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Stability of antioxidant phlorotannin beverage originated from *Sargassum serratum* on the storage time and temperature

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ABSTRACT

Stability of product quality is usually the most interest of technologist. The quality of beverage product is evaluated through colour value, biosubstance content and bioactivities. Therefore, total colour density, anthocyanin colour value, tannin colour value, polymer colour value, phlorotannin content and total antioxidant, reducing power and DPPH free radical scavenging activity of beverage were evaluated during 12 months of storage at room and cold temperature for the phlorotannin enriched beverage with antioxidants. The beverage originated from marine algae Sargassum serratum in initial day, the phlorotannin content with activities (total antioxidant, reducing power and DPPH free radical scavenging) of 200ml of beverage orderly corresponded to 30 ± 0.01 mg phloroglucinols with activities (206.272 ± 0.233 mg ascorbic acid, 301.027 ± 0.378 mg $FeSO_4$, and 67.45 ± 0.1%). Total colour density, tannin colour value, polymer colour value correspond to 0.245 ± 0.002; 0.27 ± 0.001; 114.7 ± 0.01, respectively. After 12 storage months, the phlorotannin content of beverage was 66 - 79%; activities of total antioxidant, reducing power and DPPH free radical scavenging were corresponded to 63.7 - 76.87%, 64.52 - 77.01% and 66.57 - 78.72% respectively, compared at initial day. Phlorotannin with antioxidant activities-rich beverage origin in marine algae Sargassum can be completely the vogue on the market.

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1 INTRODUCTION

Free radical is the originization of aging and causes over 60 diseases in human body such as atherosclerotic, cancer, Alzheimer's, Parkinson's, cataracts, diabetes, non-cause high blood pressure, cirrhosis, etc. Free radicals are generated in the human body due to stress, diet, etc. Free radicals exist more in the elderly than in the young. They destroy the human body according to the mechanism of the cell membrane oxidation, attack mitochondria and interfere in toxins removing as well as the absorption of food and oxygen. At the same time, the hormones and enzymes in the body are impaired by free radicals, leading to non-development body (Boveris and Puntarulo, 1998).

The natural substances derived from marine plants have been strong interest in recent years, and their

activities were investigated, i.e. antioxidant, antibacterial, anticancer, antivirus. The active ingredients are considered to use in functional foods and drugs production. They have ability to reduce free radicals in the human body. One of the active ingredients concerned in the study, and its appearance is popular with plants, was determined to be phlorotannin/ polyphenols. Their bioactivities were diverse including antioxidant, antibacterial, antifungal, etc. (Petti and Scully, 2009). Phlorotannin/ polyphenol will help the body resist oxidative stress, cancer, heart, eye disease, diseases of aging, prevent putrefaction, steam generators and other disorders that impede the operation of the intestine (Petti and Scully, 2009).

Brown algae *Sargassum* in Vietnam has large reserve, wide distribution, diversity of species, estimated 10,000 dry tons/ years (Bui Minh Ly and Le Nhu Hau, 2010). Many studies shown that brown seaweed contains a lot of phlorotannin (20-250 mg/g dry algae) (Vu Ngoc Boi et al., 2017). Their molecular weight were ranged from 126 Da to 650 kDa (Pal Singh and Bharate, 2006). Phlorotannin has many different types of linkage, such as phenyl-phenyl, dibenzodioxin, etc with the basic unit as phloroglucinol (Pal Singh and Bharate, 2006). These things make diversity of the phlorotannin structure and biological activities as described above. Thus, antioxidant phlorotannin beverage derived from seaweed is necessary for human life. This beverage will contribute to improving the health of consumers and increasing value-added products.

Furthermore, an important issue in the development of food and beverage products is the stability of the product during processing and storage. High quality food from producing for consumption is always expected by consumers (Koivikko et al., 2007). The quality of food may change during storage due to the formulas and storage condition for beverage. Bioactive components will be lost and unwanted color changes will happen when preserve conditions of food and beverages is not sufficient (Kilcast and Subramaniam, 2011). Factors that can lead to the destruction of active ingredients in food were determined, for example enzymes, pH (Rahman, 2007; Goiato et al., 2014), temperature (Harbourne et al., 2008; Festuccia et al., 2012). The stability of bioactive compounds in food depends on preservation process, and their bioactive components.

Thus, this study focused presentation of the stability of colour valued, phlorotannin content, antioxidant activities of phlorotannin beverage according to storage life of 12 months at various conditions, 5 - 10^{o}C and room temperature.

2 MATERIALS AND METHODS

2.1 Materials

The beverage was processed according to the process technology which was described by Dang Xuan Cuong *et al*. (2015) are shown in Figure 1. The beverage was stored at 2 various conditions: the room temperature and 5 - 10^{o}C in plastic bottles. The bottles were sealed and checked for leaking. The volume of each bottle was 200 mL. Every month, six bottles were collected for analysis, three for each storage condition. A total of 675 bottles have been used for study.

The experiment lasted for 12 months, and measurement was done monthly. Sample volume of each experiment was 15 L. All materials of beverage were pasteurised and assimilated before the process of production. The times of assimilation were activated at 45^{o}C with stirring speed of 3,000 rpms. Each of 2nd and 3rd assimilation lasted for one minute. The 1st assimilation was for 5 minutes. In the assimilation time, all compositions were assimilated to become a homogeneous solution. The pasteurisation equation was as follows:

$$\frac{5-6-5}{80^{0}C}$$

Two hundred mL of beverages contained: 0.05% carrageenan, 0.05% xanthan gum, 0.04% ascorbic acid, 0.07% citric acid, 17.5% saccharose, 2g phlorotannin powder (30mg phloroglucinol equivalent), 0.03% sodium benzoate, and 0.03% potassium sorbate.

Phlorotannin powder was prepared by using spray drying method for extract collected from brown algae *Sargassum seratum*. The spray drying conditions were 110^{o}C of input temperature, 1 bar of pump pressure, and 10ml/ min of pump rate (Cuong *et al*., 2015).

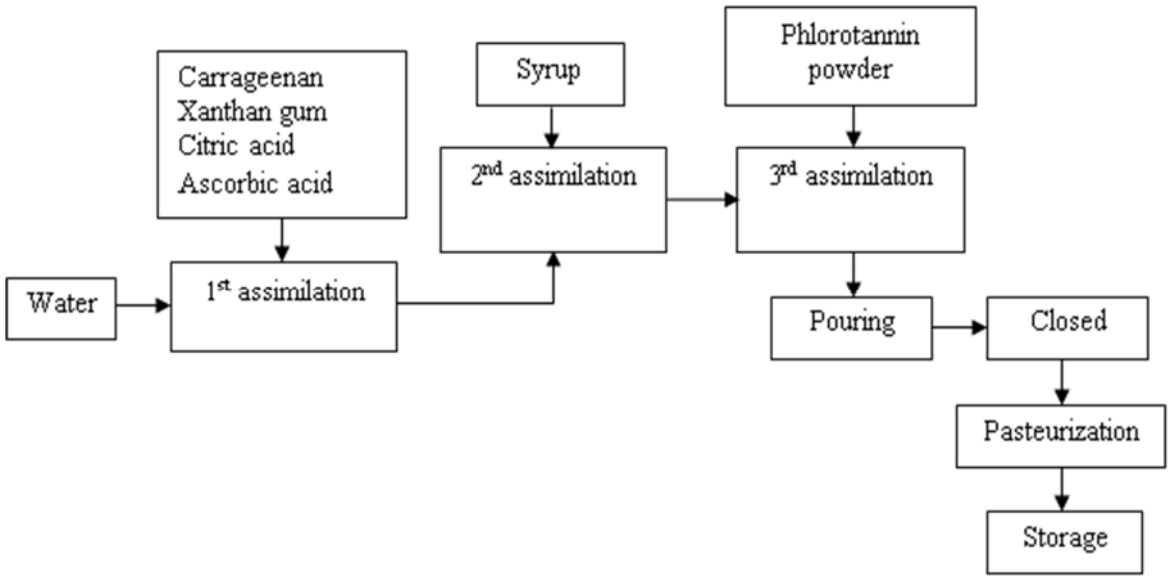

Fig. 1: The production process of beverage for the research of the beverage

2.2 Sensory evaluation

Based on Vietnamese standard of 3215-79, the point scale of 20 was used for the sensory estimation of phlorotannin-rich beverages. Important coefficient of the sense is shown in Table 1:

Table 1: Important coefficient of sensory assessment

Sense	Important coefficiency	
	Conversion (%)	In accordance with the scale of 20
Colour	30	6
Odor	20	4
Taste	25	5
State	25	5
Total	100	20

2.3 Quantification of total phlorotannin content

Phlorotannin/polyphenol content was quantified according to Swanson and Druehl (2002).

2.4 Determination of antioxidant activities

Total antioxidant activity (TA) was determined according to the method of Prieto *et al*. (1999) with ascorbic acid as a standard. Reducing power activity (RP) was determined according to the method of Zhu *et al*. (2002) with the standard of $FeSO_4$, and the method of Blois (1958) was used for the evaluation of DPPH free radical scavenging activity.

2.5 Evaluation of the beverage colour ingredients

The colour ingredients and colour value of beverage was determined follow the method of UF treatment, shown by Neslihan *et al*. (2005).

X, Y, Z values of beverage colour was measured by Konica machine, Japan. Calculation and conversion of X, Y, Z values was acted according to the method of Speranskaya (1959).

2.6 Quantification of bacteria number

Total yeast - mold number was accessed according to Vietnamese standard of 5166-90 (MOH, 1990a). Total aerobic bacteria number was evaluated according to Vietnamese standard of 5165-90 (MOH, 199b). Number Escherichia coli was quantified according to Vietnamese standard of 6846:2007 (MOST, 2007a). Number Coliform and S. Aureus was quantified according to Vietnamese standard of 4882:2007 (MOST, 2007a) and Vietnamese standard of 4830-1:2005 (MOST, 2005), respectively. Number Pseudomonas aeruginosa was identified in accordance with Vietnamese standard of 8881:2011 (MOST, 2011). Number Faecal streptococci and Cl. Perfringens was determined in accordance with Vietnamese standard of 6189-1:1996 (MOST, 1996), Vietnamese standard of 4991:2005 (MOST, 2005), respectively.

2.7 Heavy metals quantification

Arsenic, Hg, Cd and Pb were quantified in accordance with AOAC 957.22, TCVN 7604:2007 (MOST, 2007c), TCVN 7603:2007 (MOST,

2007d), TCVN 7602:2007 (MOST, 2007e), respectively.

2.8 Data analysis

The data was entered and processed with Microsoft Excel 2010 and SPSS.

3 RESULTS AND DISCUSSION

3.1 Evaluation of sensory and bacteria in the initial day

All bacteria were not found in the experimental beverage. The sensory quality of beverages was the highest value of 17.3 point. Beverages had brown-yellow, harmony of sweetly sour taste, good aftertaste, viscous status, no residue, no cloudiness (Figure 2). Brown-yellow colour is the nature colour of phlorotannin. Colour, phlorotannin content and antioxidant activities of beverages in 2 storage conditions were the same. The average value of phlorotannin content in 200 ml beverages were 30 ± 0.01 mg phloroglucinol equivalents.

Total antioxidant, reducing power and DPPH free radical scavenging activity were 206.272 ± 0.233 mg ascorbic acid equivalent/ 200ml, 301.027 ± 0.378 mg $FeSO_4$ equivalent/ 200ml and 67.45%, respectively. The colour of density, tannin and polymer orderly corresponded to 0.245 ± 0.002, 0.27 ± 0.001, 114.7 ± 0.01. Therefore, beverages meet the standards of Vietnam non-alcohol beverages, and the technology process fully fits the process of antioxidant phlorotannin beverages which originated from marine algae *Sargassum*. In addition, beverages can have the benefit in some diseases treatment. All materials were used to meet standards for food. The results of colour value measurement for the beverage are showed in Table 2.

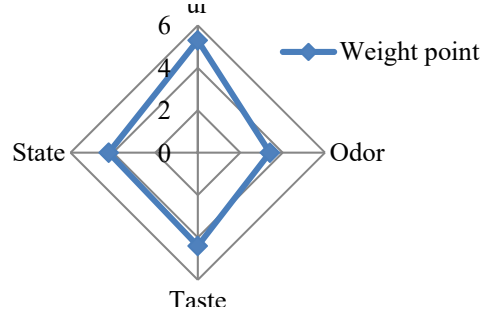

Fig. 2: Sensory quality of antioxidant phlorotannin beverage

Table 2: Values of beverage colour at various colour types

Order	Colour type	Colour values		
1	RGB 0-255	81.00	71.00	23.00
2	RGB 0-FF	51	47	17
3	RGB 0-0.1	0.31765	0.27843	0.09020
4	CMY 0-0.1	0.68235	0.72157	0.90980
5	XYZ	5.801	6.318	1.724
6	Yxy	6.318	0.41907	0.45637
7	CIE-L*ab	30.200	-2.113	29.186
8	CIE-L*CH	30.200	29.262	94.140
9	CIE-L*uv	30.200	8.478	26.767
10	HunterLab	25.135	-2.788	13.527
11	Illuminant	D65		
12	Observer	10°(1964)		

RGB: an additive color model includes red, green and blue *light*

CMY: Cyan, magenta, and yellow light

XYZ: an extrapolations of RGB

*CIE-L*ab: a color space, inside, L: lightness, a: the red/green coordinate, b: the yellow/blue coordinate*

*CIE-L*CH: a CIELab cube color space, inside, Cartesian coordinates a*, b* was replaced by chroma and hue colour*

*CIE-L*uv: A modification of "CIE 1931 XYZ"*

Colour values of beverage were performed on various types of colour, such as RGB, CMY, XYZ, CIE, HunterLab. The results will be advantaged for industry production of beverage, because the colour value will be concrete parameter for various production batches. Quality uniformity of beverage will be happened when the sensory quality of product was evaluated by the machine. If sensory quality of beverage was evaluated by eye, the accuracy of sensory results will be not good. RGB colour was basic colour, and they were acronym of red, green and blue. Hunter L, a, b colour scale is more uniform than CIE, XYZ colour scale. The understanding of beverage colour was easier when beverage colour was evaluated by using Hunter L, a, b colour scale. Thus, antioxidant phlorotannin beverage is good product of application, and active substance of beverage was extracted from marine algae. The application can

fully develop extensive into life. Beverage will be a new product of beverage processing field.

3.2 Evaluation of heavy metals, bacteria number, phlorotannin content, antioxidant activities and colour value according to the time and temperature storage for beverage

3.2.1 Heavy metals and bacteria in beverages

The analysing results showed that beverages did not contain Pb and Hg. It means that Pb and Hg did not exist in all ingredients in beverage. The other heavy metals such as Cd, As got the corresponding value of 0.001 ppm, 0.0015 ppm, respectively. Those criteria were smaller than 0.05 ppm, compared to Vietnam standard for non-ethanol beverages.

At cool temperature, beverages did not contain bacteria such as *Coliform, E. coli, Streptococci faecal, Pseudomonas aeruginosa, Staphycus aureus, Clostridium perfringens* and total mod - yeast. However, after 3 months of storage, total aerobic bacteria occurred in beverages, and beverages meet Ministry of Health's standard during12 months of storage. Total aerobic bacteria got 1.9 x 10^1 CFU/mL beverages after 12 months of storage, and according to QCVN 6-2:2010/BYT, there was 10^2 CFU/mL beverages for total aerobic bacteria (Table 3). Total aerobic bacteria were 2.7 x 10^1 CFU/mL after 12 months of storage when beverages were stored at room temperature. However, other bacteria, mod and yeast did not occur in beverages in 2 storage conditions. ANOVA and regression analysis showed that the number of bacteria changed 2-level regression function and interacted strongly with the storage time ($R^2 > 0.9$) (Fig. 3). Total aerobic bacteria of beverage in 2 other storage temperatures were not statistical signification ($p > 0.05$).

Table 3: Bacteria number and heavy metals of beverages according to the time and temperature storage

Order	Bacteria	Total aerobic bacteria		*Escherichia coli*		*Coliforms*		*Clostridium. Perfringens*		*Staphylococcus. faecal,*		*Pseudomonas aeruginosa*		*Staphycus aureus*		Total mod - yeast	
	ST / TS	5 – 10°C	RT	5 – 10°C	RT	5 – 10°C	RT	5 – 10°C	RT	5 – 10°C	RT	5 – 10°C	RT	5 – 10°C	RT	5 – 10°C	RT
1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	90	0.04	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	120	0.08	0.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	150	0.13	0.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	180	0.25	0.41	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	210	0.33	0.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	240	0.57	0.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	270	0.88	1.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	300	1.27	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	330	1.62	2.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	360	1.9	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-

"-" non detection; bacterial number unit: 10^2CFU/200mL

RT: room temperature; ST: storage temperature; TS: temperature storage

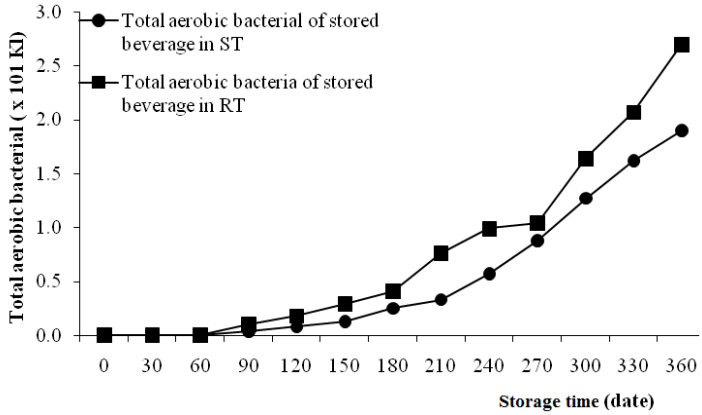

Fig. 3: Total aerobic bacterial of beverage according to storage time

Bhattacherjee *et al.* (2011) noticed that bacteria increased with the storage time as the pasteurisation of fruit juice at 75°C; however, bacteria only occurred, and increased after 9 months of storage. This study's results were suitable for previous publication. In addition, if concentration of preservatives in beverages is lower than 27/2012/TT-BYT, beverage still keeps over 12 months. This mean the materials used in the studied beverage also have antibacterial development.

Thus, beverages met Ministry of Health's standard in heavy metals content and bacteria number during 12 preservation months.

3.2.2 Phlorotannin content and antioxidant activities in accordance with the storage time

After 12 months of storage at the room temperature, total antioxidant, reducing power activity and phlorotannin content of beverages were decreased corresponding to 63.7%, 64.52%, and 66.57% respectively, compared to the initial beverages. DPPH free radical scavenging activity was decreased to 66.54% compared to the initial day (Table 4).

Table 4: Phlorotannin content and antioxidant activities of beverages according to the time and the temperature storage (data was expressed as mean ± SD, n = 3)

The storage time (month)	Phlorotannin content (mg phloroglucinol/ 200mL beverages)	Antioxidant activity		Phlorotannin content (mg phloroglucinol/ 200mL beverages)	Antioxidant activity	
		Total (mg ascorbic acid/ 200mL beverages)	Reducing power (mg $FeSO_4$/ 200mL beverages)		Total (mg ascorbic acid/ 200mL beverages)	Reducing power (mg $FeSO_4$/ 200mL beverages)
	The storage at the 5 – 10 °C temperature			The storage at the room temperature		
0	30	206.272 ± 0.233	301.027 ± 0.378	30	206.272 ± 0.233	301.027 ± 0.378
1st	29.521 ± 0.101	206.001 ± 0.100	300.867 ± 0.121	29.021 ± 0.143	205.815 ± 0.203	300.216 ± 0.205
2nd	29.175 ± 0.133	205.622 ± 0.120	299.154 ± 0.175	29.051 ± 0.174	205.004 ± 0.172	294.705 ± 0.351
3rd	28.836 ± 0.216	205.204 ± 0.133	281.013 ± 0.208	28.021 ± 0.218	203.306 ± 0.275	285.805 ± 0.264
4th	28.022 ± 0.172	200.471 ± 0.168	278.105 ± 0.206	27.822 ± 0.224	201.008 ± 0.282	278.113 ± 0.288
5th	27.573 ± 0.204	193.855 ± 0.187	272.231 ± 0.258	27.030 ± 0.250	199.361 ± 0.245	270.857 ± 0.315
6th	26.744 ± 0.115	188.912 ± 0.127	267.405 ± 0.185	26.224 ± 0.152	194.474 ± 0.158	269.104 ± 0.316
7th	26.087 ± 0.237	180.987 ± 0.342	262.184 ± 0.271	25.077 ± 0.284	187.691 ± 0.258	258.011 ± 0.284
8th	25.248 ± 0.108	173.085 ± 0.231	259.008 ± 0.306	24.207 ± 0.133	180.008 ± 0.302	247.403 ± 0.317
9th	24.515 ± 0.125	170.813 ± 0.212	254.510 ± 0.331	23.416 ± 0.152	172.115 ± 0.345	235.216 ± 0.311
10th	23.658 ± 0.132	165.281 ± 0.144	246.317 ± 0.302	22.646 ± 0.173	160.278 ± 0.184	225.658 ± 0.132
11th	22.816 ± 0.164	160.816 ± 0.164	238.060 ± 0.172	20.517 ± 0.128	147.063 ± 0.285	214.816 ± 0.269
12th	22.578 ± 0.142	154.872 ± 0.218	227.564 ± 0.301	19.677 ± 0.225	132.077 ± 0.286	196.271 ± 0.317

After 12 months of storage at 5 - 10°C temperature, activity of total antioxidant, reducing power and DPPH and phlorotannin content of beverages were decreased by 76.87%, 77.01%, 77.88% and 78.72%, respectively, compared to the initial day. It means that antioxidant activity and phlorotannin content of beverage were decreased from 11.28% to 23.13% compared to the initial day. The content of phenolic acid and flavonoid of the apple juice was decreased by 5 - 21% and 8 - 19% respectively after 11 months (Alper *et al.*, 2005). Kaempferol content of fruits decreased at all the temperature of the pasteurization

in 75°C after 9 months of storage (Bhattacherjee *et al*., 2011). Therefore, the percentage of phlorotannin content was decreased in the average, compared to the studies by Alper *et al*. (2005) and Bhattacherjee *et al*. (2011). The decrease depended on structure and content of polyphenol, the composition, and processing method of beverage.

It can be estimated that phlorotannin of beverages which has the origination of marine algae *Sargassum* was similar to polyphenol beverages of other plants. The analysis and the explanation showed that phlorotannin content were changed according to the storage time. In other words, redox processes have taken place in beverage according to the storage time (Koivikko, 2008). The changes were caused from the process of inner transformation which occur in beverage, and the variation should be continuously studied to enhance the stability of phlorotannin content and antioxidant activities in beverages.

3.2.3 Beverage colour value according to the storage time

After 8 months of storage at the 5 – 10°C temperature, colour value of beverages did not change. However, colour degree has some changes from 7th month in the beverage preserved at room temperature (Table 5). Bhattacherjee *et al*. (2011) showed that a browning degree of the fruit juices was increased with the storage time. Moreover, the browning degree of beverages during the storage time was also formed by the reaction of Maillard between sugar and amino acids and the metabolism of ascorbic acid (Shinoda *et al*., 2005). The reaction between dehydro ascorbic acid and α–amino acid also contributed to form the browning, (Kacem et al., 1987). However, D-galacturonic content increased in the browning process of apple, peace and pear juice, and these juices were not enzyme (Ibarz *et al*., 2008). Jain and Khurdiya (2009) noticed that enzyme was one of the causes of the browning process. Furthermore, browning degree was found as the fruit juice pasteurized at 75°C (Bhattacherjee *et al*. 2011). ANOVA and regression analysis showed that the changes of beverage colour value were in closely relation to the decreasing of phlorotannin content according to the storage time. They had an asymptotic trend of horizontal and the change followed 2-level regression model (R^2>0.85).

Table 5: Colour value of beverage on the storage time and temperature (data was expressed as mean ± SD, n = 3)

Storage time (month)	Total colour density	Polymer colour	Tannin colour	Total colour density	Polymer colour	Tannin colour
	The storage at the 5 – 10°C temperature			The storage at the room temperature		
0	0.245 ± 0.002	0.270 ± 0.001	114.700 ± 0.010	0.245 ± 0.002	0.270 ± 0.001	114.700 ± 0.01
1st	0.247 ± 0.001	0.278 ± 0.004	114.74 ± 0.020	0.249 ± 0.001	0.279 ± 0.002	114.750 ± 0.012
2nd	0.250 ± 0.003	0.280 ± 0.002	114.780 ± 0.010	0.252 ± 0.003	0.281 ± 0.003	114.784 ± 0.013
3rd	0.254 ± 0.001	0.283 ± 0.004	114.783 ± 0.021	0.257 ± 0.004	0.285 ± 0.002	114.785 ± 0.011
4th	0.257 ± 0.004	0.286 ± 0.003	114.786± 0.018	0.259 ± 0.003	0.288 ± 0.001	114.788 ± 0.014
5th	0.260 ± 0.001	0.290 ± 0.002	114.791 ± 0.013	0.263 ± 0.001	0.292 ± 0.004	114.794 ± 0.015
6th	0.263 ± 0.002	0.292 ± 0.001	114.794 ± 0.016	0.266 ± 0.004	0.295 ± 0.002	114.796 ± 0.012
7th	0.268 ± 0.003	0.297 ± 0.002	114.798 ± 0.012	0.270 ± 0.001	0.299 ± 0.001	114.802 ± 0.011
8th	0.274 ± 0.001	0.304 ± 0.005	114.805 ± 0.016	0.278 ± 0.002	0.307 ± 0.003	114.809 ± 0.019
9th	0.280 ± 0.004	0.310 ± 0.003	114.811 ± 0.017	0.284 ± 0.004	0.315 ± 0.002	114.813 ± 0.010
10th	0.287 ± 0.003	0.314 ± 0.001	114.816 ± 0.017	0.292 ± 0.001	0.318 ± 0.001	114.818 ± 0.016
11th	0.296 ± 0.002	0.318 ± 0.002	114.820 ± 0.018	0.299 ± 0.003	0.320 ± 0.003	114.824 ± 0.017
12th	0.314 ± 0.004	0.323 ± 0.002	114.825 ± 0.017	0.321 ± 0.004	0.325 ± 0.001	114.828 ± 0.018

In processing study, phlorotannin - rich beverage did not have neither protein nor amino acid because phlorotannin was extracted by using ethanol 96%. Carrageenan is formed by the units of galactose and 3,6-anhydrogalactose with the linkage of α-(1,3) and β-(1,4) glycosidic; xanthan gum is formed by the units of glucose, mannose and glucuronic acid; saccharose is formed by the units of glucose and fructose, D-galacturonic did not occur in the beverage (Yiu, 2006). At the same time, beverages did not also contain enzyme. Thus, antioxidant phlorotannin beverages were whitening, and the colour values were decreased according to the storage time. The whitening of beverages was closely related to phlorotannin content or polymer colour, and polymer colour contributes to total colour of the beverages.

Therefore, the data will be useful for production or research of the quality improvement of phlorotannin - rich beverages originated from marine algae *Sargassum*.

4 CONCLUSIONS

The beverage can be stored in 12 months in both conditions of storage. At room temperature and 5 – 10°C, after 12 months of storage, phlorotannin content, antioxidant activities and colour decreased to 63 - 79%, compared with the initial beverage. Antioxidant phlorotannin beverages orignated from marine algae *Sargassum* can widely be deployed in the market. However, it is necessary to investigate the extension of the storage time of the beverages.

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