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Chemical and Different Nutritional Characteristics of Brown Seaweed Lipids

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ABSTRACT

Lipids are the fatty acid or their derivative which are insoluble in water but soluble in organic solvent. Brown color seaweeds have high value of total lipids (TL) contents, ranging from 10 to 18 % of dry weight. It contains glycoglycerol lipids (GL) as lipid class, which is rich in 18:4n_2, 20:5n_2 and 20:4n_5. Brown colored seaweed also contains fucoxanthin as a main functional compound. Its stable nature of oxidation is due to the presence of polyunsaturated fatty acids (PUFAs). Oxidative stability of brown seaweeds is very high. They also show ant obesity and anti-diabetic effects.

1. Introduction

Algae can be divided into two main groups, macro-algae (seaweeds) and micro-algae. Approximately 9000 seaweed species are available worldwide, which are further divided into three main groups on the basis of their pigmentation: brown (Phaeophyta), red (Rhodophyta) and green (Chlorophyta) seaweeds. Whole parts of seaweed are available for effective biomass sources because of their high rate of absorption of carbon dioxide from the atmosphere.

Seaweeds have been used as sources of food, medicine, cosmetics, fertilizer, feed and bio-energy [1-3]. Seaweeds are enriched in non-starch polysaccharides food components such as carrageenan and alginate, which cannot be degraded by mammalian enzymes [4]. These contain high content of amino acid then the other vegetable. These are also enriched in polyphenols, especially phlorotannins which is used as an antioxidant. Although lipid content in seaweed is lower than marine fish but due to their large stock in coastal waters define it as potential source of functional lipid. Lipid content in oily fish has been reported to be approximately 20 wt. % per dry weight (DW), occasionally reaching 50 wt. % per DW, but seaweeds contain up to 1–5 wt. % total lipids per DW. [5,6]. On the other hand, recent research revealed that contents of TL and omega-3 polyunsaturated fatty acids of seaweeds fluctuate seasonally, it could reach 15 % TL per DW and could contain over 40 % omega-3 PUFAs per total fatty acids.

Several types of bioactive compounds, such as omega-3 PUFAs, omega-6 arachidonic acid, fucoxanthin, fucosterol and some polyphenols are present in brown seaweeds. Carotenoid which is found in brown seaweeds shows several physiological effects due to their unique molecular mechanisms [7].

2. Seaweed lipids

The lipid content in seaweed is very sensitive and remarkably change by species to species, it also varies by geographically, seasonally, temperature, salinity and light intensity [8].

A latest research revealed that species of tropical areas have significantly Lower lipid contents than the cold area species. A quantitative lipid analysis showed that the TL content in Sargassaceae (a major brown seaweed family) was higher in subarctic zones (approximately 6 % per DW) than tropical zones (0.9–1.9 % per DW) [9, 10].

3. Brown seaweed lipids

Seaweeds play a vital role in preserving coastal belt ecosystems especially brown seaweeds [11,12]. In Japan brown seaweeds are form a part of the staple diet. They contain valuable nutrients and bioactive components, which is not found in terrestrial plants. Major membrane lipid is also present in brown seaweeds. The composition of fatty acid of the chloroplast Glycoglycerol lipids is rich in highly unsaturated fatty acid. The main fatty acid in the GL of plant leaf is alfa linolenic acid (LNA), which is rich in monogalactosyl-diacylglycerols (MGDG), digalactosyl-diacylglycerols (DGDG), Stearidonic acid (SDA), arachidonic acid (ARA) and eicosapentaenoic acid (EPA). These are the major fatty acids in seaweeds [13, 14]. A clinical study expresses about the omega-3 PUFAs that it has important cardio-protective effect [15] and the reduction of cardiovascular disease (CVD) occur by taking of EPA and

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docosahexaenoic acid (DHA) [16,17]. ARA, the active form of omega-6 PUFA, is found help ful to develop immune response, thrombosis and brain function. ARA and DHA are also useful for neuro development of infant so it should be used in diet supplement. ARA and DHA are major constituents of cell membranes and play an important role in the structure of neurons in the central nervous system, where these are present at high concentrations [18]. Humans have a poor ability to form DHA from LNA or ARA from linoleic acid (LA) due to the low activity of delta-6 desaturase. Brown seaweed lipids contain fucosterol and fucoxanthin as functional components. Fucoxanthin exhibits characteristic biological activity, including anti-obesity [19], anti-diabetic, antioxidant and anti-cancer effects. The physiological effects of fucoxanthin have been described in detail in several reviews [20, 21].

4. Seaweed lipids Oxidative stability

Due to large number of double bonds, the major PUFAs in brown seaweed lipids, such as SDA are very easily oxidized [22,23]. Oxidative deterioration of these PUFAs is one of the very important problems in food chemistry, as lipid oxidation produce undesirable flavors, odor and lower nutritional quality and storage of lipid-containing foods. Carotenoids are degraded by carotenoid–radical inter actions and cleavage at the center of the carotenoid bone. The electron-rich status of fucoxanthin makes it less stable than other carotenoids. Thus, the low stability of fucoxanthin may be a major problem in the application of brown seaweeds to food materials as fucoxanthin resources.

5. High oxidative stability of PUFAs as GL form

GL plays an important role in photosynthesis. It is very rich in omega-3 PUFAs such as SDA, EPA and LNA. The content of these PUFAs increases with the increase of photosynthetic activities [24]. The GL of chloroplast is always exposed to oxidative stress because it has high level of PUFAs and light energy absorption for photosynthesis. Reactive oxygen species (ROS) are developed in the photosynthetic membrane. This can cause oxidative damage to many cellular components, including proteins, lipids membrane, nucleic, chlorophyll and nucleic acids. To maintain the level of ROS and to save the cells, seaweeds possess a number of antioxidants (phenolic , ascorbate, glutathione compounds, carotenoids and tocopherols) and enzymes (Catalase, Superoxide dismutase , Glutathione reductase and Ascorbate peroxidase) to scavenge the ROS and to regenerate the active forms of antioxidants [25,26]. A latest research showed that PUFAs in GL form has high oxidative stability [27]. GL also showed higher oxidative stability than Soybean oil. It is due to the protective effect of sulfoquinovosyl and galactosyl moieties on PUFAs bonded to the same GL molecule. If we want to decrease in the oxidative stability of food lipids we should also use carbohydrates [28].

6. Brown seaweed lipids Nutritional impact

Brown seaweed lipids have up to 5 % fucoxanthin [10]. Fucoxanthin shows Anti-obesity effects [19]. It also improves insulin resistance and remarkably decreases blood glucose level [29]. A research shows that when brown seaweed lipids are given to obesity/ diabetes model mice, excess fat accumulation in abdominal white adipose tissue (WAT) is gradually reduced, and glucose levels are again restored to normalize levels, mainly due to presence of fucoxanthin in the lipids.

It is also observed that a combination diet of 0.1 % fucoxanthin and fish oil also markedly decrease the blood glucose and plasma insulin quantity to the same levels. But omega-3 fish oil alone had very little effect on Abdominal WAT weight and plasma glucose level, as brown seaweed lipids contain high levels of omega-3 PUFAs, so the effect of fucoxanthin will be greater compared with that fucoxanthin alone. Another research shows that when brown coloured seaweed lipids were given to Animals, a significant increase in the component of DHA and ARA of the liver was also observed [7].

7. Conclusion

The brown seaweed families *Laminariales* and *Fucales* are two basic species, forming underwater forests which provide and develop different ecological services and effect to coastal belt ecosystems. They are also a major class of aqua cultured seaweeds and are regarded as having significant potential to serve as a biomass source. The brown seaweeds contain polysaccharides, including undigested fibers, minerals, proteins and lipids. Although the lipid content of brown seaweeds is less than the content of other nutrients, it contains biologically active compounds, such as fucoxanthin, omega-3 EPA and SDA and omega-6 ARA. Among these compounds, fucoxanthin is major to understand the characteristic functionality of brown seaweed lipids. The oxidative stability of PUFAs is occasionally problematic in the application of marine lipids to food and other products. A research study indicated the high oxidative stability of omega-3 PUFAs in brown seaweed lipids. Although more research study will be needed to confirm this characteristic oxidative stability of PUFAs in brown seaweed lipids, these lipids may be applied to nutraceuticals and functional foods as an oxidative stable omega-3 source. For the commercial use of brown seaweed lipids, a search for TL-rich seaweed materials will be important. Studies on the seasonal, regional and species variations of lipid components showed that several brown seaweed species collected in the growing stage had high levels of TL, fucoxanthin and omega-3 PUFAs.

Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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