The effect of the addition of *Chlorella* and *Spirulina* powder in the physicochemical properties and sensory acceptance of dried noodles substitute with mocaf flour

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Abstract. Noodles are popular food products among Indonesian citizens. The development of noodles with the addition of functional ingredients may increase the health benefits and nutritional value of noodle products. The study investigated the effect of adding *Chlorella* and *Spirulina* powder on the physicochemical properties and sensory acceptance of noodles. The dried noodles were partially substituted by mocaf flour, with the ratio between wheat flour and mocaf flour at 70:30. Then, the *Chlorella* or *Spirulina* powder was added to the noodles dough at concentrations of 1% and 2% by dough total weight. The effect of *Chlorella* and *Spirulina* addition to the samples was analyzed through color, proximate, total carotenoids, and consumer acceptance by hedonic test. The results showed that adding 1% and 2% of *Chlorella* and *Spirulina* powder increased the green color intensity, moisture, ash, protein, lipid, and total carotenoids, while carbohydrate content decreased. Sensory acceptance was lower at 2% addition; however, the acceptance before and after substitution with *Chlorella or Spirulina powder was* not significantly different. The results suggested that adding *Chlorella* and *Spirulina* at 1% and 2% concentrations could increase the overall nutrients without changing the sensory acceptance of mocaf-dried noodles.

1 Introduction

Noodles are popular food product in Indonesian which consume by people across ages, including children, teenagers, and adults. The attraction of noodles is attributed to the appearance, texture, and taste. Besides, noodles are often used as rice replacement because the carbohydrate content is relatively high. Based on the processing stage, noodles can be

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categorized into five types: raw, wet, dry, fried, and instant [1]. According to the data from World Instant Noodles Association (WINA), the consumption of instant noodles in 2021 in Indonesia achieved 13.27 billion portions with the market size around US$3.03 billion [2].

Currently, most of commercially available noodles are generally made from wheat flour as the main ingredient. In addition, the use of wheat flour for noodle products in Indonesia reaches 55%, while the remaining amount is 28% for bread products and 17% for several types of cakes [3]. Several noodles producer start to use local ingredients as a substitute for wheat flour, such as mocaf flour, to reduce the use of wheat flour, which is still imported from other countries. Mocaf flour (Modified Cassava Flour) is a cassava flour product that is fermented aerobically, resulting in changes in characteristics such as viscosity (adhesion), rehydration ability, solubility, higher soluble fiber content, and a softer texture compared to ordinary cassava flour [4]. The best substitution ratio for wheat flour and mocaf flour used to make dry noodles is 75:25 [5].

Noodles are high in carbohydrates but low in vitamins, minerals, and fiber. Therefore, the noodle producers often add fruit or vegetable extract to fortify the nutrition of noodles products. Several previous research, fortifying the noodles product with spinach [6,7], carrot [8], dragon fruit [9], and mustard [10]. The addition of vegetables and fruit extract improves the noodles nutrition. The substitution of spinach flour in noodles increased the protein content, ash content, and antioxidant status [6,7]. At the same time, noodles containing mustard have a higher amount of minerals [10]. The addition of dragon fruit and carrot in noodles also increased the antioxidant status of the product because of the increment of vitamin C and beta-carotene in the noodles [8,9].

In our study, microalgae as a functional ingredient were added to the noodles. Microalgae are single-celled microorganisms that can be developed as functional food ingredients that positively influence human health [11]. Various studies have proven that regular microalgae consumption can positively affect the human body, such as lowering blood pressure, improving the immune system, and increasing blood fluidity and circulation [12]. *Chlorella* sp. and *Spirulina* sp. are commercially cultivated and widely used as supplements [13]. Chlorella and Spirulina's nutritional content is complete, including polysaccharides, phytosterols and unsaturated fatty acids, protein, and essential amino acids, various vitamins and minerals, phenolic components, and pigments [14]. These two microalgae species are widely marketed as capsule, tablet, liquid, and powder supplements [15]. Thus, adding the *Chlorella* and *Spirulina* may increase the nutritional value of the noodles product.

In general, the use of microalgae is still limited to health supplements and is rarely applied to food products. Microalgae have the potential to be used in the noodle fortification process because they have complete nutritional content and are easy to cultivate [16,17]. The study aimed to investigate the physicochemical and sensory characteristics of dry mocaf noodles substituted with *Chlorella* vulgaris and *Spirulina* platensis powder at 1% and 2%. Adding *Chlorella* and *Spirulina* powder to dry mocaf noodles is expected to increase the nutritional value of noodle products. The addition of dry biomass of microalgae also promotes the food diversification of Indonesia's local ingredients.

2 Methodology

2.1 Formulation and sample preparation

The formula of mocaf noodles was composed of wheat flour and mocaf flour with a composition ratio of 70:30. To make the *Chlorella*/*Spirulina* noodles, the pre-mix flour was added with *Chlorella* powder or *Spirulina* powder at the percentage of 0% (control), 1%, and 2% of the total weight of the ingredients. The composition of other ingredients, such as salt, sodium bicarbonate, sodium tripolyphosphate, and water, was the same (Table 1).

First, the dry ingredients were measured and then mixed. The dry ingredients mixture was stirred for 2 – 3 minutes (pre-mixing) and then added with water. The dough was stirred until smooth, then left to rest for 30 minutes. Later, the dough was put into a noodle maker to form sheets of dough until the thickness reached 1.5 – 2.2 mm. The dough sheets were then inserted into the slitter section to form the dough into strands of noodles. Next, the noodles were steamed for 15 minutes at 100ºC and cooled for 5 minutes. Finally, the cooled noodles were placed in a baking dish and then dried in the oven at 60ºC for 5 hours to produce dry mocaf noodles.

Table 1. The formulation of dry noodles with addition of *Chlorella* and *Spirulina* powder

Ingredients	Control	1% Chlorella	2% Chlorella	1% Spirulina	2% Spirulina
Wheat Flour	45.5	44.5	43.5	44.5	43.5
Mocaf Flour	19.5	19.5	19.5	19.5	19.5
Chlorella powder	0	1	2	0	0
Spirulina powder	0	0	0	1	1
$NaHCO_3$	0.1	0.1	0.1	0.1	0.1
STPP	0.4	0.4	0.4	0.4	0.4
Salt	1.5	1.5	1.5	1.5	1.5
Water	33	33	33	33	33

2.2 Color analysis

Color analysis was carried out using a Portable Colorimeter 3nh NH310. Before color measurement, the dried noodles were cooked for 3 minutes, rinsed with running water and drained. The colorimeter was calibrated and brought close to the container containing the noodles samples. The color measurement will produce L*, a*, and b* values. The measurements were carried out in three repetitions (triplo).

2.3 Proximate analysis

The proximate analysis was performed on cricket flour-enriched cookies using standardized methods established by the Indonesian National Standard (SNI) 01-2891-1992 as previously described by Tedjakusuma *et al.* [18]. The moisture content was measured by gravimetry following oven-drying at 105°C for 3 hours. The ash/mineral content was determined by gravimetry after calcination at 550°C for 4 hours. The fat content was analyzed using Soxhlet apparatus with hexane as the solvent at 55°C. The protein content was analyzed using Kjehldahl method. The carbohydrate content was analyzed by difference.

2.4 Total carotenoid analysis

The total carotenoid content was determined using AOAC 938.04 as previously described by Fadila & Widyaningrum [19]. A total of seven different concentrations of β-carotene standard solution of 0.05 mg/L, 0.75 mg/L, 1.50 mg/L, 2.25 mg/L, 3.00 mg/L, 3.75 mg/L, and 4.50 mg/L was used as the standard curve. The absorbance was measured at 436nm. Total carotenoids were determined using a standard calibration curve with the line equation y = bx + a using Equation (1).

$$Total\ carotenoid\ \left(\frac{mg}{kg}\right) = \frac{\frac{A-a}{b}\times V\times f_p}{sample\ weight\ (g)} \quad (1)$$

Notes:
A = Sample absorbance
a = Intercept of the standard calibration curve
b = Slope of the standard calibration curve
V = Final volume of sample solution (ml)
fp = Dilution factor

2.5 Organoleptic analysis

An organoleptic test was conducted on 30 untrained panelists aged 16 – 30 years, requiring the understanding of each panelist of test procedures. Each noodle sample has been assigned a three-digit random code. The samples were immediately cooked before the organoleptic test. Panelists were asked to rate all samples based on their level of liking for each sensory characteristic, which included color, aroma, texture, taste, aftertaste, and overall. The scale used in this test was (1) dislike very much, (2) dislike very much, (3) dislike, (4) somewhat dislike, (5) neutral, (6) somewhat like, (7) like, (8) like very much, and (9) like very much.

2.6 Statistical analysis

The data were statistically analyzed using IBM SPSS Statistics version 25 software with the One-Way ANOVA method, then continued with the Duncan Multiple Range Test (DMRT) if there were significant differences. The significance level used is $\alpha = 0.05$.

3 Results and discussion

3.1 Color analysis of *Chlorella* and *Spirulina* dry noodles

The noodles were boiled before color analysis using a colorimeter to measure the L*, a*, and b* values. The L* value is the brightness intensity, the a* value is the red (positive) / green (negative) color intensity, and the b* value is the yellow (positive) / blue (negative) color intensity. Table 2 showed that the increasing concentration of Chlorella and Spirulina powder led to a significant decrease in the L*, a*, and b* values, with a particularly notable reduction in the L* value. The decrease in a* and b* values for noodles added with *Chlorella* powder was significant compared to the control sample but insignificant between 1% and 2% concentrations. For the dry noodles added with *Spirulina* powder, the decrement values in a* and b* were significant in each formulation. Moreover, adding *Spirulina* powder in noodles was likely to cause a more significant color change in noodles substituted with *Spirulina* powder than those substituted with *Chlorella* powder.

The green and darker color of the noodles comes from the chlorophyll pigment contained in *Chlorella* and *Spirulina* [20]. Besides, the heating process can also activate the chlorophyllase enzyme, which degrades chlorophyll so that the color of the noodles becomes darker [21]. Ozyurt *et al.* [22] reported the color change in pasta products by adding 5-15% *Spirulina* concentration. The greener color resulted from the higher concentration of *Spirulina*. Adding *Chlorella sorokiana* biomass in the 2.5-7.5% concentration produced pasta products with higher chlorophyll content, affecting the final color [23].

Table 2. Color characteristic of dry noodles with addition of *Chlorella* and *Spirulina* powder.

Samples	L*	a*	b*
Control	75.62 ± 1.61^{d}	4.33 ± 0.56^{c}	16.05 ± 1.12^{c}
1% *Chlorella*	48.73 ± 1.68^{c}	-1.31 ± 0.18^{b}	7.8 ± 0.83^{b}
2% *Chlorella*	42.25 ± 0.35^{b}	-1.61 ± 0.06^{b}	7.4 ± 0.28^{b}
1% *Spirulina*	50.08 ± 0.47^{c}	-1.38 ± 0.10^{b}	6.44 ± 1.12^{b}
2% *Spirulina*	40.09 ± 1.08^{a}	-2.30 ± 0.17^{a}	3.88 ± 0.45^{a}

Different superscripts letters indicate a significant difference ($p\leq0.05$) based on the DMRT test

3.2 Proximate analysis of *Chlorella* and *Spirulina* dry noodles

The proximate analysis measured the water, ash, protein, fat, and carbohydrate content in noodles samples. Adding the *Chlorella* or *Spirulina* powder at the concentration of 1% and 2% changed the proximate composition of the products (Table 3). Regarding the water content parameters, there was a significant increase in water content in the noodles, along with the addition of the concentration of *Chlorella* and *Spirulina* powder. Noodles added with *Chlorella* powder have a higher water content than noodles added with *Spirulina* powder. A similar result was reported by Fradique *et al.* [24], in which a greater increase in water content resulted in noodles added with *Chlorella* compared to

Spirulina. *Chlorella* and *Spirulina* are hygroscopic microalgae, so the addition of *Chlorella* or *Spirulina* powder produced noodle dough with quite good water-binding abilities [25,26]. Adding high-protein raw materials such as *Chlorella* and *Spirulina* powder could increase the water content in the dry noodle products produced, so the water content also increases [20,27]. Efforts can be made by increasing the drying duration in the noodle-making process so that the water content in the product being made complies with the quality requirements in SNI 8217:2015.

Table 3. Proximate of dry noodles with addition of *Chlorella* and *Spirulina* powder.

Samples	Water (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
Control	13.54±0.15^{a}	2.74±0.01^{a}	7.72±0.11^{a}	0.30±0.01^{a}	75.68±0.26^{d}
1% *Chlorella*	16.14±0.18^{d}	2.90±0.07^{bc}	8.22±0.13^{b}	1.18±0.01^{d}	71.55 ± 0.13^{b}
2% *Chlorella*	18.90±0.18^{e}	2.90±0.09^{bc}	8.34±0.08^{b}	1.50±0.01^{e}	68.37 ± 0.35^{a}
1% *Spirulina*	14.18±0.18^{b}	2.80±0.02^{ab}	8.74±0.17^{c}	0.35±0.00^{b}	73.93±0.03^{c}
2% *Spirulina*	15.68±0.19^{c}	2.96±0.04^{c}	9.08±0.12^{d}	0.42±0.14^{c}	71.86±0.33^{b}

Different superscripts letters indicate a significant difference ($p \leq 0.05$) based on the DMRT test

Adding *Chlorella* and *Spirulina* powder into dry mocaf noodles caused a significant increase in ash content (Table 3). However, the ash content in dry mocaf noodles with 1% *Chlorella* and 2% *Chlorella* formulations was insignificant. In noodles substituted with *Spirulina* powder, an increment of ash content was associated with adding higher *Spirulina* powder in noodles. Similar results were reported by Fradique *et al.* [24], in which the ash content in noodles was increased positively correlates with the increment of substituted at the concentration of 0.5-2% *Chlorella* or *Spirulina* biomass. The ash content of *Spirulina* and *Chlorella* powder is higher than wheat flour. In dry weight, the ash content in *Chlorella* powder, *Spirulina* powder, and wheat flour is 9% [28] and 11% [29]. and around 0.55-0.7% [30]. Therefore, the higher ash content in *Spirulina* and *Chlorella* dry noodles was likely influenced by the high ash content from *Spirulina* and *Chlorella* powder.

The increment of protein levels in dry mocaf noodles positively correlated with higher addition of *Chlorella* and *Spirulina* concentrations. The protein levels in all noodle formulations added with *Chlorella* and *Spirulina* powder significantly differed from the control. The protein content of noodles with the 1% *Chlorella* formulation was not significantly different from the 2% *Chlorella* formulation. On the other hand, the protein content of noodles with the 1% *Spirulina* formulation was significantly different from the 2% *Spirulina* formulation. Similar results were reported in research by Fradique *et al.* [24], where adding *Spirulina* and *Chlorella* biomass caused a significant increase in protein levels. The study also reported that a small percentage of substitution of wheat flour with *Spirulina* and *Chlorella* powder (0.5-2%) did not cause a significant increase in protein levels between formulas. According to Kumoro *et al.* [31] and Salim [4], the protein content in wheat (9.9%) and mocaf (1.2%) is much lower than *Chlorella* powder (49.8%) and *Spirulina* (59.4%). Substitution of wheat with mocaf reduced protein levels in controls. Substitution of *Chlorella* and *Spirulina* powder improves the protein quality of dry mocaf noodles. The lower protein content in formulations that added *Chlorella* compared to *Spirulina* was caused by the *Chlorella* protein content being lower compared to the *Spirulina* protein content [32].

Fat content was increased alongside *Chlorella* and *Spirulina* powder concentration increment in noodles. Besides, the higher fat content resulted from the addition of *Chlorella* powder in noodles compared to that from the addition of *Spirulina* powder (Table 3). The fat content of *Chlorella* biomass is 18.2% of dry weight, while the fat content of *Spirulina* sp. is 7.1% of dry weight. Therefore, the addition of *Chlorella* resulted in a higher increment of fat content compared to the addition of *Spirulina* powder in dry noodles. A similar result was reported by Kumoro *et al.* [31], which noodles containing *Chlorella* biomass had a higher fat content than noodles containing *Spirulina* biomass.

Adding *Chlorella* and *Spirulina* dry biomass into noodles caused the decrement of carbohydrate content. The decrease in carbohydrate levels was negatively correlated with adding the *Chlorella* and *Spirulina* concentration (Table 3). Higher addition of microalgae biomass resulted in lower carbohydrate content in noodles. Besides, the carbohydrate content in the noodle formulation added with *Chlorella* was lower than in the formulation added with *Spirulina*. A similar result was reported by Kumoro *et al.* [31], in which noodles added with *Chlorella* powder have lower carbohydrate content than noodles added with *Spirulina* powder.

3.3 Carotenoid content in dry mocaf noodles added with *Chlorella* and *Spirulina*

The total carotenoid content in dry noodles with *Chlorella* and *Spirulina* was significantly higher than control. The total carotenoid content of control, 2% *Chlorella* noodles, and 2% *Spirulina* noodles were 0.36±0.01 mg/kg, 12.78 ± 0.02 mg/kg, and 5.18±0.00 mg/kg (Table 4). Besides, the increment of total carotenoid content along with the higher addition of *Chlorella* and *Spirulina* in noodles. Agustini *et al.* [33] also reported that adding *Spirulina* into noodles resulted in higher total carotenoid content. However, there was no report about the effect of *Chlorella* addition on total carotenoid content in noodles. Crude extract of *Chlorella* contains 1.52 mg/g carotenoid, which is higher than the total carotenoid in *Spirulina* crude extract that reached 0.14 mg/g.

Table 4. Total carotenoid of dry noodles with addition of *Chlorella* and *Spirulina* powder

Samples	Total Carotenoid Content (mg/kg)
Control	0.36 ± 0.01^{a}
1% *Chlorella*	5.73 ± 0.00^{d}

2% *Chlorella*	12.78 ± 0.02^e^
1% *Spirulina*	4.81±0.07^b^
2% *Spirulina*	5.18±0.00^c^

Different superscripts letters indicate a significant difference ($p \leq 0.05$) based on the DMRT test

3.4 Organoleptic test result of dry mocaf noodles added with *Chlorella* and *Spirulina* powder

Overall, there was no significant difference in acceptance levels for all formulations except in the attributes of color and aroma. Noodles with the formulation of 1% *Chlorella* addition had the highest acceptance. Besides, the lowest acceptance resulted from noodles with a 2% addition of *Spirulina* (Table 5). A similar result was found in a study by Park & Cho [34], in which 1% *Chlorella* addition provided a better acceptance rate than 2% addition, even exceeding the control sample. The study of Hussein *et al.* [35] suggested that increasing the concentration of *Spirulina* addition resulted in a decrease in the acceptance rate of noodles.

The decrement of acceptance at a greater concentration of *Spirulina* addition was likely due to the color of the final product becoming darker (indicated by the L^* value) so that they become less attractive. In addition, increasing the concentration of *Spirulina* addition was likely to cause the aroma of *Spirulina* to become quite dominant, namely resembling seaweed (a bit fishy) or resembling green vegetables [36,37] and bitter aftertaste [38].

Tabel 5. Acceptance score in dry mocaf noodles added with *Chlorella* and *Spirulina*

Samples	Sensory Attribute					
	Color	Aroma	Texture	Taste	Aftertaste	Overall
Control	7.27±1.60^b	6.87±1.25^b	6.93±1.48^a	6.93±1.26^a	6.63±1.89^a	7.13±1.01^a
1% *Chlorella*	7.00±1.36^b	6.23±2.08^{ab}	7.13±1.20^a	6.97±1.22^a	6.70±1.42^a	7.17±1.23^a
2% *Chlorella*	6.67±1.42^{ab}	6.57±1.38^{ab}	6.97±1.24^a	6.47±1.28^a	6.27±1.60^a	6.50±1.31^a
1% *Spirulina*	6.73±1.76^b	6.67±1.73^b	6.80±1.30^a	6.93±1.51^a	6.67±1.82^a	6.83±1.56^a
2% *Spirulina*	5.87±1.81^a	5.70±1.91^a	6.77±1.43^a	6.33±1.95^a	6.07±2.08^a	6.40±1.81^a

Different superscripts letters indicate a significant difference ($p \leq 0.05$) based on the DMRT test

4 Conclusion

Adding *Chlorella* and *Spirulina* dry biomass at 1% and 2% concentrations in dry mocaf noodles changed the color and nutritional value of the product. However, it did not negatively affect the overall sensory acceptance of the product. The results suggested that noodles added with *Chlorella* and *Spirulina* powder had higher green intensity and darker color. Besides, adding *Chlorella* and *Spirulina* increased the water, ash, protein, fat, and carotenoid content. Incorporating the *Chlorella* and *Spirulina* dry biomass into noodles products could be a solution for diversifying the microalgae-based food and potentially increasing the nutritional value of noodles.

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References

1. S. Koswara, *Teknologi Pengolahan* (Pustaka Sinar Harapan, Jakarta, 2009)
2. World Instant Noodles Association (WINA) (2021) Noodle as a planet https://instantnoodles.org/en/ [accessed October 26, 2023]
3. United States Department of Agriculture (USDA) (2018) *Indonesia grain and feed annual report* GAIN Report ID1808
4. A. Salim, *Mengolah Tepung Singkong Menjadi Tepung Mocaf* (Lily Publisher, Yogyakarta, 2011)
5. H. F. Lala, B. Susilo, N. Komar, N. *J. Bioproses Komoditas Tropis,* **1**, 11-20 (2013)
6. L. Ramu, M. Srinivas *Int. J. Innov. Tech. Res.* **4** 5318-5322 (2016)
7. S. Susanti, B. Dwiloka, V. P. Bintoro, A. Hintono, N. Nurwantoro, B. E. Setiani *Food Res.* **5,** 266-273 (2021).
8. L. Hudi, I. A. Saidi, R. Azara, T. R. Pratiwi *IOP Conf. Ser.: Earth Environ. Sci.* **819**, 012053 (2021)
9. R. Budiono *IOP Conf. Ser.: Earth Environ. Sci.* **969**, 012035 (2022)
10. M. H. Abd-El-Khalek, M. Sheir, S. Elmesilhy *Egypt. J. Food Sci.* **47,** 65-78 (2019)
11. M. Guo *Functional Foods: Principles and Technology* (CRC Press, New York, 2013)
12. F. Sandgruber, A. L. Höger, J. Kunze, B. Schenz, C. Griehl, M. Kiehntopf, ... C. Dawczynski *Nutr.* **15** 1645 (2023)
13. A. K. Koyande, K. W. Chew, K. Rambabu, Y. Tao, D. T. Chu, P. L. Show *Food Sci. Hum. Wellness* **8** 16-24 (2019)
14. L. M. Andrade, C. J. Andrade, M. Dias, C. A. O. Nascimento, M. A. Mendes *MOJ Food Proc. Tech.* **6** 45–58 (2018)
15. A. Hallmann *Transgenic Plant J.* **1** 81-98 (2007)
16. Y. K. Lee, W. Chen, H. Shen, D. Han, Y. Li, H. D. T. Jones, J. A. Timlin, Q. Hu *Basic Culturing and Analytical Measurement Techniques. In: Handbook of Microalgal Culture: Applied Phycology and Biotechnology* (John Wiley & Sons, Oxford, 2013)
17. H. Hadiyanto, M. A. Nur *Mikroalga: Sumber Pangan & Energi Masa Depan* (UNDIP Press, Semarang, 2012)
18. F. Tedjakusuma, J. Linggadiputra, A. D. Cahya, R. Surya *IOP Conf. Ser.: Earth Environ. Sci.* **1115**, 012092 (2022)
19. A. N. Fadila, D. Widyaningrum *E3S Web Conf.* **426**, 01019 (2023)
20. M. E. Gershwin, A. Belay *Spirulina in Human Nutrition and Health* (CRC Press, Boca Raton, 2008)
21. T. Estiasih, Harijono, Waziiroh, K. Fibrianto *Kimia dan Fisik Pangan* (Bumi Aksara, Jakarta, 2016)
22. G. Ozyurt, L. Uslu, I. Yuvka, S. Gokdogan, G. Atci, B. Ak, O. Isik *J. Food Qual* **38,** 268–272 (2015)

23. J. Bazarnova, L. Nilova, E. Trukhina, M. Bernavskaya, Y. Smyatskaya, T. Aktar *Foods* **10,** 3018 (2021)
24. M. Fradique, A. P. Batista, M. C. Nunes, L. Gouveia, N. M. Bandarra, A. Raymundo *J. Sci. Food Agric.* **90**, 1656-1664 (2010)
25. Insansetyo & Kurniastuty *Teknik Kultur Fitoplankton dan Zooplankton Pakan Alami Untuk Pembenihan Organisme Laut* (Penerbit Kanisius, Yogyakarta, 1995)
26. M. T. S. Utomo, A. S. Prabakusuma *J. Sains MIPA* **15,** 167-176 (2009)
27. S. Koswara *Teknologi Pengolahan Kedelai* (Pustaka Sinar Harapan, Jakarta, 1995)
28. S. M. Shalaby, N. M. Yasin *World J. Dairy Food Sci.* **8**, 58-66 (2013)
29. M. A. B. Habib, M. Parvin, T. C. H. Huntington, M. R. Hasan *Food and Agriculture Organization of The United Nations* (2008)
30. E. Hallén, S. İbanoğlu, P. Ainsworth *J. Food Eng.* **63,** 177-184 (2004)
31. A. C. Kumoro, D. Johnny, D. Alfilovita *Int. Food Res. J.* **23,** 715-722 (2016)
32. M. Ravi, S. L. De, S. Azharuddin, S. F. D. Paul *Nut. Diet. Suppl.* **2,** 73-83 (2010).
33. T. W. Agustini, W. F. Ma'ruf, Widayat, B. A. Wibowo, Hadiyanto *IOP Conf. Ser.: Earth Environ. Sci.* **55**, 1-9 (2017).
34. S. I. Park, E. J. Cho *Korean J. Food Nut.* **17,** 120-127 (2004).
35. A. Hussein, G. Ibrahim, M. Kamil, M. El-Shamarka, S. Mostafa, D. Mohamed *Biointerface Res. Appl. Chem.* **11,** 14736 – 14750 (2021).
36. N. Ekantari, Y. Marsono, Y. Pranoto, E. Harmayani *AGRITECH* **37,** 173-182 (2017)
37. C. Lafarge, N. Cayot *Food Sci. Nut.* **7**, 918–929 (2019)
38. L. Sa'adah, F. Ghanaim, K. M. Elok *J. Kimia* **4,** 193-200 (2010)