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Quality aspects of some value added seaweed food and functional food products

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ABSTRACT

Culture of seaweed is expanding globally due to wide range application of seaweeds including human consumption as nutritious food. Despite the availability of naturally occurring seaweeds, utilization is scarcely noticed in Bangladesh. Therefore, some value added seaweed food and functional food products were experimentally manufactured and those products were found to be promising for commercial production. Proximate composition and shelf life determination by organoleptic evaluation were conducted on four value added seaweed food products *viz.*, seaweed jelly, soup, ice cream, curd and two functional food products *viz.*, seaweed singara, samosa. Crude protein, lipid, moisture and ash content of above mentioned food and functional foods items were analyzed. To study shelf life, two sets of sample; each set of sample included previously mentioned 4 value added seaweed food items and 2 value added seaweed functional food items stored both in ambient condition and in freezer at −18 °C were investigated for 1 month. Crude protein content of seaweed jelly, soup, ice cream and curd was 8.71%, 9.04%, 14.96% and 16.60%; lipid content was 6.76%, 12.67%, 10.33% and 1.10%; moisture content was 42.75%, 56.94%, 51.68% and 58.06%; ash content was 19.05%, 16.27%, 8.02% and 9.10%, respectively. Average proximate composition value of seaweed singara, samosa was found respectively as 9.80% and 10.01% crude protein, 6.88% and 6.17% lipid, 32.08% and 27.44% moisture, 13.20% and 10.01% ash. All value added seaweed food and functional food products kept open in ambient condition had a shelf life of not more than three days. Shelf life of seaweed food and functional foods in freezer was at least 1 month. Determination of optimum use of seaweeds in product development, spoilage mechanism, development of more new products, effect of these products on human health, seaweed culture technique etc. should be investigated in future.

Keywords: Seaweed product quality, macro algae, food security, Blue economy, *Hypnea*, Bangladesh

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1 Introduction

Worldwide, seaweeds have increasingly been utilizing as human food, hydrocolloids, medicine, cosmetics, animal feed, fish feed, fertilizers and soil conditioners etc. (McHugh, 2003; Buschmann et al., 2005; Van den Burg et al., 2013; Mesnildrey et al., 2012; Gade et al., 2013; Kılınç et al., 2013). Global production of farmed seaweeds from 2000 to 2012 become doubled and the trend is steadily uprising. Seaweeds culture is now overwhelming other algae cultures and practiced in about 50 countries (FAO, 2014, 2016).

From October to April, at least 150 seaweed species including 19 commercially important species remain available in Bangladeshi coast of Bay of Bengal. Among naturally available 5,000 metric ton seaweeds, harvesters of St. Martin's Island harvest and smuggle about 250-500 ton dried seaweed to Myanmar. A negligible amount of that remaining seaweeds is used by Mog or Rakhyine tribal community as food (Majumder, 2010; Sarkar et al., 2016a).

Proximate composition analysis of raw seaweeds showed that they are highly nutritious as human food (Majumder, 2010; Van den Burg et al., 2013; Siddique et al., 2013). It is not always possible to consume raw or fresh seaweeds for people live in far distant regions from coast and coastal people also has not year round availability of seaweeds. So, naturally available unused seaweed collected from St. Martin Island, Bangladesh was used in manufacture of jelly, soup, ice cream, and curd in order to make an effective way for utilization. When seaweed is used in such manner, this increase the value of seaweed. So, these products are value added seaweed products (Sarkar et al., 2016b).

Fucoïdans, a structural polysaccharide found in the cell wall of brown seaweeds has anti-thrombotic, anti-coagulant, anticancer, anti-proliferative, antiviral, anti-inflammatory properties and anti-complementary agent. The mineral fraction of some seaweeds accounts for up to 36% of dry matter. The brown seaweeds have traditionally been used for treating thyroid goiter. Phycobiliproteins in red and blue algae present antioxidant properties, which could be beneficial in the prevention or treatment of neuro-degenerative diseases caused by oxidative stress (Alzeimer's and Parkinson's) as well as in the cases of gastric ulcers and cancers. Besides fatty acids, unsaponifiable fraction of seaweeds was found to contain carotenoids (such as β-carotene, lutein and violaxanthin in red and green seaweeds, fucoxanthin in brown seaweeds), tocopherols, sterols (such as fucosterol in brown seaweeds) and terpenoids (Burtin, 2003). So food products in which seaweed is added simply as an ingredient among other ingredients but not as the principal ingredient that affect product's vital properties e.g. appearance, texture, consistency etc. like above mentioned value added seaweed products is functional seaweed food product.

Different value added seaweed products; namely, seaweed jelly, soup, ice cream, and curd, functional food products; namely, seaweed singara, samosa, and cosmetic products, for example, seaweed face pack, shampoo was experimentally manufactured. These products has potentiality to be produced commercially (COAST-Trust, 2013; DoF, 2014; Sarkar et al., 2016b). Moreover, these food and functional food products may can be an option of solution for food security and development of 'Blue Economy' in Bangladesh (Duarte et al., 2009; DoF, 2014). But as food product their internal quality factors (chemical, physical, microbial) were not judged. So, a study focused on chemical composition i.e. proximate composition of these food products has done so that a general idea about nutritional value could be generated. On the other way, for marketing, how much time the products take for quality deterioration must have to be considered. The overall objectives of this research was to determine the proximate composition of value added seaweed food and functional food products and to determine the shelf life of those products organoleptically.

2 Materials and Methods

2.1 Preparation of seaweed food products

Hypnea sp. powder of 2.52 g was boiled in water to extract phycocolloids so that gelation property of phycocolloids can be used to manufacture seaweed jelly, soup, ice cream, and curd. Seaweed singara and samosa was manufactured conventionally except 2.52 g *Hypnea* sp. powder was added with filling. Details methodology for manufacture of these products has reported by Sarkar et al. (2016b). As a control, the above mentioned food products were manufactured without any addition of seaweed powder.

2.2 Proximate composition analysis of food products

Crude protein, lipid, moisture and ash content of 3 samples from each food and functional foods items and food products without seaweed powder were analyzed according to standard procedure of AOAC (AOAC, 2000).

Crude protein of the samples was estimated by using a Kjeltec 2020 digestion Unit. A sample of 0.5 g and a blank was taken in the digestion tube for digestion at high temperature; 10 mL of concentrated sulfuric acid and 1.1 g digestion mixture were added in the tube. Then the digestion tubes were set in digestion chamber fixing at 420 °C for 45 min ensuring water supply, easier gas outlets etc. After digestion the tubes were allowed to cool and 5 mL of sodium thiosulphate ($Na_2S_2O_3$) (33%) and 30 mL sodium hydroxide (NaOH) solution was added in each tube. Then the distilled extraction was collected with 25 mL of Boric acid (4%) and titrated with standard HCl (0.2 N). Generally, the nitrogen values obtained was converted into percentage of crude protein by multiplying with a conversion factor of 6.25 or 5.85 assuming that protein contains 16% or 17% nitrogen for animal or plant protein. In this study, for all the food and functional food products except seaweed ice cream and curd, the value of conversion factor was 6.25 as the protein source was seaweed powder i.e. plant protein. For seaweed ice cream and curd, average value of conversion factor for animal and plant protein was taken as these foods contain both animal and plant protein.

$$\%N = \frac{ME_N \times V_t \times S_{HCl}}{W_s} \times 100 \quad (1)$$

where, ME_N = milli-equivalent of nitrogen (0.014), V_t = volume of titrant (mL), S_{HCl} = strength of HCl, and W_s = weight of sample (g).

$$\%CP_p = \%N \times 5.87 \quad (2)$$

For seaweed ice cream and curd,

$$\%CP_{pa} = \%N \times 6.06 \quad (3)$$

where, CP_p and CP_{pa} designate crude protein (containing plant protein) and crude protein (containing plant and protein), respectively.

Crude lipid was determined by extracting a weighed quantity (2-3 g) of samples with analytical grade acetone in ground joint Soxhlet apparatus. Extraction was allowed to continue by heating in the electric heater at 70 °C temperature until clear acetone (without oil) was seen in siphon, which took about 3 h. Then the round bottom flask of the apparatus was separated and the extract was transferred to a preweighed beaker and left for evaporation of acetone in an oven at 105 °C. After the evaporation of acetone, only the lipid was left in the beaker which was later calculated in percentage.

$$\%CL = \frac{W_{BL} - W_{BE}}{W_s} \times 100 \quad (4)$$

where, CL = crude lipid, W_{BL} = weight of beaker with lipid (g), W_{BE} = weight of empty beaker (g), and W_s = weight of sample (g).

Moisture content was determined by placing an accurately weighed amount (about 2-3 g) sample in a pre-weighed porcelain crucible in a thermostat oven (Gallenkamp, HOTBOX, Model OVB-306) at 105 °C for about 24 h until a constant weight was obtained. The dried crucible then transferred to desiccators for cooling and weighed using a sensitive electric balance. The percentage of moisture was calculated using the following equation:

$$\text{Moisture } (\%) = \frac{W_F - W_D}{W_F} \times 100 \quad (5)$$

where, W_F and W_D designate weight (g) of fresh and dried samples, respectively.

For determination of ash content, accurately weighed samples (about 2-3 g) were taken in porcelain crucibles and placed in a muffle furnace at 550 °C for 6 h. The crucibles were then taken out for the future use, cooled in desiccators and weighed in a sensitive electric balance. The percentage of ash was then determined.

$$\text{Ash content } (\%) = \frac{W_{CA} - W_C}{W_s} \times 100 \quad (6)$$

where, W_{CA} and W_C designate weight (g) of crucible with ash and empty crucible, respectively.

2.3 Shelf life of food products

Freezer is very much conventional at retail selling in Bangladesh. So, two sets of sample, each set of sample included previously mentioned 4 value added seaweed food items and 2 value added seaweed functional food items stored both in ambient condition and in freezer (Sharp Deep Freezer SJC 315WH) at -18 °C covered by cellophane paper were organoleptically (appearance, changes in texture, smell, taste, sign of microbial contamination) investigated for 1 month (MPI, 2012). The samples in ambient condition was examined at 1 d interval and the samples in freezer was examined at 7 d interval.

3 Results and Discussion

3.1 Proximate composition of food products

Mean nutrient values of 4 value added seaweed food items and 2 value added seaweed functional food items are presented in Table 1 and Fig. 1. Crude Protein, lipid and ash content of different raw *Hypnea* spp. ranged from 11.1-25.5% crude protein, 0.5-6.35% lipid and 11.0-39.03% ash, respectively (Zafar, 2005; Majumder, 2010; Siddique et al., 2013; DoF, 2014). In the present study, the highest and the lowest protein contents were found in seaweed curd and seaweed jelly, respectively. May be bacterial enzymatic activity requires for curd formation from milk is responsible for the availability of higher nitrogen percentage in calculation of proximate composition, thus, the highest value of protein (Fox and Condon, 1982). The highest lipid and ash contents were found in a seaweed functional food product- seaweed singara. Seaweed singara was deep fried in oil and beside lipid and ash content of seaweed itself, use of potato as

Table 1. Proximate composition of value added seaweed food and functional food products

Proximate composition	Value added seaweed food and functional food products					
	Jelly	Soup	Ice-cream	Curd	Singara	Samosa
Protein (%)	8.71 ± 0.10	9.04 ± 0.07	14.96 ± 0.03	16.60 ± 0.44	9.80 ± 0.19	10.01 ± 0.47
Lipid (%)	6.76 ± 0.31	12.67 ± 0.18	10.33 ± 0.08	1.10 ± 0.04	6.88 ± 0.27	6.17 ± 0.31
Moisture (%)	42.75 ± 0.45	56.94 ± 0.29	51.68 ± 0.34	58.06 ± 0.07	32.08 ± 0.31	27.44 ± 0.14
Ash (%)	19.05 ± 0.11	16.27 ± 0.21	8.02 ± 0.51	9.10 ± 0.45	13.20 ± 0.11	10.01 ± 0.25

Values are mean±SD of 3 individual measurements

Table 2. Organoleptic quality changes of value added seaweed food products kept in ambient condition

Products	Observ. date	Organoleptic characteristics					Overall quality
		Appearance	Texture	Smell	Taste	Microbial cont.	
Jelly	Day 1	Fresh	Viscous	Sweet	Good	Nil	Consumable
	Day 3	Rotten	No stickyness	Putrid	Insipid	fungal colonies	Non consumable
Soup	Day 1	Fresh, attractive	Dense liquid	Aeromatic	Good	Nil	Consumable
	Day 3	Spoiled	Gel	Putrid	Corrosive	Nil Nil	Non consumable
Ice cream	Day 1	Fresh	Solid	Pleasant	Good	Nil	Consumable
	Day 3	Soft muddy	Gel	Sour	Acidic	Nil	Non consumable
Curd	Day 1	Natural	As usual	Milky	Good	Nil	Consumable
	Day 3	Discolored	Normal	Strong sour odor	Acidic	>20 fungal colonies in 7 cm diameter	Non consumable
Singara	Day 1	Fresh	Crispy	Pleasant	Good	Nil	Consumable
	Day 3	Loss of bloom fully	Soft	Rancid and putrid	Insipid	Nil	Non consumable
Samosa	Day 1	Fresh	Crispy	Pleasant	Good	Nil	Consumable
	Day 3	Loss of bloom fully	Soft	Rancid and putrid	Insipid	Nil	Non consumable

Table 3. Organoleptic quality changes of value added seaweed food products kept in freezer

Products	Observation date	Organoleptic characteristics					Overall quality
		Appearance	Texture	Smell	Taste	Microbial cont.	
Jelly	1st Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
	3rd Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
Soup	1st Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
	3rd Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
Ice cream	1st Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
	3rd Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
Curd	1st Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
	3rd Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
Singara	1st Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
	3rd Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
Samosa	1st Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable
	3rd Week	Icy, natural	Normal	Normal	Normal	Nil	Consumable

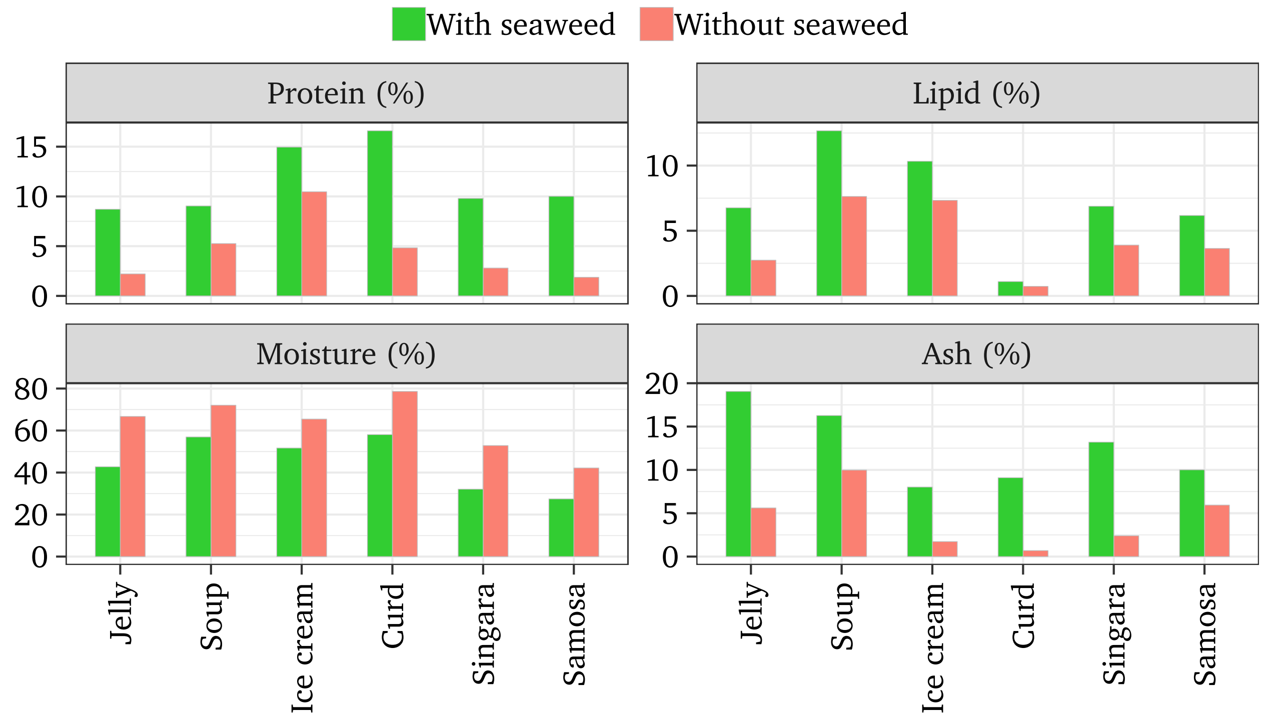

Figure 1. Protein, lipid, moisture and ash contents in food products with and without seaweed

an ingredient of singara which is naturally rich in minerals may result the highest lipid and ash content (Toma et al., 1978). So, this product can be used as mineral source in human diet. Based upon the nature of different products i.e. solid or liquid, different moisture content was found. Beside protein, lipid, moisture and ash content, according to some other works (Wong and Cheung, 2000; Matanjun et al., 2009; Siddique et al., 2013; Marinho-Soriano et al., 2006), considerable amounts of carbohydrate and fiber may be found in these products.

Protein, lipid, moisture and ash content of seaweed food and functional food products compared with food products without seaweed powder is shown Fig. 1. In every case, protein, lipid and ash content was higher than conventional food products. Use of seaweed powder in manufacture of the products is the reason for nutrient value increase of those products. But moisture content was higher in every conventional food items because all ingredients in conventional products were same as seaweed added products except inclusion of seaweed powder.

3.2 Shelf life of food products

It is found that samples kept open in ambient condition had a shelf life of not more than three days (Table 2). On second day, signs of organoleptic quality deterioration e.g. discoloration, objectionable odor, fragmented texture etc. was seen and on third day complete quality deterioration was found (Fig. 2). It is a quiet natural phenomenon that such kind of food items kept open in ambient condition start quality degradation within 24 h. Although spoiled at the 3rd day of observation but no microbial contamination was seen in soup; may be spices used in soup prevented microbial contamination (Rahman et al., 2017). Similar organoleptic quality changes were found for ice cream and curd. May be the major ingredient i.e. milk is common in those; thus showed similar organoleptic quality changes. Again, very much similar organoleptic quality changes were found for singara and samosa. In this case, although ingredients were not same but their processing was same. So, deteriorative quality changes of seaweed products can be controlled by optimization of amount of ingredients and processing method.

But, for the samples kept in freezer, no quality changes were observed for 1 month. In case of thawing after 1 month, some rancid odor is found for singara and samosa and slight dull taste for the rest of the samples was observed. Even at −20 °C, reactions responsible for development of rancidity occurred but relatively in lower rate than normal ambient condition (Aubourg et al., 2005). So, it can be concluded that, at freezing condition, shelf life of seaweed food and functional foods is at least 1 month (Table 3 and Fig. 2).

Samples kept open in ambient condition were susceptible to microbial contamination, lipid oxidation and evaporation of moisture content. Therefore, the

Figure 2. Seaweed food and functional food products at starting and different stages of organoleptic quality evaluation

shelf life of those samples were short. So far observed, growth of moulds in seaweed jelly and curd as nutrient rich medium may be related to quality deterioration of these products. For seaweed jelly, possibility for occurrence of mycotoxins producing moulds should be considered (Udota and Urua, 1970). Although no microbial colony on soup and ice cream was found as jelly and soup but fungus can grow on these products also (Bouakline et al., 2000; Pitt and Hocking, 2009). However, the mechanism of spoilage of those products should be studied. It is well known that freezing always slow down all chemical reactions. Thus, a higher shelf life for frozen samples was found.

4 Conclusions

Proximate composition of seaweed products are promising. Discovery of health beneficial effects of seaweeds as food, making seaweeds attractive to conscious consumers throughout the world. So, those product can be a new food and export item for Bangladesh. Mass awareness on nutritional value of these products has to be required to introduce them commercially. High nutrient value and shelf life of different food and functional food can be achieved by optimum use of seaweeds in products. Further, determination of optimum use of seaweeds in product development, spoilage mechanism, development of more new products, effect of these products on human health, seaweed culture technique etc. should be investigated in future.

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Conflict of Interest

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

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