

Development of Herbal Syrup from Ginger (*Zingiber officinale*), Lemongrass (*Cymbopogon citratus*), Seaweed (*Kappaphycus striatum*), and Beetroot (*Beta vulgaris* L.)

Mansoor Abdul Hamid^{1,2}, Han Fei Loh^{2,*}, Sugiyanto³, Moh. Mahfud Effendi⁴, Akhsanul In'am⁴

¹Food Security Research Group, ²Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia,

³Mathematics Department, Faculty of Science and Technology, Universitas Islam Negeri Sunan Kalijaga, Indonesia,

⁴Department of Mathematics Education, Universitas Muhammadiyah Malang, Indonesia. Tel. +6019-8127369, Fax. +6088-320259.

Corresponding author*

chot@ums.edu.my

Abstract: The traditional method of herbal syrup production is by simmering a mixture of sliced herbs for several hours before undergoing a straining process to utilize the liquid parts. The usage of fresh herbs and this simmering process made the product inconsistent in quality. Therefore, in this study, ginger and lemongrass have been used in powder form, and seaweed, and beetroot were added to study they effects on the quality of the herbal syrup. Nine formulations of herbal syrup were developed, where all the formulations set with a fixed amount of ginger and lemongrass powder at 2.4% and 1.0%, respectively. The percentage of seaweed and beetroot used ranged from 1.5% to 2.5% and 0.5% to 1.5%, respectively. The best formulation was selected based on ranking and hedonic of sensory evaluation, as well as its physicochemical properties. Results showed that formulation 3, which consisted of 2.4% ginger, 1.0% lemongrass, 1.5% seaweed, and 1.5% beetroot, was chosen as the best formulation with a brighter color, significantly higher ($p < 0.05$) total soluble solid (49.70 ± 0.06 brix), and viscosity (1143.33 ± 1.15 cp) due to the addition of seaweed. Furthermore, the F3 sample also took significantly longer ($p < 0.05$) (80 min) to show sedimentation. Proximate values of F3 were significantly higher ($p < 0.05$) in ash ($3.36 \pm 0.22\%$), protein ($0.39 \pm 0.02\%$), and crude fiber ($6.22 \pm 0.11\%$), but lower in carbohydrates ($46.22 \pm 0.25\%$). F3 has showed a significantly higher ($p < 0.05$) in antioxidant activity on DPPH scavenging power compared to control with 85.73 ± 0.96 and 51.19 ± 0.89 respectively.

Keywords: herbal syrup, sensory evaluation, physicochemical properties, proximate value, antioxidant activity.

Introduction

Malaysia is a country with tropical rainforests which contains about 2000 plant species that have medicinal properties and provide health benefits (Malaysian Investment Development Authority, 2019). According to the World Health Organization (WHO, 2004), approximately 80% of the world's population use traditional herbal medicine as their primary form of healthcare. The growth of the local herbal industry and the use of herbs are increasing all over the world, including Malaysia. Herbal products which are composed of herbs, herbal preparations, or completed herbal products with active components derived from plant materials or plant parts with active compounds such as flavonoids, carotenoids, alkaloids and others in the

herbal products provide many health benefits to humans (Wang *et al.*, 2022).

A syrup made from herbs or known as jamu was traditionally made by using honey or sugar as a sweetener. In accordance with the Malaysian Food Regulation 1985 (Malaysian & International Law Book Services, 2021), the sugar concentration cannot be less than 35% to prevent the growth of microorganisms. Ginger (*Zingiber officinale*) is one of the most significant and popular herbs in the world. It is primarily used in food as a spice and flavour as it contains a lot of oleo resins which greatly enhances the flavour and spiciness of foods. Besides, ginger has long been used in traditional oriental medicine to warm the stomach, stimulate perspiration and treat colds. Ginger is antiemetic, anti-inflammatory, anti-ulcer, anti-platelet, and

antioxidant, according to clinical trials (Wang, 2020). Many scientific studies have also demonstrated the anticancer, antibacterial, antifungal, hypoglycemic, and anti-atherosclerotic properties of ginger (Prasad & Chandra, 2022).

Lemongrass contents of citral, the primary constituent of the essential oil, is what gives the herb its citrus flavour, therapeutic benefits, and medicinal uses (Khan, 2022). Lemongrass's antiseptic, antibacterial, antifungal, and anti-inflammatory qualities make it a popular ingredient in pharmaceutical processes. Lemongrass has also traditionally been used to ease pain and lower fever. Moreover, lemongrass contains monoterpenoid components that exhibit antioxidant properties (Faheem et al., 2022). In this study, ginger and lemongrass will be applied in combination. This action is frequently employed due to their complementing flavour profiles in combination and also its can safely lower blood sugar levels and exhibit antibacterial properties ((Christy et al., 2022). Furthermore, they work to reduce nausea and indigestion. Seaweed is easily accessible because it is grown commercially in Sabah and *Kappaphycus striatum* species that rich in carrageenan was utilized in this study as a thickening agent. This seaweed is abundant in vitamins, minerals, proteins, fiber, trace elements, and bioactive compounds (Peñalver, et al., 2020). Previous studies indicated that the unattractive colour of herbal syrup products was the main problem that caused low acceptability of the product. Therefore, beetroot (*Beta vulgaris L.*) was chosen to improve the product's appearance due to its reddish-purple colour of pigment named betalain and always used in food as a natural colorant (Sadowska-Bartosz & Bartosz, 2021). Beetroot is also a root vegetable with high bioactive components, including betalains, polyphenols, flavonoids, ascorbic acid, and carotenoids, that promotes good health (Chhikara et al., 2019). Hence, beetroot has made a significant contribution

to the creation of functional food products in the industry (Bangar et al., 2022).

This study aims to investigate the acceptance, physicochemical and nutritional properties of herbal syrup made from ginger, lemongrass, seaweed and beet root. Selected of best formulation was done based on its acceptability through sensory evaluation, and this formulation was then analyzed its nutritional properties and antioxidant activity.

Materials and Methods

Materials

Ginger, lemongrass and beetroot were purchased from local market, whereas seaweed was purchased from Wet Market Kota Kinabalu, and sugar (99% sucrose) was purchased from retail shop around Kota Kinabalu, Sabah, Malaysia.

Methods

Preparation of Powder

All the materials were washed and dried using a drying cabinet set at 65 °C until the samples reached constant weights. Then, the dried materials were ground into fine powder.

Sample Preparation

The preparation of herbal syrup was referred to Tewari and Kumar (2014) with minor modifications. All ingredients were weighed separately based on percentage in accordance to the formulations. Sugar was added into a water-containing pot and stirred properly until boiling. This was followed by the addition of ginger and lemongrass powder and subsequently, beetroot powder and seaweed were added. The mixture was continuously stirred to produce an even and homogenized solution until it reached 35 brix. The mixture was cooled before being poured into sterile containers and covered with lid. The sample for each formulation was prepared based on Table 1.

Table 1. Formulation for the development of herbal syrup

Formulation	Percentage (%)				
	Ginger powder	Lemongrass powder	Seaweed powder	Beetroot powder	Sugar
Control	2.40	1.00	-	-	48.30
F1	2.40	1.00	1.50	0.50	48.30
F2	2.40	1.00		1.00	48.30
F3	2.40	1.00		1.50	48.30
F4	2.40	1.00	2.00	0.50	48.30
F5	2.40	1.00		1.00	48.30
F6	2.40	1.00		1.50	48.30
F7	2.40	1.00	2.50	0.50	48.30
F8	2.40	1.00		1.00	48.30
F9	2.40	1.00		1.50	48.30

Sensory Evaluation

A ranking sensory test was conducted by recruiting fifty panels to get the three most preferable formulations. Then, hedonic sensory test which involved the three selected formulations and the control formulation was carried out. The hedonic sensory test was conducted by taking fifty undergraduates from the Faculty of Food Science and Nutrition, Universiti Malaysia Sabah (UMS). The scale used included be dislike extremely (1), dislike very much (2), dislike moderately (3), dislike slightly (4), neutral (5), like slightly (6), like moderately (7), like very much (8) and like extremely (9). The attributes tested in this test were colour, taste, aroma, viscosity, aftertaste and overall acceptance.

Physicochemical Analysis of Herbal Syrup Formulations

The physicochemical analysis was carried out on control sample and all nine formulations in triplicate for the selection of the best formulation. Parameters such as pH, colour, viscosity, total soluble solid (brix) and sedimentation time were assessed. pH value was determined by pH meter, colour of the sample was determined by Hunter Lab, total soluble solid (brix) was determined by using refractometer. The viscosity of the syrup was determined by using a Brookfield viscometer with RV-04 and 100 rpm. A sedimentation time test was carried out using a simple method referred to Agrawal and Karthikeyan (2014) with modifications. 100 ml of the sample was poured into a container, shaken and set aside. Then, all

samples were checked every 10 min up to 2 hours for any sedimentation.

Proximate Analysis

Proximate analysis was carried out on the control sample and the best formulation is as follow the AOAC method. The analysis includes determination of content of moisture, ash, crude protein, crude fat, crude fiber and carbohydrates. Three replications were performed for each to provide an average value.

Analysis of antioxidant activity

Determination of the antioxidant activity of herbal syrup products was measured using the [1,1-diphenyl-1-picrylhydrazyl] (DPPH) method referred to Oana-Viorela *et al.* (2017) with slight modifications. A 0.1mM DPPH solution was made by dissolving 39.4 mg of DPPH in 1000ml of methanol. 3.00 ± 0.02 g of the sample was mixed with 30 ml of methanol and put into a water bath shaker (250 rpm for 1 hr) and centrifuged (6000 rpm for 10 min). 1ml of supernatant was pipetted and mixed with 1ml of DPPH methanol solution. The mixture was incubated in a dark room for 30 min and then the absorbance was measured at 517 nm using a UV-VIS Spectrophotometer. The blank sample was methanol only while the control was a solution of 1 ml of DPPH with 1 ml of methanol without sample. The result was determined by using equation 1:

$$\text{Antioxidant activity (\%)} = \frac{A^0 - A^1}{A^0} \times 100\% \quad \text{----- (1)}$$

Where,

A^0 = Absorbance of control (Absorbance of DPPH + methanol)

A^1 = Absorbance of sample (Absorbance of DPPH + sample)

Statistical analysis

Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 28 with significance at $p < 0.05$. Data of ranking sensory evaluation test data was analyzed by using Friedman test and one-way ANOVA test with Tukey post hoc test. Hedonic sensory evaluation test data and physicochemical analysis were subjected to one-way ANOVA test with Tukey's post hoc test. Meanwhile, test data comparing the best formulation with the control sample was analyzed using an independent sample t test. Data of storage study was analyzed by one-way ANOVA with Tukey's post hoc test.

Results and Discussion

Sensory evaluation acceptance

Based on the data from ranking test, it was found that there was no significant difference ($p > 0.05$)

between the control formulation, F2, F3 and F6. All these formulations were then chosen and proceeded to hedonic sensory test. All these formulations gave higher ranking due to the concentration of beetroot powder added which affected positively the colour, taste and overall acceptance. These results showed that beetroot can affect sensory acceptance and is suitable to be used in producing herbal syrup.

Formulation F3 distinguished itself significantly ($p < 0.05$) from F2, F6, and the control sample from the aspect of colour. The control sample had the lowest mean score, whereas F3 had the highest meanscore. This finding suggests that the panellists preferred the reddish-purple herbal syrup over the yellow-coloured control sample. There was a significant difference between F3 and F6 and the control sample ($p < 0.05$) in terms of taste. F3 and F2 did not differ significantly ($p > 0.05$). Nonetheless, F3 (6.84 ± 1.27) had a higher mean score than F2 (6.04 ± 1.48). This indicates that the panellists favoured F3's taste over F2's. This might be due to the higher percentage of beetroot used which was believed to lessen the strong flavour of ginger since F3 had a higher percentage of beetroot (1.5%) than F2 (1.00%). F6 had the lowest mean score of all attributes indicated that the greater percentage of seaweed in formulation compared to F2 and F3 that resulted in a stronger fishy that that appeared to be unfavourable to the panellists. The details of all the attributes vales as shown in Table 2.

Table 2. Hedonic sensory mean scores of control and herbal syrup formulations

Attributes	Sample			
	Control	F2	F3	F6
Colour	5.62 ± 1.84c	6.50 ± 1.15b	7.28 ± 1.29a	6.52 ± 1.33b
Taste	5.98 ± 1.74b	6.04 ± 1.48ab	6.84 ± 1.27a	5.12 ± 1.86c
Aroma	5.96 ± 1.50bc	6.12 ± 1.80b	7.22 ± 1.09a	5.36 ± 1.31c
Viscosity	5.84 ± 1.53bc	6.42 ± 1.26ab	6.60 ± 0.90a	5.72 ± 1.37c
Aftertaste	5.46 ± 1.74b	5.64 ± 1.99ab	6.42 ± 1.65a	5.36 ± 1.51b
Overall Acceptance	5.72 ± 1.51b	5.84 ± 1.58b	7.12 ± 1.36 a	5.64 ± 1.06b

*Values are expressed as mean ± standard deviation with alphabet.

There was a significant difference among all the samples ($p < 0.05$) from the aspect of aroma. F3's aroma was preferred by most of the panellists while lowest preference of aroma was seen in F6.

Through this result it can be found that panellists preferred formulations that contained lesser amount of seaweed since F3 had a lower content of seaweed (1.5%) as compared to that of F6 (2.0%).

F2 and F3 significantly differed from the F6 sample ($p < 0.05$) from the view of viscosity. It is seen that F3 had the greatest mean score and followed by F2. The sole difference between F2 and F3 formulations was the amount of beetroot powder. The solute content in both formulations was the reason to this circumstance as F3 had a slightly higher viscosity than F2 due to its higher solute concentration. It is because more energy is required to translate or spin these molecules in solution, the viscosity will increase as the concentration of solutes rises (Yadav *et al.*, 2010).

F3 showed a significant difference ($p < 0.05$) in aftertaste attribute compared to F6 and the control sample but no significant difference ($p < 0.05$) with F2. However, the mean score of F3 was higher than F2. Since ginger has a strong hot and spicy aftertaste, higher amount of beetroot used in F3 (1.5%) was believed to be able to reduce the strong aftertaste of ginger and make it more acceptable to the panellists. F6 got the lowest mean score among all the formulations and this can be attributed to the highest proportion of seaweed used compared to F2 and F3. The results of overall acceptability revealed a significant difference between F3 and the control, F2 and F6 ($p < 0.05$). The mean score of F3 was the greatest while the mean score for F6 was the lowest. This demonstrated the significant

mean score difference between F3 and F6, showing the panelists' lowest overall acceptability to F6.

Physicochemical properties

The detail of physicochemical properties of all herbal syrup formulations as shown in Table 3. The control sample showed a significant difference ($p < 0.05$) as compared to the other formulations in pH. According to Ediaty *et al.* (2019), the pH value of the herbal syrup is usually in the range between 4.0 - 6.0. The [6]-gingerol compound found mainly in ginger is acidic and stable between pH 1 - 7 (Bhattarai *et al.*, 2001). In addition, betacyanin found in beetroot is also slightly acidic and stable between pH 3 - 7 (Herbach *et al.*, 2006). The pH of all formulations met the criteria as a syrup. All samples showed a significant difference ($p < 0.05$) from one another in total soluble solids. According to Malaysian Food Regulations 1985, the syrup must be a liquid made up of drinkable water and not less than 35% of sugar, glucose, high fructose corn syrup, or a mix of both. This standard was met by all formulation samples. Nonetheless, brix value increased from F1 to F9 due to the inclusion of beetroot and seaweed, both of which contain mainly sucrose (Bavec *et al.*, 2010) and carrageenan that can contribute to the brix value. A study by Sharma *et al.* (2019) found that the brix value increases when beetroot content increases.

Table 3. Physicochemical properties mean scores of different formulations of herbal syrup

Formulation	Physicochemical Properties					
	pH	TSS(Brix)	Colour			Viscosity(cp)
			L*	a*	b*	
Control	5.69±0.01 ^a	46.8±0.06 ^j	36.33±0.05 ^a	5.59±0.03 ⁱ	30.47±0.11 ^a	1003.40±0.53 ^j
1	5.35±0.01 ^{bc}	49.0±0.03 ⁱ	11.84±0.01 ^b	21.24±0.07 ^f	12.67±0.17 ^b	1120.00±1.00 ⁱ
2	5.40±0.07 ^{bc}	49.4±0.00 ^h	10.14±0.13 ^d	23.93±0.07 ^c	8.34±0.32 ^d	1130.67±1.15 ^h
3	5.46±0.05 ^b	49.7±0.06 ^g	9.67±0.01 ^{de}	24.81±0.04 ^a	8.26±0.14 ^d	1143.33±1.15 ^g
4	5.30±0.03 ^{cde}	50.5±0.06 ^f	10.95±0.06 ^c	20.93±0.09 ^g	10.37±0.33 ^c	1175.33±0.58 ^f
5	5.30±0.01 ^{cde}	51.3±0.12 ^e	9.37±0.26 ^e	22.21±0.07 ^e	7.74±0.10 ^d	1186.67±1.16 ^e
6	5.26±0.03 ^{def}	50.8±0.00 ^d	8.04±0.47 ^f	24.29±0.07 ^b	8.46±0.18 ^d	1199.33±1.53 ^d
7	5.15±0.02 ^f	51.1±0.06 ^c	9.51±0.08 ^e	20.56±0.06 ^h	10.64±0.54 ^c	1229.67±1.16 ^c
8	5.30±0.07 ^{cde}	51.4±0.12 ^b	8.15±0.16 ^f	22.18±0.08 ^e	10.07±0.33 ^c	1239.00±1.00 ^b
9	5.21±0.07 ^{ef}	51.8±0.06 ^a	7.10±0.08 ^g	23.44±0.05 ^d	8.04±0.40 ^d	1255.33±1.16 ^a

*Values are expressed as mean ± standard deviation with different alphabet indicated significantly different.

All samples had positive L^* , a^* and b^* values. The control had the highest L^* value, whereas F9 had the lowest L^* value. This clarifies why F9 was darker than the other samples. This is resulted from the different amounts of seaweed and beetroot used. The control sample only contains ginger and lemongrass, which gives the product a yellow tint, whereas the F9 contained the highest amounts of beetroot and seaweed. Control had the lowest a^* value whereas F3 had the highest a^* value. This explains that F3 had more redness compared to the other samples. This is due to the highest proportion of beetroot in F3, F6 and F9. According to Kohajdová *et al.* (2018), increasing the content of beetroot will increase the value of a^* due to the presence of betalain pigments. All samples had positive b^* values, indicating that yellowness was present in all samples. The control had the greatest b^* value (30.47 ± 0.11) whereas the lowest b^* value was observed in F9 (8.04 ± 0.40). The control was more yellow than the other samples as only ginger and lemongrass were used while beetroot and seaweed were added in all the other formulations.

Significant difference ($p < 0.05$) in viscosity was detected in all formulations. F9 had the highest viscosity because it contained the highest proportion of seaweed and solids compared to other formulations. Seaweed contains carrageenan especially kappa carrageenan, which is widely used as thickening agent to provide textural functionality, especially for gelling and viscosity in various food applications (Hotchkiss *et al.*, 2016). According to Nassri and Schey (2020), a liquid's viscosity can be raised by adding a thickening agent. Sedimentation started after 70 minutes where by addition of 1.5% seaweed began to settle at 80 minutes, the sample containing 2.0% seaweed settled at 90 min while the sample containing 2.5% seaweed settled at 100 min. This had proven that the addition of seaweed as a thickening agent can slow down the sedimentation time as shown in Figure 1. Since higher viscosity results in a longer sedimentation time (Momen- Heravi *et al.*, 2012), it can be observed that there is an increasing trend of sedimentation time from control to F9 since viscosity increased from control to F9.

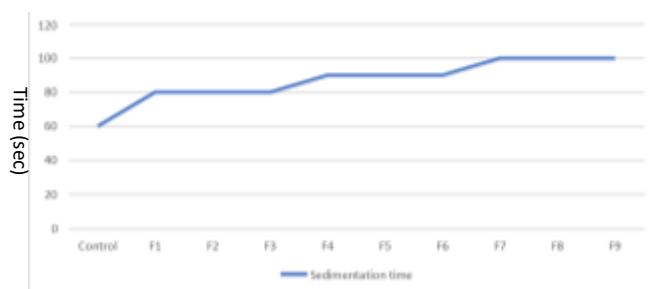


Figure 1: Sedimentation time of all herbal formulations

The most acceptable ginger and lemongrass herb syrup formulation was chosen through the sensory test and physicochemical analysis. According to the physicochemical analysis, all the sample formulation achieved the acceptable range of physicochemical characteristics. Throughout the ranking and hedonic sensory test, F3 was chosen as the best formulation based on higher acceptance in most of the attributes tested.

Proximate analysis and antioxidant activity analysis

Both formulations showed a significant difference ($p < 0.05$) in moisture content. The moisture content of F3 was higher compared to control without seaweed and beetroot. Similar results can be seen in the study of Amin *et al.* (2022), due to its water-holding capacity, which explains how the hydrocolloid can bind a lot of water, the presence of seaweed will enhance the product's moisture content (Hamid *et al.*, 2019). This is due to the hydrocolloid carrageenan's free OH^- ions, which have the ability to bind to water (Amin *et al.*, 2022). F3 had a higher ash content value and significantly differs ($p < 0.05$) from control sample. Minerals are abundant in herbs (Volpe *et al.*, 2015). The rise in ash content has been facilitated by ginger, lemongrass, seaweed, and beetroot. Ginger is abundant in manganese, magnesium, potassium, calcium, sodium, iron, zinc, phosphorus and copper (Ajayi *et al.*, 2013). Moreover, lemongrass contains a variety of minerals, including calcium, potassium, magnesium, and iron (Frey, 2018). Seaweed also contains 4.80% ash (Adharini *et al.*, 2019). Beetroot is also high in magnesium, potassium, iron, and manganese (Deshmukh *et al.*, 2018).

Table 4: Nutritional content and antioxidant activity (DPPH) of control sample and best formulation (F3)

Nutrient	Percentage (%)	
	Control sample	F3
Moisture	41.52 ± 0.39b	43.07 ± 0.13a
Ash	1.65 ± 0.08b	3.36 ± 0.22a
Protein	0.19 ± 0.01b	0.39 ± 0.02a
Crude Fat	0.75 ± 0.09a	0.81 ± 0.15a
Crude Fibre	4.13 ± 0.13b	6.22 ± 0.11a
Carbohydrates	51.75 ± 0.53a	46.22 ± 0.25b
Antioxidant activity (DPPH)	51.19 ± 0.89b	85.75 ± 0.96a

*Values are expressed as mean ± standard deviation with alphabet.

The results revealed a significant difference in protein content between the two formulations ($p < 0.05$). In comparison to the control, F3 had a higher protein level. Beetroot and seaweed both provide a slight amount of protein. Seaweed (*Kappaphycus striatum*) has 0.73% protein according to Adharini *et al.* (2019) while beetroot has 1.61% protein according to Deshmukh *et al.*, 2018. Beetroot can improve crude protein content, as demonstrated by studies by Abdo *et al.* (2021). There was a significant difference ($p < 0.05$) between both formulation in crude fat content. F3 had a higher crude fat content than control. This might be due to the increased fortification of seaweed and beetroot. According to a study by Yadav *et al.* (2016), the addition of beetroot increased the fat in the product. Besides, *Kappaphycus striatum* has a very low fat content supported by a study of Adharini *et al.* (2019). Hence, the beetroot may have contributed more to the increase in fat in the F3 sample.

A significant difference ($p < 0.05$) in the crude fibre content was observed between the control and F3. F3 had a greater crude fibre content than the control. Ginger is a fiber-rich herb (Hayes, 2020). Ginger has 2.4% fibre, as claimed by Bag (2018). Ginger powder contains between 4.9 and 5.6% crude fibre, according to Sangwan *et al.*, 2014. Lemongrass is rich in holocellulose (68.51%), α -cellulose (35.0 - 44.16%), and lignin (17.39 - 27.38%) (Kaur & Dutt, 2013). *Kappaphycus striatum* contains 1.18% fibre according to a study by Adharini *et al.* (2019). According to Deshmukh *et al.* (2018), beetroot has 2.8% fibre. Research by Panditrao and Yadav (2022) also showed an increase in crude fibre content as a result of

increased beetroot content. The carbohydrate content of the control was $51.75 \pm 0.53\%$ while for F3 was $46.22 \pm 0.25\%$. Both samples showed a significant difference in this content ($p < 0.05$).

F3 showed a significantly higher ($p < 0.05$) antioxidant activity compared to the control sample. The possibility of the difference is due to the antioxidant property from beetroot and seaweed found in F3. Besides, herbs including ginger and lemongrass are proven to be powerful antioxidants. Ginger contains bioactive substances called gingerols, particularly 6-gingerol in fresh ginger and 6-shogaol in dried ginger. 6-shogaol was shown to have the excellent anti-inflammatory and antioxidant effects. Lemongrass is another fragrant herb with antioxidant qualities (Kielsing & Prudencio, 2019). Many advantageous bioactive substances, including flavonoids, anthocyanins, alkaloids, tannins, terpenes, phenolics, saponins and catechins are present in lemongrass extracts and essential oils (Tavares *et al.*, 2015).

Beetroot is also a great source of antioxidants as it contains flavonoids, ascorbic acid, carotenoids and phenolic acids (Wootton-Beard & Ryan, 2011). Additionally, beetroot contains betalain, a highly bioactive pigment (Clifford *et al.*, 2015). Numerous studies have illustrated that betalain has a strong antioxidant capacity (Vidal *et al.*, 2014). Thus, the addition of beetroot content in the product can increase antioxidant activity. This situation can also be seen in the study by Sharma *et al.* (2020). In a study by Nurshahida (2020), the ability of antioxidant chemicals to neutralize radical cations was used to demonstrate the potential of seaweed and its usage as antioxidants. Simplest form, the

antioxidant activity of syrup products can be increased by adding beetroot and seaweed.

Conclusions

The transformation of ingredients into powder form made its easier to control and maintained its concentrations. Formulation F3 which consists of 2.4% ginger powder, 1.0% powder, 1.5% beetroot, 1.5% seaweed and 48.3% sugar has been chosen as the best formulation based on sensory test and physicochemical test. Apart from having a higher ash and protein content, F3 also showed a greater antioxidant property as compared to the control.

Conflict of Interest: The authors declare that there are no conflicts of interest concerning the publication of this article.

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