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Research Article

Dietary Fiber Content, Fatty Acid and Starch Digestible Rate of Seaweed and Seaweed based Products in Sri Lanka

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Abstract

Sri Lanka has available around 10 edible marine algae species along coastal belt. The diets rich in fiber such as marine algae and their products have a positive effect on health since their consumption has been related to decreased incidence of several diseases. This project focus on evaluate the dietary fiber content and fatty acids in six native Sri Lankan species and their products. The total dietary fiber content (TDF), Fatty acid content (FA) were determined for six seaweed species belong to Phaeophyta and chllorophyta and Rhodophyta, extracts and prepared products. Then vitro starch digestibility rate was also determined in seaweed based vegetable soup sample. The highest TDF value was found in following three native Sri Lankan species *Sargassum* species (77%), *Ulva reticulate* (70%), *Ulvalactuca* (66%). The seaweed extrct agar was reported highest value 77%while carrageenan found 74%. Seaweed based products were found low dietary fiber content than seaweed available species and extracts. Seaweed based soup: 45%, Ulva jam: 58% and agar fruit jam 40%, All the products were found TDF value more than 44% except agar mixed fruit jam. TDF value of wheat brand 44%. The Seaweed based soup found increased by 20% in the dietary fiber content than market available vegetable soup The In vitro starch digestible rate of seaweed soup found correlation to the dietary fiber level of the products. Apart from there were 18 types of fatty acids (SAFA) in the seaweed of *Gracilaria verrucosa*. Nine types saturated fatty acids (SAFA) made up of 60%. Three types mono unsaturated fatty acids (MUFA) for 20% and five types of polyunsaturated fatty acids (PUFA) for 5.8%.

The Sri Lankan species and their extracted polysaccharides were found rich source of dietary fiber, saturated and unsaturated fatty acids. The higher dietary fiber in seaweed based foods effect on the digestibility and palatability.

Keywords: Dietary Fiber; Unsaturated Fatty Acids; Seaweeds; Polysaccharides; Digestibility

Introduction

Seaweeds can be classified based on its pigment into red algae (Rhodophyta), brown algae (Phaeophyta), and green algae (Chlorophyta); based on its nutrition and chemical composition. Red algae and brown algae are often used as food resources for humans [1]. The structure of algae is strongly influenced by the season, age, species and geographical location [2]. The typical carbohydrates in algae varieties consist of agar, carrageenan, alginates, fucoidan, laminaran (b-1.3-glucan), cellulose, and mannitol. The amorphous, slimy fraction of red, green and brown algae fiber is mainly consists of water-soluble agar, (L-D galactose) carrageenan, alginates and/or fucoidan and main reserved are laminaran (b-1.3-glucan) and mannitol [1]. Dietary fiber consists of soluble and insoluble fiber. Soluble dietary fiber has function in to prevent diseases such as colon cancer, cardiovascular disease, and obesity [3]. Whereas insoluble dietary fiber has the ability to decrease intestinal transit time [4]. Fatty acids are the main constituent of fat and raw material for all lipids in living organisms. Fatty acids are divided into saturated fatty acids(SAFA) and unsaturated fatty acids. Unsaturated fatty acids can be divided into two major groups, namely monounsaturated fatty acids (MUFA) and poly saturated fatty acids (PUFA) [5]. Sargassum speces belongs to Phaeophycean containing highest dietary fiber and fatty acids with 20carbon atoms, such as eicosatetraenoic acid (EPA, ω3 C20: 5) and arachidonic acid (AA, ω6 C20: 4) (Burtin, 2003). Unsaturated essential fatty acids, i.e. omega-3 (EPA, ω3 C20: 5) may reduce the risk of heart disease, thrombosis and arterioclerosis [3]. Type of red and brown algae which different from others based on its fatty acid composition are Gracilari verrucosa with rich PUFA (n-6) and Sargassum species with rich PUFA (n-3) [6].

Materials and Methods

The sample of *Sargassum, Ulva, Gracilaria*, and *Kapphaphycus* were obtained from the South west to North east coast of Sri Lanka. Samples were collected and washed. Thallus were cut into shaft, blades. The cut parts were dried, and then each part was crushed. Fiber analysis on the Thallus was conducted by enzymatic method to determine total dietary fiber. Measurements of total dietary fiber were analyzed by enzymatic methods [3]. Total of 1g sample mixed with 25 ml of 0.1 M Phosphate buffer, and then added 100 µL of alpha amylase enzyme, incubated at 100°C for 15 minutes. After incubation, it was distilled by water distiller for 20 ml and the pH of the solution adjusted to 7.0 by using NaOH and protease enzyme was added to incubate 30 minutes at 600C. Then solution become cool pH value was declined with added 4 ml of HCl. Total of 200 µ aminoglycoside enzymes was added and incubated at temperatures of 60°C for 30 minutes.

Fatty acid was analyzed by gas chromatography with method according to [7] 1M Sodium methoxide solution (prepared by dissolving approximately 2.3 g of metallic Sodium in 100 ml of methanol). Accurately, 1.0061 g of oil sample was weighed into a 50 ml beaker. Thereafter, 3 ml of benzene followed by 1.5 ml of sodium methoxide were added into it. The mixture was shacked well and 4.5 ml of methanol was added and mixed.

Then, the beaker was kept on a hot plate maintained at 50 °C for 15 minutes. Thereafter, it was allowed to cool to room temperature and 10 ml of distilled water was added. Finally, 9 ml of hexane was added and mixed well. The mixture was allowed to stand for about 10 minutes to separate water and hexane layers. Carefully, the upper hexane layer was taken from a dropper to a test tube and dried over anhydrous sodium sulphate to remove any traces of moisture. Thereafter, it was transferred to a capped vial for Gas Chromatography analysis. (Perkin- Elmer Corporation, Norwalk, CT). The starch digestibility rate of the seaweed based soup and white bread samples were analyzed by sample submitted to the Industrial Technology Institute.

Results and Discussion

The highest TDF value was found in following three native Sri Lankan species *Sargassum wightti* (77%), *Ulva reticulate* (70%), *Ulvalactuca* (66%).

The total dietary fiber fractions ranged between 61-77% in red, green and brown algae. The red algae *Kapphaphycusalaverazii* indicated 76% dietary fiber while *Gracilaria verrucosa* was found 60%. The *Ulvalactuca* was had 66% whereas *Sargussumwighti* was indicated highest value 77%.

The seaweed polysaccharides agar was reported highest value 76%while carrageenan found 66%. Seaweed based products, such as soup species: 45%, Ulva jam: 58% and agar fruit jam 40%, were found low dietary fiber content than seaweed species. All the products were found TDF value more than 44% except agar mixed fruit jam, was TDF value of wheat brand 44%. The Seaweed based soup found increased by 20% in the dietary fiber content than market available vegetable soup The Sri Lankan species and their extracted polysaccharides were found rich source of dietary fiber. The higher dietary fiber in seaweed based foods effect on the digestibility and palatability.

Parameter	Total Dietary fiber content (%)
Ulvalactuca	66 ± 0.03
Ulvareticulata	70 ± 0.03
Gracilaria edulis	61 ± 0.34
Grcilaria verrucosa	60 ± 0.01
Sargassumwightti	77 ± 0.012
Kapphaphycusalverazii	76 ± 0.032
Agar	77 ± 0.02
Carrageenan	66 ± 0.04
Alginic acid	73 ± 0.01
Ulva Jam	58 ± 0.23
Seaweed soup	45 ± 0.21
Agar fruit jam	40 ± 0.02

Table 1: Total Dietary fiber content of six seaweed species and seaweed based products.

Parameter	Total sugar (mg/ml) 1h 2h 3h	In vitro starch digestion rate	Total dietary fiber content (%)
Seaweed based soup	0.13 ± 0.01 0.25 ± 0.0 0.36 ± 0.01	29.73 ± 0.44	30.71 ± 0.44
White Bread	0.43 ± 0.01 0.83 ± 0.02 1.20 ± 0.01	100	1

Table 2: Total sugars in dialysate at different time intervals and in vitro starch digestion rate of seaweed based soup samples, and dietary fiber content.

Results of *in vitro* starch digestion rate of seaweed based soup sample showed that it had low starch digestion rate compared to white bread as the references. As research findings have shown that *in vitro* starch digestion rate has good correlation with *in vivo* glycemic response. The *In vitro* starch digestible rate was also found correlation to the dietary fiber level of the products.

Fatty acid composition of seaweeds

Palmitic acid has the highest value in the composition of fatty acids in *Gracilaria verrucosa* Palmitic acid is a saturated fatty acid that composed the most synthesized lipids in plants rather than stearic acid [8]. According to Burtin [4], The red and brown algae are particularly rich in fatty acids with 20 carbon atoms: eicosatetraenoic acid (EPA, ω3 C20 :5) and arachidonic acid (AA, ω6 C20: 4). *Gracilaria* provides an interesting source of gamma linolenic acid (GLA) (20 to 25% of the total lipidic fraction), which is a precursor of prostaglandins, leucotriens and thromboxane involved in the modulation of immunological, inflammatory and cardio-vascular responses.

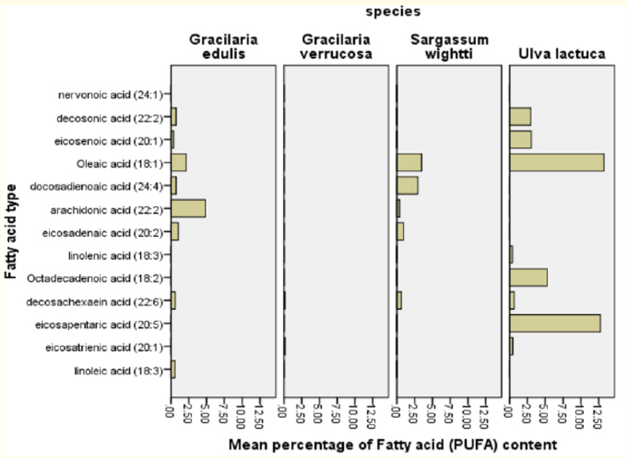

Figure 1: Mean percentage of Fatty acid (PUFA) content of economically important seaweed species available in Sri Lanka.

Among four different seaweed species considerable amounts of fatty acids and related compounds were observed. Fatty acid analysis shows that the PUFA compounds present in *Ulvalactuca* species are decreasing in the order of eicosapentaric acid (20:5), Oleaic acid (18:1), Octadecadenoic acid (18:2), eicosenoic acid (20:1), decosonic acid (22:2). The eight compounds were isolated. The Predominance identified compounds are given in Figure-1. From the identified five fatty acids, eicosapentaric acid (20:5), contributes highest composition, then followed by Oleaic acid (18:1). The relative quantity in Octadecatrienoic acid was found to be lesser among identified fatty acids.

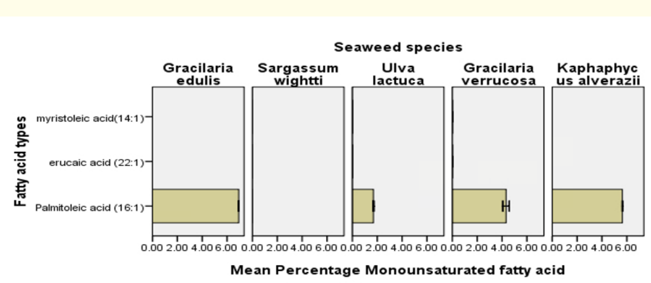

Figure 2: Mean percentage of mounasaturated fatty acids of economically important seaweed species available in Sri Lanka.

Gas chromatographic analysis of red algae sample extract showed the presence of monounsaturated fatty acids (MUFAs), mainly Palmitoleic acid (16:1). Red algae species *Gracilaria edulis* shows highest value. This difference may be due to environmental effect. Many micro algae have been shown to be a good source of MUFA.

The highest saturated fatty acids content was found in *Sargassumwightti*. The main available acids were Caprylic acid and Butyric acid. The brown seaweed showed they were suitable source of bio-fuel industry

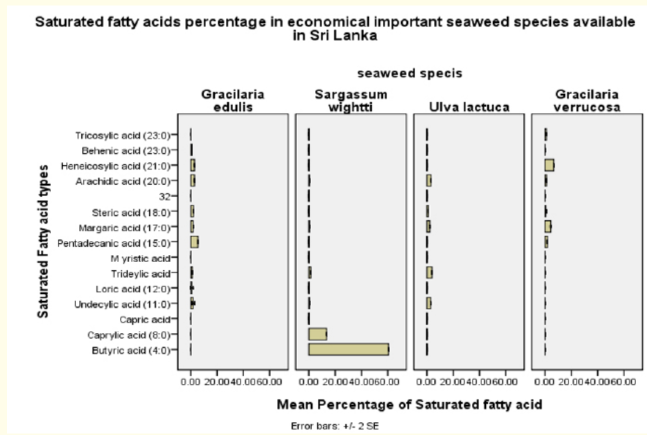

Figure 3: Saturated fatty acids percentage in economically important seaweed species available in Sri Lanka.

Conclusion

Insoluble dietary fiber and total dietary fiber were found most abundant on Sargassum species, whereas soluble dietary fiber was found most abundant in agar. We found 18 types of fatty acids (SAFA) in the seaweed of *Gracilaria verrucosa*. Nine types saturated fatty acids (SAFA) made up of 60%. Three types mono unsaturated fatty acids (MUFA) for 20% and five types of polyunsaturated fatty acids (PUFA) for 5.8%. The higher dietary fiber in seaweed based foods effect on the digestibility and palatability. This gives an indication that seaweed based sample may be having low glycemic index due to high dietary Total fiber content.

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