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The effect of physicochemical and sensory characteristics of red and black *oncom* to the consumer acceptability

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Abstract

Oncom is an Indonesian traditional fermented food made from agro-industry waste. Despite its popularity, *oncom* is mainly produced on a small scale using traditional methods, which leads to varied qualities. The study aimed to determine the influence of physicochemical properties and sensory characteristics of *oncom* towards their sensory acceptability. The red and black *oncom* from three producers in Bogor, Indonesia, produced with different process conditions and materials, were subjected to color and texture analysis, proximate and amino acid composition analysis, and sensory analysis. Textural properties varied depending on the raw materials added, and color parameters were affected by the mold used. Moreover, the highest hardness was typical of black *oncom*, while red *oncom* appeared to have the highest cohesiveness, springiness, and redness. The primary content of red *oncom* was protein and carbohydrates, while black *oncom* consisted primarily of fat and protein. The amino acid content of red *oncom* ranged from 2.11-4.09%, while black *oncom* was 6.49-15.51% and was dominated by glutamic acids, which were reported to impart an umami taste. Orange color, red color, beany aroma, and umami taste were the attributes that best described red oncom. In contrast, black *oncom* was best described by its brown color, umami taste, and nutty aroma attributes. The acceptability of red *oncom* was higher than that of black *oncom*. Umami taste and red color were found to be drivers of liking.

1. Introduction

One of the main current priorities on the food and agriculture sector is to produce adequate food in terms of quantity and quality simultaneously to meet the nutritional needs of the growing population. A sustainable food system can promote food security and reducing waste by utilizing waste that can be consumed as food (Capone *et al.*, 2014). Waste produced by the agricultural industry is rich in components that can be used as substrates in the fermentation process (Sadh *et al.*, 2018), such as peanut pressed cake and tofu waste.

Oncom is a traditional Indonesian food produced by mold fermentation of food waste. The umami taste and unique aroma make it acceptable in Indonesia, particularly in West Java. According to data on consumption patterns of West Java population in 2020, Bogor had the highest average weekly consumption of *oncom* compared to other cities and districts in West Java Province. The demand for *oncom* is supported by the large number of producers in West Java region, especially Bogor.

Oncom, despite its popularity, is currently produced on a small scale using traditional methods, leading to unstable quality (Sastraatmadja *et al.*, 2002). As of yet, *oncom* still lacks official reference standard to compare its quality, which is different from similar fermented products, namely soybean tempeh that already has standard, several parameters of tempeh were used for comparison. The variations in *oncom* characteristics can be attributed to differences in fermentation stages, raw composition, and fermentation starters as reported in previous *oncom* research (Sastraatmadja *et al.*, 2002; Kumbhare, 2014; Mulyani and Wisma, 2016; Rohimah *et al.*, 2021).

The acceptability of food product is primarily determined by the product's sensory characteristics which can also be influenced by its physicochemical properties but in *oncom,* this issue was not been fully understood. This research aimed to evaluate the physicochemical and sensorial properties of red and black *oncom*. In addition, consumer acceptability testing on *oncom* was conducted to identify the relationship

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between physicochemical and sensory characteristics on the sensory acceptability of *oncom*. The outcomes were planned to improve the quality and acceptability of *oncom*.

2. Materials and methods

2.1 Materials

Premature *oncom* samples were obtained from six local producers in Bogor, West Java Province, Indonesia. Surveys were carried out on *oncom* producers' locations and observations of *oncom*'s raw materials, packaging, and fermentation condition. Red *oncom* samples (36 hrs of fermentation) were obtained from producers in the Leuweung Kolot, Leuwiliang, and Karadenan areas. In comparison, black *oncom* samples (12 hrs of fermentation) were obtained from the Cisaeur, Jatake, and Dramaga areas. The collected material was transported to the laboratory of the Food Technology Department in IPB University, Bogor, West Java Province, Indonesia and continued its fermentation process in a room-temperature condition for 12 hrs.

2.2 Texture profile analysis and color analysis

Texture profile analysis of *oncom* was performed using TA-XT2i Texture Analyzer (Stable Micro Systems Ltd, Surrey, UK) equipped with a probe P/25. The fresh samples were divided into a rectangular shape (2×2×2 cm^3). The side of the sample was the object of probe contact. The setting was set with a trigger force of 5 g, compression ratio of 40 cm/100 cm, pre-test speed, test speed, and post-test speed of 1.0 mm/s (Qiu *et al.*, 2022).

The color was measured using a Konica Minolta CR-300 Chromameter (Konica Minolta Sensing, Japan). The L*, a*, and b* values were determined. L* characterized the lightness of the *oncom* samples ranging from 0 (darkest) to 100 (lightest); a* characterized redness (the scale of green to red with negative values defined as hues of green and positive ones for hues of red); and b* characterized yellowness (the scale of blue to yellow with negative values for hues of blue and positive ones for hues of yellow) (Andriati *et al.*, 2018).

2.3 Proximate analysis

Proximate analysis of *oncom* was performed using Association of Officiating Analytical Collaboration (AOAC) International methods to obtain its content of moisture, ash, crude protein, fat, and carbohydrates.

2.3.1 Determination of moisture content

Water content analysis was carried out using the oven gravimetric method (AOAC, 2005). Empty aluminum cups were first dried in an oven (Binder, Germany) at a temperature of 105°C for 15 mins, transferred to a desiccator for 15 mins, and weighed. A sample of 1-2 grams was weighed on the cup. The cup containing the sample was then dried in an oven for 3 hrs at a temperature of 105°C, stored in a desiccator for 15 mins, and weighed until a constant weight was obtained.

2.3.2 Determination of ash content

Ash content analysis was carried out using the gravimetric method (AOAC, 2005). The empty crucible was dried in an oven at a temperature of 105°C for 15 mins, cooled, and weighed. The sample was weighed of about 2-3 g in the crucible, charred, and put into an electric furnace at a temperature of 550°C. The crucible was then cooled and weighed.

2.3.3 Determination of crude protein content

Crude protein was analyzed using the Kjeldahl method (AOAC, 2005). The finely ground *oncom* sample was weighed 0.5-1.0 grams and put into the Kjeldahl flask together with 1.0±0.1 K_2SO_4, 40±10 mg HgO, and 2.0±0.1 mL H_2SO_4, boiled until the liquid became clear and cooled. Sample distillation was then carried out by transferring the sample into a distillation apparatus and rinsing it with 1-2 mL of distilled water 5-6 times. NaOH -Na_2SO_3 solution was added for about 8-10 mL. An Erlenmeyer containing 5 mL of 3.5% H_3BO_3 solution and 4 drops of methylene red-methylene blue indicator was placed under the condenser on the distillation apparatus. Distillation was carried out, then diluted with demineralized water to a volume of 50 mL. The final stage was titration with 0.02 N HCl solution.

2.3.4 Determination of fat content

Fat content was determined using the Soxhlet method with modification (AOAC, 2005). A sample of 2 -5 g was put into a filter paper sleeve which was then covered with cotton and dried in an oven at a temperature of less than 105°C for about 1 hr to ensure it was free of water. The sleeve containing the sample was then put into a Soxhlet apparatus connected to a fat flask that had been added with n-hexane solvent. The fat extraction process was carried out for about 6 hrs. The solvent in the fat flask was distilled after completion, the fat flask was removed and dried in an oven at 105°C until constant weight. The fat flask was then cooled and weighed.

2.3.5 Determination of carbohydrate content

The determination of carbohydrate content was carried out using the by difference method. The carbohydrate percentage was counted by subtracting other components such as water, ash, fat, and protein on

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a wet basis from 100% (AOAC, 2005).

2.4 Amino acid analysis

Amino acid analysis was performed according to the in-house method by precolumn derivatization using the *o* -phthalaldehyde (OPA) method in sample preparation and HPLC. The preparation of *oncom* samples was done using the Kjeldahl method. Protein was hydrolyzed in 6 N HCl at 110°C for 24 hrs inside a nitrogen atmosphere and dried. The hydrolysates were dissolved in 0.01 N HCl 10 mL and filtered with the addition of buffer (1M potassium borate buffer, pH 10.4, 1:1). Samples were added by 25 µL OPA reagent in a vial bottle, then rested for 1 min. About 5 µL of samples were injected into Shimadzu CBM 20A HPLC (Shimadzu Corp., Japan) performed on a Thermo Scientific ODS-2 Hyersil column, using a mobile phase consisting of a mixture A:B, buffer A consisted of Na-Acetate pH 6.5 (0.02%), Na-EDTA (0.005%), methanol (9.00%), and THF (1.50%) which were dissolved in 1 L water (H.P) while buffer B was a mixture of methanol 95% and water (H.P) filtered by 0.45 µm membrane filter paper at a flow-rate of 1 mL/min. Amino acid analysis can be done by using the pre-column reaction of amino groups with an OPA reagent, which will react with primary amino acids in an alkaline environment containing mercaptoethanol to form a fluorescent compound.

2.5 Sensory analysis

Sensory analysis was evaluated using Quantitative Descriptive Analysis (QDA) and hedonic tests. Prior to the tests, the panelist was introduced to the study, and they were asked if they were willing to participate with the consent form. The ingredients used in the samples were informed to the panelist to avoid recruiting someone with food allergies.

All red and black *oncom* attributes were generated and discussed by focus group discussion (FGD) session by eight trained panels (six women and two men, aged 26-35 years) from the Department of Food Science and Technology, IPB University, Indonesia. Through consensus, panelists generated a list of terms (descriptors) and definitions to describe the samples (Meilgaard *et al.*, 2016). In addition, cooked nuts, cooked soybeans, and several aroma descriptors were also presented as references to confirm the perceived sensation from the samples.

The sensory profiles of red and black *oncom* were evaluated by the QDA method according to ISO 8586:2012 standard. The eight trained panelists with confirmed taste sensitivity rated attribute intensities of six *oncom* on a questionnaire using an unstructured 15 cm line scale (Meilgaard *et al.*, 2016). Each panelist received a score sheet. The intensity of attributes was ranked using a line scale from weak to strong (Piornos *et al.*, 2020).

For consumer acceptability analysis, there were seventy consumers aged 26-35 years old participated in this study. Consumers were questioned about the frequency of their bean and peanut consumption, and only consumers who consumed *oncom* at least once per week were invited to participate. Consumers were given the questionnaires on paper and asked to rate and express their acceptance on the hedonic scale. The acceptability test was carried out voluntarily by consumers of both sexes (Mongi and Gomezulu, 2022). The test used a 7-9 point hedonic scale (Lawless and Heymann, 2010).

2.6 Data analysis

Statistical analysis of the physicochemical and QDA results was performed using SPSS version 25 (IBM, USA). One-way analysis of variance (ANOVA) was used. Duncan's multiple range test was performed to determine the differences between mean values, which were considered statistically significant at $p \leq 0.05$. The correspondence analysis was employed to map the relationship between samples and sensory attributes in biplots (Baker *et al.*, 2016). PLSR was applied to assess the relationship between sensory characteristics and acceptability of *oncom* (Liggett *et al.*, 2008; Yang and Lee, 2020). All the data was analyzed using XLSTAT (Addinsoft, France).

3. Results and discussion

3.1 Production of oncom in Bogor

The observation results showed a difference in the raw materials used to produce red *oncom* and black *oncom* among six producers (Table 1). Other differences also existed in production conditions, such as fermentation duration, starters, and lighting conditions. The three producers produced red *oncom* using tofu waste as raw material and for fermentation, also used red *oncom* made in the previous day as a starter. In contrast to the red *oncom* from a producer in Karadenan area, which was often produced without adding *onggok*, the red *oncom* from Leuweung Kolot and Leuwiliang areas used *onggok* to mix with different percentages. Fermentation in Leuweungkolot and Leuwiliang red *oncom* continued for 48 hrs, while Karadenan red *oncom* dough was turned over after 24 hrs to continue its fermentation on the other side for the next day. Karadenan red *oncom* was fermented in a semi-open space, while the *oncom* from the other two producers were fermented in a closed space.

Black *oncom* from two producers in the Jatake and

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Table 1. Ingredients (%) used to produce red and black *oncom* in Bogor.

Ingredients	Red *oncom*			Black *oncom*		
	Karadenan	Leuweungkolot	Leuwiliang	Cisaeur	Jatake	Dramaga
Peanut-pressed cake	0	0	0	100	100	66.7
Soybean hull	0	0	0	0	0	33.3
Tofu waste	100	99	97	0	0	0
Tapioca waste	0	1	3	0	0	0

Cisaeur areas was made with peanut-pressed cake, while Dramaga black *oncom* was made with the addition of soybean hull left over from making tempeh. This unique aspect sets Dramaga black *oncom* apart. According to the Indonesian FDA, black *oncom* is defined as a fermented product from peanut-pressed cake mixed with cassava dregs, cassava flour, and/or tapioca with a black *oncom* starter. The raw materials were soaked and steamed to soften them and remove contaminants. The steaming process can soften the beans and eliminate bacterial and mold contamination of the beans (Owens *et al.*, 2015).

3.2 Physicochemical characteristics of red and black oncom

The physical characteristics observed in this research still refer to the individual perspective considering that *oncom* does not yet have formal quality reference parameters to compare quality between products. The texture profile parameters measured include hardness, cohesiveness, and springiness values (Table 2). The physical characteristics of red *oncom* significantly differed from those of black *oncom*.

The difference in hardness might be caused by the peanut-pressed cake used in black *oncom* (Tables 1 and 2). Black *oncom* made from peanut-pressed cake contained lower moisture content and higher fat content (Table 3). This phenomenon was in line with literature on similar products, which reports that texture can be influenced by moisture and fat content (Wikandari *et al.*, 2020). The higher the moisture content, the softer the food texture will be (Wikandari *et al.*, 2020), while the higher the fat content, the hardness level will increase (Rolon *et al.*, 2017).

The difference between the three red *oncom* hardness was not significant, but red *oncom* without *onggok* had a significant difference in the level of cohesiveness compared to red *oncom* with *onggok*. *Onggok* itself, as a solid tapioca residue, is rich in carbohydrate content, mainly starch, which reaches 60% (Arnata *et al.*, 2021). The presence of starch in products can increase the cohesiveness of food (Gafuma *et al.*, 2018). The presence of carbohydrates can influence the density of mycelia, thereby increasing the strength of foods because the mycelia of mold penetrate strongly into the substrate (Wikandari *et al.*, 2020). A similar phenomenon occurred in the springiness and cohesiveness of red

Table 2. Physical characteristics of red and black *oncom.*

Parameter	Red *oncom*			Black *oncom*		
	Karadenan	Leuweungkolot	Leuwiliang	Cisaeur	Jatake	Dramaga
Hardness (N)	514.35±2.05^{a}	859.1±20.65^{a}	948.55±31.75^{ab}	1347.95±397.88^{bc}	2666.2±136.47^{d}	1461.25±729.57^{c}
Cohesiveness (-)	0.68±0.02^{c}	0.78±0.01^{d}	0.75±0.01^{d}	0.44±0.00^{a}	0.46±0.02^{a}	0.57±0.01^{b}
Springiness (mm)	0.75±0.03^{d}	0.81±0.02^{e}	0.74±0.00^{d}	0.52±0.01^{b}	0.46±0.00^{a}	0.59±0.00^{c}
L*	69.85±0.49^{c}	71.24±2.73^{c}	72.78±2.09^{c}	46.67±5.02^{a}	43.91±2.80^{a}	61.93±4.25^{b}
a*	34.09±1.13^{d}	26.13±4.75^{c}	16.18±3.91^{b}	7.80±1.64^{a}	2.91±1.35^{a}	2.64±0.30^{a}
b*	58.84±1.94^{d}	57.87±2.08^{d}	46.82±4.96^{c}	16.45±0.23^{b}	8.74±2.36^{a}	14.51±1.02^{b}

L*: lightness; a*: (+) red – (-) green; b*: (+) yellow – (-) blue. Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different ($p>0.05$) as determined by ANOVA (Duncan's multiple range test).

Table 3. Proximate composition of red and black *oncom.*

Parameter	Red *oncom*			Black *oncom*		
	Karadenan	Leuweungkolot	Leuwiliang	Cisaeur	Jatake	Dramaga
Moisture (%wb)	76.19±0.65^{f}	72.32±0.04^{e}	69.21±0.17^{d}	61.80±0.48^{b}	57.23±0.39^{a}	67.95±1.58^{c}
Ash (%db)	3.71±0.08^{d}	2.99±0.02^{c}	2.62±0.03^{b}	2.06±0.03^{a}	2.26±0.03^{a}	2.14±0.44^{a}
Fat (%db)	1.61±0.17^{a}	1.83±0.10^{a}	2.07±0.06^{a}	31.75±1.65^{d}	28.34±0.84^{c}	12.25±0.76^{b}
Protein (%db)	16.37±0.45^{a}	15.64±0.3^{a}	15.85±0.21^{a}	40.77±1.29^{c}	40.95±1.09^{c}	30.53±1.86^{b}
Carbohydrate (%db)	78.30±0.65^{a}	79.55±0.37^{a}	79.47±0.18^{a}	25.42±2.51^{a}	28.48±1.12^{b}	55.08±2.6^{c}

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different ($p>0.05$) as determined by ANOVA (Duncan's multiple range test).

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oncom, which was better than black *oncom*. It could be related to the growth of mold on red *oncom,* which was better than black *oncom*. Research reported that tempeh with thick mycelia has higher cohesiveness and springiness values (Wikandari *et al.*, 2020).

Color presents a visual appeal that is relevant to a product's acceptability in consumers' eyes (Rocha, 2019; Pramesti *et al.*, 2023). *Oncom*'s color parameters and appearance were generally different (Table 2 and Figure 1). The a* and b* values for red *oncom* were higher than black *oncom* (Table 2). Fermentation of waste with *Neurospora sitophila* produces orange-red *oncom* due to red hyphae (Mulyani and Wisma, 2016). Karadenan red *oncom* had denser mold with higher red color value, while Leuwiliang red *oncom* had less red color than the other two red *oncom*. The lack of light intensity in the production room was thought to affect mold growth, considering that Karadenan red *oncom* production condition was exposed to bright light. Carotene synthesis in the mycelial growth of *Neurospora* sp. can be induced by light (Wöstemeyer *et al.*, 2005).

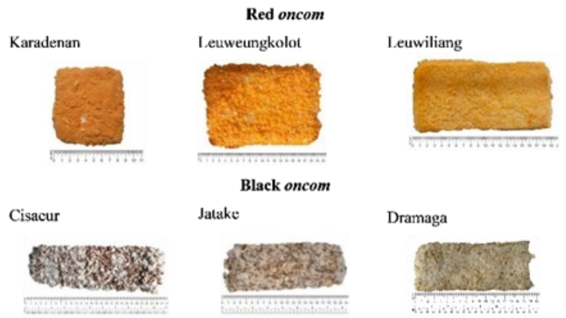

Figure 1. Red and black *oncom* produced by 6 producers in Bogor.

Red *oncom* and black *oncom* had proximate composition with different concentrations in general (Table 3). All three red *oncom* had moisture content ranging from 69.21-76.19% wb. This amount tends to be higher than black *oncom*, which ranges from 57.23-67.95% wb. Tofu waste as the raw material has a moisture content of around 76-80% of its total weight (Rahman *et al.*, 2021), higher than peanut-pressed cake, which contains only around 4.3% of water (Ginting *et al.*, 2018). However, soaking the cake before processing allows water to absorb into the seeds (Prayudani *et al.*, 2023) which caused the moisture content of black *oncom* to be higher than the peanut-pressed cake itself. In red *oncom*, adding *onggok* could reduce its moisture content and cause a significant difference. *Onggok* contains around 14% water (Kiramang, 2011), which could reduce the moisture content of red *oncom* if added to the composition.

Red *oncom* had higher ash content than black *oncom*. Looking at the raw material used, the ash content of tofu waste ranges from 3.7-5.3%, higher than that of peanut-pressed cake, which is 3.3% (Ginting *et al.*, 2018; Rahman *et al.*, 2021). Also, soaking the peanut pressed cake can reduce ash content because minerals are generally soluble in water (Essington, 2003). Both of them could reduce the ash content in black *oncom*. The three red *oncom* had differences in ash content, which could have been caused by adding *onggok* to the composition. The greater the number of *onggok*, the ash content would decrease, as the ash content of *onggok* is lower by 1.2% (Kiramang, 2011).

Red *oncom* contained more than 90% protein and carbohydrates, while black *oncom* contained fat, protein, and carbohydrates dominating each other. Black *oncom*, with the majority of raw materials being peanut-pressed cake, contained almost 70% fat and protein. Peanut-pressed cake significantly increased the fat and protein content of *oncom*. Peanut-pressed cake has a higher fat content than tofu waste, 35.87% db and 4.5-17% db, respectively (Ginting *et al.*, 2018; Mulyasari *et al.*, 2022). Tofu waste contains around 21.4-27% protein, while protein content in peanut-pressed cake may reach 33% (Sitanggang *et al.*, 2020; Mulyasari *et al.*, 2022).

Adding soybean hulls to the Dramaga black *oncom* composition reduced the fat percentage and increased the carbohydrate content. The protein and fat content of black *oncom* made with the addition of soybean hull were significantly different from *oncom* without the hull and tended to be lower than Cisaeur black *oncom* and Jatake black *oncom*, namely 30.53% and 12.25%, respectively. Soybean hull contains protein and fat about 1.65% and 0.34% of its total weight (Istiansari, 2014). Apart from that, soybean hull also contributes to moisture content because its content reaches 82.45% (Istiansari, 2014).

3.3 Amino acid composition of red and black oncom

Red and black *oncom* had 15 amino acids based on the results of amino acid composition analysis (Table 4). Variations in the type of protein in the raw material used might affect the amino acids contained in *oncom*. The total amino acid content increased with the increasing use of peanut-pressed cake, so black *oncom* had higher amino acid content than red *oncom*. The peanut-pressed cake is the residue that remains after oil extraction from peanuts and contains 23.20 g/100 g of amino acids (Bujang and Taib, 2014). Soybeans contain 34.64 g/100 g of amino acids (Bujang and Taib, 2014), but only about 23% is found in tofu waste (Liu, 2008).

Amino acids in fermented foods can influence the taste characteristics of the food product. According to (Tseng *et al.*, 2005), amino acids can be grouped into

Table 4. Amino acid composition of red and black *oncom*.

Amino Acid (%w/w)	Red *oncom*			Black *oncom*		
	Karadenan	Leuweungkolot	Leuwiliang	Cisaeur	Jatake	Dramaga
Threonine	0.22	0.25	0.13	0.46	0.64	0.32
Glutamate	0.58	0.67	0.33	3.01	3.09	1.13
Histidine	0.23	0.21	0.13	0.48	0.53	0.31
Lysine	0.04	0.05	0.02	0.17	0.22	0.13
Valine	0.25	0.29	0.16	0.69	0.94	0.4
Methionine	0.03	0.04	0.02	0.1	0.15	0.05
Ileucine	0.26	0.28	0.15	0.6	0.88	0.53
Leucine	0.32	0.37	0.18	1.02	1.36	0.67
Phenylalanine	0.21	0.24	0.13	0.8	0.94	0.42
Aspartic Acid	0.42	0.49	0.24	1.65	2.05	0.75
Serine	0.24	0.25	0.13	0.75	0.85	0.37
Glycine	0.24	0.25	0.14	0.76	0.92	0.35
Alanine	0.26	0.3	0.16	0.62	0.98	0.38
Tyrosine	0.13	0.15	0.07	0.53	0.65	0.24
Arginine	0.23	0.25	0.13	1.6	1.3	0.44
Total	3.65	4.09	2.11	13.25	15.51	6.49

amino acids that taste like MSG, sweet, bitter, and tasteless. Glutamic acid was dominant and had the highest content in six *oncom* samples, followed by aspartic acid. Glutamic acid is known as an amino acid that is important in creating umami taste in food and has been used as a flavor enhancer worldwide (Gunawan-Puteri *et al.*, 2015). The dominant glutamic acid content indicates the potential of *oncom* as a food that produces umami taste. The concentration of aspartic acid also influences the intensity of the umami taste (Utami *et al.*, 2016).

Some amino acids can influence the bitter taste of food, such as leucine and arginine (Kong *et al.*, 2018), which were found to be relatively high in black *oncom*. However, the bitter taste may not appear if amino acids are present as structural components of the native protein (Aluko, 2017). According to research on soy sauce, the presence of bitter amino acids at a certain threshold can increase the umami taste so that the bitter taste may be masked (Lioe *et al.*, 2005).

3.4 Sensory characteristics of red and black oncom

A total of 15 sensory attributes describing red *oncom* and black *oncom* were obtained from FGD results. The attributes of red *oncom* consist of musty, beany (aroma); bitter, umami (taste); orange, red (color); hardness, springiness, cohesiveness, juiciness (texture), and sour (aftertaste). The sensory attributes of black *oncom* consist of musty, nutty (aroma); bitter, umami (taste); white, brown (color); hardness, springiness, cohesiveness, juiciness (texture), and bitterness (aftertaste). These sensory attributes were used in the sensory test.

The profiles of the three red *oncom* observed were different (Figure 2). One of the differences was in the intensity of color attributes. The dominant orange and red colors in red *oncom* are produced by the mold *N. sitophila,* which produces red hyphae (Mulyani and Wisma, 2016). Karadenan red *oncom* has the highest intensity of orange and red color attributes compared to the other two *oncom,* as in Figure 1. This phenomenon could be understood because the mold grew well on it. As previously reported, Karadenan red *oncom* was produced in a semi-open space with enough light, thereby increasing the growth of *Neurospora* (Wöstemeyer *et al.*, 2005).

The difference in juiciness in the three red *oncom* could be due to the *onggok* added, which might function as fiber. Karadenan red *oncom* had higher moisture content (Table 3) than the other two samples, but the intensity of juiciness rated by the panelists tended to be lower. Leuwiliang red *oncom* had the highest intensity of juiciness attribute among the three red *oncom*. The higher composition of *onggok* might work as fiber that can bind the water (Setijawaty *et al.*, 2019).

Another attribute that differed in intensity between the three red *oncom* observed was the musty aroma. A musty aroma is associated with mushrooms (Utami *et al.*, 2016). The mushroom or musty aroma of *oncom* can be obtained from the mold used in fermentation (Inamdar *et al.*, 2020). *Neurospora* sp. has been identified to produce the compound 1-octen-3-ol, which has a mushroom aroma (de Carvalho *et al.*, 2012). Therefore, the high intensity of the musty aroma of Karadenan red *oncom* followed by Leuweungkolot red *oncom* and Leuwiliang red *oncom* might related to the denser mold growth, as seen in Figure 1.

The profiles of the three black *oncom* samples observed were different (Figure 2). One of the differences was in the color attributes, namely brown and white. The intensity of brown color in Cisaeur black *oncom* and Jatake black *oncom* was higher than Dramaga black *oncom*; in contrast, the intensity of white color of Dramaga black *oncom* had the highest value compared to the other two black *oncom* observed. Jatake black *oncom* and Cisaeur black *oncom* were made from 100% peanut-pressed cake, which has a brown color, making these two black *oncom* tend to be darker. The higher intensity of Dramaga black *oncom*'s white color could be caused by the soybean hull as its composition with a lighter color (Marom *et al.*, 2015).

Figure 2. Spider web and PCA result of red and black *oncom*'s sensory attributes.

Another attribute that differed in intensity between the three black *oncom* observed was nutty aroma. The panelists rated the nutty aroma of black *oncom* made from peanut-pressed cake higher in intensity than the one made with the addition of soybean hull. Pyrazine compound can contribute to nutty aroma in *oncom,* commonly reported in roasted peanut products (Baker *et al.*, 2003). Aromas associated with fungi were also found in black *oncom* and tended to differ significantly in intensity. No research has been found on similar fermented peanut products about their musty or mushroom aroma. Still, *Rhizopus* sp. has been identified to produce a musty aroma on similar fermented products (Mei Feng *et al.*, 2007).

Umami taste attribute was present in all three black *oncom* but was significantly different in intensity, especially in Dramaga black *oncom*. Umami taste can be caused by amino acids, especially glutamic amino acid and aspartic acid (Gunawan-Puteri *et al.*, 2015; Utami *et al.*, 2016). As previously reported, these two amino acids dominated the amino acid composition of black *oncom* (Table 4). Dramaga black *oncom* had a lower umami taste intensity than Cisaeur black *oncom* and Jatake black *oncom*, presumably because the amino acid content of Dramaga black *oncom* tended to be lower.

Three black *oncom* observed also had significant differences in hardness. Black *oncom* with peanut-pressed cake composition had a hardness value that tended to be higher than black *oncom* with the addition of soybean hull. This difference in hardness may be caused by the fat content contained in food products (Rolon *et al.*, 2017). The physical test result confirmed that Dramaga black *oncom* had the lowest hardness value among the three black *oncom* observed.

The relationship between attributes could be shown by the location of the attributes and both red and black *oncom* samples on the PCA curve (Figure 3). Karadenan red *oncom* had dominant characteristics, namely orange color, red color, musty aroma, springiness, and sour aftertaste. Meanwhile, juiciness and hardness were the dominant attributes of Leuwiliang red *oncom*. Leuweungkolot red *oncom* had dominant umami taste and beany aroma. In black *oncom*, Cisaeur black *oncom* had dominant characteristics, namely hardness, juiciness, bitter aftertaste, and bitter taste. Meanwhile, Jatake black *oncom* showed dominant characteristics of nutty aroma, musty aroma, and umami taste. White color and springiness were the dominant attributes of Dramaga black *oncom*. The PCA maps showed that each *oncom* had no similarities with other products, as seen in each sample point located far from each other.

3.5 Relationship between physicochemical and sensory characteristics to oncom's sensory acceptability

Red *oncom* was preferred over black *oncom* in general (Table 5). Karadenan red *oncom*'s overall liking score was the highest, and Leuwiliang red *oncom*'s score

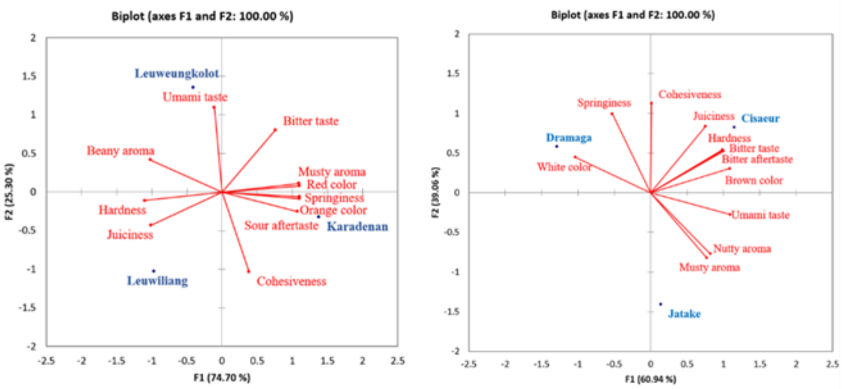

Figure 3. PCA result showing the description of the red and black *oncom* by sensory attributes.

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was significantly different from the other two red *oncom*. In black *oncom*, Cisaeur black *oncom* was preferred over the other two black *oncom*. The most liked red *oncom* had the dominant sensory characteristics of orange color, red color, musty aroma, springiness, and sour aftertaste as well as the highest moisture content, a* value, and b* value. Black *oncom*, with the highest overall liking score, had the dominant characteristics of hardness, juiciness, bitter aftertaste, and bitter taste, as well as the highest fat content and springiness value.

Table 5. Overall liking score of red and black *oncom*.

Sample	Overall liking score
Red oncom	
Karadenan	5.4±1.0^{a}
Leuweungkolot	5.3±0.9^{a}
Leuwiliang	4.4±1.0^{c}
Black oncom	
Cisaeur	4.9±1.1^{b}
Jatake	4.4±1.1^{c}
Dramaga	3.8±1.3^{d}

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (p>0.05) as determined by ANOVA (Duncan's multiple range test).

The results of QDA data analysis and consumers' acceptability with PLSR showed that there was a relationship between sensory characteristics and overall liking of *oncom*. Figure 4 shows this relationship, with the quality of PLSR plot obtained from both dimensions being 97.34% and characterized by an umami taste and red color on the positive end. Based on the PLSR result, the umami taste appeared very close to the overall liking point, indicating that umami taste was the largest driver of liking.

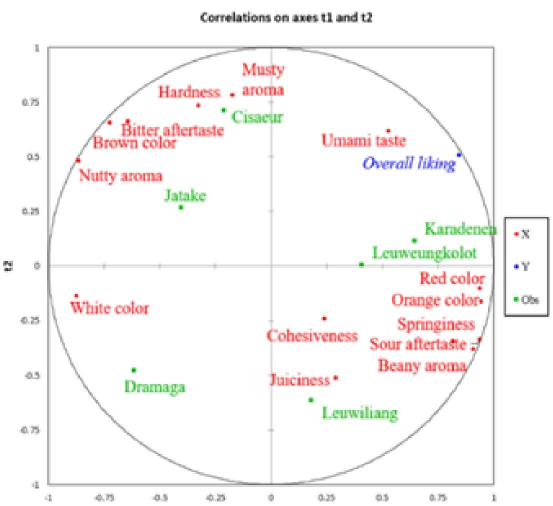

Figure 4. Partial least squares regression model showing the relationship between sensory attributes and consumers' overall liking score of oncom.

The result that the umami taste attribute can encourage acceptance is supported by research stating umami can increase the degree of liking of food (Wang *et al*., 2020). Regarding the amino acid composition, *oncom* contained amino acids that give an umami taste, such as glutamate and aspartic acids (Gunawan-Puteri *et al*., 2015; Utami *et al*., 2016), which tended to be higher in content than other amino acids according to the data in Table 3. Colors can encourage consumer liking and acceptance (Spence, 2015). The red color of food can increase appetite (Foroni *et al*., 2016), and red color has appeared naturally in red *oncom* from the fermentation process.

4. Conclusion

The difference in raw materials as ingredients, mold used, and fermentation conditions significantly impacted the physicochemical and sensory characteristics of red and black *oncom*. Red *oncom* had higher water content, ash content and cohesiveness due to the use of tofu waste as raw material. Black *oncom* had higher fat, protein, total amino acids, and hardness levels due to using peanut-pressed cake as raw material. The total amino acid content increased with the increasing use of peanut-pressed cake, so black *oncom* had higher amino acid content than red *oncom*. The presence of glutamic acid and aspartic acid as amino acids was reported to contribute to the umami taste of red and black *oncom*. Black *oncom* was best defined by its brown color, umami taste, and nutty aroma. In contrast, red *oncom* was best described by sensory features like red color, orange color, beany aroma, and umami taste. The characteristics of *oncom*, such as umami taste and red color attributes, were believed to drive consumers' acceptability of *oncom*.

Conflict of interest

The authors declare no conflict of interest.

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