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The nutritional quality and preference of wheat noodles incorporated with *Caulerpa* sp. seaweed

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Abstract

Noodles are generally made from wheat flour, so their nutritional contents and characteristics depend on flour and other ingredients used. In the present work, fresh noodles were fortified with *Caulerpa* sp. filtrate in proportions of 0, 5, 10, 15, and 20%, and the quality and characteristics of fresh noodles obtained were determined. The assessments were conducted on the proximate compositions, dietary fibre, β-carotene, total phenolic content, textural properties, physical properties, and sensory qualities of noodles. The addition of *Caulerpa* sp. filtrate increased the ash contents of noodles, and the ash contents of noodles were 1.45 ± 0.03 to 1.52 ± 0.04%. The β-carotene contents of noodles increased from 1.92 ± 0.19 to 3.68 ± 0.40 mg/kg with the addition of 15% *Caulerpa* sp. filtrate. Furthermore, total phenolic compounds were increased to a maximum of 85.2 ±1.82 mg GAE/100 g with the addition of *Caulerpa* sp. filtrate. The tensile strengths of noodles increased as *Caulerpa* sp. filtrate increased, while the elongations of noodles slightly decreased with the addition of *Caulerpa* sp. filtrate. The brightness of noodles decreased, and the greenness increased with the addition of *Caulerpa* sp. filtrate. Noodles with 15 and 20% *Caulerpa* sp. filtrate had significantly higher cooking yields than noodles without *Caulerpa* sp. filtrate. Consumer acceptance of noodles was not affected by *Caulerpa* sp. filtrate. *Caulerpa* sp. noodles could be a nutritional benefit for daily diets since they contain more β-carotene, minerals, and phenolic compounds.

Introduction

Noodles are long thin pieces of dough made from a mixture of eggs, flour, and water, and are typically cooked in soup or boiling water (Taneya *et al.,* 2014). Noodles came to China prior to 5000 BC, then spread to other Asian countries, such as Japan, Thailand, Korea, and Indonesia (Lee *et al.,* 2002). Noodles are consumed as one of the basic foodstuffs in many Asian countries (Sikander *et al.,* 2017) and preferred by people of all ages because they are relatively inexpensive and easy to serve. Noodles are also widely consumed in Indonesia, which is not the primary producer of wheat flour. Despite being a staple food in Indonesia, noodles have low or insufficient nutritional components, such as carotene and minerals.

Vitamin A and mineral deficiencies are a concern in Indonesia. The prevalence of vitamin A, calcium, iron, and zinc deficiencies was predicted to be 44.8, 54.2, 32.4, and 35.5%, respectively (Prasetyo, 2018). Furthermore, vitamin A, iron, and zinc deficiencies are the most common occurrences in adult women. WHO (2009) stated that in Indonesia, the prevalence of vitamin A deficiency in pregnant women was estimated at 17.1% of the population, and that in preschool children it was 19.6% of the population. The prevalence of these deficiencies was included in the moderate public health problems category. The National Institute of Health Research and Development, Ministry of Health of Indonesia (Balitbangkes), reported that the prevalence of anaemia, which was mostly caused by iron deficiency in the adult population of Indonesia, was 18.4 - 20.1% in 2013 (Balitbangkes, 2013).

Seaweeds are valuable marine plants that have been used as major food ingredients (Ali *et al.,* 2010; Fleurence *et al.,* 2012; Agusman *et al.,* 2014). Most Europeans and Americans use processed seaweeds as additives in their food preparation (Ismail and Hong, 2002). Seaweeds have been used for centuries in the preparation of salads, soups, and low-calorie foods in Asia (Jiménez-Escrig and Sánchez-Muniz, 2000). Macroalgae are not included in the food balance sheets compiled by the FAO for fish and fishery products due to the lack of data; however, in 2012, it was estimated that approximately 9 million tons of cultivated macroalgae were intended for direct human consumption, mostly in East Asia and in forms recognised by consumers (FAO, 2014).

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Caulerpa spp. including *C. lentillifera* and *C. racemosa* var. *turbinata* are particularly popular in the Indo-Pacific regions (Nagappan and Vairappan, 2014). Some species of this genus are mainly used as food in the form of fresh vegetables owing to their palatable taste, nutritional properties, and consumers' general health awareness of the advantages of using natural products. As a result, their popularity have risen in recent years. Based on preliminary market surveys, the total annual cultivation of *Caulerpa* sp. harvested in Fiji, Samoa, and Tonga Islands was 123 t of wet material (Morris *et al.,* 2014). In Indonesia, these green algae are naturally abundant, but are underutilised, and their annual production is underreported. In some areas, such as Jepara, Bali, Takalar, and Aceh, seaweeds have been consumed as vegetables (Fithriani, 2015).

Caulerpa spp. reportedly contain vitamins, minerals and phenolic compounds, and fibre. *Caulerpa* spp. contain nutrients that are useful for the body. *C. racemosa* has 50.2% carbohydrates, 17.3% protein, 2.1% fat, and 26.7 - 33.7% ash (dry basis) (Nagappan and Vairappan, 2014). *Caulerpa* contains 170 - 216 μg/100 g of vitamin A, and 3.20 - 8.15 mg/100 g of β-carotene (Gaillande *et al.,* 2017). Santoso *et al.* (2006) reported that *Caulerpa* contained 3.8 ± 0.3, 18.5 ± 5.3, 3.2 ± 0.2, 25.7 ± 1.2, 0.010 ± 0.0002, 0.813 ± 0.237, and 0.008 ± 0.003 mg/g of Mg, Ca, K, Na, Zn, Fe, and Cu, respectively. The total phenolic content of *Caulerpa* spp. varied. Nurjanah *et al.* (2019) reported that fresh *Caulerpa* sp. contained 2,856 ± 197 mg GAE/100 g phenolic compounds. Rusli *et al.* (2016) found that fresh *Caulerpa* contained 69,349 ± 596 mg GAE/100 g phenolic compounds. Therefore, adding seaweeds in the noodle-making process is expected to produce noodles that are high in minerals, β-carotene contents, and phenolic compounds.

The present work thus aims to diversify the usage of seaweed by incorporating it into the fresh noodle-making process. *Caulerpa* sp. filtrate was added in the fresh noodle-making process, and the effect of the filtrate on the noodles produced was observed based on nutrition, quality, and other characteristics.

Materials and methods

Caulerpa sp. filtrate preparation

Caulerpa sp. seaweeds were harvested at Binuangen Beach, Banten Province, Indonesia, in May 2018. The collected fronds were thoroughly washed with filtered seawater to remove epiphytes, debris, and attached coral. The cleaned seaweeds were rinsed with filtered seawater, packed in plastic, and then transported in cold conditions (0 - 5°C) to the Laboratories of Research Centre for Marine Fisheries Product Processing and Biotechnology, in Jakarta. The *Caulerpa* sp. seaweeds were kept at -20 ± 2°C, thawed for ± 1 h, and rinsed with fresh water before use. A total of 250 g of seaweed was subjected to a juicer (Miyako, China) to obtain the filtrate (green aqueous) and the residue of *Caulerpa* sp. (containing mostly fibre); the juicer automatically separates filtrates and solids into different containers. The filtrate was immediately used as a noodle ingredient.

Noodle preparation

Noodles were manufactured using a cold extrusion approach equipped with an automatic noodle maker HR2332 (Phillips, China). A completely randomised design was applied in the present work, where the proportion of *Caulerpa* sp. filtrate increased with treatment (0, 5, 10, 15, and 20%). The noodle formula used was based on 300 g of total composition. Briefly, 3 g of salt and 1.5 g of carrageenan were added to 195 g of wheat flour. The powder was ground and transferred to an automatic noodle maker, and 15 g of yellow egg, water, and *Caulerpa* sp. filtrate were added (the amount of water added was adjusted based on the proportion of *Caulerpa* sp. filtrate). After the machine was switched on, the kneading process of the dough was run for 5 to 7 min. After that, the machine began to extrude the dough through the mould automatically. The noodle was then placed on a tray and steamed for 5 min. Finally, the noodle was kept in the cold (0 - 5°C) for analysis.

Proximate composition, total dietary fibre, and β-carotene analysis

The proximate analysis (moisture, ash, protein, fat), total dietary fibre, and β-carotene of noodles were measured following a method by AOAC (1999). The carbohydrate contents were calculated by subtracting the sum of protein, fat, moisture, and ash from 100%.

Phenolic content analysis

The phenolic contents of noodles and fresh seaweeds were measured. Five grams of noodles or fresh seaweed was chopped and transferred to a 15 mL tube containing 10 mL of methanol. Then, the mixture was mixed with a vortex for 5 min, and macerated for 30 min at room temperature. The filtrate was obtained by centrifugation at 5,000 rpm for 5 min at 5°C. The filtrates were tested for their phenolic contents. The total phenolic content was determined using the Folin-Ciocalteu method (Kaur and Kapoor, 2002). Briefly, 200 μL of filtrate (1 mg/mL) was brought up to 3 mL with distilled water, mixed thoroughly with 0.5 mL of Folin-Ciocalteu reagent for 3 min, and followed by the addition of 2 mL of 20% (w/v) sodium carbonate. The mixtures were incubated for an additional 60 min in the dark, and absorbance was measured at 650 nm (Multiskan Go, Finland). The total phenolic contents were calculated from the calibration curve, and the results were expressed as mg of gallic acid equivalent (GAE) per 100 g weight.

Physical analysis

Water activity (a_w) of noodles was measured using the Novasina thermoconstanter device (Novasina, Switzerland) following the tool usage protocol. Prior to measurement, the tools were calibrated with SALT-90 salts (Li *et al.,* 2011).

Colour measurements were executed at 25 ± 1°C using a Hunterlab ColorFlex (Hunterlab-Reston, USA). This spectrophotometer uses an illuminate of D65 and a 10° angle observer as a reference. The instrument was standardised each time with a black and white ceramic plate. Samples were filled in glass vials, and Hunter values a* (redness), b* (yellowness), and L* (lightness) were measured in triplicate (Timmermans *et al.,* 2011).

Cooking yields (%) of noodles were calculated based on the increased weight of the noodles after boiling. Briefly, 20 g of noodles were boiled for 5 min and rinsed for 1 min before weighing (Chang and Wu, 2008).

Texture analysis

Twenty grams of noodles were cooked and then flushed with cold water. The measurement of the texture profile analysis (TPA) of noodles was done using the texture analyser TAXT (Stable Micro Systems, UK) equipped with load cells of 5 kg and a probe cylinder of 35 mm. The TPA of noodles was measured 5 min after the noodles were cooked. Three strands of noodles were arranged in parallel on a flat surface and then pressured twice at a compression of 70% and a test speed of 1.0 mm/s. From the curve, the landfill, level of hardness (high topped), and adhesiveness (negative area of the first and second curves) were obtained. From force-time curves of the TPA, the hardness (height of the peak) and adhesiveness (negative area between the first and second peaks) were determined. Springiness was indicated by the ratio between the recovered height after the first compression and the height of the first compression. Cohesiveness was indicated by the ratio between the area under the second peak and the area under the first peak (Park *et al.,* 2003)

The tensile strength and elasticity of noodles were measured using TAXT (Stable Micro Systems, UK) equipped with load cells of 5 kg and probe Spaghetti tensile grips (A/SPR). Before running the test, the ring arm of the probe was calibrated at a distance of 15 mm. Twenty grams of noodles were cooked and then flushed with cold water. The samples were fixed on the probe. The pre-test speed, test speed, post-test speed, distance, and trigger were set to 1.0 mm/s, 3.0 mm/s, 10.0 mm/s, 100 mm, and 3 g, respectively. Fifteen strands of noodles were tested for each sample for replication. The tensile strength was the maximum force value needed to break the noodle. The measurement of distance at the break would give an indication of sample elasticity.

Sensory analysis

The sensory evaluation for the samples was carried out using a 7-point hedonic test. Briefly, 50 panellists (28 females and 22 males), which consisted of students and lab assistants from the Food Technology Department of Bogor Agricultural University, were selected. The panellists were aged from 23 - 30 years old. Noodles were served after cooking in hot water for 1 min. The evaluation was made on overall acceptance of the cooked noodle strands. The panellists were instructed to mark the perceived intensity of overall acceptance with a number from 1 to 7. A seven-point scale was described for the sensory evaluation (hedonic test): 1, strongly dislike; 2, dislike; 3, slightly dislike; 4, neither like nor dislike; 5, like slightly; 6, like; and 7, strongly like (Charutigon *et al.,* 2008). The scores were tabulated, representing the verdict of the individual panellists. Finally, the mean value was taken for each characteristic of the samples, representing the panellists' judgement on the sensory quality of the noodles.

Statistical analysis

Differences in *Caulerpa* sp. filtrate on noodle quality and characteristics were analysed by one-way analysis of variance (ANOVA) followed by Tukey's *post hoc* test. Sensory data were analysed by the Kruskal-Wallis test. The significance level was defined as $p < 0.05$. Statistical analyses were performed using IBM SPSS Statistics V21 (IBM, USA). Data were expressed as means ± standard deviations.

Results and discussion

Proximate composition, dietary fibre, β-carotene, and phenolic contents of Caulerpa noodles

Table 1 shows the proximate compositions, dietary fibre, β-carotene, and phenolic contents of *Caulerpa* noodles. The incorporation of *Caulerpa* sp. filtrate did not significantly affect ($p > 0.5$) the moisture, protein, fat, and carbohydrate contents of noodles. The *Caulerpa* sp. filtrate significantly affected ($p = 0.030$) the ash content of noodles, where the increase in the proportion of *Caulerpa* sp. filtrate increased the ash content of noodles. The control sample yielded the lowest value of ash at 1.35 ± 0.03%, and the incorporation of 20% *Caulerpa* sp. filtrate yielded the highest value of ash at 1.52 ± 0.04%. The increase in the ash content of the noodles containing *Caulerpa* sp. filtrate ranged from 0.06 to 0.17% of the control. Ash content indicates the mineral content of the product. The amount of minerals in noodles with *Caulerpa* sp. filtrate were calculated from the ratio of each mineral related to the ash content of seaweed from the aforementioned literature, which is approximately 5% of seaweed minerals. From the calculation, we estimated that noodles with *Caulerpa* sp. filtrate had 10.75 - 30.47 mg/g Mg, 52.36 - 148.35 mg/g Ca, 9.06 - 25.66 mg/g K, 72.74 - 206.08 mg/g Na, 0.0283 - 0.0802 mg/g Zn, 2.3009 - 6.5193 mg/g Fe, and 22.6 - 64.2 mcg/g Cu. Based on the data released by Harvard Health (2018), the recommended amount of mineral consumption for adults is 320 - 420 mg/day, 1,000 – 1,200 mg/day, 4.7 g/day, 2,300 mg/day, 8 - 11 mg/day, 8 mg/day, and 900 mcg/day for Mg, Ca, K, Na, Zn, Fe, and Cu, respectively. Based on that standards, it could be concluded that the noodles with *Caulerpa* sp. filtrate could be a good source of Mg, K, and Fe. Seaweed has been suggested to fortify the mineral content of noodles (Keyimu, 2013). The intake of composite noodles with sea lettuce might contribute to the ash requirement (Apaydin *et al.,* 2010).

The *Caulerpa* sp. filtrate did not significantly affect (p = 0.554) the dietary fibre content of noodles. The β-carotene content of noodles significantly (p = 0.007) increased with the addition of ≥ 10% *Caulerpa* sp. filtrate. It is therefore suggested to add *Caulerpa* sp. filtrate equal to or greater than 10% to enrich the β-carotene content of the noodles. The highest β-carotene content of *Caulerpa* noodles was 3.68 mg/kg. Studies on the fortification of noodles with vitamin A have been carried out, such as the addition of pumpkin flour to instant noodles, resulting in a β-carotene content of 55.2 mg/kg (Lee *et al.,* 2002). The addition of carrot puree to instant noodles resulted in a β-carotene content of 15.8 mg/kg (Prerana and Anupama, 2020). Although the β-carotene content in *Caulerpa* noodles was lower than that in previous studies, *Caulerpa* noodles can be recommended as an alternative source of β-carotene. The recommended amount of β-carotene per day is 900 mcg (Harvard Health, 2018). *Caulerpa* sp. has been suggested as an alternative source of β-carotene and vitamin A (Gaillande *et al.,* 2017).

Caulerpa is reportedly an alternative source of phenolic compounds, and the antioxidant activity of *Caulerpa* sp. was determined by its phenolic content (Khairy and El-Sheikh, 2015). In the present work, the results showed that there was a significant increase (p = 0.000) in the phenolic content of noodles with *Caulerpa* sp. filtrate as compared to the control; and the highest phenolic content of noodles was 85.41 ± 5.2 mg GAE/100 g. Phenolics are primary antioxidant compounds found in seaweed (Ismail and Hong, 2002; Luo *et al.,* 2010) and are commonly found in terrestrial plants (Giada, 2013). Efforts to increase the content of phenolics in noodles and pasta products have also been carried out by adding grape marc (300 - 400 mg GAE/100 g) (Marinelli *et al.,* 2015), date kernel (160 ± 0.12 mg GAE/100 g) (Abdel-Moemin, 2016), powdered tea (171 - 334 mg GAE/100 g) (Yu *et al.,* 2020), and banana flour (90.4 ± 2.20 GAE/100 g). Qingke barley noodles have 36.30 - 71.80 mg GAE/100 g total phenolic compounds (Tuersuntuoheti *et al.,* 2020). Our results indicated that noodles with *Caulerpa* sp. filtrate are an alternative source of phenolic compounds.

The total phenolic contents of *Caulerpa* sp. varied. Nurjanah *et al.* (2019) reported that the total phenolic contents of fresh *Caulerpa* sp. was 2,856 ± 197 mg GAE/100 g, and Rusli *et al.* (2016) found that fresh *Caulerpa* sp. contained 69,349 ± 596 mg GAE/100 g. The phenolic content of *Caulerpa* sp. seaweed used in the present work was 111.35 ± 5.09 mg GAE/g (data not shown in the results), which was much lower than the phenolic contents of *Caulerpa* sp. reported in the literature. In the present work, *Caulerpa* seaweed was kept in a freezer and thawed before use. We also found that *Caulerpa* noodles yielded lower phenolic content than *Caulerpa* seaweed. Nguyen *et al.* (2011) reported that the phenolic content of *Caulerpa* sp. was subjected to changes in thermal exposure and drying processes.

Table 1. Proximate composition, dietary fibre, β-carotene, and phenolic contents of *Caulerpa* noodles.

Samples	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Dietary fibre (%)	β-carotene (mg/kg)	Phenolic (mg GAE/100 g)
Control	38.52 ± 0.36^{a}	1.35 ± 0.03^{a}	9.10 ± 0.40^{a}	2.83 ± 0.21^{a}	48.20 ± 0.62^{a}	3.20 ± 0.44^{a}	< 0.02^{a}	63.24 ± 3.76^{b}
5% filtrate	38.12 ± 0.41^{a}	1.41 ± 0.01^{ab}	9.31 ± 0.66^{a}	2.52 ± 0.17^{a}	48.67 ± 0.68^{a}	2.75 ± 0.18^{a}	< 0.02^{a}	79.31 ± 6.4^{c}
10% filtrate	37.83 ± 0.42^{a}	1.49 ± 0.04^{bc}	9.32 ± 0.77^{a}	2.43 ± 0.19^{a}	48.95 ± 1.19^{a}	3.04 ± 0.06^{a}	2.99 ± 1.40^{b}	85.41 ± 5.2^{c}
15% filtrate	38.15 ± 0.19^{a}	1.46 ± 0.03^{bc}	9.21 ± 0.40^{a}	2.59 ± 0.09^{a}	48.62 ± 0.38^{a}	2.79 ± 0.06^{a}	3.68 ± 0.49^{b}	85.29 ± 1.82^{c}
20% filtrate	37.62 ± 0.23^{a}	1.52 ± 0.04^{c}	9.39 ± 0.57^{a}	2.93 ± 0.30^{a}	48.55 ±0.46^{a}	3.12 ±0.52^{a}	1.92 ± 0.19^{b}	79.31 ± 2.99^{c}

Data are means ± standard deviations of triplicates (n = 3). Means in the same column with different superscript are significantly different (p < 0.05).

The cooking process also affected the phenolic content in food, and noodles enriched with tea powder lost 1.5 times more of their phenolic compounds than uncooked noodles after boiling with water (Yu *et al.,* 2020). We suspected that optimal results could be obtained if the filtrate used comes from fresh *Caulerpa* seaweed instead of frozen seaweed.

Colour, water activity (a_w), and cooking yield characteristics of Caulerpa noodles

Colour is the first assessment that determines consumer acceptance of products in the market. Table 2 shows the characteristics of noodle colour at different proportions of *Caulerpa* sp. filtrate. The results show apparent differences in chroma values among the different noodle samples. The lightness (L*) of noodles significantly ($p = 0.000$) decreased with increasing *Caulerpa* sp. filtrate addition, ranging from 47.10 ± 0.60 - 55.91 ± 2.07, as compared to the control (65.50 ± 0.32). Moreover, there was significantly ($p = 0.000$) higher greenness (a*) with the increasing amounts of *Caulerpa* sp. filtrate. The green colour of noodles came from the *Caulerpa* sp. filtrate, which was dark green in colour. There was a significant ($p = 0.003$) difference in the yellowness (b*) of noodles. Noodles incorporated with 5% *Caulerpa* sp. filtrate showed higher yellowness than noodles incorporated with 15 and 20% *Caulerpa* sp. filtrate. The colour change of noodles was expected due to the green colour of the *Caulerpa* sp. filtrate. The addition of carrot puree in the process of making noodles affected the colour of the noodles produced, resulting in noodles that tended to be reddish-orange in colour (Prerana and Anupama, 2020). The appearance of *Caulerpa* sp. noodles is shown in Figure 1.

Moisture is known to play a key role in product quality and stability, including in fresh noodles (Li *et al.,* 2011). Food scientists realised that water activity is far more critical than moisture contents of food products because the value of water activity is the determining factor for microbial growth and is also closely related to most enzymatic and chemical reactions and physical nature (Maltini *et al.,* 2003).

Table 2. Colour, water activity, and cooking yield of *Caulerpa* noodles.

Samples	L*	a*	b*	a_w	Cooking yield (%)
Control	65.50 ± 0.32[a]	4.41 ± 0.1[a]	31.98 ± 0.8[ab]	0.975 ± 0.001[a]	3.22 ± 1.05[a]
5% filtrate	55.91 ± 2.07[b]	0.46 ± 0.16[b]	32.93 ± 0.36[a]	0.975 ± 0.002[a]	3.53 ± 1.22[a]
10% filtrate	50.38 ± 0.89[c]	-0.46 ± 0.17[c]	32.55 ± 0.61[ab]	0.974 ± 0.003[a]	3.60 ± 0.57[a]
15% filtrate	44.74 ± 0.35[d]	-1.27 ± 0.23[d]	31.57 ± 0.45[b]	0.978 ± 0.001[a]	5.14 ± 0.66[b]
20% filtrate	47.10 ± 0.60[e]	-1.04 ± 0.13[d]	31.81 ± 0.70[b]	0.973 ± 0.001[a]	6.42 ± 0.26[c]

Data are means ± standard deviations of triplicates ($n = 3$). Means in the same column with different superscript are significantly different ($p < 0.05$). L* = lightness (0 = black, 100 = white); a* = redness/greenness (+ = red, - = green); and b* = yellowness/blueness (+ = yellow, - = blue).

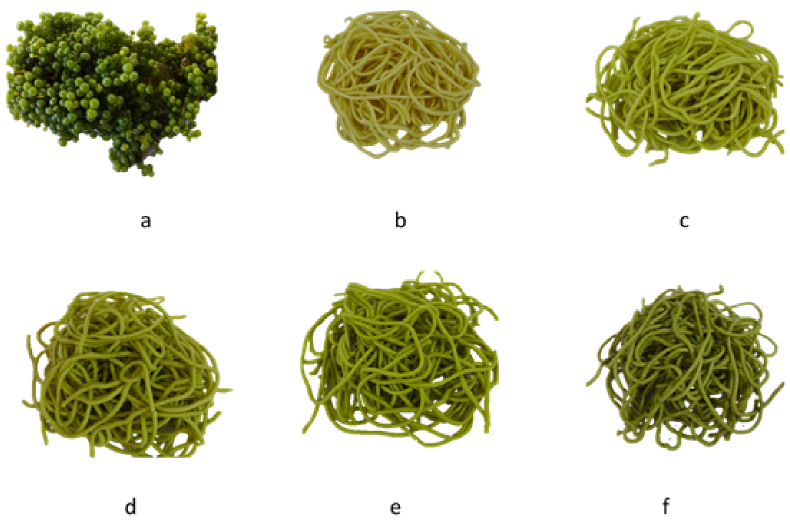

Figure 1. The appearance of *Caulerpa* seaweed and *Caulerpa* noodle: (a) *Caulerpa* sp., (b) control (without *Caulerpa* filtrate), noodle with *Caulerpa* sp. filtrate of (c) 5%, (d) 10%, (e) 15%, and (f) 20%.

The addition of *Caulerpa* sp. filtrate did not significantly (p = 0.152) affect the water activity of noodles (Table 2). The water activity of a product is influenced by humectants such as glycerol, sucrose, maltose (Badola *et al.,* 2017) and salt (Lupin *et al.,* 1981). The filtrate from *Caulerpa* is thought to contain a limited amount of salt; thus, is not able to suppress the a_w value of the noodles. Fresh *Caulerpa* sp. seaweed contains 4% (wet basis) salt, but in the thawing process of seaweed after frozen storage, some of the water is melted and carries a liquid cell containing salt (Sihono *et al.,* 2018). The filtrate has a low salt content due to the thawing of frozen seaweed and rinsing of the seaweed during preparation of the filtrate.

The cooking yield of noodles is shown in Table 2. The results of this study show that the addition of filtrate significantly affected (p = 0.035) the cooking yield of noodles, where the addition of > 15% *Caulerpa* sp. filtrate significantly increased the cooking yield of noodles as compared to the control. These results are in line with the results of research conducted by Chang and Wu (2008), where the addition of seaweed increased the yield after cooking because the existing hydrocolloid and fibre compounds from seaweed are thought to bind more water, thus affecting the yield of noodles. Incorporating oat hydrocolloids in noodles significantly increased the cooking yield of Asian noodles (Inglett *et al.,* 2005).

In addition to cooking yield, another parameter related to the cooking quality of noodles is cooking loss. Cooking loss provides information about the integrity and weight loss of noodles during cooking, which is very closely related to the dissolution and loss of gelatinised starch in water. Therefore, it will be considered in further research.

Texture profile of Caulerpa noodles

Textural properties are the most critical characteristic when assessing quality and consumers' acceptance of cooked noodles (Bhattacharya *et al.,* 1999). The tensile strength and elasticity of the noodles were measured by a texture analyser with noodle spaghetti tensile grips, and those tests were performed analogous to the ability of the noodles to twirl using a spoon. The textures of *Caulerpa* noodles are shown in Table 3. Noodles with 10, 15, and 20% *Caulerpa* sp. filtrate had a higher ($p < 0.05$) tensile strength than the control noodles, indicating that noodles with 10, 15, and 20% *Caulerpa* sp. filtrate needed more force to break as compared to the control noodles. On the other hand, noodles incorporated with *Caulerpa* sp. filtrate had (p = 0.015) slightly lower elasticity as compared to the control. The increase in tensile strength of the noodles due to the addition of *Caulerpa* sp. filtrate is thought to be due to the salt content of the filtrate. Research conducted by Hu *et al.* (2017) showed that the addition of salt increased the tensile strength of dough at the right salt concentration, but the increase in tensile strength of dough usually will be followed by a decrease in the elasticity. Salt helps in the formation of a dough structure network, increasing the gluten network structure and thereby increasing the tensile strength of the dough (Butow *et al.,* 2002). The salt solution has a strong penetration so that flour absorbs water more quickly during the dough kneading process, which elevates and improves the formation of the gluten formation network. Salt also increases the density of the internal gluten network (Lynch *et al.,* 2009; Hu *et al.,* 2017).

Texture profile analysis (TPA) was used to analyse the effect of *Caulerpa* sp. filtrate on the hardness, adhesiveness, cohesiveness, and chewiness of noodles. There were no significant differences in the hardness (p = 0.098), springiness (p = 0.632), gumminess (p = 0.101), or chewiness (p = 0.137) of noodles with *Caulerpa* sp. filtrate as compared to the control group (without adding *Caulerpa* sp. filtrate). Prerana and Anupama (2020) reported that the consumer did not prefer noodles with a maximum hardness, which is one of the advantages of adding *Caulerpa* sp. filtrate, as it does not affect the hardness of the noodles produced. Incorporation of noodles with fruit puree or vegetable puree usually reduces the hardness of

Table 3. Texture of *Caulerpa* noodles.

Samples	Tensile Strength (G)*	Elasticity (mm)*	Hardness (kg)**	Adhesiveness (g.sec)**	Springiness**	Gumminess**	Chewiness**
Control	23.65 ± 0.52^{a}	37.96 ± 9.13^{a}	8.84 ± 2.7^{a}	-45.54 ± 21.55^{a}	0.73 ± 0.07^{a}	6067.48 ± 2298.10^{a}	4444.52 ± 1766.14^{a}
5% filtrate	26.64 ± 0.62^{ab}	29.39 ± 2.18^{b}	8.84 ± 2.02^{a}	-33.96 ± 14.83^{bc}	0.73 ± 0.11^{a}	6267.33 ± 1449.73^{a}	4694.69 ± 1320.70^{a}
10% filtrate	29.35 ± 1.6^{bc}	36.13 ± 0.96^{ab}	7.68 ± 2.78^{a}	-33.79 ± 14.91^{c}	0.73 ± 0.09^{a}	5325.33 ± 2366.33^{a}	3957.45 ± 2017.25^{a}
15% filtrate	30.43 ± 1.7^{cd}	32.57 ± 3.22^{ab}	8.26 ± 2.08^{a}	-43.91 ± 18.25^{a}	0.73 ± 0.08^{a}	5465.56 ± 1566.30^{a}	4007.97 ± 1329.52^{a}
20% filtrate	32.91 ± 2.68^{d}	36.33 ± 1.61^{ab}	7.98 ± 2.84^{a}	-42.88 ± 20.15^{abc}	0.71 ± 0.11^{a}	5494.6 ± 2344.63^{a}	4010.89 ± 2011.24^{a}

*Data are means ± standard deviations (n = 15). **Data are means ± standard deviations (n = 45). Means in the same column with different superscript are significantly different ($p < 0.05$).

noodles because sugar and fibre contained in the puree interrupt the gluten network (Chinachoti, 1993; Wang *et al.,* 2002). *Caulerpa* sp. filtrate had a lower fibre content, which did not significantly affect the fibre content and hardness of the noodles. Lee *et al.* (1998) reported that the amount of gluten determined the springiness, gumminess, and chewiness of noodles. In the present work, the amount of flour added was the same for each formula; therefore, they are thought to produce noodles with almost the same level of springiness, gumminess, and chewiness. Noodles with 5 and 10% of *Caulerpa* sp. filtrate were significantly less adhesive (p = 0.001) than the control noodles, indicating that the stickiness of the noodles decreased by 5 - 10% following *Caulerpa* sp. filtrate incorporation.

Sensory evaluation

Hedonic test results of *Caulerpa* sp. noodles using a 7-point hedonic test are shown in Figure 2. There was no significant (p = 0.446) difference in the overall acceptance of noodles with the addition of *Caulerpa* sp. filtrate. The overall values of noodles ranged from 4.70 - 4.90 (neither dislike nor like). This result indicated that fortification of noodles with *Caulerpa* sp. filtrate does not affect overall consumer acceptance. The addition of certain ingredients to improve the nutrition of a product is expected not to reduce consumer acceptance; it is even expected to be able to increase the sensory acceptance of the product so that the product can be more accepted by consumers (Chadare *et al.,* 2019).

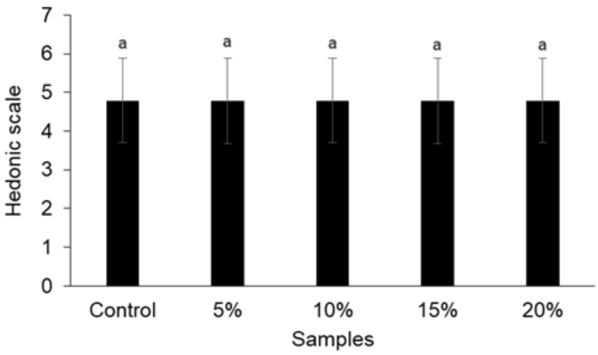

Figure 2. The hedonic test of *Caulerpa* noodles. **Data are means ± standard deviations (n = 50). Means in the same column with different superscript are significantly different ($p < 0.05$).

Conclusion

The present work demonstrates the effect of *Caulerpa* sp. filtrate on the ash, β-carotene and phenol contents of wheat noodles. Generally, the β-carotene, ash and phenol contents of noodles increased with *Caulerpa* sp. filtrate fortification. The addition of *Caulerpa* sp. filtrate changed the appearance, elasticity, and adhesiveness of noodles, but the hedonic test showed that *Caulerpa* sp. filtrate did not affect consumer acceptance of noodles. Noodles with *Caulerpa* sp. filtrate with higher β-carotene, ash, and phenol contents may be preferred by the consumer because of the health benefits and nutritional value of the noodle. Therefore, the present work shows that *Caulerpa* noodles could have nutritional benefits in daily diets.

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