Chemical composition and physicochemical properties of red seaweeds (*Kappaphycus alvarezii, Eucheuma spinosum* and *Eucheuma striatum*) from Sabah, Malaysia

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Abstract

Three tropical red seaweeds taken from Kunak, Sabah namely *Kappaphycus alvarezii* (KA), *Eucheuma spinosum* (ESp) and *Eucheuma striatum* (ESt) contains an important source of bioactive compounds for development of functional foods. The present study was aimed to investigate the nutrient and physicochemical properties of these red seaweeds. It was found that KA contained the highest level of protein and crude fibre with 3.72% and 12.5%, DW respectively. Nutrients content showed significant different among the 3 seaweed species, with value of 0.02-0.05% DW in lipid, ash (14.1-20.2% DW), energy (288-303 kcal) and carbohydrate (70.2-71.8% DW) ($p<.05$). Comparing the element contents of these species, KA was rich in K, Mn, Fe and Cu, while ESp was rich in Mg, Ca, Na and Zn. As for the physicochemical properties of the seaweeds, their swelling capacity (SWC), water retention capacity (WRC), and oil retention capacity (ORC) ranged from 20.6 to 34.1 ml/g DW, 8.4 to 13.4 g/g DW and 2.3 to 3.0 g/g DW, respectively. SWC and ORC of KA was higher than those of ESp and ESt ($p<0.05$). This study suggested that KA showed high nutritional value could be potentially used as ingredients in human food application.

Keywords: red seaweed, proximate composition, physicochemical properties

Introduction

Seaweed, one of marine macroalgae is widespread around the world either cultivated or existed in wild. They are categorized according to their colour pigmentation including red (Rhodophyta, brown (Phaeophyta) and green (Chlorophyta). In Asian countries, seaweeds have become as a source for human food, animal feed, herbal remedies, fertilizer, fungicides, herbicides and as well as a source of pharmaceutical ingredients (McHugh, 2003). Many researchers had stated that seaweeds are nutritive food which contain vitamin, protein, mineral, fiber contents, polyunsaturated fatty acids, essential fatty acids as well as macro and trace elements which are beneficial to human and animal (Ortiz et al. 2006; Fleurence, 1999). Seaweeds also source of phycocolloids such as agar, alginate, and carrageenan for various industrial applications (Alberto et.al, 2011; Mabeau et.al, 1993). Since seaweed has increasingly become an economically important natural resource in Malaysia, seaweed farming has played an important role in the development of aquaculture sector in Sabah but the information on their mineral and nutritional composition is still limited and rather fragment. Therefore the present study aimed to determine the proximate composition, mineral composition and physicochemical properties of red algae *Kappaphycus alvarezii*, *Eucheuma spinosum* and *Eucheuma striatum* collected from the Kunak, Sabah.

Materials and methods

2.1 Sample preparation

The three seaweeds sample (*K. alvarezii, E. spinosum* and *E. striatum*) were collected from Kunak, Sabah. The seaweeds were thoroughly cleaned and dried at 50°C in oven overnight. Then they were ground into fine powder using a tabletop grinding machine.

2.2 Proximate composition and mineral elements analysis

The analyses were carried out in triplicate. The proximate compositions (moisture content, crude protein, ash, fat, crude fibre, carbohydrate and gross energy) of the powder samples were determined according to the standard method (AOAC, 2000). Major mineral elements (Ca, Mg, Na, K) and trace elements (Fe, Zn, Cu and Mn) were determined by inductive coupled plasma mass spectroscopy (Agilent 7500a series), in house method based on AOAC 999.10.

2.3 Physicochemical properties analysis

Swelling capacity seaweed samples was measured by the bed volume technique (Kuniak and Marchessault, 1972). Water retention and oil retention capacity of seaweed samples were determined following the method conducted by (Ang, 1991). The results of SWC, WRC, and ORC were expressed as ml/g DW, g/g DW and g/g DW, respectively.

2.4 Statistical analysis

All the data collected were subjected to statistical analysis with ANOVA and any difference between the treatments means was performed by Duncan Multiple Test using SAS 9.1 at $P<0.05$.

Results and discussion

The proximate composition of moisture content, ash, protein, fat, crude fiber energy and carbohydrate in *K. alvarezii, E. spinosum* and *E. striatum* is shown in Table 1. From results, the crude fiber content from *K. alvarezii* is higher than *E. spinosum* and *E.striatum.* As for carbohydrate, there was a significant difference among seaweeds samples with highest value from *E. spinosum*, followed by *K. alvarezii* and E*. striatum*. High content of carbohydrate in red algae might be due to their phycocolloid content in their cell walls (Kasimala et.al, 2015). The ash content in both *K. alvarezii* and *E.spinosum* species were similar to each other with 14.10 – 14.90%, and there was no significant difference among them. However, the ash content in *E. striatum* is higher (20.21% DW) than other two species High amount of ash in seaweed is associated to its ability to absorb minerals and trace elements from its surrounding and because of this, some seaweeds species are used as treatment on heavy metal in water sources (Peña-Rodríguez et.al, 2011). From the analysis, the crude fiber content from *K. alvarezii* is slightly higher than *E. spinosum* with 12.50% DW and 12.10 % DW respectively. It is due to their high content of polysaccharides.

The mineral contents of *K.alvarezii, E.spinosum* and *E.striatum* are shown in Table 2*.* Among the macro minerals, K, Mg and Na were the most abundant in these seaweeds. The results showed that *K.alvarezii* contained high quantity of K followed by Mg, Na and Ca, whereas Fe, Mn, Zn and Cu are present in minor quantities. Similar results were reported on high K content than Na in red seaweed samples (Benjama & Masniyom, 2012).

Table 1. Proximate composition of *Kappaphycus alvarezii, Eecheuma spinosum and Eucheuma striatum* (% dry weight of sample)

Seaweeds	*K.alvarezii*	*E. spinosum*	*E. striatum*
Moisture	10.29±0.03[a]	9.19±0.01[b]	7.93±0.01[c]
Protein	3.73±0.01[a]	3.20±0.04[b]	1.56±0.01[c]
Ash	14.10±0.07[c]	14.90±0.00[b]	20.21±0.01[a]
Fat	0.05±0.00[a]	0.06±0.00[a]	0.02±0.01[b]
Crude Fibre	12.50±0.07[a]	8.10±0.07[c]	12.10±0.14[b]
Energy (kcal)	303±0.71[a]	304 ±0.00[a]	288±4.24[b]
Carbohydrate	71.83±0.01[b]	72.65±0.04[a]	70.28±0.04[c]

[abc] mean value with different superscript within the same column is different (P<.05)

Table 2. Selected mineral content (mg/100 g dry weight of sample) of *Kappaphycus alvarezii, Eucheuma spinosum* and *Eucheuma striatum* collected from east coast of Sabah, Malaysia..

Seaweeds	*K.alvarezii*	*E. spinosum*	*E. striatum*
Elements (mg/100g DW)			
Na	109.19±32.31[c]	311.87±14.28[a]	266.71±2.63[b]
K	6993.24±28.03[a]	4109.22±108.63[b]	4148.56±22.98[b]
Mg	231.30±2.31[c]	299.46±11.31[a]	271.94±0.16[b]
Ca	186.35±2.35[b]	202.65±6.44[a]	195.91±1.07[ab]
Mn	1.09±0.01[a]	0.29±0.00[c]	0.57±0.01[b]
Fe	50.49±0.49[a]	4.73±0.14[c]	7.53±0.07[b]
Cu	0.02±0.00[a]	0.01±0.00[b]	0.01±0.00[b]
Zn	0.68±0.02[b]	1.40±0.01[a]	0.63±0.01[b]
Na/K ratio	0.02	0.08	0.06

[abc] mean value with different superscript within the same column is different (P<.05)

Table 3. The swelling, water and oil retention capacity of *K.alvarezii, E. spinosum* and *E. striatum*

Seaweeds	SWC (ml/g DW)*	WRC (g/g DW)	ORC (g/g DW)
K. alvarezii	34.19 ± 0.72[a]	10.03 ± 0.09[ab]	3.07 ± 0.11[a]
E. spinosum	20.63 ± 0.38[c]	13.43 ± 2.57[a]	2.34 ± 0.22[b]
E. striatum	22.17 ± 0.15[b]	8.45 ± 0.09[b]	2.84 ± 0.06[ab]

[abc] mean value with different superscript within the same column is different (P<.05)

Table 3 showed the physicochemical evaluation on those three red seaweed species. The SWC of the seaweeds were significantly different with *K.alvarezii* was the highest (34.19ml/g DW) than *E. striatum* (22.17ml/g DW) and followed by *E. spinosum* (20.63ml/g DW). Water retention capacity (WRC) of *E.spinosum* was the highest followed by *K. alvarezii* and *E. striatum* with 13.43, 10.03 and 8.45 g/g DW respectively. SWC and WRC properties of seaweeds are related to their polysaccharide characteristics which indicated that this type of seaweeds may be used as functional ingredient that will contribute in improving physical properties of food products. In this study, ORC value was presented high in *K. alvarezii* followed by *E. striatum* and *E. spinosum*. The high ORC reported in this study suggested that its ability to stabilize food emulsion. Therefore, this seaweeds could be a good alternative as stabilizers in formulate food products and probably in animal feed pellet production.

Conclusion

From results, it was found that *K. alvarezii* and *E. spinosum* contained high levels of carbohydrate and crude fiber contents. These seaweeds contained high quantity of macro minerals and trace elements which beneficial in food application. Their nutritional compositions together with their physicochemical properties in terms of swelling capacity, water and oil retention capacity suggested that *K.alvarezii* has a potential food to be functional ingredients in food industry. Further studies concerned fatty acid, amino acid profile, vitamin and toxic elements are required to deliver more information for safer and more versatile utilization of these red seaweed species.

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