Food Research 7 (Suppl. 3) : 1 - 11 (2023)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

The effect of natural dye from *Caulerpa* sp. microcapsules on jelly drink quality

*Dewi, E.N. and Purnamayati, L.

Department of Fish Product Technology, Faculty of Fisheries and Marine Sciences, Diponegoro University, Jl. Prof. H. Soedarto, SH, Tembalang, Semarang 50275, Indonesia

Article history:
Received: 11 November 2022
Received in revised form: 29 June 2023
Accepted: 27 September 2023
Available Online: 31 October 2023

Keywords:
Caulerpa sp.
Chlorophyll,
Microcapsule,
Natural colorant,
Jelly drink

DOI:
https://doi.org/10.26656/fr.2017.7(S3).1

Abstract

Jelly drink is a hydrocolloid-based drink with a low gel consistency, making it easy to consume. Dyes are food additives often added to jelly drinks to increase attractiveness. However, synthetic dyes are known to negatively affect health. *Caulerpa* sp. macroalgae are rich in chlorophyll pigment and have functional properties such as antioxidants and can be used as an organic dye, replacing synthetic dyes. The purpose of this study was to determine the effect of *Caulerpa* sp. microcapsules as a natural dye on the physical and chemical properties of seaweed jelly drinks and to recommend concentrations. This study used chlorophyll from *Caulerpa* sp. in microcapsules that were added to jelly drinks with 0–4,000 ppm concentrations with 1,000 ppm intervals. The drinks' physical properties were analyzed based on color, viscosity, dissolved solids, and syneresis level. The chemical properties analysis covered sugar, dietary fiber, chlorophyll, and total phenol levels, and antioxidant and organoleptic activity. The transition temperature of the jelly drinks was analyzed using Differential Scanning Calorimetry. A higher concentration of *Caulerpa* sp. microcapsules affected the characteristics of jelly drinks. The highest addition of *Caulerpa* sp. microcapsules resulted in increased chemical characteristics, however, lowered the soluble solids, degree of syneresis and panelist's acceptance. The best concentration was found at 2000 ppm. The *Caulerpa* sp. microcapsules has the potential as a natural colorant and improves product characteristics.

1. Introduction

Red algae are macroalgae and a source of hydrocolloid-based products like carrageenan and agar, which function as a thickener and gelling agent. Hydrocolloid products are used in food because of their ability to increase aqueous solution viscosity, to form a film, and gel with different hardness levels (Kılınç *et al.*, 2013). A jelly drink is a hydrocolloid beverage with sugar and other food additives (usually dyes). The weak consistency of the drink causes the gel to crumble easily when aspirated (Winarti *et al.*, 2018).

The consumer appeal in the food and beverage industry is often influenced by adding dyes, especially synthetic ones. Colored foods may influence consumers' choices regarding food and increase their appetite. Synthetic dyes are common because they are economical and produce stable and attractive colors, especially under storage conditions such as humidity, temperature, air and easy to obtain (Kumari and Meghwal, 2016; Zahra *et al.*, 2017). However, according to Dafallah *et al.* (2015), synthetic dyes affect our health. They found that synthetic dyes can reduce HDL cholesterol and glutathione secretion and weaken the immune system. Synthetic dyes may also lead to increased blood glucose, LDL cholesterol, and lipid peroxidase levels. Merinas-Amo *et al.* (2019) reported that, based on in vivo tests, daily consumption of synthetic dyes may result in increased tumor cell growth, but did not cause DNA modification or damage. According to Kobylewski and Jacobson (2012), some synthetic dyes exert carcinogenic and cancer-causing effects in animals.

Natural dyes are a potentially less harmful alternative colorant for food and beverages because they have antioxidant and anti-inflammatory functional properties and can strengthen the immune system (Okafor *et al.*, 2016). Other sources of natural dyes are vegetables, fruits, and seeds that contain pigments, including chlorophyll, anthocyanins, and carotenoids

---

*Corresponding author.
Email: *nurdewisatsmoko@gmail.com*

eISSN: 2550-2166 / © 2023 The Authors.
Published by Rynnye Lyan Resources

(Mohamad *et al*., 2019). Macroalgae that contain chlorophyll pigment are another source of natural dyes, such as the *Caulerpa* sp. According to Othman *et al*. (2018), the chlorophyll content in *Caulerpa* sp. is higher (7.29 µg/g) than in *Gracilaria* (2.80 µg/g) and *Euchema* (2.97 µg/g) seaweeds. The high chlorophyll content in *Caulerpa* sp. makes it a potentially viable source of natural dyes for foods and beverages. However, chlorophyll is a natural green pigment that does have weaknesses, namely an unstable reaction to heat, light, and oxygen (Haryatfrehni *et al*., 2015). Microencapsulation helps maintain chlorophyll stability during storage. It is a process to stabilize the functional properties and physicochemical characteristics by providing a barrier between the coated material. The resulting microcapsule product is easy to apply and stable during storage (Bakry *et al*., 2016; Corrêa-Filho *et al*., 2019).

Natural dyes are commonly used in jelly drinks. Tensiska *et al*. (2017) added anthocyanin microcapsules from purple sweet potato with different concentrations to jelly drinks. The jelly drinks with 3,000 ppm added were less popular among panelists because of their red color with low intensity. Trilaksani *et al*. (2015) reported that an increased concentration of *Spirulina platensis* decreased the panelists' acceptance of the color and aspirated power of jelly drinks. However, it did results in increased antioxidant activity in the jelly drinks. Besides, Suryani *et al*. (2017) added 1% Rosella natural dye to jelly drinks, resulting in a slightly dark red product which affected the panelists' acceptance. Research into *Caulerpa* sp. microcapsules added to jelly drinks has not yet been done. Hence, this study is the first to do so. This study aimed to determine the effect different concentrations of *Caulerpa* sp. microcapsules have on the physical and chemical characteristics of seaweed jelly drinks and to determine the best concentration of *Caulerpa* sp. microcapsules to jelly drinks.

2. Materials and methods

2.1 Materials

The macroalgae, *Caulerpa* sp. were obtained fresh from Jepara, Central Java, Indonesia. Other materials were ethanol 96%, gum arabic, carrageenan, gelatin, tween 80 (Merck, Germany), agar (Swallow, Indonesia), sugar (Gulaku), and mineral water (Aqua (Indonesia)).

2.2 Chlorophyll extraction from Caulerpa sp.

Chlorophyll was extracted from *Caulerpa* sp. as described by Derrien *et al*. (2017) with some modification by drying fresh *Caulerpa* sp. at room temperature for 48 hrs and subsequently shredding it in a blender (Maspion, Indonesia). *Caulerpa* sp. was then soaked with 1:5 ethanol for 24 hrs after which the filtrate was separated from the pulp using a filter cloth. The solvent then was subject to rotary evaporation. The extract obtained was put in a dark bottle and stored at 5° C.

2.3 Chlorophyll microencapsulation

Chlorophyll microencapsulation followed the freeze-drying (Ningbo Yinzhou Sjia Lab Equipment Co., LTD) based on the method described by Yamashita *et al*. (2017) and involved dissolving 10% chlorophyll extract in distilled water by adding 1% tween 80. Then, gelatin (2%) and gum Arabic (8%) was added and homogenized using Ultra Turrax at 10,000 rpm for 3 mins to act as the coating material. Next, the mixture was freeze-dried for 24 hrs at -35°C. The resulting chlorophyll microcapsules were packed in polypropylene plastic, placed in an airtight jar, and stored at 5°C.

2.4 Jelly drinks production

Making the jelly drinks involved dissolving 0.2% carrageenan, 0.1% agar, and 10% sucrose in mineral water to which the chlorophyll microcapsules with 0 ppm (A), 1,000 ppm (B), 2,000 ppm (C), 3,000 ppm (D), and 4,000 ppm (E) were added. The homogenous mixture was heated to a boil for 5 mins and poured into a glass bottle to be stored at room temperature.

2.5 Color

The color was measured with a Chromameter Minolta CR 400 with the result expressed as L*, a*, and b* values (Anthonissen *et al.,* 2018). The L* represents brightness, a*(+) represents red hue, a*(-) represents green hue, b*(+) represents yellow hue, and b*(-) represents blue hue.

2.6 Viscosity

The viscosity was measured by the method described by Mohan *et al*. (2020), with a viscometer (Brookfield Engineering Laboratories, USA). The viscometer was used to analyze 50 mL samples at 100 rpm.

2.7 Dissolved solids

Dissolved solids were analyzed based on AOAC (2010), by homogenizing a 0.5 g sample with 6 mL of distilled water heated for 5 mins in a water bath (Memmert, Germany). The samples were then cooled and distilled water was added to the tera limit and filtered. Next, 5 mL of the filtrate was placed on a porcelain plate and weighed (A). The filtrate was then evaporated in an oven at 105°C until dry and reached a constant weight temperature (B). The proportion of dissolved solids is measured and expressed in dry weight.

2.8 Syneresis rate

The syneresis rate was analyzed based on the method described by Gani *et al*. (2014). A jelly drink was poured into a plastic cup and stored at 5°C for 72 hrs. The syneresis rate is the difference between the initial weight and final weight divided by the initial weight and multiplied by 100%. The final weight is of the gel contained in a jelly drink separate from the water.

2.9 Total sugar

The total sugar was analyzed following the method described by Permana *et al*. (2020), by using a refractometer to detect and measure it (Atago Co, Ltd, Japan).

2.10 Dietary fiber

First, the crude fiber was measured gravimetrically according to AOAC (2017), with a 0.5 g sample, added with 0.1 mL alpha-amylase enzyme, and heated and stirred at 100°C for 15 mins. The cooled sample was then added with 20 mL distilled water, 1 mL of 1% pepsin enzyme, and was subsequently reheated in a water bath for 1 hr. Next, 5 mL 1 N NaOH and 0.1 mL beta amylase enzyme were added, and heated for 1 hr. The sample was then separated and washed twice using 10 mL acetone and ethanol and dried in an oven at 105°C for 24 hrs as crude fiber. To create a suspension, 400 mL of 95% ethanol was added to 100 mL filtrate. The filtrate was once again filtered with free ash filter paper and washed with acetone and ethanol. Finally, the filtrate was dried in an oven at 105°C for 24 hrs after which it was weighed as a soluble crude fiber.

2.11 Chlorophyll analysis

The chlorophyll content was measured according to the method described by Guo *et al*. (2015), from the samples dissolved in pure acetone (Merck) and homogenized for 5 mins. The sample was then filtered with Whatman filter paper No. 1 (Merck). A spectrophotometer (Shimadzu, Japan) at 663 nm was used to measure the absorbance of chlorophyll-a and chlorophyll-b at 645 nm. The content of both types was measured using the following equation and with the total chlorophyll expressed in mg/l:

$$\text{Total chlorophyll} = 8.02\ A_{663} + 20.21\ A_{645}$$

2.12 Total phenols

The total phenols were determined based on the method described by Nurjanah *et al*. (2019), where a 2 mL sample was mixed with 1 mL Folin-Ciocalteu (Merck) reagent and homogenized. A 3 mL of 3% sodium carbonate solution was then added to the homogenized solution and was subsequently set aside for 30 min while stirred. A UV-Vis spectrophotometer (Shimadzu, Japan) at 760 nm was used to measure the absorbance. The total phenols were expressed as microgram gallic acid per milligram of the dry sample using gallic acid standard curves.

2.13 Antioxidant activity

The antioxidant activity was measured according to Sihono *et al*. (2018) with modification. A 2,2-diphenyl-1-picrylhydrazil (DPPH) (Merck) and a 1 mL sample of chlorophyll microcapsule solution in methanol were mixed with 2 mL of DPPH in methanol (0.1 mm) and homogenized and stored in the dark at room temperature for 25 mins. The absorbance was measured with a UV-Vis spectrophotometer (Shimadzu, Japan) at 760 nm. The percentage of DPPH free radicals was calculated by dividing the difference between the absorbance of the sample with that of the control multiplied by 100%. The control was the pure DPPH solution.

2.14 Sensory analysis

The sensory analysis was based on Solicha *et al*. (2021) using a hedonic shore sheet by 30 trained panelists. The parameter includes appearance, odor, texture, and taste, using a scale of 1-9, with a scale of 1 representing very unlikely to 9 very likely.

2.15 Differential scanning calorimetry

The differential scanning calorimetry was measured based on the method described by Górska *et al*. (2020), with a DSC-60Plus and Flow Control Unit (Shimadzu, Japan). The sample was heated to 30–300°C using an aluminum seal that flowed nitrogen at 10 mL/min.

2.16 Statistical analysis

The statistical analysis consisted of triplicate samples analyzed in ANOVA. If there was a significant difference ($\alpha < 0.05$), Tukey tests were performed. The data were analyzed with SPSS 23 software.

3. Results and discussion

3.1 Color

Table 1 shows that *Caulerpa* sp. microcapsules affected the jelly drink's color which turned a darker green as more microcapsules were added. The microcapsules made the drinks darker (decreased L*) and shifted the hue towards green (increased a*(-)) and yellow (increased b*). They also increased the chlorophyll content of jelly drinks. Chlorophyll consists of chlorophyll a and b, where chlorophyll a has a green-

https://doi.org/10.26656/fr.2017.7(S3).1

blue color intensity and chlorophyll b has a green-yellow color intensity (Paciulli *et al*., 2017). The decreased L* is likely linked to the heat during the jelly beverage processing affecting chlorophyll. High temperatures cause chlorophyll to turn brown because magnesium ions are released and replaced by hydrogen ions, resulting in the formation of pheophytin components (Kwartiningsih *et al*., 2021). The treatment of E jelly drink has a highest green dark color. The darkening of the jelly drinks was also a result of the Maillard reaction between sugar and amino acids from gelatin contained in *Caulerpa* sp. microcapsules. The results are in agreement with Cano-Lamadrid *et al*. (2020), who added pomegranate to jelly candy resulting in a darkening effect as a result of the Maillard reaction.

Table 1. The color of the jelly drinks.

Sample	L	A	B
A	58.60±0.21^{e}	-0.50±0.03^{b}	5.84±0.08^{a}
B	46.81±0.43^{c}	-0.03±1.91^{a}	11.09±0.22^{b}
C	40.02±0.12^{a}	-2.35±0.01^{c}	16.74±0.01^{c}
D	53.71±0.08^{d}	-2.42±0.03^{c}	18.38±0.26^{d}
E	43.40±0.18^{b}	-3.78±0.09^{d}	21.37±0.07^{e}

Values are presented as mean±SD. Values with different superscript within the same column are statistically significantly different at 5%.

3.2 Viscosity

The viscosity test results are shown in Table 2 and showed that the higher the concentration of *Caulerpa* sp. microcapsules, the higher the viscosity of the jelly drinks. Viscosity is influenced by several factors. Gomaa and Ayoub (2021) reported that the addition of gum tragacanth to jelly could increase viscosity. According to Elshafeey and El-Dahmy (2022), viscosity is linked to the polymer used. It is also affected by carrageenan and gelatin which have gelling agent properties and can when combined, produce an elastic gel (Saha and Bhattacharya, 2010) and can therefore increase the viscosity of jelly drinks.

Table 2. Physical characteristics of the jelly drinks.

Sample	Viscosity (cP)	Dissolved solids (%)	Syneresis rate (%)
A	15.65±0.05^{a}	5.45±0.05^{a}	10.82±0.06^{e}
B	44.30±0.10^{b}	6.30±0.01^{b}	8.93±0.10^{d}
C	56.60±0.30^{c}	6.56±0.04^{c}	7.32±0.05^{c}
D	57.55±0.05^{c}	7.49±0.18^{d}	5.81±0.02^{b}
E	72.90±2.50^{d}	9.24±0.01^{e}	3.66±0.02^{a}

Values are presented as mean±SD. Values with different superscript within the same column are statistically significantly different at 5%.

3.3 Dissolved solids

Dissolved solids increased with the concentration of *Caulerpa* sp. microcapsules (Table 2) and ranged from 5.45–9.24% in the jelly drinks. Dissolved solids relate to components that can dissolve in a solution, especially sugar and other soluble components (Azlan *et al*., 2020; Wei *et al*., 2020). Dewi *et al*. (2021) reported that the use of gelatin and gum arabic as a coating material in chlorophyll microencapsulation caused an increase in the solubility of microcapsules in water. Gelatin and gum arabic are easily soluble in water because the former contains hydrophilic amino acids and the latter is a carbohydrate that acts as an emulsifier (Alkarib *et al*., 2016; Felix *et al*., 2016). Dissolved solids were shown to increase by Azlan *et al*. (2020) who added gum arabic to rosella juice. Montenegro *et al*. (2012) explained this as gum arabic being a polysaccharide consisting of D-galactose, D-glucuronic acid, and L-arabinose which are easily soluble in water.

3.4 Syneresis

Syneresis is a condition in which a liquid with a low molecular weight separates from the gel surface during storage due to the formation of new intermolecular bonds. This condition causes the gel structure to go through an imbalance so that the liquid is released (Park *et al*., 2021). The results of the syneresis analysis are shown in Table 2 and show that increased concentrations of *Caulerpa* sp. in the jelly drink resulted in decreased syneresis. Carrageenan and chlorophyll microcapsules were able to form a strong matrix because of the ability of gelatin as a coating material to form an elastic gel when combined with carrageenan (Saha and Bhattacharya, 2010). In addition, gelatin can bind water to the matrix structure. It acts as a stabilizer that can increase the ability to bind water (Dimitrellou *et al*., 2020; Bahar *et al*., 2021). Pancapalaga and Ashari (2020) reported that the higher the gelatin in the material, the more matrix capable of binding water is formed. As more gelatin is introduced to the drinks, water is released less and the syneresis value is therefore reduced. The syneresis values in this study were 3.66–10.82% which are better than in Shi *et al*. (2017), who made yogurt with the addition of 0.1% gelatin resulting in a syneresis value of 31.5%.

3.5 Total sugar

The more *Caulerpa* sp. microcapsules were added to the jelly drink, the higher the total sugar rose (Table 3). Total sugar is the number of monosaccharides and disaccharides in a food (Erickson and Slavin, 2015). The sugar in this study was the basic ingredient for the jelly drinks and was sourced from sucrose sugar (disaccharide). The total sugar value for the control jelly drink (A) was 3.66%. The highest total sugar value of 10.82% was in jelly drink E. During the process of cooking the jelly drinks, *Caulerpa* sp. in the microcapsules separates from the gelatin and gum arabic coating material. The hydrolysis of gum arabic produces L-arabinose and D-galactose in the form of free sugars (Li *et al*., 2018), which explains the raised total sugar levels.

3.6 Dietary fiber

The dietary fiber increased as *Caulerpa* sp. microcapsules were added (Table 3). Dietary fiber is a plant material that contains cellulose and polysaccharides that cannot be digested by digestive enzymes (Dhingra *et al*., 2012). The dietary fiber in this study was sourced from carrageenan and gum arabic. Carrageenan acted as the main ingredient in the manufacturing process of jelly drinks. Hernawati *et al*. (2013) explained that *Eucheuma* sp. seaweed is a source of dietary fiber and that carrageenan is its main polysaccharide. The dietary fiber value of the control jelly drink (A) was 0.43% and increased as *Caulerpa* sp. microcapsules were added and also increased because of the gum arabic coating material. Mariod (2018) reported that gum arabic is an exudate from the acacia tree and contains more than 80% fiber. The *Caulerpa* sp. microcapsules increased the dietary fiber content of the jelly drinks and jelly drink E contained 0.96% dietary fiber. The results in this study are similar to Praseptiangga *et al*. (2016), who reported that the addition of gum arabic to jackfruit leather increased its fiber content by up to 58%.

3.7 Chlorophyll

Caulerpa sp. contains chlorophyll, which is a green pigment, and is a single-celled alga with a green thallus and is therefore a green alga. Its green color is caused by chlorophylls a and b contained in algal plastids for photosynthesis (Tapotubun *et al*., 2020). The results of the total chlorophyll analysis are shown in Table 3 and the chlorophyll content was 0.07–0.10 ppm. The more *Caulerpa* sp. microcapsules were added to the jelly drinks, the higher the chlorophyll content became. The chlorophyll presence was also reflected by the color of the jelly drinks because they turned dark green, which indicates that chlorophyll survived the heating process. These results are in agreement with Nurbaya *et al*. (2021), who applied betacyanin microcapsules to a beverage model to produce betacyanin that persisted and survived 10 min of heating. Dewi *et al*. (2018) applied phycocyanin microcapsules to jelly candies turning them blue, which indicates that the phycocyanin survived processing.

3.8 Total phenol

As shown in Table 3, the total phenol content of the jelly drinks ranged from 2.24–17.39%. It increased as microcapsules were added to the drinks and there were five times higher total phenol determination on control compared to the addition of 4,000 ppm microcapsules *Caulerpa* sp. The rise in total phenol content was linked to the chlorophyll content in jelly drinks. Novelina *et al*. (2015) reported that the chlorophyll extract was detected to contain phenolic components, alkaloids, flavonoids, and steroids. The research concurred with the research of Siddiqui *et al*. (2017) on the *Nepeta bracteata* flower. The phenolic compound in *Caulerpa* sp. is very important since it belongs to a group with scavenging properties.

3.9 Antioxidant

The results of antioxidant testing in Table 3 show that the higher the concentration of *Caulerpa* sp. in the jelly drinks, the higher the antioxidant value. This is likely a direct result of the *Caulerpa* sp. addition. According to Marraskuranto *et al*. (2020), *Caulerpa* sp. contains bioactive and phenolic compounds with antioxidant activity. According to Tanna *et al*. (2018), *Caulerpa* sp. seaweed is rich in total antioxidants compared to other seaweeds. The antioxidant value of *Caulerpa* sp. is 150.8±5.7% and that of *Ulva* sp. is 67%. Antioxidant activity may also be affected by the microencapsulation method used on *Caulerpa* sp., as it can maintain the bioactive compounds and increase stability and antioxidant value (Dewi *et al*., 2022; Saini *et al*., 2022).

3.10 Differential scanning calorimetry

The thermal analysis results of the jelly drinks with

Table 3. Chemical characteristics of the jelly drinks

Sample	Total sugar (%)	Dietary fiber (%)	Chlorophyll (ppm)	Total phenol (ppm)	Antioxidants (%)
A	3.66±0.02^{a}	0.43±0.02^{a}	0.07±0.00^{a}	2.24±0.06^{a}	3.79±0.07^{a}
B	5.81±0.02^{b}	0.53±0.02^{b}	0.08±0.00^{b}	5.14±0.13^{b}	14.84±0.13^{b}
C	7.32±0.05^{c}	0.72±0.00^{c}	0.08±0.00^{b}	10.72±0.12^{c}	18.62±0.26^{c}
D	8.93±010^{d}	0.85±0.03^{d}	0.09±0.00^{c}	14.05±0.13^{d}	26.50±0.07^{d}
E	10.82±0.06^{e}	0.96±0.00^{e}	0.10±0.00^{d}	17.39±0.06^{e}	31.12±0.13^{e}

Values are presented as mean±SD. Values with different superscript within the same column are statistically significantly different at 5%.

the addition of *Caulerpa* sp. microcapsules are shown in Figure 1. The *Caulerpa* sp. can be mixed until homogeneous, as indicated by the appearance of one peak in the five jelly drink samples. Dewi *et al*. (2021) reported that the appearance of a peak in the *Caulerpa* sp. microcapsules indicated an interaction between the coating material and that the enthalpy temperature of gelatin measured was >200°C, while that of gum arabic was 122°C. In the control jelly drink (A) the enthalpy temperature was 139°C and in the jelly drink with added *Caulerpa* sp. the enthalpy reached 155–169°C. These results are in agreement with Ang *et al*. (2019) who reported that the enthalpy temperature change of curcumin increased after the microencapsulation process with gelatin was carried out. This indicates a cross-linking between curcumin and gelatin. Furthermore, Jamaludin *et al*. (2017) mentioned that the temperature of film enthalpy of carrageenan and gum arabic ranged from 100–200°C, which is in agreement with this study.

3.11 Sensory analysis

The average value of the hedonic test on appearance ranged from 3.87 to 7.80 and differed significantly between treatments. The highest value on the appearance parameter was for the jelly drink with 0.1% *Caulerpa* sp. added. This indicates that the panelists preferred the appearance of a jelly drink with a lighter color and a lower concentration of *Caulerpa* sp. According to Tapotubun *et al*. (2020), *Caulerpa* sp. contains the pigments chlorophyll, beta carotene, and Caulerpin. *Caulerpa* sp. produces a green pigment.

The aroma assessment in the hedonic test was likely primarily influenced by the distinctive aroma of

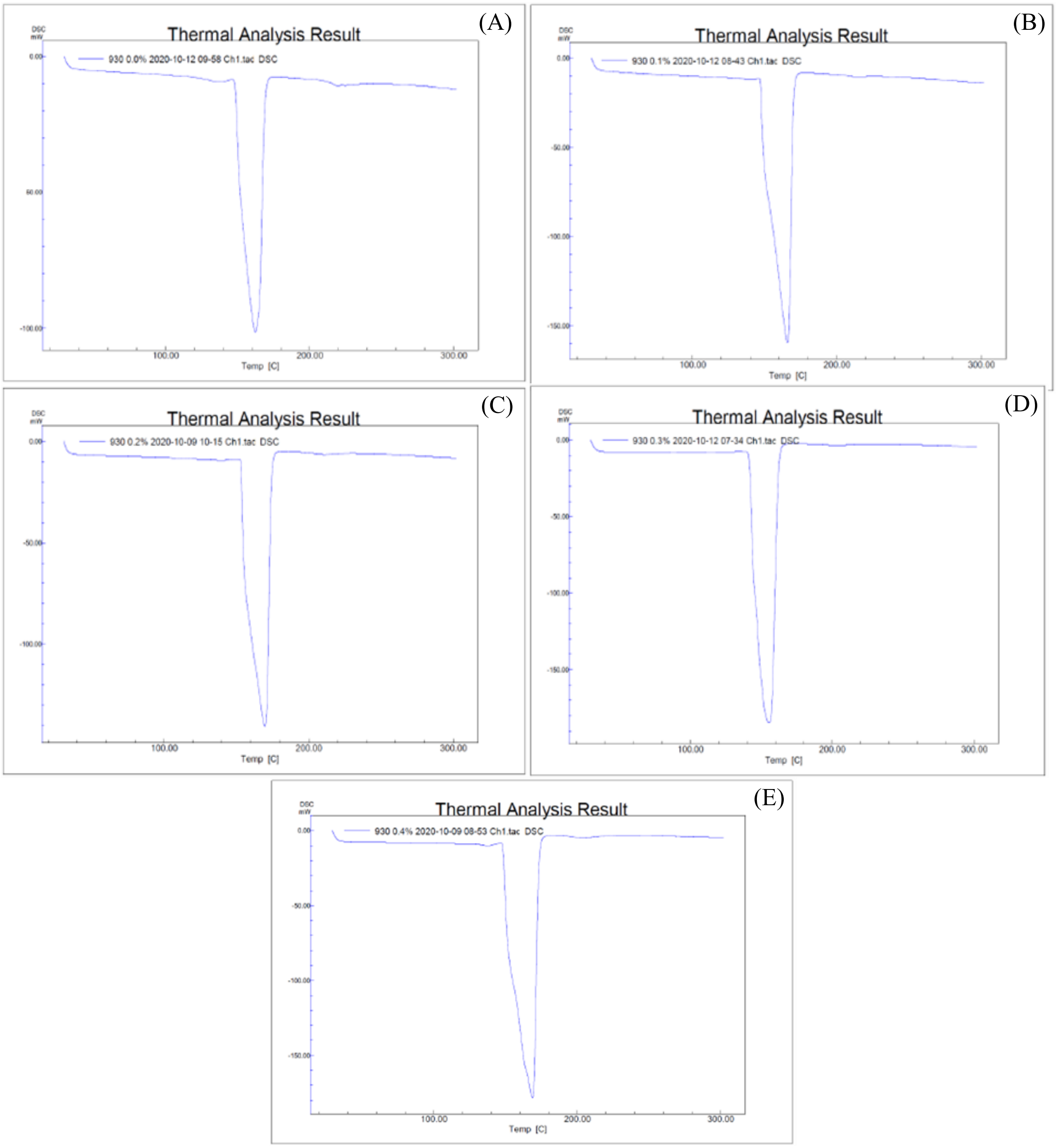

Figure 1. Differential calorimetry scans of the jelly drink without chlorophyll microcapsules (A), jelly drink 1000 ppm chlorophyll microcapsules (B), jelly drink 2000 ppm chlorophyll microcapsules (C), jelly drink 3000 ppm chlorophyll microcapsules (D) and jelly drink 4000 ppm chlorophyll microcapsules (E)

Table 4. Sensory properties of the jelly drinks

Samples	Appearance	Odor	Texture	Taste
A	5.30±0.88^{c}	5.57±0.63^{c}	4.60±1.04^{d}	4.80±1.27^{c}
B	7.80±0.92^{a}	7.07±0.91^{a}	7.80±0.92^{a}	7.20±1.03^{a}
C	5.70±0.99^{b}	5.97±0.79^{b}	6.00±0.79^{c}	6.40±0.89^{b}
D	4.00±1.05^{d}	4.17±1.26^{d}	5.83±0.91^{e}	4.67±1.09^{d}
E	3.87±1.01^{e}	3.17±1.12^{e}	6.23±0.68^{b}	3.50±1.20^{e}

Values are presented as mean±SD. Values with different superscript within the same column are statistically significantly different at 5%.

seaweed. Therefore, at higher concentrations, the smell will be stronger. Scoring ranged from low to high defined as dislike to like respectively. The average score ranged from 3.17 to 7.07. *Caulerpa* sp. has a fishy-marine odor which was unpopular among the panelists. The most-liked sample was that with 0.1% *Caulerpa* sp. added to it, most likely because of a relatively subtle smell from a lower *Caulerpa* sp. and higher water concentration. According to Jonathan *et al*. (2022), a difference in the ratio of water and natural dye extracts in the process will result in a different aroma for each treatment because the water dilutes the distinctive aroma.

The average value of the panelists' preference was in the range of 4.60 to 7.80, which stands for *neutral* to *like*. The Kruskal-Wallis test showed a significant difference in the preference for texture. The panelists preferred the texture with the lowest concentration *Caulerpa* sp. of 0.1%, which was less chewy and easier to drink. According to Nurjanah *et al*. (2018), *Caulerpa* sp. is seaweed and a potential source of fiber.

Taste is the most important parameter in consumer acceptance of a product (Fiorentini *et al*., 2020). The level of preference for the panelists to the taste parameters ranged from 3.50 to 7.20 (somewhat dislike to like). The Kruskal-Wallis test showed that the concentration of *Caulerpa* sp. significantly influenced the panelists' preference regarding taste, likely due to the additional sugar. The taste was additionally influenced by chemical compounds, temperature, and interactions with other components. The sweet taste came from aliphatic organic compounds containing OH--groups such as alcohol, several amino acids, and glycerol. The main source of sweetness was sugar.

4. Conclusion

Adding a Caulerpa microcapsule on the jelly drink significantly affects all the tested parameters. As the higher concentration, the physical and chemical characteristics were improved; however, the panellist acceptance decreased. The best concentration was found at 2000 ppm. The Caulerpa microcapsules has the potential as a natural food colorant.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

This study was supported by a research fund from the Ministry of Research, Technology and Higher Education, 2020 with grant number: 257-105/UN7.P4.3/PP/2020.

References

Alkarib, S.Y., MohamedElhassan, D.E. and Nur, A.O. (2016). Evaluation of gum rabic as a film coating former for immediate release oral tablet formulation. *World Journal of Pharmacy and Pharmaceutical Sciences*, 5(1), 32–41.

Ang, L.F., Darwis, Y., Por, L.Y. and Yam, M.F. (2019). Microencapsulation curcuminoids for effective delivery in pharmaceutical application. *Pharmaceutics*, 11(9), 1–23. https://doi.org/10.3390/pharmaceutics11090451

Anthonissen, M., Meirte, J., Moortgat, P., Maertens, K., Daly, D., Fieuws, S., Lafaire, C., Cuyper, L.D. and Kerckhove, E.V. (2018). Influence on clinical parameters of depressomassage (part I): The effects of depressomassage on color and transepidermal water loss rate in burn scars: A pilot comparative controlled study. *Burns*, 44, 877-885. https://doi.org/10.1016/j.burns.2017.11.004

AOAC. (2010). Official Methods of Analysis. 18th ed. USA: Association of Official Analytical Chemistry International.

AOAC. (2017). Rapid total dietary fiber (AOAC 2017.16). Official Methods of Analysis of AOAC International. USA: Association of Official Analytical Chemistry International.

Azlan, T.N.N.T., Hamzah, Y. and Majid, H.A.M.A. (2020). Effect of gum arabic (*Acacia senegal*) addition on physicochemical properties and sensory acceptability of roselle juice. *Food Research*, 4(2), 449–458. https://doi.org/10.26656/fr.2017.4(2).293

Bahar, A., Samik, Basukiwardojo, M.M.S., Kusumawati, N., Muslim, S. and Auliya, A.S. (2021). Effect of milk on physico-chemical and functional of herbal jelly drink. *Advances in Engineering Research*, 209, 34–39.

Bakry, A.M., Abbas, S., Ali, B., Majeed, H., Abouelwafa, M.Y., Mousa, A. and Liang, L. (2016). Microencapsulation of oils: a comprehensive review of benefits, techniques, and applications. *Comprehensive Reviews in Food Science and Food Safety*, 15(1), 143–182. https://doi.org/10.1111/1541-4337.12179

Cano-Lamadrid, M., Calín-Sánchez, Á., Clemente-Villalba, J., Hernández, F., Carbonell-Barrachina, Á.A., Sendra, E. and Wojdyło, A. (2020). Quality parameters and consumer acceptance of jelly candies based on pomegranate juice "*Mollar de Elche*". *Foods*, 9(4), 1–17. https://doi.org/10.3390/foods9040516

Corrêa-Filho, L.C., Moldão-Martins, M. and Alves, V.D. (2019). Advances in the application of microcapsules as carriers of functional compounds for food products. *Applied Sciences (Switzerland)*, 9(3), 1–18. https://doi.org/10.3390/app9030571

Dafallah, A.A., Abdellah, A.M., Rahim, E.A.A. and Ahmed, S.H. (2015). Physiological effects of some artificial and natural food coloring on young male albino rats. *Journal of Food Technology Research*, 2 (2), 21–32. https://doi.org/10.18488/journal.58/2015.2.2/58.2.21.32

Derrien, M., Badr, A., Gosselin, A., Desjardins, Y. and Angers, P. (2017). Optimization of a green process for the extraction of lutein and chlorophyll from spinach by-products using response surface methodology (RSM). *LWT-Food Science and Technology*, 79, 170-177. https://doi.org/10.1016/j.lwt.2017.01.010

Dewi, E.N., Kurniasih, R.A. and Purnamayati, L. (2018). The application of microencapsulated phycocyanin as a blue natural colorant to the quality of jelly candy. *IOP Conference Series: Earth and Environmental Science*, 116(1), 012047. https://doi.org/10.1088/1755-1315/116/1/012047

Dewi, E.N., Perdana, N.E. and Purnamayati, L. (2021). The protection of fish gelatine and arabic gum as coating materials to the quality chlorophyll *Caulerpa racemosa* encapsulation. *Journal of Physics: Conference Series*, 1943(1), 012171. https://doi.org/10.1088/1742-6596/1943/1/012171

Dewi, E.N., Purnamayati, L. and Jaswir, I. (2022). Effects of thermal treatments on the characterisation of microencapsulated chlorophyll extract of *Caulerpa racemosa. International Food Research Journal*, 29(6), 1279 – 1292. https://doi.org/10.47836/ifrj.29.6.05

Dhingra, D., Michael, M., Rajput, H. and Patil, R.T. (2012). Dietary fibre in foods: a review. *Journal of Food Science and Technology*, 49(3), 255–266. https://doi.org/10.1007/s13197-011-0365-5

Dimitrellou, D., Solomakou, N., Kokkinomagoulos, E. and Kandylis, P. (2020). Yogurts supplemented with juices from grapes and berries. *Foods*, 9(9), 1158. https://doi.org/10.3390/foods9091158

Elshafeey, A.H. and El-Dahmy, R.M. (2022). A novel oral medicated jelly for enhancement of etilefrine hydrochloride bioavailability: In vitro characterization and pharmacokinetic evaluation in healthy human volunteers. *Saudi Pharmaceutical Journal*, 30(10), 1435-1447. https://doi.org/10.1016/j.jsps.2022.07.004

Erickson, J. and Slavin, J. (2015). Total, added, and free sugars: are restrictive guidelines science-based or achievable. *Nutrients*, 7(4), 2866–2878. https://doi.org/10.3390/nu7042866

Felix, P.H.C., Birchal, V.S., Botrel, D.A., Marques, G.R. and Borges, S.V. (2016). Physicochemical and thermal stability of microcapsules of cinnamon essential oil by spray drying. *Journal of Food Processing and Preservation*, 41(3), e12919. https://doi.org/10.1111/jfpp.12919

Fiorentini, M., Kinchla, A.J. and Nolden, A.A. (2020). Role of sensory evaluation in consumer acceptance of plant-based meat analogs and meat extenders: a scoping review. *Foods*, 9(9), 1334. https://doi.org/10.3390/foods9091334

Gani, Y.F., Suseno, T.I.P. and Surjoseputro, S. (2014). Differences of carrageenan concentration on physicochemical and organoleptic properties of rosella-soursop jelly drink. *Journal of Food Technology and Nutrition*, 13(2), 87-93.

Gomaa, E. and Ayoub, M.M. (2021). Vardenafil oral jellies as a potential approach for management of pediatric irritable bowel syndrome. *Saudi Pharmaceutical Journal*, 29(9), 955-962. https://doi.org/10.1016/j.jsps.2021.07.020

Górska, A., Brzezińska, R., Wirkowska-Wojdyła, M., Bryś, J., Domian, E. and Ostrowska-Ligęza, E. (2020). Application of thermal methods to analyze the properties of coffee silverskin and oil extracted from the studied roasting by-product. *Applied Sciences*, 10(24), 1–15. https://doi.org/10.3390/app10248790

Guo, H., Yao, J., Sun, Z. and Duan, D. (2015). Effects of salinity and nutrients on the growth and chlorophyll fluorescence of *Caulerpa lentillifera*. *Chinese*

Journal of Oceanology and Limnology, 33(2), 410–418. https://doi.org/10.1007/s00343-015-4105-y

Haryatfrehni, R., Dewi, S.C., Meilianda, A., Rahmawati, S. and Sari, I.Z.R. (2015). Preliminary study the potency of macroalgae in Yogyakarta: Extraction and analysis of algal pigments from common Gunungkidul seaweeds. *Procedia Chemistry*, 14, 373–380. https://doi.org/10.1016/j.proche.2015.03.051

Hernawati, Manalu, W., Suprayogi, A. and Astuti, D.A. (2013). The carrageenan dietary fiber suplementation in feed to improving blood lipid parameters of hypercholesterolemic mice. *Makara Seri Kesehatan*, 17(1), 1–9. https://doi.org/10.7454/msk.v17i1.2004

Jamaludin, J., Adam, F., Rasid, R.A. and Hassan, Z. (2017). Thermal studies on Arabic gum - carrageenan polysaccharides film. *Chemical Engineering Research Bulletin*, 19, 80-86. https://doi.org/10.3329/cerb.v19i0.33800

Jonathan, H.A., Fitriawati, I.N., Arief, I.I., Soenarno, M.S. and Mulyono, R.H. (2022). Fisikokimia, mikrobiologi dan organoleptik yogurt probiotik dengan penambahan buah merah (*Pandanus conodeous* L.). *Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan*, 10(1), 33-41. https://doi.org/10.29244/jipthp.10.1.34-41

Kılınç, B., Cirik, S., Turan, G., Tekogul, H. and Koru, E. (2013). Seaweeds for food and industrial applications. *Food Industry*, 31, 735–748. https://doi.org/10.5772/53172

Kobylewski, S. and Jacobson, M.F. (2012). Toxicology of food dyes. *International Journal of Occupational and Environmental Health*, 18(3), 220–246. https://doi.org/10.1179/1077352512Z.00000000034

Kumari, R. and Meghwal, M. (2016). Benefits of food colors and safety in usage. *Ingredients South Asia*, 1, 22–24.

Kwartiningsih, E., Ramadhani, A.N., Putri, N.G.A. and Damara, V.C.J. (2021). Chlorophyll extraction methods review and chlorophyll stability of katuk leaves (*Sauropus androgynous*). *Journal of Physics: Conference Series*, 1858(1), 1–7. https://doi.org/10.1088/1742-6596/1858/1/012015

Li, M., Huang, M., Zhang, Z., Yang, Q., Yang, Y., Bao, Z. and Ren, Q. (2018). Determination and correlation of the solubility of L-arabinose and D-galactose in binary solvent mixtures from 278.15 to 333.15 K. *Korean Journal of Chemical Engineering*, 35(10), 2043–2051. https://doi.org/10.1007/s11814-018-0116-7

Marraskuranto, E., Nursid, M., Utami, S., Setyaningsih, I. and Tarman, K. (2020). Phytochemical content, antibacterial content and antibacterial *Caulerpa racemosa* extract with different solvent. *Postharvest and Biotechnological Journal*, 16(1), 1–10. https://doi.org/10.15578/jpbkp.v16i1.696

Mariod, A.A. (Ed.) (2018). Gum Arabic Dietary Fiber. In Gum Arabic., p. 237-243. USA: Academic Press.https://doi.org/10.1016/B978-0-12-812002-6.00020-8

Merinas-Amo, R., Martínez-Jurado, M., Jurado-Güeto, S., Alonso-Moraga, Á. and Merinas-Amo, T. (2019). Biological effects of food coloring in in vivo and in vitro model systems. *Foods*, 8(176), 1–19. https://doi.org/10.3390/foods8050176

Mohamad, M.F., Dailin, D.J., Gomaa, S.E., Nurjayadi, M. and El Enshasy, H. (2019). Natural colorant for food: A healthy Alternative. *International Journal of Scientific and Technology Research*, 8(11), 3161–3166.

Mohan, A., Hadi, J., Gutierrez-Maddox, N., Li, Y., Leung, I.K.H., Gao, Y., Shu, Q. and Quek, S.Y. (2020). Sensory, microbiological and physicochemical characterisation of functional manuka honey yogurts containing probiotic *Lactobacillus reuteri* DPC16. *Foods*, 9(1), 1-17. https://doi.org/10.3390/foods9010106

Montenegro, M.A., Boiero, M.L., Valle, L. and Borsarelli, C.D. (2012). Gum arabic: More than an edible emulsifier. In Verbeek, C.J.R. (Ed.) Products and Applications of Biopolymers. IntechOpen E-Book.

Novelina., Anggraini, T. and Hermansyah, R. (2015). Production of liquid chlorophyll from the leaves of green grass jelly (Premna oblongifolia Merr.). *International Journal on Advance Science Engineering Information Technology*, 5(5), 366–369. https://doi.org/10.18517/ijaseit.5.5.584

Nurbaya, S.R., Putri, W.D.R., Murtini, E.S. and Khamidah, A. (2021). The application of betacyanin microcapsules as natural food colorant on beverage model. *IOP Conference Series: Earth and Environmental Science*, 679, 012036. https://doi.org/10.1088/1755-1315/679/1/012036

Nurjanah, Mardiono, J.A. and Rudy, C. (2018). The changes of crude fiber component of *Caulerpa racemosa* spesies origin from Tual) as a result from boiling process. *Science and Technology Marine Tropical Journal,* 10(1), 35–48.

Nurjanah., Jacoeb, A.M., Asmara, D.A. and Hidayat, T. (2019). Phenolic compound of fresh and boiled sea grapes (*Caulerpa* sp.) from Tual, Maluku. *Food Science and Technology Journal*, 1(1), 31-39. https://doi.org/10.33512/fsj.v1i1.6244

Okafor, S.N., Obonga, W. and Ezeokonkwo, M.A.

(2016). Assessment of the health implications of synthetic and natural food colorants – a critical review. *UK Journal of Pharmaceutical Biosciences*, 4(4), 1–11.

Othman, R., Amin, N.A., Sani, M.S.A., Fadzillah, N.A. and Jamaludin, M.A. (2018). Carotenoid and chlorophyll profiles in five species of Malaysian seaweed as potential Halal Active Pharmaceutical Ingredient (API). *International Journal on Advanced Science, Engineering and Information Technology*, 8 (4–2), 1610–1616. https://doi.org/10.18517/ijaseit.8.4-2.7041

Paciulli, M., Palermo, M., Chiavaro, E. and Pellegrini, N. (2017). Chlorophylls and colour changes in cooked vegetables. In Yahia, M.E. (Ed.) Fruit and Vegetable Phytochemicals: Chemistry and Human Health, 2nd ed., p. 703–719. United Kingdom: Wiley Online. https://doi.org/10.1002/9781119158042.ch31

Pancapalaga, W. and Ashari, B. (2020). Rabbit skin gelatine effect towards yoghurt quality. *Foodscitech*, 3(1), 33–37. https://doi.org/10.25139/fst.v0i0.2683

Park, J.J., Olawuyi, I.F., Park, G.D. and Lee, W.Y. (2021). Effects of gelling agents and sugar substitutes on the quality characteristics of carrot jelly. *Korean Journal of Food Preservation*, 28(4), 469–479. https://doi.org/10.11002/kjfp.2021.28.4.469

Permana, T., Ramaputra, J. and Santoso, F. (2020). Product development of low sugar ready-to-drink (RTD) soy jelly drink. *Journal of Functional Food and Nutraceutical*, 2(1), 43–52. https://doi.org/10.33555/jffn.v2i1.41

Praseptiangga, D., Aviany, T.P. and Parnanto, N.H.R. (2016). Pengaruh penambahan gum arab terhadap karakteristik fisikokimia dan sensoris fruit leather nangka (*Artocarpus heterophyllus*). *Jurnal Teknologi Hasil Pertanian*, 9(1), 71–83. https://doi.org/10.20961/jthp.v9i2.12858

Saha, D. and Bhattacharya, S. (2010). Hydrocolloids as thickening and gelling agents in food: a critical review. *Journal of Food Science and Technology*, 47 (6), 587–597. https://doi.org/10.1007/s13197-010-0162-6

Saini, R.K., Prasad, P., Lokesh, V., Shang, X., Shin, J., Keum, Y.S. and Lee, J.H. (2022). Carotenoids: Dietary sources, extraction, encapsulation, bioavailability, and health benefits—A Review of Recent Advancements. *Antioxidants*, 11(4), 795. https://doi.org/10.3390/antiox11040795

Shi, M., Mathai, M.L., Xu, G., McAinch, A.J. and Su, Q. (2019). The effects of supplementation with blueberry, cyanidin-3-O-β-glucoside, yoghurt and its peptides on obesity and related comorbidities in a diet induced obese mouse mod. *Journal of Functional Foods*, 56, 92-101. https://doi.org/10.1016/j.jff.2019.03.002

Siddiqui, N., Rauf, A.M.D., Latif, M.A.M.D. and Mahmood, Z. (2017). Spectrophotometric determination of the total phenolic content, spectral and fluorescence study of the herbal Unani drug Gul-e-Zoofa (*Nepeta bracteata* Benth). *Journal of Taibah University Medical Sciences*, 12(4), 360–363. https://doi.org/10.1016/j.jtumed.2016.11.006

Sihono, S., Tarman, K., Madduppa, H. and Januar, H.I. (2018). Metabolite profiles and antioxidant activity of *Caulerpa racemosa* with different handlings. *Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology*, 13(3), 93–100. https://doi.org/10.15578/squalen.v13i3.355

Solicha, F., Dewi, E.N., and Purnamayati, L. (2021). Application of *Caulerpa racemosa* extract as a natural colourant in raw noodles. *Food Research*, 5 (Suppl. 3), 62-69. https://doi.org/10.26656/fr.2017.5(S3).009

Suryani, M., Mardiah and Suprayatmi, M. (2017). Addition of graviola leaves (*Annona muricata*) extract into roselle *(Hibiscus sabdariffa*) jelly drink. *Jurnal Agroindustri Halal*, 3(1), 33–40. https://doi.org/10.30997/jah.v3i1.689

Tanna, B., Choudhary, B. and Mishra, A. (2018). Metabolite profiling, antioxidant, scavenging and anti-proliferative activities of selected tropical green seaweeds reveal the nutraceutical potential of *Caulerpa* spp. *Algal Research*, 36, 96-105. https://doi.org/10.1016/j.algal.2018.10.019

Tapotubun, A.M., Matrutty, T.E., Riry, J., Tapotubun, E.J., Fransina, E.G., Mailoa, M.N., Riry, W.A., Setha, B. and Rieuwpassa, F. (2020). Seaweed *Caulerpa sp.* position as functional food. *IOP Conference Series: Earth and Environmental Science*, 517, 012021. https://doi.org/10.1088/1755-1315/517/1/012021

Tensiska, T., Marta, H., Cahyana, Y. and Amirah, N.S. (2017). Application of encapsulated anthocyanin pigments from purple sweet potato (*Ipomoea batatas* L.) in jelly drink. *KnE Life Sciences*, 2(6), 482–493. https://doi.org/10.18502/kls.v2i6.1069

Trilaksani, W., Setyaningsih, I. and Masluha, D. (2015). Formulation of red seaweed and Spirulina platensis Based jelly drinks. *Indonesian Journal of Fisheries Processing*, 18(1), 74–82. https://doi.org/10.17844/jphpi.2015.18.1.74

Wei, K., Ma, C., Sun, K., Liu, Q., Zhao, N., Sun, Y., Tu,

K. and Pan, L. (2020). Relationship between optical properties and soluble sugar contents of apple flesh during storage. *Postharvest Biology and Technology*, 159, 111021. https://doi.org/10.1016/j.postharvbio.2019.111021

Winarti, S., Sarofa, U. and Rodiyah, K.F. (2018). Karakteristik jelly drink sinbiotik dari susu kedelai dan ekstrak buah naga merah (*Hylocereus polyrhizus*). *Agrointek*, 12(1), 61–72. [In Bahasa Indonesia]. https://doi.org/10.21107/agrointek.v12i1.3806

Yamashita, C., Chung, M.M.S., dos Santos, C., Mayer, C.R.M., Moraes, I.C.F. and Branco, I.G. (2017). Microencapsulation of an anthocyanin-rich blackberry (*Rubus* spp.) by-product extract by freeze-drying. *LWT-Food Science and Technology*, 84, 256-262. https://doi.org/10.1016/j.lwt.2017.05.063

Zahra, N., Kalim, I., Saeed, M.K., Mumtaz, Z., Amjad, N., Alim-un-Nisa, Hina, S., Masood, S., Ahmed, I. and Ashraf, M. (2017). Effect of natural and synthetic dyes on human health. *International Research Journal of Biological Sciences*, 6(10), 23–29.