Nutritional Profile of Freeze-dried Red Seaweeds From Semporna, Sabah

Mansoor Abdul Hamid, Patricia Matanjun & Tiang Ming Chee
School Of Food Science & Nutrition, Univerisiti Malaysia Sabah,
Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia

Abstract
Three varieties of Kappaphycus alvarezii, which were widely cultivated in Semporna , Sabah include Aring-Aring, Crocodile Skin, and Green Flower was dried through freezed drying process and then analyzed to determine its proximate chemical composition, vitamin C, mineral element, and also fatty acid profile. The seaweeds found were high in dietary fiber (81.80 – 84.60%) and ash (6.36 – 8.97%) and low in lipid content (0.40 – 0.54%) on dry weight (DW) basis. Protein content in these seaweeds are range from 4.67 – 4.73% DW. Vitamin C content in these seaweeds is significantly high (21.10 – 32.57 mg/100g). The PUFA content in Aring-Aring was 8.02%, Crocodile Skin 8.45% and Green Flower 12.12%. This study was conducted to give a basic nutritional data for these three varieties of Kappaphycus alvarezii as guidance for further investigation especially for heat sensitive components such as antioxidant.
Keywords: Nutritional profile, red seaweed, proximate values, freeze-dried

1. Introduction

The chemical composition of seaweed around the world had been well documented, but still there is no report available on the nutritional composition of the different variety in *Kappaphycus alvarezii especially processed gone through freeze dry method*. It started to gain its popularity around Asia region and now it had spread over to other countries like South Africa and Pacific Island (Bindu et al., 2010). Looking at the increasing demand on seaweed product such as food (Phang & Wee, 1991), and industrial product (Phang, 1998), it show the importance of the study on the three variety of *Kappaphycus alvarezii* which includes *Aring-Aring, Crocodile Skin,* and *Green Flower.* The information obtained is important in providing data on searching for nutritious and healthy food product from the sea especially seaweed based on the potential nutrient content in it.

2. Material and methods

2.1 Collection of samples

The three seaweeds were collected from the coastal areas of Semporna, Sabah. All three seaweed was harvested at 50 days and it was washed thoroughly with distilled water to remove the holdfasts and epiphytes. It was then placed into a freezer (-20ºC) immediately after collection and freeze dried. For most of the analysis, dried sample were used except for analysis of fatty acid composition where fresh samples were used. The dried and grounded samples were stored in a plastic container and covered with aluminum foils. Inert nitrogen gas was passed into containers and samples were stored at -20ºC until further analysis. Analyses were carried out in triplicate.

2.2 Analytical Methods

2.2.1 Proximate/ biochemical analysis

Moisture content (oven method; AOAC 934.01), ash content (oven method; AOAC 942.05), crude protein (Kjedhal method; AOAC 976.05), crude lipid (Soxhlet extraction with diethyl ether; AOAC 920.39) and soluble and insoluble dietary fibers (enzymatic-gravimetric method; AOAC 991.19, 991.42) were determined (AOAC, 2000). The vitamin C of the seaweeds was determined using spectrophotometer method (AOAC 967.22). Triplicate determinations were performed for each nutrient analysis.

2.2.2 Gas Chromatography separation of fatty acid

Fatty acids present in seaweeds were determined by using a Fison 8000 gas chromatograph (30m X 0.32mm X 0.25mm Supelco-Wax capillary column) and a Fison EL-980 flame ionization detector of their methyl esters (FAMEs). The carrier gas used was helium. It was then being identified by analyzing the retention times compared to the methyl fatty acid standard (Merck, Germany) (Sanchez-Machado et al., 2004).

2.2.3 Mineral elements

Mineral element that was present in the seaweeds was determined by atomic absorption spectrophotometer (Perkin Elmer, model 3310). The element includes Magnesium, Sodium, Potassium, Calcium, Zinc, Iron, and Copper. Sample was digested by wet ashing and dissolve in 1M HNO_3 (AOAC, 2000). Triplicate result was taken and the concentration of the elements was determined by comparing to the calibration curve of the standard elements.

2.2.4 Statistical procedure

Mean and standard deviation (SD) will be calculated and determined for every nutrient analyzed along the study. It was expressed as means ± SD (n=3) with significant differences at $p<0.05$. It was analyze by one way analysis of variance (ANOVA) using SPSS system version 19.0 for Windows.

3.0 Result and discussion

3.1 Proximate and biochemical composition

All the nutrient content of the seaweed was based on dry weight. From the result, the protein content of Aring-Aring was the lowest (4.06%) followed by Green Flower (4.50%) and Crocodile Skin (5.26%). The protein level was within range of brown seaweed and red seaweed (3 - 47% DW) (Darcy-Vrillon, 1993; Matanjun et al., 2009). The variation of the protein content in these seaweeds might due to genetic characteristic (Yeang, 2009) and the geographical differences in environment (Fleurence, 1999; Haroon et al., 2000)

While for fat content, the content is relatively low compare to other studies such as *Eucheuma cotonii* (1.1%) (Matanjun et al., 2009) and *Gracillaria changgi* (3.3%) (Norziah and Ching, 2002). The content for Aring-Aring, Crocodile Skin and Green flower were 0.47%, 0.51% and 0.44%. The differences between the seaweeds studied might due to mineral content in the environment where element such silicon, nitrogen and phosphorus play roles in determine the total content of fat in seaweeds. The low level content of fat in seaweeds makes them a good food ingredient and additive in food, health and beauty products.

Table 1. Proximate composition and vitamin C content of Aring-Aring, Crocodile Skin and Green Flower (% dry weight of samples)

Nutrient (%)	*K.alvarezii* var. Aring-Aring	*K.alvarezii* var. Crocodile Skin	*K.alvarezii* var. Green Flower
Moisture content	4.74±0.08[a]	4.67±0.03[a]	4.73±0.06[a]
Ash	6.36.±0.30[a]	7.30±0.52[a]	8.97±0.59[b]
Protein	4.06±0.06[a]	5.26±0.06[c]	4.50±0.06[b]
Crude fat	0.48±0.02[b]	0.54±0.02[c]	0.40±0.02[a]
Total dietary fiber (TDF)	84.60±1.14[b]	82.28±0.53[a]	81.80±0.72[a]
Soluble dietary fiber	71.29±1.03[b]	69.26±0.36[a]	71.27±0.43[a]
Insoluble dietary fiber (IDF)	13.31±0.15[b]	13.02±0.24[a]	10.54±0.39[a]

Values are expressed as mean ± standard deviation, n=3
Values in the same row with different superscript letters are significantly different ($p<0.05$)

The total dietary fiber in the Green Flower was the lowest (81.80%) followed by Crocodile Skin (82.28%) and Aring-Aring (84.60%). The dietary fiber content in the seaweeds studied was extremely high compare to other studies (Jiménez-Escrig and Sánchez-Muniz 2000; Mabeau and Fleurence 1993). For the soluble fiber content in Aring-Aring (71.29%) and Green Flower (71.27%), they were significantly higher than Crocodile Skin (69.26%). Soluble dietary fiber normally will be associated with having hypocholesterolemic and hypoglycemic effects, while insoluble fiber helps in decreasing the in digestive tract transit time. It seems that the seaweeds content high dietary fiber have potential in improving the health quality of human being (Burtin, 2003; Matanjun et al., 2009).

In three seaweeds that being studied, it was found that Aring-Aring has the highest level of vitamin C content (32.57 mg/100g) and was significantly higher ($p<0.05$) than Crocodile Skin (21.10 mg/100g) and Green Flower (22.55 mg/100g). It shows that these seaweeds can be a natural source of vitamin C to human.

3.2 Fatty acid composition

There was fourteen type of fatty acids were identified, most of the fatty acid identified coming from saturated fatty acid where they ranged from 62.58-69.49% for all the three seaweeds. These results were similar with other study on red seaweed (Sanchez-Machado et al., 2004). The high saturated fatty acid might occur due to hydrogenation on the double bond of unsaturated fatty acid during sample storage. The level of PUFA content in the seaweeds was ranged from 8.02-12.12%. All three seaweeds contained the essential fatty acids γ-Linolenik acid (C18:3ω6). From the result, the type of fatty acid that was found in the seaweeds is tending to be long carbon chain (C14-C24).

Table 2: Saturated fatty acid content (% of total fatty acid content) of Aring-Aring, Crocodile Skin, and Green Flower

Fatty Acid (%)	Carbon No.	*K.alvarezii* var. Aring-Aring	*K.alvarezii* var. Crocodile Skin	*K.alvarezii* var Green Flower
Myristic	C14:0	3.13±0.00[b]	3.23±0.00[c]	3.06±0.00[a]
Palmitic	C16:0	41.16±0.05[c]	34.07±0.08[a]	35.95±0.03[b]
Stearic	C18:0	1.91±0.00[b]	2.30±0.02[c]	1.50±0.01[a]
Arachidic	C20:0	-	3.18±0.01[b]	0.75±0.03[a]
Behenic	C22:0	11.20±0.01[b]	12.93±0.01[c]	10.64±0.02
Tricosanoic	C23:0	10.43±0.00[b]	9.19±0.06[a]	10.35±0.03[b]
Lignoceric	C24:0	1.64±0.00[b]	1.68±0.00[c]	0.33±0.01[a]
Total saturated fatty acid		69.49±0.04[c]	66.59±0.07[b]	62.58±0.03[a]

FA Fatty acid, MUFAs mono-unsaturated fatty acid, PUFA polyunsaturated fatty acid
Values are expressed as mean ± standard deviation, n=3
Values in the same row with different superscripts letters are significantly different ($p<0.05$)

Table 3: Unsaturated fatty acid content (% of total fatty acid content) of Aring-Aring, Crocodile Skin and Green Flower.

Fatty Acid (%)	Carbon No.	*K.alvarezii* var. Aring-Aring	*K.alvarezii* var. Crocodile Skin	*K.alvarezii* var Green Flower
Palmitoleic	C16:1	17.52±0.04[a]	17.36±0.01[a]	21.49±0.08[b]
Oleic	C18:1ω9c	4.97±0.01[b]	6.62±0.03[c]	3.72±0.02[a]
Linoleic	C18:2ω6c	-	1.89±0.00[b]	0.77±0.00[a]
γ-Linolenic	C18:3ω6	6.23±0.02[a]	6.56±0.06[b]	9.48±0.09[c]
cis-11-Eicosenoic	C20:1	-	1.04±0.00	-
cis-8,11,14-Eicosatrinoic	C20:3ω6	-	-	1.47±0.00
Arachidonic	C20:4ω6	1.79±0.01[b]	-	0.40±0.00[a]
Total		30.52±0.05[a]	33.47±0.09[b]	37.34±0.16[c]
MUFAs		22.49	25.02	25.21
PUFAs ω6		8.02	8.45	12.12
PUFAs ω3		0	0	0

FA Fatty acid, MUFAs mono-unsaturated fatty acid, PUFA polyunsaturated fatty acid
Values are expressed as mean ± standard deviation, n=3
Values in the same row with different superscripts letters are significantly different ($p<0.05$)

3.3 Mineral element

The mineral content of Aring-Aring, Crocodile Skin and Green Flower in mg/100g sample (DW) is show in table 4. The highest macro-element found in the three seaweeds was K (463.77-464.18 mg/100g), followed by Na (219.30-222.31 mg/100g), Ca (117.93-131.47 mg/100g) and Mg (30.10-30.43 mg/100g). While for micro-element, the amount is relatively low where all three elements (Zn, Fe, and Cu) had the concentration of below 3.5 mg/100g. Mineral content will differ with each other because of several factors such as genetic species, sea condition, and seasons and also the physiology and morphology of the seaweed (Krishnaiah et al., 2008).

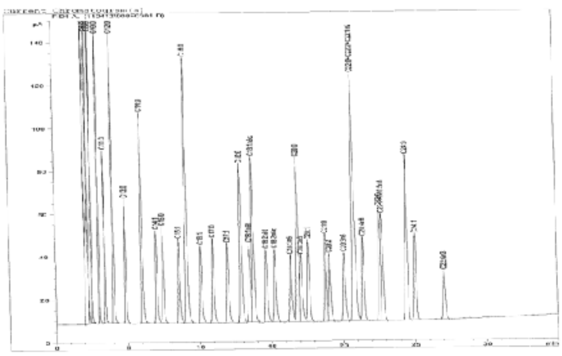

Diagram 1: Chromatogram for Methyl Ester Fatty Acid Standard

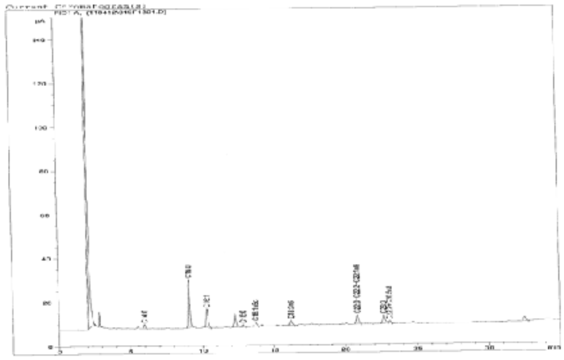

Diagram 2: Fatty acid chromatogram for Aring Aring

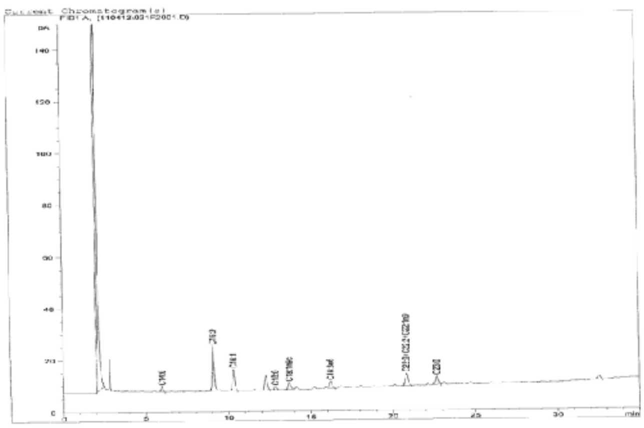

Diagram 3: Fatty acid Chromatogram for Crocodile Skin

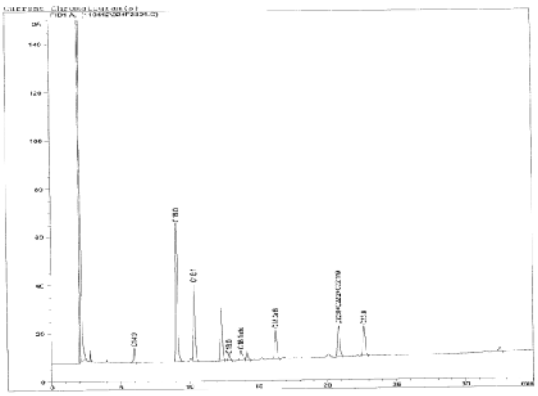

Diagram 4: Fatty acid chromatogram for Green Flower

Table 4. Mineral Contents of Three Varieties *Kappaphycus alvarezii* (mg/100g dry basic)

Variety	Mg	Na	K	Ca	Zn	Fe	Cu	Ratio Na/K
***K. alvarezii* var. Aring-Aring**	30.43± 0.04^{c}	222.31± 2.05^{a}	463.77± 0.11^{a}	131.47± 0.48^{c}	3.09± 0.09^{b}	1.33± 0.42^{a}	0.18± 0.00^{a}	0.48
***K. alvarezii* var. Crocidle skin**	30.34± 0.03^{b}	219.30± 1.25^{a}	463.85± 0.06^{a}	128.22± 0.28^{b}	2.23± 0.07^{a}	0.73± 0.00^{a}	0.88± 0.00^{b}	0.47
***K. alvarezii* var. Green flower**	30.10± 0.02^{a}	219.56± 2.20^{a}	464.18± 0.06^{b}	117.93± 0.16^{a}	2.21± 0.09^{a}	3.27± 0.00^{b}	0.06± 0.10^{a}	0.47

Values are expressed as min ± standard deviation, n=3
Values in the same row with different superscripts letters are significantly different ($p<0.05$)

4.0 Conclusion

The three variety of *Kappaphycus alvarezii* that was found widely in Malaysia was analyzed for its biochemical and mineral composition. Its nutritional composition was then being analyzed and it was found that all three seaweed contains very high amount of dietary fiber and vitamin C which is essential and beneficial to human being. It had provide a basic data toward this kind of variety for further studies on usage and application of the seaweed into food product and also nutraceutical product looking at the high nutrient value in the studied seaweeds.

References

AOAC. 1999. Official methods of analysis of AOAC international, 16th edition. AOAC International, Md., USA

Bindu, M.S. and Levine, I.A. 2010. The commercial red seaweed *Kappaphycus alvarezii* – an overview on farming and environment. *Journal Applied Phycology, DOI 10.1007/s10811-010-9570-2.*

Burtin, P. 2003. Nutritional value of seaweeds. *Journal of Environment Agriculture Food Chemistry* **2:**498–503

Darcy-Vrillon, B. 1993. Nutritional aspects of the developing use of marine macroalgae for the human food industry. International Journal of Food Science and Nutrition. **44:** 23–35

Fleurence, J. 1999, Seaweed proteins: biochemical, nutritional aspects and potential uses, Trends in Food Science and Technology, **10:** 25–28.

Haroon A. M., Szaniawska A., Normant M., dan Janas U., 2000, The biochemical composition of Enteromorpha spp. from the Gulf of Gdańsk coast on the southern Baltic Sea, Oceanologia, **42 (1):** 19–28.

Jiménez-Escrig A. dan Sánchez-Muniz F.J. 2000. Dietary fibre from edible seaweeds : chemical structure, physicochemical properties and effects on cholesterol metabolism. *Nutrition Research* **20:** 585-598.

Krishnaiah, D., Sarbatly, R. Prasad, D. M. R., dan Bono, A. 2008. Mineral Content of Some Seaweed from Sabah's South China Sea. *Asian Journal of Scientific Research.* **1(2):** 166-170.

Matanjun, P., Mohamed, S., Mustapha, N. M., dan Muhammad, K. 2009. Nutrient content of tropical edible seaweeds, *Eucheuma cottonii*, *Caulerpa lentillifera* and *Sargassum polycystum. Journal of Applied Phycology.* **21:** 75-80.

Norziah, M.H. dan Ching, C.Y. 2000. Nutritional Composition of edible seaweed *Gracilaria changgi*. *Food Chemistry* **68**: 69-76.

Phang, S. M., dan Wee, Y. C. 1991. Benthic Marine Algae. *The State of Nature Conservation in Malaysia.* 51–61.

Phang, S.M. 1998. The seaweed resources of Malaysia. *Seaweed Resources of the World,* Japan International Cooperation Agency, 79-91.

Sanchez-Machado, D. I., Lopez-Cervantes, J., Lo´pez-Hernandez, J., dan Paseiro-Losada, P. 2004a. Fatty acids, total lipid, protein and ash contents of processed edible seaweeds. Food Chemistry, 85: 439–444

Yeang, C.H. 2009. Integration of Metabolic Reactions and Gene Regulation. *Plant Systems Biology*. New York: Humana Press. 265-285