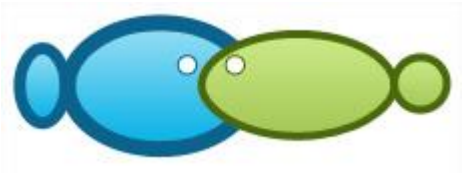

Antioxidant activity of tropical seaweed *Sargassum muticum* fucoidan

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Abstract. Synthetic antioxidants can have toxic and carcinogenic effects, thus an alternative source of natural antioxidants is needed. Fucoidan from seaweed is a source of natural antioxidants. The objective of this research was to determine the antioxidant activity of fucoidan from *Sargassum muticum* (Yendo) Fensholt from Alor Island, East Nusa Tenggara. Fucoidan extraction was carried out using distilled water at 85°C. The test parameters observed included: yield, total sugar content, sulfate content, functional group analysis and antioxidant activity with Radical Scavenging Activity (RSA) of the 1,1-diphenyl2-picrylhydrazyl (DPPH), ferric Reducing Antioxidant Potential (FRAP), and reducing power methods. The results showed that the fucoidan extract from *S. muticum* had a yield of 3.87±0.13%, the total sugar content of 64.34±2.10% and the sulfate content of 17.72±0.92%. FTIR analysis showed that fucoidan from *S. muticum* had functional group similarities compared to commercial fucoidan from *Fucus vesiculosus*. The DPPH inhibition activity of *S. muticum* fucoidan at concentrations of 500, 1,000, 2,000, 3,000 and 4,000 ppm was 35.67±0.96, 39.40±0.66, 42.88±1.46, 45.58±3.66, and 53.57±4.59%, respectively. The IC50 DPPH value was 3.75 ppm, and the FRAP value at a concentration of 1,000 ppm was 126.58±5.39 μM g^{-1}. The antioxidant activity of *S. muticum* fucoidan was lower than that of vitamin C, but not significantly different from that of commercial fucoidan.
Key Words: DPPH, radical scavenging activity, reducing power, sulfate content, FTIR.

Introduction. Incidences of degenerative diseases such as diabetes mellitus, atherosclerosis, coronary heart disease, stroke, and cancer have been increasing, one cause of which is due to free radicals (Kang et al 2010). Free radicals are molecules that are unstable and very reactive because they contain one unpaired electron; accordingly, these species react with surrounding molecules to achieve stability (Rohmatussolihat 2009) and can damage tissue (Kang et al 2010). The body's defence system can prevent tissue damage by producing endogenous antioxidants (Halliwell 1992). Moreover, if the amount of free radicals in the body exceeds the amount of antioxidants, it will cause oxidative stress (Sarma et al 2010). Therefore, to prevent oxidative stress, exogenous antioxidants are needed (Ribeiro et al 2014). Currently, there are many synthetic antioxidants, including butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT), but both are toxic and carcinogenic (Hu et al 2010) and have side effects that can damage the liver (Kumar et al 2008). Therefore, the development of natural antioxidants is essential.

One source of natural antioxidants that needs to be developed is brown seaweed (Ye et al 2009) which contains fucoidan (Lim et al 2014; Marudhupandi et al 2014b; Balboa et al 2013). Morya et al (2012) reported that brown seaweed was the largest producer of fucoidans. Fucoidan is currently being investigated due to its bioactivity as an antioxidant, anticoagulant, immunostimulant, and antitumor and anti-inflammatory agent (Li et al 2008).

The brown seaweed *Sargassum* sp. was reported to have the highest fucoidan content, followed by *Turbinaria* sp. and *Padina* sp. (Sinurat et al 2015). In Indonesia, the brown seaweed *Sargassum* sp. is found in abundance (Talha 2015). However, so far, few fucoidan bioactivity studies have been published and include topics like: anticoagulants

from *S. crassifolium* (Sinurat et al 2011), immunostimulants from *S. binderi* (Sinurat et al 2016) and anticancer agents from *Sargassum* sp. and *Turbinaria* sp. (Isnansetyo et al 2017). The investigation of the fucoidan from brown seaweed, as a source of antioxidants, is still very limited. Therefore, the objective of this research was to evaluate the antioxidant activity of fucoidan from *Sargassum muticum* (Yendo) Fensholt obtained from the Alor Island, East Nusa Tenggara.

Material and Method

Materials. *S. muticum* was obtained from the Alor Island, East Nusa Tenggara, in March 2018. The seaweed was washed with running water until clean to remove particulate matter. Afterwards, the seaweed was dried in an oven at 50°C for 15 minutes. The sample was cut into small pieces and then ground and sieved with a 60 mesh sieve. Subsequently, the seaweed powder was weighed to determine the initial weight of the dried seaweed.

Fucoidan extraction. The method reported by Sinurat & Kusumawati (2017) uses water to extract fucoidan from *S. muticum*. Up to 100 grams of dry seaweed powder was weighed and then soaked in distilled water (1:20 b/v) while stirring mechanically on a hot plate stirrer at 200 rpm for 4 hours at 85°C. The extract was filtered using a 625 mesh filter, and the filtrate was collected. To the filtrate there were added 2% $CaCl_2$ crystals while stirring for 30 minutes at room temperature. Further, the composite was centrifuged (3,000 rpm, 40 min, 5°C). The filtrate was collected and the sediment was discarded. Next, ethanol was added to the filtrate (1:3 v/v), and the composite was centrifuged (3,000 rpm, 40 min). The resulting sediment was dissolved completely, by using water. Afterward, the precipitate was dried by using a freeze dryer.

Determination of yield. The yield was obtained from the ratio of the weight of the fucoidan extracts to the weight of the dried sample. The yield of fucoidan was determined by using the following formula:

$$\text{Yield (\%)} = (\text{Weight of fucoidan/Weight of sample}) \times 100\%$$

Total sugar determination. The total sugar content of the *S. muticum* fucoidan was analyzed by using the phenol-sulfate test, according to Dubois et al (1956). The sugar tested in this study was the fucose and xylose. Standard fucose solutions (100, 150, 200, 250 and 300 ppm), standard xylose solutions (5, 10, 15, 20 and 25 ppm) and sample solutions from *S. muticum* fucoidan (500 ppm) were prepared. Phenol-sulfate testing was carried out by adding 2.5 mL of concentrated H_2SO_4 to each of these solutions, which were shaken until homogeneous and then chilled for 20 minutes in an ice-water bath. To each solution there was added 0.5 mL of 5% phenol and the solutions were shaken until homogeneous and then chilled in an ice-water bath for 30 minutes. The absorbance of all the prepared solutions was monitored using a Perkin Elmer Lambda 25 UV-VIS spectrophotometer with a wavelength of 490 nm for the fucose standard and 480 nm for the xylose standard.

Sulfate content determination. The sulfate content of the fucoidan extract of *S. muticum* was measured by the $BaCl_2$-gelatin method (Dodgson & Price 1962). The $BaCl_2$-gelatin solution was prepared by dissolving 0.5 g of gelatin in 100 mL of distilled water which was stirred on a hot plate stirrer at a temperature of 60-70°C until homogeneous. Once the solution was homogeneous, 0.5 g of $BaCl_2$ was added, and the mixture was left overnight at 4°C. Sample solutions were prepared by dissolving 6 mg of *S. muticum* fucoidan extract in 2 mL of 3.5 N HCl until homogeneous. Then, the samples were hydrolyzed for 17-18 hours in an oven at 105°C. After hydrolysis, a centrifugation was carried out to ensure that the sample obtained was only the filtrate. Samples solutions of commercial *F. vesiculosus* fucoidan were also prepared. Standard K_2SO_4 solutions were prepared at concentrations of 200, 400, 600, 800, and 1,000 ppm. The sample solution was mixed with 3% TCA and $BaCl_2$-gelatin into a 96-well microplate with successive

comparisons of 40, 120 and 60 µL. Next, mechanical stirring was carried out, the solution was allowed to stand for 15 minutes, and the absorbance was then measured using a UV-VIS spectrophotometer (Multiply Go) at a wavelength of 360 nm. The standard K_2SO_4 and commercial fucoidan solutions were treated the same way as the sample solution.

Analysis of functional groups. Analysis of the functional groups was conducted using a Fourier transform infrared (FTIR) spectrophotometer (Perkin-Elmer 577) to identify the types of functional groups in the fucoidan extract of *S. muticum*. The sample (2 mg) and potassium bromide (200 mg) were crushed until homogeneous. Next, the powder mixture was pressed into thin and transparent pellets at a pressure of 7,000 Pa. The pellet was put in a sample pan to perform infrared spectrum measurements in a 4,000 – 5,000 cm^{-1} wavenumber range (Sinurat & Kusumawati 2017). Commercial *F. vesiculosus* fucoidan was used as a standard.

DPPH free radical scavenging test. Fucoidans extracted from *S. muticum* were analyzed for antioxidant activity based on the scavenging activity of the 1,1-diphenyl2-picryl hydrazyl (DPPH) free radical using the method of Clarke et al (2013) with some modifications. Sample solutions of *S. muticum* fucoidan and *F. vesiculosus* fucoidan (500-4,000 ppm) and vitamin C (4-10 ppm) were prepared by using distilled water and they were homogenized. A DPPH solution (0.76 mM) was prepared from 3 mg of DPPH powder, which was dissolved in 10 mL of distilled water and then stored at 4°C before use (maximum 24 hours). The absorbance was then measured at a wavelength of 517 nm using a UV-VIS spectrophotometer (Multiply Go). Antioxidant activity was expressed as the percentage inhibition and the half maximal inhibitory concentration (IC50). The inhibition activity was calculated using the following formula:

$$\text{Inhibitory activity } (\%) = \frac{(\text{C} - \text{D}) - (\text{A} - \text{B})}{(\text{C} - \text{D})} X\ 100$$

Where:
A = sample (160 µL of sample + 40 µL of 0.76 mM DPPH);
B = sample control (160 µL of sample + 40 µL of distilled water);
C = negative control (160 µL of distilled water + 40 µL of 0.76 mM DPPH);
D = blank (200 µL of distilled water).

Measurement of ferric reducing antioxidant potential (FRAP). The FRAP test was carried out based on the method described by Clarke et al (2013) involving the reduction reaction of Fe^{3+} to Fe^{2+}. The process of changing iron (III) chloride to the iron (II) complex can be monitored using a spectrophotometer at a wavelength of 595 nm. Changes can be seen from the formation of blue color in solution. The pH 3.6 acetate buffer solution was made from 0.775 g of sodium acetate trihydrate ($CH_3COON.3H_2O$), which was added with 4 ml of concentrated acetic acid and dissolved in distilled water to exactly 250 mL. Acetate buffers can be stored as stock solutions at 4°C. A solution of 10 mM L^{-1} 2,4,6-tripyridil-s-triazine (TPTZ) was prepared from 0.15 g of TPTZ dissolved in 40 mM L^{-1} HCl to exactly 50 mL. A solution of 40 mM L^{-1} HCl was made by dissolving 0.828 mL of concentrated HCl in 250 mL of distilled water. The TPTZ solution was stored at 4°C for a maximum of 1 day before being used. A solution of 20 mM L^{-1} $FeCl_3.6H_2O$ was prepared by dissolving 0.54 g of $FeCl_3.6H_2O$ in a volume of exactly 100 mL distilled water. The $FeCl_3.6H_2O$ solution can be stored at 4°C for up to 1 day before being used. The preparation of FRAP reagent was realized by mixing 25 mL of acetate buffer, 2.5 mL of TPTZ solution and 2.5 mL of $FeCl_3.6H_2O$ solution (10:1:1) and then by adding distilled water to exactly 100 mL. The standard solutions of $FeSO_4.7H_2O$ (10,000 µM L^{-1}) were prepared by first dissolving 2.78 g of $FeSO_4.7H_2O$ in 1,000 mL of distilled water, then by adjusting the concentrations at 50, 100, 150, 200, 250 and 300 ppm. Sample solutions from *S. muticum* fucoidan (1,000 ppm), commercial *F. vesiculosus* fucoidan (1,000 ppm) and vitamin C (7 ppm) were prepared. A 20 µL sample solution was added to 150 µL of FRAP reagent in a 96-well microplate and then read at a wavelength of 595 nm using a

UV-VIS spectrophotometer (Multiply Go). The standard $FeSO_4$ solution, commercial fucoidan, and vitamin C were treated the same way as the sample.

Measurement of reducing power activity. The reducing power of fucoidans was tested, according to Kumar et al (2008). The sample solution (1 mL) was amalgamated with sodium phosphate buffer and $K_3Fe(CN)_6$ solution. Then the mixture was incubated at 50°C for 20 min, then there were added trichloroacetic acid solution (2.5 mL) and $FeCl_3$ (0.5 mL, 1%). The reaction mixture was determined at 700 nm on a UV-2000 spectrophotometer (Unico (Shanghai) Instrument Co., Ltd., China).

The analysis of data. All values are expressed as the means ± standard deviation (n=3). The data were processed by Excel 2007 and SPSS for Windows (Microsoft Windows, Inc).

Results and Discussion

The fucoidan yield. Table 1 shows that the yield of fucoidan generated from *S. muticum* is 3.87±0.13%. The results of this study are in line with Sinurat & Kusumawati (2017), who reported that the content of fucoidan from brown seaweed was 2-4%. Sinurat & Kusumawati (2017) performed the extraction using the same method and produced a lower yield of fucoidan, which was 3.36% from *S. binderi* Sonder originating from Banten, Indonesia. Balboa et al (2013) collected *S. muticum* from the Spanish coast in the summer and extracted fucoidan using water, obtaining a yield of fucoidan that was 4% higher. Lim et al (2014) reported that for *S. binderi* and *Padina* sp. from Malaysian waters, extraction using acid solvents produced fucoidan yields of 6.16±0.08% and 2.06±0.23%, respectively. The fucoidan yield difference is caused by the extraction method used, species of seaweed, the harvest season, and geographical location (Stanislav et al 2012).

Total sugar content. The bioactivity of fucoidan is partially related to the primary monosaccharide composition (Li et al 2008). In this experiment, fucose and xylose were used as standards for the constituent monomer compounds of fucoidan (Sinurat & Kusumawati 2017). Table 1 shows that the total sugar content in *S. muticum* fucoidan was 64.34±2.10%. These results were higher than the total sugar content in commercial *F. vesiculosus* fucoidan, which was 53.03±3.63%. However, based on statistical tests, there were no significant differences ($p>0.05$) in the total sugar content of *S. muticum* fucoidan and commercial fucoidan. The monosaccharides found in *S. muticum* fucoidan were mainly fucose (58.23±1.87%) and xylose (6.11±0.24%). It was reported by Bilan et al (2010) that the main monomers in fucoidan were fucose and a small number of other monosaccharides such as xylose.

Table 1

The characteristics of *Sargassum muticum* fucoidan and commercial fucoidan

	Fucoidan from S. muticum (%)	*Commercial fucoidan (%)*
Yield	3.87±0.13	-
Total sugar	64.34±2.10[a]	63.00±0.74[a]
Fucose	58.23±1.87[b]	58.47±0.92[b]
Xylose	6.11±0.24[c]	4.53±0.18[c]
Sulfate	17.72±0.92[d]	30.94±1.26[d]

[a-d] The different letter in the same line showed significant difference ($p>0.05$).

The total sugar content in *S. muticum* fucoidan was lower than in *S. binderi* fucoidan (76.25%) (Sinurat & Kusumawati 2017). *Lessonia nigrescens* fucoidan from Chile extracted using ethanol solvents had a lower total sugar content, which was 57.46±1.23% (Guiyan et al 2014). The total sugar content of fucoidan can be influenced by the extraction method used (Ponce et al 2003). Polysaccharides have high solubility in

distilled water, which explains the higher total sugar content observed in distilled water extractions (Sinurat & Kusumawati 2017). Moreover, seaweed species and geographical location also influence the total sugar content in fucoidan (Stanislav et al 2012).

Analysis of functional groups. Patterns of *S. muticum* fucoidan functional groups were determined using Fourier-transform infrared spectroscopy (FTIR). As shown in Table 2, *S. muticum* fucoidan and commercial *F. vesiculosus* fucoidan have similar absorbances. According to Na et al (2010), the absorption peak at approximately 3,400 cm^{-1} indicates an O-H stretching band originating from hydroxyl groups, whereas the peak 1,600 cm^{-1} indicates the presence of a C=O stretching band from carbonyl groups. According to Sinurat et al (2016), the absorption peak at approximately 1,600 cm^{-1} indicated the presence of uronic acid in *S. muticum* fucoidan and commercial fucoidan at 1,631-1,637 and 1,639 cm^{-1}, respectively. Uronic acid is a component that is sometimes found in fucoidans, with different concentrations observed in each species.

Table 2

Functional group analysis of *Sargassum hystrix* fucoidan and commercial fucoidan

Wavelength (cm^{-1})		*Reference*	*Interpretation of functional groups*
S. muticum	*Commercial*	*wavelength (cm^{-1})*	*(Pretsch et al 2009)*
3,433-3,434	3,467	3,200-3,500	Hydroxyl (O-H)
2,938-2,939	2,941	2,700-3,000	Methyl (C-H)
1,631-1,637	1,639	1,350-1,800	Carbonyl (C=O)
1,254-1,255	1,256	1,000-1,300	Sulfonyl (S=O)
827-830	844	700-850	Sulfonate (S-O)

Fucoidan is a sulfated polysaccharide with fucose as a major component, which is a monosaccharide that has a methyl group attached to the C5 position (Li et al 2008). The characteristics of fucoidan compounds can be seen from the FTIR spectra, as evidenced by the absorption peak at approximately 1,200 cm^{-1} (S=O), which is attributed to polysaccharide sulfates, and at around 800 cm^{-1} (COS), representing equatorial or axial sulfate positions (Sinurat & Kusumawati 2017). The presence of an absorption band attributed to methyl groups (CH_3) further supports the characterization of the compound as fucoidan.

Signals in the wavenumber range of 1,240-1,260 cm^{-1} indicate the presence of sulfate esters (S=O). Likewise, in this study, peaks from *S. muticum* fucoidan (1,254-1,255 cm^{-1}) and commercial fucoidan (1,256 cm^{-1}) were demonstrated. Signals at 827-830 cm^{-1} indicate the presence of the equatorial 6-sulfate group in *S. muticum* fucoidan, whereas commercial fucoidan has an axial 4-sulfate group, which was shown at 844 cm^{-1}. The position of this sulfate group will influence the bioactivity of fucoidan compounds (Usov & Bilan 2009). Marudhupandi et al (2014a) stated that absorbance in the 2,900 cm^{-1} region indicated a C-H stretching vibration of the pyranose ring, and this is observed in *S. muticum* fucoidan (2,938-2,939 cm^{-1}) and commercial fucoidan (2,941 cm^{-1}). The results showed that the extract from *S. muticum* contains a fucoidan compound, as does the *F. vesiculosus* extract. The infrared spectrum of *S. muticum* fucoidan and commercial fucoidan is shown in Figure 1.

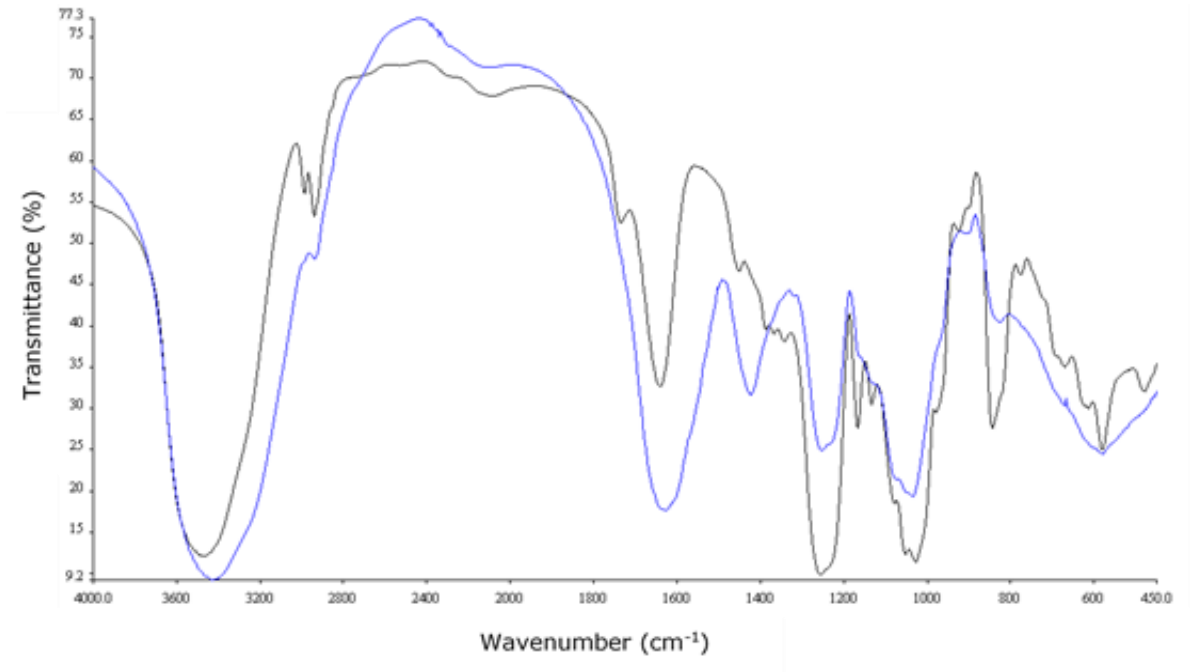

Figure 1. The infrared spectrum of *Sargassum muticum* fucoidan and commercial fucoidan.

: *S. muticum* fucoidan
: Commercial fucoidan

DPPH radical scavenging activity. The type of antioxidant contained in a compound determines its antioxidant activity. According to Yang et al (2011), antioxidants can be classified based on their solubility as lipophilic (nonpolar) and hydrophilic (polar) antioxidants. Hahn et al (2012) stated that fucoidan compounds were polysaccharide sulfates, therefore these antioxidants are hydrophilic, making them easily soluble in water. Table 3 shows that as the concentration of *S. muticum* fucoidan increases, the DPPH free radical capture activity also increases. Sedjati et al (2017) stated that a higher percentage of free radical (DPPH) inhibition means that the compound has greater antioxidant potential.

Table 3

DPPH inhibitory activity by *Sargassum muticum* fucoidan and commercial fucoidan

Concentration (ppm)	*Inhibition of DPPH (%)*	
	S. muticum fucoidan	*Commercial fucoidan*
500	35.67±0.96[a]	37.81±4.29[a]
1,000	39.40±0.66[b]	40.07±0.25[b]
2,000	42.88±1.46[c]	37.05±0.02[c]
3,000	45.58±3.66[d]	38.89±3.07[d]
4,000	53.57±4.59[e]	40.03±1.38[e]

The same alphabet in the same line represented no significant difference ($p>0.05$).

The ability of *S. muticum* fucoidan (IC_{50} 3,754 ppm) to counteract DPPH radicals was not significantly different compared to commercial fucoidan but was smaller compared to vitamin C (IC_{50} 9.4 ppm). Huang et al (2016) reported that *S. glaucescens* crude fucoidan had an IC_{50} of 4,270-5,150 ppm, meaning that the compound could donate hydrogen atoms, inhibit free radicals and have potential as a natural antioxidant. When compared to the values obtaines by thethese studies above, *S. muticum* fucoidan has higher antioxidant activity. However, Lim et al (2014) reported an IC_{50} value from *S. binderi* fucoidan of 2,010±0.29 ppm, which is higher than the antioxidant activity of the *S.*

muticum fucoidan. This result is due to the differences in seaweed species that can affect fucoidan bioactivity (Stanislav et al 2012).

Ferric reduction activity potential (FRAP). FRAP is a method of determining the antioxidant activity by measuring the capacity of antioxidants to reduce Fe^{3+} to Fe^{2+} through electron donation. The Fe^{3+} species derived from the FRAP reagent was a mixture of acetate buffer, TPTZ and $FeCl_3$. The reduction reaction results in the formation of a blue-colored Fe(II) tripyridyltriazine complex, which can be detected by spectrophotometry at a wavelength of 595 nm. A more intense blue indicates the formation of more Fe^{2+} ions. Therefore, a higher intensity of the blue color formed represents a higher antioxidant potential (Clarke et al 2013).

Table 4

FRAP values of *Sargassum muticum* fucoidan, commercial fucoidan, and vitamin C

Sample	*Concentration (ppm)*	*FRAP value (μM/g)*
Vitamin C	7	64.35±2.05
Commercial fucoidan	1,000	53.95±8.84[a]
S. muticum fucoidan	1,000	126.58±5.39[a]

The same alphabet in the same line showed no significant differences (p>0.05).

The FRAP value obtained from *S. muticum* fucoidan was 126.58±5:39 μM g^{-1} at a concentration of 1,000 ppm. Table 4 shows that *S. muticum* fucoidan FRAP value was higher when compared with commercial fucoidan (53.95±8.84 μM g^{-1}) at the same concentration. Clarke et al (2013) stated that the smaller the FRAP value, the higher the antioxidant activity in the sample. This result is due to a lower concentration of the sample needed to achieve the absorbance produced by a solution of 1 mM $FeSO_4$ (to convert Fe^{3+} to Fe^{2+}). Thus, *S. muticum* fucoidan has lower antioxidant activity than commercial fucoidan. However, after statistical testing, there was no significant difference (P>0.05) in antioxidant activity between *S. muticum* fucoidan and commercial fucoidan.

According to Ale et al (2011), the sulfate content greatly influences fucoidan bioactivity; the higher the sulfate concentration, the higher the bioactivity. The sulfate content in fucoidan can also affect antioxidant activity (Huang et al 2016). This study confirmed that *S. muticum* fucoidan has a sulfate content (17.72±0.92%) that is lower than commercial fucoidan (30.94±1.26%); thus, *S. muticum* fucoidan has lower antioxidant activity as well. Prabu et al (2013) reported that *S. wightii* fucoidan had a FRAP value of 42.46±3.97 μM g^{-1} at a concentration of 2,750 ppm, which showed better antioxidant activity than *S. muticum* fucoidan. The results difference imight be due to the properties of the used seaweed species, also affecting fucoidan bioactivity as an antioxidant.

Reducing power. The testing of antioxidant activity was carried out by using the reducing power method. Wang et al (2008) reported that reducing power has a direct and positive correlation with antioxidant activity. In the reaction system, the antioxidant component in the sample causes the reduction of Fe^{3+} to Fe^{2+}, which can be monitored the absorbance value at a wavelength of 700 nm. A higher absorbance value indicates a higher reducing power in the sample (Huang et al 2016). The test results in Figure 2 showed that the absorbance value of *S. muticum* fucoidan at a concentration of 2,000-4,000 ppm ranged from 0.41±0.01 to 0.75±0.03. Commercial fucoidan absorbance values of the same concentration range were from 0.26±0.07 to 0.44±0.01. *S. muticum* fucoidan had higher reducing power activity than commercial fucoidan.

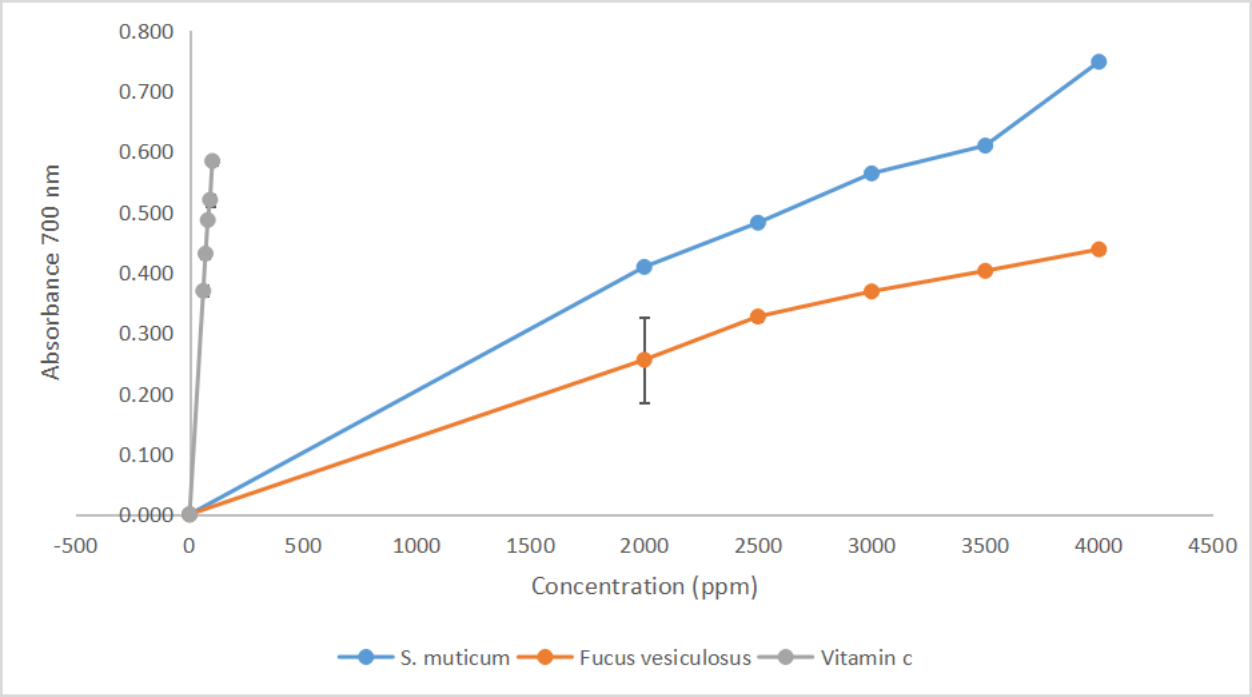

Figure 2. Reducing power activity of *Sargassum muticum* fucoidan, commercial fucoidan and vitamin C.

Previous studies have reported that when testing the reducing power, the absorbance at 700 nm for *Laminaria japonica* fucoidan at a concentration of 2,000 ppm was approximately 0.12 (Wang et al 2008), while the absorbance of *S. glaucescens* fucoidan was 0.45 (Huang et al 2016). This research shows that *S. muticum* fucoidan has a higher antioxidant activity than *L. japonica* fucoidan, but a lower antioxidant activity than *S. glaucescens* fucoidan. These results differences indicate that fucoidan antioxidant activity depends on the seaweed species. The antioxidant activity is also sensitive to the extraction methods, environmental growth and seasons (Stanislav et al 2012).

Conclusions. Our study results showed that the characteristic of *S. muticum* fucoidan was similar to commercial fucoidan. The antioxidant activity of *S. muticum* fucoidan (IC_{50} DPPH value of 3,754 ppm) was lower than that of vitamin C (IC_{50} DPPH value of 9.40 ppm). The antioxidant properties of *S. muticum* fucoidan were relatively better than those of the commercial fucoidan.

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