



EUCHEUMA: Seafood with Potential for Beverage Applications

By **Dongying Yang, Qin Liu, Li Cheng Sow and Hongshun Yang**

Food Science and Technology Programme, c/o Department of Chemistry, National University of Singapore

Seaweed is commonly used in the food industry as gelling agents and stabilisers. Recent studies which focus more on the nutrients and contents in seaweed have recommended it as a good food option for their richness in soluble dietary fibres, proteins, minerals, polyunsaturated fatty acids (PUFAs), vitamins and antioxidants, while having a low caloric value. Apart from the beneficial variety of nutrients for consumers, seaweed also has the potential to be used in medicinal applications (Mohame et al., 2012).

Eucheuma, a category of edible red seaweed mostly found in Southeast Asia, grows mainly within the range of 20 degrees at either side of the equator. Many species of Eucheuma are farmed in areas such as Lord Howe Island and south-western Australia, including *Eucheuma* spp, *E. kappaphycus*, *E. cottonii* and *E. denticulatum*.

Apart from commercial applications, Eucheuma has also been used as a food ingredient and distinguished for its accessibility, nutrient content and benefits to human health. According to Matanjun et al. (2009), *E. cottonii* is high in crude protein, dietary fibre, omega-3 fatty acids, vitamin C and minerals (calcium, iron, magnesium, potassium, zinc and iodine). Thereby, regular consumption of Eucheuma will help improve bodily functions, including promoting a healthy digestive system and preventing colon

cancer and cardiovascular diseases. It can also lower blood pressure, cholesterol and blood sugar levels and promote brain development, anti-ageing processes and tissue repair.

Antioxidant Properties

Polyphenols, one of the most common compounds found in seaweed extract, is able to reduce oxidative damage and the risk of chronic diseases. Antioxidant properties of *E. kappaphycus* extract was assayed and compared with other seaweed varieties. The total antioxidant activity of the methanol extract was 2.88 mg ascorbic acid equivalents per gram extract in *E. kappaphycus*, which was significantly higher than that in *Gracilaria edulis* and *Acanthophora spicifera*. The fractions extracted from the three seaweed species and their total antioxidant activities are

shown in **Table 1**. According to the study, Eucheuma provides good antioxidants to the daily diet, similar to fruits and vegetables.

Breast Cancer Prevention

The antioxidant properties of Eucheuma help prevent diseases such as breast cancer. According to Namvar et al. (2012), *E. cottonii* polyphenol-rich extract (ECME) was anti-proliferative against breast cancer cell lines, including oestrogen-independent MB-MDA-231 human breast cancer cells (IC₅₀ was 42 µg/ml) and oestrogen-dependent Michigan Cancer Foundation-7 (MCF-7) (IC₅₀ was 20 µg/ml). However, for normal cell lines, ECME was non-toxic. **Figure 1** illustrates that oestrogen-dependent MCF-7 cells were firstly apoptotic but they lost the integrity of the membrane after

Table 1. Total antioxidant activity of fractions extracted from three seaweed varieties, respectively (n=4). Unit: mg ascorbic acid equivalents/g extract. (Adapted from Ganesan et al., 2008.)

Seaweed	Fractions				
	Petroleum ether	Ethyl acetate	Dichloromethane	Butanol	Aqueous
<i>Euchemia kappaphycus</i>	8.04 ± 0.43a	1.61 ± 0.32b	0.63 ± 0.11c	0.26 ± 0.04d	1.42 ± 0.23b
<i>Gracilaria edulis</i>	18.04 ± 0.57a	7.17 ± 0.41b	1.08 ± 0.21c	0.34 ± 0.02d	0.89 ± 0.07c
<i>Acanthophora spicifera</i>	23.98 ± 1.11b	32.01 ± 2.35a	3.05 ± 0.28c	0.51 ± 0.06e	1.87 ± 0.14d

Results are reported as mean ± standard deviation. Within each row, means with different letters are significantly different ($P < 0.05$) among different fractions.

being treated with *E. cottonii* extract. Compared to previously used tamoxifen, the *E. cottonii* ethanol extract (ECE) was very effective in inhibiting tumour growth, increasing the concentrations of tissues (liver, plasma and kidney), malondialdehyde, and enhancing superoxide dismutase activity and concentrations of erythrocyte glutathione ($P < 0.05$) (Shamsabadi et al., 2013).

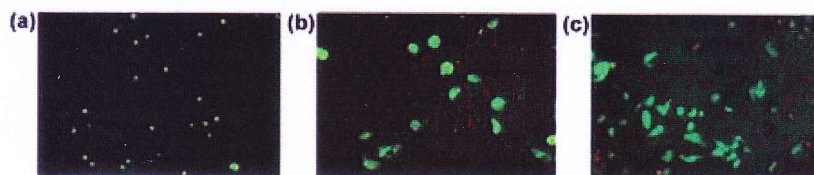


Figure 1. Effect of *Eucheuma cottonii* extract on morphological changes of MCF-7 cell via fluorescence microscope. Strained by *Acridine Orange / Propidium Iodide* (AO/PI). (a) control cells treated by 0.1% DMSO; (b) cells treated by 25 µg/ml *E. cottonii* extract after 24-hour incubation; (c) cells treated by 25 µg/ml *E. cottonii* extract after 48-hour incubation. (Cited with permission from Namvar et al., 2012)

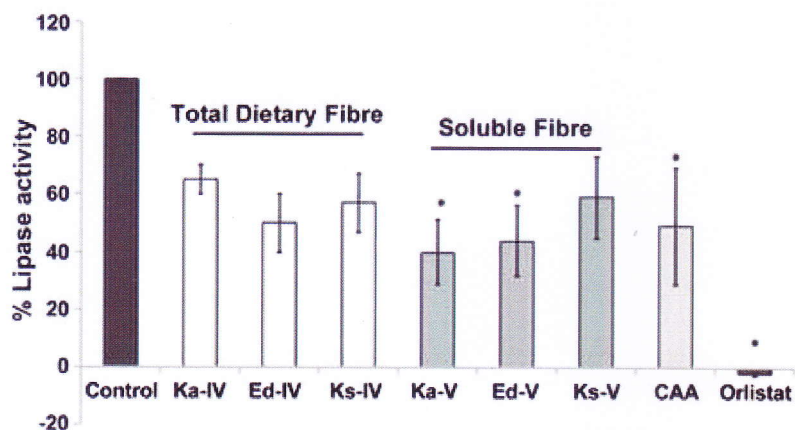


Figure 2. The pancreatic lipase activity of different processed lipase enzymes. Total dietary fibre and soluble fibre were named as IV and V. *K. alvarezii* (Ka), *E. denticulatum* (Ed) and *K. striatus* (Ks) were added to the lipase enzyme at 3.8 mg/ml respectively. CAA at 3.8 mg/ml was applied as a comparison and 100% lipase enzyme was included as control. All the other results were normalised to control the result of the lipase enzyme. Data are reported as mean \pm SEM of triplicate independent determinations (n=3). The "*" indicates $P < 0.05$ compared with the control. One-way ANOVA is performed via Bonferroni's test. (Adapted from Balasubramaniam et al., 2013)

Healthy Digestion, Cholesterol and Blood Sugar Control

Prebiotics are dietary carbohydrates which can help to increase the population of probiotics within the colon; thus, good for digestion. Dietary fibre is one of the most important prebiotics in our daily life. *E. cottonii* contains a significantly higher amount of soluble fibre (18.25%) when compared with other kinds of seaweed such as *S. polycystum* (5.57%). The large amount of soluble fibre in *Eucheuma* can lead to lower cholesterol levels and help

maintain blood sugar balance.

E. cottonii appears to have the potential to lower cholesterol and have a lower glycaemic index, since many soluble fibres have hypocholesterolemic and hypoglycaemic effects, which effectively prevents metabolic syndromes (Matanjan et al., 2009). In addition, the high soluble fibre content in *Eucheuma* can also help treat obesity and diabetes by inhibiting the activities of lipase and α -amylase as shown in **Figure 2** (Balasubramaniam et al., 2013).

Cardiovascular Disease Prevention

Studies have shown that PUFAs are beneficial for a healthy cardiovascular system. Seaweed contains both omega-3 and omega-6 PUFAs. High dietary omega-6 PUFAs has the ability to decrease LDL as well as HDL cholesterol, which adversely affects the risk of heart disease. Instead, omega-3 PUFAs can decrease LDL without decreasing HDL (Matanjan et al., 2009). However, the intake of omega-3 PUFAs in a westernised diet is far from sufficient according to the recommendation from FAO or WHO (Miyashita et al., 2011). The ω_6/ω_3 ratio of *Eucheuma* is about 0.10, which not only makes it a good source of omega-3 PUFAs but also an important role in balancing PUFAs.

Hypertension Prevention

Seaweed can contribute to the daily intake of K, Ca, Mg, Li, Ba, Fe, Co and Cd. Moreover, the concentration of many important minerals including K, Mg, Fe, Mn, Cu, Zn and Co as examined by Rohani-Ghadikolaei (2012) were even higher than those in terrestrial vegetables. In particular, the ratios of Na/K were pretty low for *E. cottonii* (0.14) (Matanjan et al., 2009), which means it can be added to the diets of people who are at risk of hypertension, since a high Na/K ratio is widely associated with hypertension (Moreda-Pifeiro et al., 2012).

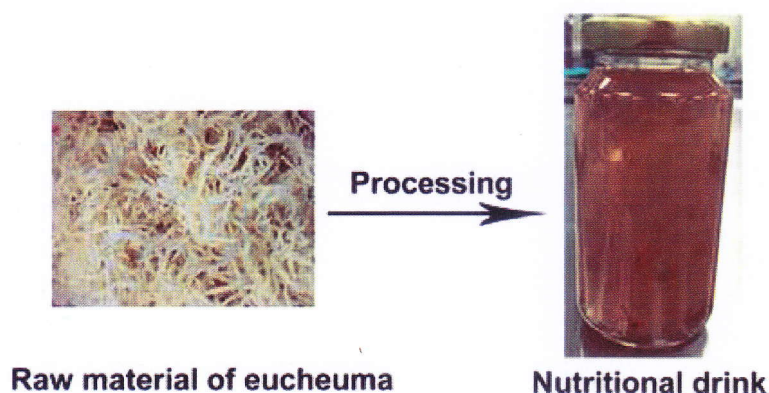


Figure 3. Eucheuma is processed into a nutritional beverage.

Brain Development

Besides helping to boost metabolism, the high iodine content in Eucheuma ($9.42 \mu\text{g}\cdot\text{g}^{-1}$) is also extremely crucial in pregnancy and breastfeeding for the normal development of a baby or child's brain cells since iodine is an important component of thyroid hormones [thyroxine, T4 and triiodothyronine, T3] (Matanjun et al., 2009). Iodine deficiency during those periods or early childhood can cause dysfunction in intellectual growth and brain development (Berbel & de Escobar, 2011). Furthermore, for normal development, the foetus relies on maternal T4 and iodine. As such, mothers are strongly recommended to ensure the proper iodine daily intake (250 to 300 μg for expectant mothers, and double the amount for normal non-pregnant women) during their pregnancy. In comparison with terrestrial vegetables and fruits (0.02 to 0.88 $\mu\text{g}/\text{g}$), Eucheuma is a better choice to supply iodine.

Based on the above-mentioned benefits, adding Eucheuma to our daily

diet can therefore enhance the structure of our nutrients and bring a good balance that protects human health from disorder. Our lab has successfully utilised Eucheuma to prepare low-calorie beverages with sucrose content of less than 7%, which complies with the Health Promotion Board – Singapore's regulation for 'healthier choice' food. **Figure 3** shows an example of processing Eucheuma or its extracts into a seaweed beverage.

Conclusion

Seaweed draws great attention from scientists for their high nutritional value. Eucheuma is especially recommended according to its optimal mix of nutrients: high amount of dietary fibre, omega-3 fatty acids, amino acids, minerals, vitamins and antioxidants, with a low concentration of sodium. It has properties of both seafood and vegetables, thus it is a promising ingredient for an application in beverages. ■

References

- Balasubramaniam, V., Mustar, S., Khalid, N.M., Rashed, A.A., Noh, M.F.M., Wilcox, M.D. and Pearson, J.P. (2013). Inhibitory activities of three Malaysian edible seaweed on lipase and α -amylase. *Journal of Applied Phycology*, 25: 1405-1412.
- Berbel, P. and de Escobar, G.M. (2011). Iodine and brain development. In *Handbook of Behaviour, Food and Nutrition*, 2105-2134. Springer: New York.
- Ganesan, P., Kumar, C.S. and Bhaskar, N. (2008). Antioxidant properties of methanol extract and its solvent fractions obtained from selected Indian red seaweed. *Biore-source Technology*, 99: 2717-2723.
- Matanjun, P., Mohamed, S., Mustapha, N.M. and Muhammad, K. (2009). Nutrient content of tropical edible seaweed, *Eucheuma cottonii*, *Caulerpa lentillifera* and *Sargassum polycystum*. *Journal of Applied Phycology*, 21: 75-80.
- Miyashita, K., Narayan, B., Tsukui, T., Kamogawa, H., Abe, M. and Hosokawa, M. (2011). Brown seaweed lipids as potential source of omega-3 PUFA in biological systems, in S.K. Kim (Ed.), *Handbook of Marine Macroalgae: Biotechnology and Applied Phycology* (pp. 329-339). Chichester, UK: John Wiley & Sons, Ltd.
- Mohamed, S., Hashim, S.N. and Rahman, H.A. (2012). Seaweed: A sustainable functional food for complementary and alternative therapy. *Trends in Food Science & Technology*, 23: 83-96.
- Moreda-Piñero, A., Peña-Vázquez, E. and Bermejo-Barrera, P. (2012). Significance of the presence of trace and ultra-trace elements in seaweed, in S.K. Kim (Ed.), *Handbook of Marine Macroalgae: Biotechnology and Applied Phycology* (pp. 116-170). Chichester, UK: John Wiley & Sons, Ltd.
- Namvar, F., Mohamed, S., Fard, S.G., Behravan, J., Mustapha, N.M., Alitheen, N.B.M. and Othman, F. (2012). Polyphenol-rich seaweed (*Eucheuma cottonii*) extract suppresses breast tumour via hormone modulation and apoptosis induction. *Food Chemistry*, 130: 376-382.
- Shamsabadi, F.T., Khoddami, A., Fard, S.G., Abdullah, R., Othman, H.H. and Mohamed, S. (2013). Comparison of tamoxifen with edible seaweed (*Eucheuma cottonii* L.) extract in suppressing breast tumour. *Nutrition and Cancer*, 65: 255-262.