sifat sensori utama sambal-terasi yang disebabkan oleh penggunaan pelbagai jenis terasi dan ciri kimia terasi, termasuklah penambahan garam. Sambal-terasi adalah sos cili yang mengandungi terasi, makanan laut masin yang difermentasi dari Indonesia. Enam jenis terasi berbeza dengan pelbagai ciri kimia termasuk kandungan komposisi, kandungan garam, asid amino bebas, amina biogen serta asid lemak rantai pendek, disediakan sebagai sambal-terasi (pada 6%, berat terasi segar). Lima garam meja sambal-terasi ditambahkan, bertujuan untuk mencapai kandungan garam yang sebanding dengan sambal-terasi dengan kandungan garam tertinggi antara enam sambal-terasi yang disebutkan. Lapan puluh tujuh panelis tidak terlatih menilai kesesuaian sambal-terasi dalam ujian hedonik dan sembilan ahli panel terlatih menilai keamatan mereka terhadap sifat manis, pahit, masin, masam, umami, hanyir dan rebon. Penambahan jenis terasi berbeza telah menjejaskan ciri sensori sambal-terasi. Sebatian yang tidak diingini yang dihasilkan semasa penghasilan terasi (amina biogen dan asid lemak rantai pendek) masih boleh dilihat dalam sambal-terasi, oleh itu kehadiran mereka harus dikawal. Masin, umami dan rebon telah dikenal pasti sebagai sifat rasa/perisa yang diingini yang dipertingkatkan dengan penambahan garam. Kepahitan telah dikenal pasti sebagai sifat rasa yang tidak diingini, yang boleh dikurangkan dengan penambahan garam. Kandungan garam sebanyak 2-2.5% dalam sambal-terasi adalah dicadangkan sebagai kompromi yang baik berkenaan dengan aspek sensori dan pengambilan garam.

Kata kunci: Analisis deria; garam; rasa; sambal-terasi; terasi

Introduction

Terasi is a salty paste of underutilized fish/seafood used in Indonesia, consisting mostly of planktonic shrimp, known as *rebon.* Throughout Asia, closely related products are well-known, such as *belacan* in Malaysia; *kapi* in Thailand and Cambodia; *bagoong-alamang* in Philippines; *mam-ruoc* or *mam-tom* in Vietnam; *jeotgal/jeot* in Korea; and *ngapi-seinsa* or *hmyinnga-pi* in Myanmar (Ruddle &

Ishige 2010). These paste products not only differ largely as a result of variations in the raw material used and manufacturing practices (Damanik-Ambarita et al. 2019; Guan et al. 2011), but also vary due to the different amounts of salt added. Various reports indicate large variations in the amount of salt used during the production of fish or shrimp paste. For instance, 5-20 % (Hajeb & Jinap 2012; Kleekayai et al. 2016), more than 30 % of salt (Campbell-

Platt 1987), while sometimes even no salt is added at all during the production of fish/shrimp pastes in some parts of Myanmar, Indonesia, Thailand, and The Philippines (Ruddle & Ishige 2010). Consequently, both chemical characteristics and salt content among different shrimp pastes vary greatly. Typically, in *terasi*, salt is the second major ingredient used, apart from *rebon* or other aquatic animals.

Excessive salt intake is among others a risk factor for cardiovascular diseases, which is currently the main cause of death in Indonesia (World Health Organization 2018). Therefore, the Indonesian Ministry of Health formulated new dietary guidelines (Permenkes 2013 No 30) which includes the advice to limit the intake of salt (2 g sodium per day or 5 g salt per day). However, in 2007, the average intake of salt among Indonesians was 5.6 g per capita per day, while in 2017 it has increased to 6.3 g per capita per day, resulting in a salt intake above the recommended levels by more than half of the population. Salt intake has been reported to originate mainly from non-labelled foods, eaten at home or out of home (Hardinsyah 2017). Interestingly, Choong et al. (2012) reported that the preferred consumption of dishes containing the high salt sodium shrimp paste *belacan* in Malaysia, seemed to discourage discretionary salt use. This implies that despite their high salt content, the addition of shrimp paste to foods could overall limit the salt intake. In Indonesia, *terasi* is typically used in chili sauce, known as *sambal-terasi*. Damanik-Ambarita et al. (2019) identified the sensory profiles of *sambal-terasi* made according to recipes from several restaurants. However, the authors found that the use of high amounts of *terasi* (12.5 % dry matter content, equal to about 17 % fresh weight of *terasi*) and salt (5.6%) to make *sambal-terasies*, produced a too salty or too bitter *sambal-terasies*. Panelists were hardly able to identify other mild tastes/flavors, therefore, the real impact of *terasi* and the sensory profile of *sambal-terasi* were considerably complex. Consequently, for this study, the amount of *terasi* was reduced to 6 % fresh weight (and therefore also reducing their salt content) so that the key attributes of *sambal-terasi* could be better investigated. This study also evaluated the impact of different types of *terasi* (including salt content) on the sensory characteristics of *sambal-terasi.* The impact of the addition of salt on the sensory characteristics of *sambal-terasi* was also further studied.

Materials and Methods

TERASI SAMPLES

Terasi samples were collected from six famous regions for *terasi* production or *sambal-terasi* consumption in Indonesia and were coded as A (from West Java), B (from Jakarta), C (from North Sumatera), D (from Central Java), E (from West Kalimantan), and F (from East Java). *Terasi* A, D, and F were taken from traditional factories. *Terasi* D and F contained salt and *rebon;* while *terasi* A was also

composed of small fish, and rice bran. However, detailed compositional data were not shared by the producers, and/or were unavailable. Meanwhile, *terasi* B, C, and E were taken from markets without specific information regarding the ingredients used nor the production process and date. Although the information is a great interest for this study, unfortunately, the producers considered these data as confidential and unable to share the information when the authors asked for further details. All samples were stored in a freezer (-28±2°C) until they were further analyzed or used.

CHEMICAL ANALYSES

Terasi samples were analyzed in Indonesia in triplicate for their moisture, fat, protein, and carbohydrate content as described by Damanik-Ambarita et al. (2019). NaCl (salt) content, was measured indirectly by the determination of chloride ions by using the method as described by Damanik-Ambarita et al. (2019). The data was used to normalize the amount of salt added to *sambal-terasi* samples with salt addition. The total amount of salt was equal to the highest salt content amongst six *sambal-terasies* (*sambal-terasi* A). At a later stage of the research, *sambal-terasi* samples were analyzed in Belgium for their sodium, calcium, magnesium, and potassium content by using inductively coupled plasma optical emission spectrometry, ICP-OES (Varian Vista MPX, Palo Alto, CA, USA), while phosphorous were measured by using the colorimetric method of Scheel. The methods of analyses have been described by Damanik-Ambarita et al. (2019). Free amino acids (FAAs), biogenic amines (BAs) and short chain fatty acids (SCFAs) were determined according to the method as described by Damanik-Ambarita et al. (2019).

CHILI SAUCE AND *SAMBAL-TERASI* PREPARATION

A base of chili sauce was prepared one time for all *sambal-terasies* by using a standard recipe as described by Damanik-Ambarita et al. (2019), to avoid differences due to the chili sauce. The sauce contained fresh, minced and blended ingredients of *Capsicum annuum*, a large sweet and mild variety of chili, also known in Indonesia as Taiwanese-chili (25%). Additional ingredients consisted of tomato (20 %); shallot (15 %); garlic (14 %); palm oil (9 %); onion (7 %); palm sugar (5 %); candle nut (3 %); ginger (1 %) and lemon grass (1 %) (all on fresh weight). Ingredients were bought from local supermarkets located near the laboratory of the Department of Food Technology, Universitas Pelita Harapan (UPH), Karawaci, Indonesia. To prepare the chili sauce, all ingredients were sautéed for approximately 45 min for a 12 kg of mixture. *Terasi* was heated (about 30 s) until the aroma was released; and mixed (6 % fresh weight) and sautéed together with chili sauce (about 20 min for 1 kg of sauce). One set of six *sambal-terasies* was prepared without salt adjustment. Salt content, based on chloride-determination in *terasi,* amounted for

sambal-terasies A to F, respectively, 1.97, 0.71, 1.36, 0.62, 0.28, 0.79 g/100 g product. To another set of five *sambal-terasies* (B-F), table salt was added aiming to have a final salt content of 1.97 % (based on chloride determination; on fresh weight), representing the highest salt content among six *sambal-terasies* (*sambal-terasi* A). These samples were identified, respectively, as B+Salt; C+Salt; D+Salt; E+Salt and F+Salt. Therefore, in total 11 *sambal-terasies* were prepared one day before the sensorial evaluation (overnight storage at 4 °C). All samples were kept frozen (-28±2 °C) before sending to Belgium for mineral analyses as previously explained.

QUANTITATIVE EVALUATION OF SELECTED TASTE/ FLAVOR ATTRIBUTES OF THE *SAMBAL-TERASI'S* BY A TRAINED PANEL

Eleven *sambal-terasies* were sensorially assessed by nine trained panelists (1 male and 8 females, age between 23 and 41 years) by considering the following taste/flavor attributes of *sambal-terasies*: salty, sour, sweet, bitter, umami, *rebon* and fishy. The trained panel was selected among 72 panelists (students and staffs at a Department of Food Technology) based upon 80 % accuracy through a series of basic test identifications. Although the hotness of the sauce is by no doubt another important flavor attribute, it was not considered in the sensory trial in view of the relatively high number of other attributes already considered and because the hotness is evidently caused by the presence of similar amounts of chili sauce in the first place. This sensory evaluation was carried out with two replications on different days.

Panelists were trained six times during a two-hour session in a two weeks period, and conducted subsequent sensory analyses e.g. triangular tests, same different tests, and descriptive sensory analysis. They were taught and became familiar with the sensory vocabularies applied to rate chili sauces and *sambal-terasies* flavor attributes using 15-cm unstructured line scales (0 meant no taste and 15 meant the highest or most extreme intensity of the respective taste which was agreed upon in the panel as explained next). For each of the sensory attributes the following reference materials were chosen to train the panel to carry out a quantitative sensory assessment for each attribute: sucrose (sweetness), NaCl (saltiness), vinegar containing 25 % acetic acid (sourness), caffeine (bitterness), monosodium glutamate (umami), dried *rebon* (*rebon*), and dried anchovies (fishy). The reference materials were dissolved at various concentrations covering a particular range in chili sauce (after an initial training in water). The highest concentration for each reference material (the maximum of the scale (15)) was determined by evaluating various concentrations followed by a group discussion with the whole panel with respect to their expectancy vis à vis each particular taste or flavor attribute in *sambal-terasi*. For instance, for the *rebon* attribute, dried *rebon* was added to the chili sauce in a concentration range (0-20%). The taste panel considered the sauce containing 20% *rebon* as

the highest concentration corresponding to the maximum score of 15 in the unstructured line scale.

For all sensory trials, panelists were served individually with 10 g of each *sambal-terasi* sample on small red plates (diameter of 8 cm), coded with a random three-digit number. They each tasted a 0.5-1 g sample of *sambal-terasi* using a tea spoon, in a sensory panel booth at 24 °C with red lighting to disguise the samples' appearance. All *sambal-terasies* were maintained at 24 °C as well. Plain crackers and water were consumed between samples to rinse the palate.

HEDONIC SENSORY EVALUATION OF *SAMBAL-TERASI'S* BY AN UNTRAINED PANEL

The eleven prepared *sambal-terasies* were also sensorially evaluated by a group of 87 panelists (69 females, 18 males; age of 17-41 years). Panelists were students and staff of UPH Karawaci and participated in similar tests with other foods before. They had no respiratory and fish or shrimp allergy and did not consume any food at least 30 min before sensory testing.

The panelists evaluated each individual *sambal-terasi* using a score ranging from 1 (dislike very much) to 7 (like very much). This resulted in an overall scoring for each sample. In addition for each sample they also evaluated particular taste attributes as mentioned using the same score. Finally, each panelist was asked in an open-end question to identify the samples which they liked/disliked the most. The procedures for the hedonic sensory tests were generally adapted from Meilgaard et al. (2006) and the International Organization for Standardization (ISO) 11136:2014 for hedonic test.

DATA ANALYSIS

Raw (non-normalized) sensory data were used. All statistics analyses were done by using SPSS 24 (IBM, New York, USA). The confident level was set at 5% for Analysis of Variance (ANOVA) and followed by Tukey's test to identify statistical differences among the samples for the set of *sambal-terasi* without salt addition. To test the effect of salt addition to the *sambal-terasi*es; one-way ANOVA combined with planned contrast analysis was done to evaluate the sensory data with and without salt addition by either un-trained or trained panelists.

RESULTS AND DISCUSSION

CHEMICAL CHARACTERISTICS OF *TERASI* SAMPLES (*TERASI* A-F)

Tables 1-3 show the chemical characteristics of the *terasi* samples. The proximate composition, salt content and water activity were significantly different (p<0.05) among the *terasi* samples (Table 1), which is not surprising as these *terasies* were taken from different provinces with variation in ingredient(s) and production processes.

TABLE 1. Proximate composition, salt, and water activity (a_w) of commercial products of *terasi* samples

Parameter g/100g; on fresh weight (FW)	Commercial products of *terasi*						p-value
	A	B	C	D	E	F	
Water content	27.01 ± 0.18a	30.94 ± 0.05b	32.23 ± 0.33c	27.46 ± 0.24a	37.41 ± 0.49e	35.16 ± 0.14d	<0.001
Protein	22.63 ± 0.01a	36.99 ± 0.21c	31.54 ± 0.08b	42.83 ± 0.39f	41.56 ± 0.48e	38.74 ± 0.02d	<0.001
Fat	2.28 ± 0.06a	3.91 ± 0.18bc	2.19 ± 0.49a	4.46 ± 0.46c	3.55 ± 0.11b	3.76 ± 0.05bc	<0.001
Ash	43.42 ± 0.05f	24.72 ± 0.16d	30.88 ± 0.49e	17.88 ± 0.08b	11.93 ± 0.20a	19.11 ± 0.24c	<0.001
Carbohydrate	4.66 ± 0.07bc	3.44 ± 0.19ab	3.15 ± 0.56a	7.37 ± 1.17d	5.56 ± 0.11c	3.23 ± 0.07ab	<0.001
Salt	32.83 ± 0.23f	11.76 ± 0.02c	22.74 ± 0.19e	10.28 ± 0.01b	4.60 ± 0.01a	13.05 ± 0.04d	<0.001
aw* at 20 °C	0.700 ± 0.002d	0.671 ± 0.003b	0.688 ± 0.002c	0.658 ± 0.006a	0.796 ± 0.003e	0.662 ± 0.000a	<0.001

All data are expressed as the mean ± SD from three independent replications. Means with different letters are significantly different (*p*<0.05) for each parameter (row); *no unit; *Terasi* A from West Java, B was from Jakarta, C was from North Sumatera, D was from Central Java, E was from West Kalimantan, and F was from East Java

Similarly, FAAs, BAs (especially putrescine and cadaverine) and SCFAs (such as propionic-, butyric- and isobutyric-, isovaleric-acid), that are major contributors to specific taste attributes and the (pungent) odor of fermented foods (Belitz et al. 2009), also differed significantly within the samples (Tables 2-3).

SENSORY EVALUATION OF THE *SAMBAL-TERASIES* WITHOUT SALT ADDITION (*SAMBAL-TERASIES* A-F)

Figure 1 shows that the sensory characteristics of the six different types of *sambal-terasies* (without extra salt added) as evaluated by the trained panelists, differed significantly (p<0.05) on all intensities of taste/flavor attributes, except for sourness and sweetness. Therefore, these two attributes were not considered further.

Sambal-terasi A, having the highest salt content, also had the highest saltiness. While for all the other samples, the saltiness was not significantly different, despite substantial differences in their salt content. *Sambal-terasi* A had also the highest umami taste. *Sambal-terasies* C and F had also not significantly different in their umami intensities from *sambal-terasi* A. It should be noted however that umami taste of *sambal-terasi* F was not significantly different from *sambal-terasi* B, which had the lowest umami taste. *Sambal-terasi* B also had the lowest fishy and *rebon* taste, while the other *sambal-terasies* did not differ significantly from each other with respect to these attributes. *Sambal-terasi* E was clearly having an off-note in bitterness, while for the other samples, no differences in bitterness could be noted.

The trends observed in the quantitative sensory evaluation corresponded reasonably well with those observed in the hedonic test with the untrained panel (Table 4). *Sambal-terasies* A and C had the highest hedonic scores with respect to saltiness and umami. They also however had the highest scores for the *rebon* and fishy taste. Similarly, as for the quantitative evaluation, *sambal-terasi* E clearly had a deviating score with respect to bitterness, resulting in the lowest sensory appreciation for this attribute. Also *sambal-terasies* B and D however had a low appreciation with respect to their bitter notes. This resulted in a clear overall preference for *sambal-terasies* A and C, but *sambal-terasi* A was liked by most of the panelists. The lowest overall appreciation was observed for *sambal-terasi* E, which was however not statistically different compared to *sambal-terasies* B and D. Again however a clearly higher number of panelist indicated they disliked *sambal-terasi* E, while the number of panelists disliking *sambal-terasi* B, D and F was comparable.

Some patterns were seen that could potentially be linked between the chemical characteristics of *terasies* to the sensory characteristics of *sambal-terasies*. The bitterness increased by the increase of histamine (R^2 0.83), tryptamine (R^2 0.87), beta-phenylethylamine (R^2 0.64), isovaleric acid (R^2 0.61), propionic acid (R^2 0.64) and iso-butyric acid (R^2 0.60). These findings show that the undesirable compounds formed during the production of *terasi* could still be perceived when the *terasi* is incorporated into chili sauce. Thus, their presences should be controlled in *terasi*.

As the panelists were asked to explain which taste attribute contributed to their appreciation of the most liked/disliked sample, insight in key taste attributes of *sambal-terasies* could be obtained (Table 5). Considering *sambal-terasi* A, with the highest overall hedonic score, it was obvious that its saltiness was a key element with respect to its sensory appreciation, followed by its umami and *rebon* flavor. *Sambal-terasi* C seemed to be appreciated as more equilibrated with respect to its saltiness, umami and *rebon* taste. The taste attributes bitterness and fishy were not or nearly not considered with respect to the sensory appreciation of these most preferred *sambal-terasies*.

Considering the least appreciated *sambal-terasi* E, it became obvious its bitterness, already identified by the trained panel, was clearly a key factor. Also for the other less appreciated *sambal-terasies* B, D and F, bitterness was considered as the most relevant taste attribute.

As a preliminary conclusion, it could be stipulated that a sufficient saltiness of *sambal-terasies* is clearly a key sensory attribute, combined with an absence of a too strong bitterness and the presence of umami and *rebon* notes.

TABLE 2. Free amino acids (FAAs) content and biogenic amines (BA) for each *terasi* sample (g/100 g dry matter)

FAA	A	B	C	D	E	F	SEM*	p-value
Aspartic acid	0.64	0.87	0.62	0.68	1.9	1.4	0.040	<0.001
Glutamic acid	1.0	1.3	1.2	2.6	3.4	6.0	0.114	<0.001
Asparagine1	<LOD	<LOD	0.11	<LOD	<LOD	<LOD	<0.001	<0.001
Serine	0.16	0.34	0.34	0.25	0.25	0.73	0.012	<0.001
Glutamine1	0.01	<LOD	0.01	0.02	0.01	0.06	0.003	<0.001
Histidine	0.06	0.09	0.15	0.25	0.18	0.51	0.011	<0.001
Glycine	0.37	0.52	0.86	1.4	1.3	2.4	0.059	<0.001
Threonine	0.37	0.46	0.53	0.36	0.72	1.1	0.030	<0.001
Citrulline	0.70	0.59	0.51	1.4	1.4	3.0	0.065	<0.001
Arginine	0.04	0.24	1.0	0.11	0.26	0.28	0.017	<0.001
Alanine	0.96	1.8	2.2	2.2	2.5	4.1	0.106	<0.001
Tyrosine	0.36	0.35	0.63	0.52	1.2	1.2	0.065	<0.001
Valine	0.37	0.84	0.69	1.1	1.2	2.2	0.067	<0.001
Methionine	0.13	0.08	0.13	0.43	0.83	0.78	0.052	<0.001
Tryptophan	0.08	0.10	0.06	0.16	0.26	0.32	0.020	<0.001
Phenylalanine	0.22	0.33	0.54	0.86	0.95	1.6	0.037	<0.001
Isoleucine	0.17	0.58	0.63	1.0	1.4	1.9	0.045	<0.001
Leucine	0.28	1.0	1.2	2.0	2.7	4.2	0.089	<0.001
Lysine	0.64	0.91	1.3	1.7	2.0	3.5	0.065	<0.001
Proline	0.15	0.28	0.39	0.62	0.94	0.93	0.009	<0.001
Tryptamine1	<LOD	0.01	0.03	0.05	0.20	0.07	0.022	0.001
β-phenylethylamine	0.04	0.19	0.26	0.48	1.00	0.28	0.067	<0.001
Putrescine	0.31	1.00	2.00	1.60	1.00	2.10	0.113	<0.001
Cadaverine	0.49	0.76	1.20	3.00	0.47	1.30	0.060	<0.001
Histamine	0.05	0.08	0.07	0.06	0.12	0.06	0.013	0.020
Tyramine	0.10	0.19	0.47	1.80	0.85	1.10	0.066	<0.001

All values are means of two independent replicates; *SEM: Standard error of the mean
[1] LOD asparagine: 1.10 x 10^{-4} g/100g *terasi* (fresh weight)*;* LOD glutamine: 1.43 x 10^{-4} g/100g *terasi* (fresh weight); LOD Tryptamine: 4 x 10^{-4} g/100g *terasi* (fresh weight)

TABLE 3. Short chain fatty acids (SCFAs) content (g/100g dry mater) for each *terasi* sample

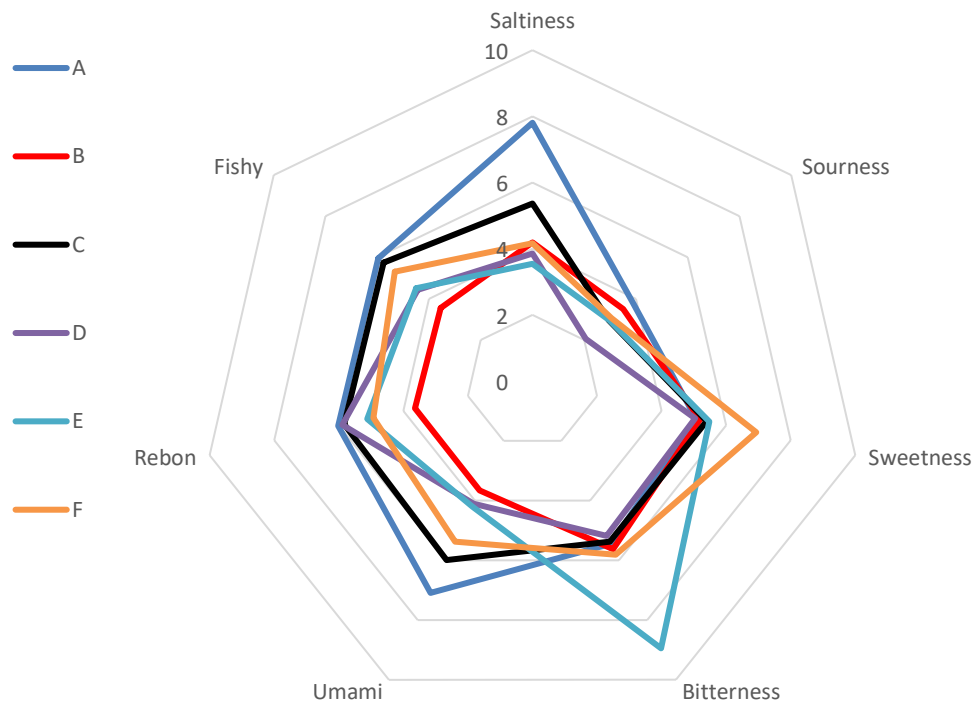| SCFA	A	B	C	D	E	F	SEM*	p-value
Acetic acid	0.63	0.87	0.80	1.1	1.4	1.5	0.119	<0.001
Propionic acid (PA)	0.055	0.055	0.054	0.085	0.11	0.072	0.008	<0.001
Isobutyric acid (IBA)1	0.048	0.069	0.16	<LOD	0.24	0.009	0.008	<0.001
Butyric acid (BA)1	0.13	0.063	<LOD	0.013	<LOD	0.018	0.008	<0.001
Isovaleric acid (IVA)	0.17	0.28	0.44	0.051	0.64	0.11	0.016	<0.001
Total SCFAs	1.0	1.3	1.4	1.2	2.3	1.7		
Sum PA+IBA+BA+IVA	0.40	0.47	0.65	0.15	0.98	0.21		

All values are means of three independent replicates; * SEM: Standard error of the mean
LOD for Isobutyric Acid and Butyric Acid: 2 × 10^{-4} g/100g *terasi* (fresh weight)

In view of the relatively high differences in salt content between the *sambal-terasies* and the observation that the most preferred samples contained in fact the highest salt content, it was hypothesized that by adding salt to the less preferred samples, the overall sensory appreciation of those samples could be improved. Therefore, table salt was added to each of the *sambal-terasies* with the aim to reach a salt content similar to that of the *sambal-terasi* A. As on the time of the experiments only the chloride content data of the samples were available, it was not surprising that some

Sample	Saltiness	Sourness	Sweetness	Bitterness	Umami	*Rebon*	Fishy
A	7.8 ± 2.0[b]	3.9 ± 2.2[a]	5.1 ± 1.8[a]	5.5 ± 2.6[a]	7.1 ± 2.4[c]	6.0 ± 2.3[b]	5.9 ± 1.5[b]
B	4.2 ± 2.2[a]	3.5 ± 2.3[a]	5.2 ± 2.9[a]	5.6 ± 2.3[a]	3.7 ± 1.7[a]	3.6 ± 1.5[a]	3.6 ± 1.1[a]
C	5.4 ± 2.1[a]	3.0 ± 1.7[a]	5.4 ± 2.1[a]	5.4 ± 2.8[a]	6.0 ± 2.1[bc]	5.8 ± 1.6[b]	5.7 ± 2.0[b]
D	3.9 ± 1.9[a]	2.1 ± 1.6[a]	5.0 ± 2.9[a]	5.2 ± 2.7[a]	4.1 ± 2.1[ab]	5.9 ± 1.2[b]	4.4 ± 1.7[ab]
E	3.5 ± 2.3[a]	3.0 ± 1.6[a]	5.5 ± 3.0[a]	8.9 ± 2.8[b]	4.2 ± 2.5[ab]	5.1 ± 2.1[ab]	4.5 ± 1.9[ab]
F	4.2 ± 1.3[a]	3.0 ± 2.0[a]	6.9 ± 2.6[a]	5.8 ± 2.0[a]	5.4 ± 1.8[abc]	4.9 ± 2.2[ab]	5.3 ± 2.0[b]
SEM	0.662	0.646	0.863	0.847	0.704	0.615	0.583
p-value	<0.001	0.122	0.241	<0.001	<0.001	0.001	<0.001

Score 0 (absence of flavor) to 15 (maximum flavor perceived). All data are expressed as the mean ± SD from 9 trained panelists. Means with different letters are significantly different ($p < 0.05$) for each parameter taste/flavour (column)

FIGURE 1. Mean perceived intensity of taste/flavor of six different *sambal-terasies* (spider diagram above) and its variability among treatments (table, below)

discrepancies between the salt content, based on the actual sodium content (as determined by ICP-OES) of the supplemented samples were observed (Table 6). Overall however, the goal of increasing the sodium content of *sambal-terasies* B-F towards the sodium content of *sambal-terasi A* was achieved. It should also be realized that not only sodium ions are responsible for the salt taste, but that for instance also potassium, magnesium, calcium and phosphate ions may contribute as Li-Chan and Cheung (2010) had been noted. Moreover, potassium, magnesium, calcium, and phosphates can also act as salt replacer (Kilcast & Ridder 2007; Liem et al. 2011; Manabe et al. 2009). However, these minerals may have differences in saltiness intensities in sea salts having similar amount of sodium (Vella et al. 2012) as these minerals have also other taste(s) or aftertaste. Although other chemical characteristics present in *terasi* may contribute to the differences in the

sensory characteristics of *sambal-terasi,* former study (submitted paper) showed that there was no specific pattern to link the proximate compositions, free amino acids, and biogenic amines contents to the sensory characteristics of *sambal-terasi.*

IMPACT OF TABLE SALT ADDITION TO THE SENSORY CHARACTERISTICS AND APPRECIATION OF *SAMBAL-TERASIES*

Considering the data obtained by the trained panel (Figure 2), it is obvious that in all samples, the saltiness of all supplemented *sambal-terasies* significantly increased, which is not surprising. Similarly, the umami taste of all *sambal-terasies* increased, albeit for *sambal-terasi* C not significantly. The *rebon* flavor was the lowest for *sambal-terasi* B, while addition of salt increased its *rebon* flavor significantly, which was also observed in *sambal-terasies*

TABLE 4. Average hedonic scores of the *sambal-terasies* obtained by an untrained panel and the planned contrast analysis result

Sample	Saltiness	Sourness	Sweetness	Bitterness	Umami	*Rebon*	Fishy	Overall	Σ Liked the most	Σ Disliked the most
A	4.20 ± 1.58c	3.78 ± 1.59b	3.72 ± 1.44d	3.31 ± 1.70c	4.07 ± 1.54d	4.00 ± 1.45b	3.94 ± 1.56c	4.21 ± 1.53c	20	4
B	2.60 ± 1.28ab	2.45 ± 1.23a	2.66 ± 1.25ab	1.86 ± 1.00ab	2.58 ± 1.17a	2.74 ± 1.17a	2.66 ± 1.22a	2.65 ± 1.16ab	2	11
C	3.78 ± 1.47c	3.56 ± 1.50b	3.33 ± 1.42cd	2.98 ± 1.63c	3.73 ± 1.37cd	3.81 ± 1.34b	3.62 ± 1.49bc	4.01 ± 1.39c	11	0
D	2.52 ± 1.41ab	2.55 ± 1.35a	2.41 ± 1.30ab	2.21 ± 1.56ab	2.87 ± 1.45ab	2.92 ± 1.36a	2.99 ± 1.47a	2.73 ± 1.38ab	0	14
E	2.11 ± 1.22a	2.29 ± 1.37a	2.12 ± 1.18a	1.67 ± 0.99a	2.48 ± 1.29a	2.82 ± 1.50a	2.84 ± 1.45a	2.28 ± 1.40a	3	34
F	3.05 ± 1.51b	2.76 ± 1.31a	2.91 ± 1.35bc	2.33 ± 1.32b	3.20 ± 1.50bc	3.07 ± 1.37a	3.01 ± 1.39ab	3.02 ± 1.35b	3	13
p-value1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
B+Salt	3.94 ± 1.54*	3.62 ± 1.50*	3.81 ± 1.44*	3.14 ± 1.61*	4.01 ± 1.52*	3.78 ± 1.48*	3.66 ± 1.46*	4.26 ± 1.35*	9	1
C+Salt	3.92 ± 1.55	3.38 ± 1.46	3.67 ± 1.41	3.06 ± 1.73	3.98 ± 1.41	3.88 ± 1.43	3.72 ± 1.55	4.12 ± 1.47	10	5
D+Salt	3.69 ± 1.64*	3.56 ± 1.56*	3.54 ± 1.52*	2.95 ± 1.65*	3.94 ± 1.49*	3.71 ± 1.45*	3.47 ± 1.42*	4.04 ± 1.43*	5	1
E+Salt	4.16 ± 1.52*	3.54 ± 1.62*	3.54 ± 1.60*	3.09 ± 1.72*	3.95 ± 1.54*	3.81 ± 1.51*	3.59 ± 1.53*	4.12 ± 1.48*	11	4
F+Salt	4.12 ± 1.65*	3.35 ± 1.52*	3.62 ± 1.41*	2.85 ± 1.62*	3.98 ± 1.57*	3.84 ± 1.40*	3.48 ± 1.54*	4.23 ± 1.33*	13	0

Hedonic score: 1 (dislike very much); 2 (dislike moderately); 3 (dislike slightly); 4 (neutral, neither dislike nor like); 5 (like slightly); 6 (like moderately); 7 (like very much); An overall score was given for each sample and for each sample the selected taste attribute was evaluated as well using the same scoring scale; All data are expressed as the mean ± SD from 87 panelists; [1] for *sambal-terasies* without salt addition; *Significance of planned contrast analysis are at p-value<0.05, comparing each *sambal-terasi* without vs with salt addition to a final salt content of 1.97%

TABLE 5. Reasons of panelists liking and disliking of *sambal-terasies,* with (+Salt) and without salt addition (to a final salt content of 1.97%)*

Sambal-terasi	Total of responses	Saltiness	Sourness	Sweetness	Bitterness	Umami	*Rebon*	Fishy
Number of panellists identifying the particular taste/flavor attribute as decisive in their sensory appreciation (liking)								
A	33	16	1	4	0	6	5	1
B	6	2	0	2	0	2	0	0
C	20	5	1	3	0	6	5	0
D	0	0	0	0	0	0	0	0
E	3	0	0	0	0	1	2	0
F	3	0	0	2	0	1	0	0
B+Salt	19	9	0	4	0	4	2	0
C+Salt	18	7	1	2	0	5	3	0
D+Salt	8	2	1	1	0	1	2	1
E+Salt	19	6	2	2	0	5	3	1
F+Salt	25	10	0	3	0	8	4	0
Number of panellists identifying the particular taste/flavor attribute as decisive in their sensory appreciation (disliking)								
A	6	0	1	0	4	0	0	1
B	19	1	1	2	11	2	1	1
C	0	0	0	0	0	0	0	0
D	23	0	4	2	14	0	0	3
E	49	6	3	2	32	2	0	4
F	17	0	1	3	11	1	1	0
B+Salt	2	1	0	0	1	0	0	0
C+Salt	7	0	0	0	5	1	0	1
D+Salt	2	0	0	0	1	0	0	1
E+Salt	7	1	1	1	2	1	0	1
F+Salt	0	0	0	0	0	0	0	0

*Each panelist could give more than one taste/flavor attributes; [1]*terasi* was generally defined as fishy and *rebon* flavor according to panelists

TABLE 6. Calcium, magnesium, sodium, potassium, phosphor and salt content of *sambal-terasi* with (+Salt) and without salt addition

Sambal-terasi	Dry matter (g/100g FW)	Calcium*	Magnesium*	Sodium*	Potassium*	Phosphor*	Salt**
A	33.80	5.90	1.57	30.80	14.10	4.23	2.65
B	31.90	4.86	1.55	7.20	14.90	4.62	0.58
C	33.50	3.48	1.50	20.70	13.90	4.06	1.76
D	33.50	5.01	1.50	6.90	14.20	4.54	0.59
E	33.90	5.36	1.51	2.90	14.50	4.72	0.25
F	34.10	4.76	1.42	8.90	14.40	4.41	0.77
B+Salt	34.50	4.57	1.41	27.20	13.90	4.18	2.39
C+Salt	33.90	3.65	1.41	24.80	13.60	3.98	2.14
D+Salt	32.70	4.63	1.50	21.10	14.10	4.44	1.75
E+Salt	34.90	4.86	1.45	24.60	14.50	4.29	2.18
F+Salt	34.60	4.51	1.40	24.20	14.50	4.20	2.13
SEM	-	0.110	0.027	0.409	0.212	0.079	-

Note: * in mg/g dry matter *sambal-terasi* samples, all data are the mean of twice replications; ** in g/100 g fresh weight *sambal-terasi* samples, calculated based on sodium content; SEM: standard error of mean

Score 0 (absence of flavor) to 15 (maximum flavor perceived). All data are expressed as the mean ± SD from 9 trained panelists. * representing the significant planned contrast-test (p<0.05)

FIGURE 2. Comparison between the addition of salt (+Salt) and the original *sambal-terasi* of five different *sambal-terasi*es

D. Thus, it seems that increasing the salt content can improve key taste attributes which were identified to contribute positively to the overall sensory appreciation of *sambal-terasies*. In parallel, also the bitterness of *sambal-terasies* was reduced, in particular and significantly for the least appreciated *sambal-terasi* E. Previously, Keast and Breslin (2002) reported on the impact of various sodium salts on the reduced bitterness of a number of compounds. Similarly, Henney et al. (2010) reported on the suppression of bitterness by sodium.

Apart from boosting the desirable taste characteristics of *sambal-terasies*, a moderate increase of their salt content will also result in a softening of the bitter notes if present in the original *terasi*. In addition, it was shown via a contrast test, that all supplemented *sambal-terasies* were not appreciated different compared to *sambal-terasi* A (p > 0.05 for all sensory attributes).

Again the trends observed in the quantitative sensory evaluation by the trained panel were confirmed by the outcome of the hedonic sensory evaluation by the untrained panel. The overall hedonic scores for all supplemented samples, except *sambal-terasi* C+Salt, increased significantly compared to their original equivalents (Table 4). Similarly, all the scores for the considered taste attributes improved significantly for the supplemented *sambal-terasies* B-F+Salt. Comparing all supplemented *sambal-terasies* with *sambal-terasi* A *via* a planned contrast analysis, no significant differences could be found (p<0.05). For all salt supplemented samples, except *sambal-terasi* C, an improved sensory appreciation could be noticed. One of the reasons for this is due to the amount of sodium (20 mg/100 g of *sambal-terasi* C, Table 6) that gives the saltiness and umami in *sambal-terasi* C could already be sufficient to provide the acceptance levels needed by panelists. Therefore, there were no significant changes occurred compared to the salt supplemented *sambal-terasi* C. Also, all sensory attributes of *sambal-terasi* C were considerably balanced. The acceptability levels of all the key attributes that panelists appreciated (saltiness, umami, *rebon*) and did not appreciate (fishy and bitterness) in *sambal-terasi* C were insignificant as those of *sambal-terasi* A and all other salt-supplemented *sambal-terasies*. Sodium plays a role in enhancing the palatability of food flavor, which also provides an overall balance among all sensory attributes of foods (Henney et al. 2010). For the supplemented samples only s*ambal-terasi* D+Salt was appreciated by a rather limited number of panelists. Interestingly, it was noticed that its salt content was the only one below 2 g/100 g (on fresh weight basis, based on sodium determination). Although this is a conclusion which in a larger scale study should be confirmed, it seems to suggest that a salt content of 2-2.5 g (based on sodium content) could be considered as a good compromise to achieve an equilibrated sensory appreciation of *sambal-terasies* without avoiding excessive salt intake. As previously mentioned in the introduction section, in Indonesia, the salt intake is above the recommended level of WHO, and chili sauce (including *sambal-terasi*) was considered as one of the predominant sources of salt intake (Hardinsyah 2017). The findings of our study could improve the manufacturing practices on how to use appropriately salt and *terasi* in the production of *sambal-terasi*. Thus, salt is only added if necessary (when the salt content of *sambal-terasi* is < 2-2.5 g/100 g). When excessive salt is added (e.g. salt content >2.5 g/100 g), there are tendencies to add sugar, monosodium glutamate, or other types of flavor enhancers to balance the overpower tastes/flavors of *sambal-terasi* (Damanik-Ambarita et al. 2019). This practice, unfortunately, will cause problem in overuse of sodium, sugar and other food additives. Although no data could be found with respect to the sensory threshold or preference levels with respect to the salt content in chili sauces or *sambal-terasi*, it seems reasonable to speculate that by the addition of *terasi* to the chili sauces, the salt content of the *sambal-terasi* can be kept lower compared to the chili sauces without *terasi*. Peptides (Ohta et al. 2005) or amino acids such as sodium aspartate (Nakagawa et al. 2014) are known to enhance the salty taste. In addition, odorous compounds could also improve salty taste perception as proven for sardine aroma (Lawrence et al. 2011) or as documented for another fermented product such as soy sauce (Chokumnoyporn et al. 2015). In view of the nature of *terasi* and its production, it is obvious that there are a variety of compounds present in *terasi* which potentially will enhance the salty taste of products in which it is used. Apart from its sodium content, other compounds present in *terasi* can have an impact on the salty perception of *sambal-terasi*.

CONCLUSION

The addition of *terasi* to chili sauce is a common practice in Indonesia in order to create a desirable salty, umami and *rebon* tastes/flavor, the key attributes in *sambal-terasi*. The addition of different types of *terasies* significantly changed the sensory characteristics of *sambal-terasies*. The undesirable compounds formed during production of *terasi* (biogenic amines and short chain fatty acids) could still be perceived in *sambal-terasi,* therefore their presences should be controlled. A sufficient amount of salt (2.0-2.5 % of total weight) is necessary to reduce the bitterness and to enhance the desirable taste/flavor attributes.

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