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Production of *Gracilaria* powder

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Key words: Microbiological qualities, Physico-chemical properties, Sensory qualities, Proximate composition, Trained panelists

Abstract

This study aimed to produce *Gracilaria* powder and standardize the process with desirable microbiological qualities, sensory qualities, and physico-chemical properties and proximate composition. In the production of *Gracilaria* powder, three treatments were prepared to determine the best way of washing and cleaning the *Gracilaria* seaweeds. Treatment one (T1) was untreated or washed with potable water, Treatment two (T2) was treated with Sodium Metabisulfite and Treatment three (T3) was treated with Chlorine. The best treatment was Treatment two (T2) with 28 MPN/g Escherichia coli count, 120 CFU/g Mold and Yeast Count and 630,000 Aerobic Plate Count. Sensory qualities were also determined by trained panelists as to color, texture, and aroma. Overall, *Gracilaria* powder was dark brown, granulated, and with perceptible seaweed aroma. Using the Treatment two (T2), *Gracilaria* was turned into powder by cooking, drying, pulverizing, and sifting. Powdered *Gracilaria* was submitted for physico-chemical properties, proximate composition and microbial composition and the results obtained were 0.537 A_w at 24.70°C, 6.92% ash, 12.61% Moisture, 3.31 Crude Fat, 14.58% Crude Protein, 12.00% Iodine, 60.64% Dietary Fiber, 95.93 mg/100g Iron, 615.88 mg/100g Calcium and 647.34 mg/100g Sodium. The produced *Gracilaria* powder will be used to develop, formulate, and standardize *Gracilaria* enriched products.

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Introduction

A large percentage of the population in the Philippines suffers from one or more forms of malnutrition including micronutrient deficiencies. Among Filipino children, the four major deficiency disorders are protein-energy malnutrition, iodine deficiency disorder, Vitamin A deficiency, and iron deficiency. According to the news article issued by the International Council for Control of Iodine Deficiency Disorder (ICCIDD) on May 2013, despite the ASIN Law which mandated the addition of iodine to all salt and other food products, endemic goiter has still been recognized in most parts of the country and 50,000 Filipino newborns have mental problems due to Iodine deficiency. Therefore, it is necessary to find more specific and focused strategies for vulnerable groups with iodine deficiency to eradicate related disorders even with adequate iodine nutrition.

Seaweed is a macroalgae with an increasing economic value on the global market. Recently, the use of seaweed is growing in popularity in the food industry to produce nutritious and useful foods due to its richness in polysaccharides, minerals, fiber, protein, and omega-3 fatty acids. Additionally, seaweed is a source of hydrocolloids, which are typically used in the processing of a variety of food products like sauces, ice cream, and soup as a thickening agent, gelling agent, emulsifier, and stabilizer (Hamid *et al.*, 2020).

In addition, Seaweeds are also a great source of dietary fiber. Dietary fiber consists of two fractions: soluble and insoluble, and its properties are mainly determined by the proportion of these two fractions. Thus, soluble fiber is characterized by its ability to form viscous gels, in contact with water, in the intestinal tract. Insoluble fiber does not form gels in contact with water but can retain water in its structural matrix, producing an increase in fecal mass that accelerates intestinal transit. These differences in the behavior of the fibers in the intestinal transit result in different properties. Insoluble fiber is sparsely fermented and has a marked laxative and intestinal regulating effect, while soluble fiber is fermented in high proportion, and its main properties are related to the decrease of cholesterol and glucose in the blood and the development of intestinal microbiota (Peñalver *et al.*, 2020). Finally, the ratio of fiber soluble/insoluble (S/I) is higher in seaweeds than in terrestrial vegetables, with an average content of 24.5 g/100 g for soluble fiber and 21.8 g/100 g for insoluble fiber (Peñalver *et al.*, 2020).

Furthermore, Seaweeds are widely used for food consumption by humans and domesticated animals, it has globally displayed a substantial upsurge over the years. It has consistently increased from 1990 to 2018 and registered a total of 32.9 million metric tons in 2018 from 5.05 million metric tons in 1990, resulting in a six-fold growth (FAOSTAT, 2021). In the Philippines, emerging technologies in seaweed processing are becoming more popular. But even though there are more and more studies on seaweeds being done around the world, little is known about the microbiological makeup of the edible seaweeds in the Philippines. In the practice of eating seaweed fresh and raw, it is important to examine its microbiological aspect as it may contain fecal and other human pathogens (Besagas and Gamolo, 2018). In connection to Organic Agriculture Act of 2010 (Republic Act No. 10068) as amended by Republic Act No. 11511 in 2021 to “promote, propagate, develop further and implement the practice of organic agriculture.”, that increases farm productivity and farmers’ incomes, encourage the participation of indigenous organic farmers in promoting their sustainable practices, and protect the health of farmers, consumers and the public among others (Cabrera and Waguey, 2023), the *Gracilaria* in the Philippines specifically from the coastal area of Rabon, Rosario, La Union is naturally grown and abundant.

As years passed by, according to the FAO Globefish Research Programme, dried seaweed products currently completely dominate the market. Seaweeds have recently become more widespread in new markets and introduced as an ingredient in several new products in the US and European markets, and these alternative methods of drying are gaining popularity (Lovdal *et al.*, 2021).

According to a study conducted by Colorado State University, Sulfur and sulfite compounds have been used for centuries to prevent discoloration and reduce spoilage during the preparation, dehydration, storage, and distribution of many foods. However, sulfites may initiate asthmatic reactions in some people, especially those with asthma. As a result, the Food and Drug Administration (FDA) has banned the use of sulfites on fresh fruits and vegetables for sale or served raw to consumers. They are still used as an antimicrobial agent and to help preserve the color of some dried fruit products. Sodium metabisulfite is often available at pharmacies or where wine-making supplies are sold. In using sodium metabisulphite as an antimicrobial agent, stir 1 tablespoon (21 grams) of sodium metabisulfite into one quart (1000 milliliters) of cold water. Allow the produce to be soaked for 10 minutes, and then remove with a slotted spoon, drain well, and dehydrate.

Due to health and safety concerns, do not use burning sulfur to pretreat fruits for drying. 1.5g of sodium metabisulphite dissolved in 1 liter of water will give 1000ppm (0.1%) SO_2. The most practical way to make a sulfite solution is to prepare a stock solution of 8,000 ppm (0.8%). This is done by dissolving 12g (2.5 level teaspoons) of sodium metabisulphite in 1 liter of water. The stock solution can be diluted by adding extra water to give weaker solutions (FAO, 2019).

Also, according to an article published by PubMed in 2014, sodium metabisulphite is used as an antioxidant agent in many pharmaceutical formulations. It is extensively used as a food preservative and disinfectant.

It was also proven as an anti-microbial agent in shrimp. Which one study conducted they dipped the shrimp into 1.25% sodium metabisulphite solution (1.5 kg/100 liters) for 1 minute with moderate agitation followed by draining. This study has demonstrated the effectiveness of sodium metabisulphite as an agent in delaying melanosis development in shrimp. Its antimicrobial effect was confirmed.

According to the Guidelines for the Use of Chlorine Bleach as a Sanitizer in Food Processing Operations by Oklahoma State University (2016), Chlorine bleach can be a very effective method of killing undesirable microorganisms Chlorine bleach solutions may be used for sanitizing raw fruits and vegetables during the washing or peeling process. The federal regulations that apply differ slightly from those for sanitizing solutions given above. The Code of Federal Regulations of the US Food and Drug Administration (21 CFR Part 173) specifies two conditions for the permitted use of hypochlorite solutions in washing produce: (a) the concentration of sanitizer in the wash water must not exceed 2000 ppm, (b) the produce must be rinsed with potable water following the chlorine treatment. Most operations, unless the produce is very dirty, will not need a sanitizer concentration greater than 200 ppm total chlorine to achieve the desired sanitizing effect. Contact times of one minute or greater are typically sufficient to achieve a thorough kill.

Meanwhile, the Drying method is used to inhibit all microbial growth including yeast and mold, and aerobic plate count (APC)-also known as the standard plate count, aerobic mesophilic count, total plate count, or aerobic colony count, a measurement of the number of microorganisms that can grow aerobically at mesophilic temperatures (Salami *et al.*, 2022). The drying method is used to reduce the water activity (A_w) to 0.6 or below, while bacteria of relevance are inhibited at much higher A_w. Determination of the optimal A_w and moisture content is therefore essential. The surface-to-volume ratio is very high for most seaweeds and the drying time is relatively short which makes it feasible to dry at low temperatures (<< 60 °C) without risking microbial growth during drying. Typical low-temperature drying methods are sun drying and drying with dehumidified air but may also be achieved by electromagnetic drying by microwaves or radio frequency. The latter may also be used for high temperature drying alone or in combination with hot air drying, infrared drying, or alternatively by superheated steam drying. These high-temperature drying methods may be designed to inactivate both bacteria and spores of bacteria. This may be of interest when the dried seaweeds are intended for use as ingredients in moist foods intended to have a shelf life after the addition of the seaweeds (Lovdal *et al.*, 2021).

Materials and methods

Research design

Complete Randomized Design (CRD) was used in the study with three treatments: Treatment One (1) used Potable water, Treatment Two (2) used Metabisulfite for washing, and Chlorine for Treatment Three (3) was used for washing the *Gracilaria* sp.

Description of raw material

Gracilaria sp. was bought from farm growers in Rabon, Rosario, La Union. The seaweeds were washed thoroughly with clean potable water. The attached debris and shells were removed. Cleaned seaweeds were washed using three different methods and then air-dried for 5-7 days.

Potable water for washing and cleaning the raw Gracilaria sp.

Fresh *Gracilaria* seaweeds were washed with potable water and cleaned by removing the attached shells, stones, and algae. The cleaned *Gracilaria* seaweeds were washed again with potable water 10 times then were air-dried for 5-7 days and packed in zip-top bags

Sodium metabisulfite for washing and cleaning the raw Gracilaria sp.

Fresh Gracilaria seaweeds were washed with potable water and cleaned by removing the attached shells, stones, and algae. The cleaned *Gracilaria* was washed again with potable water for 10 times. For every 5 kilograms of fresh *Gracilaria*, a solution of 10L of sodium metabisulfite and water (1 tbsp to 1000 mL) was prepared, and for soaking for 1 minute, then it was rinsed with mineral water. Cleaned seaweeds were air-dried for 5-7 days and packed in zip-top bags.

Chlorine for washing and cleaning the raw Gracilaria sp.

Fresh *Gracilaria* seaweeds were washed with potable water and cleaned by removing the attached shells, stones, and algae. The cleaned *Gracilaria* was washed with potable water 10 times. For every 5 kilograms of fresh *Gracilaria*, a solution of 10L chlorine and water with 200 ppm concentration (1 tbsp to 3.786 L) was prepared for soaking for 1 minute then it was rinsed with mineral water. Cleaned seaweeds were air-dried for 5-7 days and packed in zip-top bags.

Production of Gracilaria sp. powder

After determining the best pre-treatment to be used in powdering *Gracilaria sp.,* production of Gracilaria powder proceeded. Fresh *Gracilaria* seaweeds were washed with potable water and cleaned by removing the attached shells, stones, and algae. The cleaned *Gracilaria* sp. were washed with potable water 10 times, soaked in a solution of sodium metabisulfite (1 tbsp to 1000 ml of water) for 1 minute, and rinsed with mineral water. Cleaned seaweeds were air-dried for 5-7 days. The dried seaweeds were then pulverized using a Commercial Miller until fine (Fig. 1 and 2).

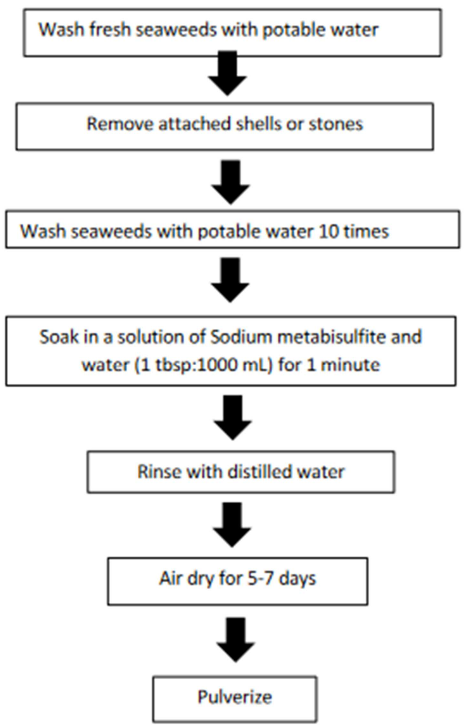

Fig. 1. Process flow chart of powdered *Gracilaria*


a.*Gracilaria* sp. harvested from Rabon, Rosario, La Union

b.Removal of debris and attached shells


c.Washing before the pre-treatment

d.Air drying of *Gracilaria sp.*


e.Dried *Gracilaria* sp.

f.Commercial miller for pulverizing dried *Gracilaria*

g.Powdered *Gracilaria* sp.

Fig. 2(a-g). Processing for powdered *Gracilaria* sp.

Microbiological analysis of raw and powdered Gracilaria sp.

Gracilaria sp. as it was harvested near the shoreline, is often exposed to microbiological contamination which is why raw and powdered Gracilaria were submitted to the Department of Science and Technology Regional Office I, City of San Fernando, La Union for Aerobic Plate Count, Molds and Yeast Count and Escherichia Coli, respectively before it can be used for further processing of seaweed enriched products.

Aerobic plate count of raw and powdered Gracilaria sp.

This laboratory test provides the microbiological population present in the powdered *Gracilaria* sp. Aerobic microorganisms are microorganisms that can live and survive where there is oxygen. The Pour Plate method was used to determine the Aerobic Plate Count of the raw and powdered *Gracilaria*.

Yeast and molds count of raw and powdered Gracilaria sp.

According to the Food and Agriculture Organization (FAO), both yeasts and molds, produce varying degrees of food deterioration and decomposition. Due to their capacity to produce toxic byproducts known as mycotoxins, several foodborne molds and possibly yeasts may also pose a risk to human or animal health. Most mycotoxins are stable substances that are not ruined by home cooking or food processing. The preformed toxin may still be there even though the organisms that produce the toxin may not endure food preparation. Due to their capacity to trigger allergic reactions or even infection, several foodborne molds and yeasts may potentially pose a risk. That is why it is important to know the Yeast and Mold Count. In this study, the Pour Plate method was used to determine the colony-forming unit of the Yeast and Mold in the sample.

Escherichia coli of raw and powdered *Gracilaria sp.*

Escherichia coli is part of a larger group of fecal coliforms, an assortment of bacterial species mainly sourced from feces, and the focus of many monitoring and research efforts since numerous *E. coli* serotypes can cause human illness if ingested (Kaper *et al.*, 2004; Jang *et al.*, 2017). That is why determining the *E. coli* count is important to identify if there is fecal matter present in *Gracilaria sp.* and in this study, enumeration of *Escherichia coli* was done thru Multiple Tube Fermentation to determine the colony-forming unit of *E. coli.*

Physico-chemical analysis of powdered Gracilaria sp.

Powdered *Gracilaria* sp. was submitted to determine the water activity at Chempro Analytical Services Laboratories, Inc., Shaw Blvd, Orambo, Pasig City.

Water activity determination of powdered Gracilaria sp.

The water activity (Aw) of a food is the ratio between the vapor pressure of the food itself, when in a completely undisturbed balance with the surrounding air media, and the vapor pressure of distilled water under identical conditions. The optimal A_w for a food product is usually a compromise between several priorities. At A_w below 0.30, lipid oxidation will occur and the Maillard reaction has an optimum at A_w = 0.65, and high temperature drying should therefore not be used down to this level. Seaweed processors will, in general, avoid drying to lower moisture content than needed for the preservation of the products as the weight loss and drying costs represent a direct economic loss. That is why it is important to determine the water activity. In this study, Water Activity Meter was used to determine the available water to support biological and chemical reactions.

Proximate composition raw and powdered Gracilaria sp.

Raw and powdered *Gracilaria sp.* underwent proximate analysis which included the Moisture content, Ash, Crude protein, Crude fat, Iodine, Dietary fiber, Iron, Calcium, and Sodium. Samples were submitted to the Department of Science and Technology Regional Office I, City of San Fernando, La Union, and Chempro Analytical Services Laboratories, Inc., Shaw Blvd, Orambo, Pasig City, respectively.

Moisture content

The moisture content is an important criterion in determining the quality and shelf-life of processed seaweed meals where high moisture may hasten the growth of microorganisms. In addition, drying and storage of seaweeds are likely to affect the moisture content of the seaweed examined (Rohani-Ghadikolael *et al.*, 2012). Moisture Content was analyzed using Gravimetry.

Crude protein

Seaweeds contain up to 47% of protein on a dry weight basis, which is close to the protein content of traditional protein sources such as meat, egg, soybean, and milk. The protein content is generally low in brown algae (4-24% of dry weight) and high in red (8-47% of dry weight) and green algae (9-33% of dry weight) and can be comparable to other protein sources like soybean (38% of dry weight). The crude protein content of seaweeds is widely calculated from total nitrogen content (N × 6.25) (Thiviya *et al.*, 2022). Kjedahl method was used to determine the Crude protein of the raw and powdered *Gracilaria* sp.

Crude fat

Seaweeds were found to be a rich source of polyunsaturated fatty acids (PUFA), particularly of omega-3 fatty acids which have been associated with the lowering of plasma cholesterol and triglycerides levels, reduced risk of developing cardiovascular diseases, improved immune system, etc. The American Heart Association recommended the ingestion of fish, preferably oil, at least twice a week. (Article Detail - International Journal of Studies Advanced Research, 2020). In this study, Crude fat was determined using Solvent Extraction

Ash

Ash refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in a food sample. The inorganic residue consists mainly of the minerals present in the food sample. Determining the ash content is part of the proximate analysis for nutritional evaluation (Ismail, 2017). Ash was analyzed using Gravimetry.

Iodine

Edible seaweeds accumulate iodine from seawater and are therefore a good dietary source of iodine. Adequate consumption of seaweed can eliminate iodine deficiency disorders, but excessive iodine intake is not good for health. The recommended dietary reference intake of 0.15 mg/ d and 0.14 mg/d for iodine has been established in the United States and Taiwan, respectively (Yeh *et al.*, 2014). Iodometry was used to determine the Iodine content of powdered *Gracilaria* sp.

Dietary fiber

Dietary fiber is recognized today as an important element for healthy nutrition. Dietary fiber consists of a series of compounds comprising a broad mixture of carbohydrates and polymers present in plants, including both oligosaccharides and polysaccharides, such as cellulose, hemicellulose, pectic substances, gums, resistant starch, and inulin, which may be associated with lignin and/or other non-carbohydrate components (polyphenols, waxes, saponins, cutins, and resistant protein) (Peñalver *et al.*, 2020). Dietary fiber was determined using the Enzymatic Gravimetric method.

Iron

Seaweeds have higher concentrations of minerals like iron and copper than many popular terrestrial food sources like meats and spinach (MacArtain *et al.*, 2007). Atomic Absorption Spectrophotometry was used to determine the Iron content of powdered *Gracilaria* sp.

Calcium

Due to their marine habitat, seaweeds have a high mineral content and a wide variety of minerals that they can absorb. Important minerals, like calcium, accumulate in seaweeds at much higher levels than in terrestrial food sources (MacArtain *et al.*, 2007). Atomic Absorption Spectrophotometry was used to determine the Calcium content of powdered *Gracilaria* sp.

Sodium

The algae acquire from the marine environment, in which they live, a great wealth of mineral elements, being known for its high content of minerals between 8–40% of the dry weight of the seaweed. They are worth highlighting the great abundance of essential minerals such as sodium, calcium, magnesium, potassium, chloride, sulfate, phosphorus, and micronutrients such as iodine, iron, zinc, copper, selenium, molybdenum, fluoride, manganese, boron, nickel, cobalt, etc. However, the mineral composition may vary depending on the taxonomic group, geographical, seasonal, and physiological variations, and even with the type of processing and mineralization method applied. Algae are a primary source of iodine, providing the daily iodine requirement (150 μg/day). Because of their high mineral content, algae can be used as a dietary supplement to help achieve the recommended daily amounts of some macro minerals and trace elements (Peñalver *et al.*, 2020). To determine the Sodium Atomic Absorption Spectrophotometry was used.

Results and discussion

After a series of microbial tests were conducted, proper washing of *Gracilaria* sp., was established using three different treatments. Treatment One (1) used Untreated or washed with Potable water, Treatment Two (2) used Metabisulfite for washing, and Chlorine for Treatment Three (3) was used for washing the *Gracilaria* sp. Table 1 shows the result of the microbiological properties of each treatment. Of all the Treatments, Treatment 2 got the lowest count of *Escherichia coli Count,* Mold, and Yeast Count with 28 MPN/g and 120 CFU/g, respectively. Meanwhile, Treatment 1 got the lowest Aerobic Plate Count (APC) with 9.2 MPN/g.

Even though the APC count of Treatment 1 is considerably low, the *E. coli* Count should be the prime focus because the presence of *E. coli* means that there is fecal matter present which can be detrimental to human health. Meanwhile, APC can be used to assess sanitary quality, sensory acceptability, and compliance with good manufacturing standards (GMPs). APC results can give food processor information on the quality or handling history of the raw materials, food processing and storage conditions, and handling of the end product.

Table 1. Microbiological properties of the three treatments

Test method	Treatment 1 Potable water	Treatment 2 Treated with sodium metabisulfite	Treatment 3 Treated with chlorine
Escherichia Coli count	>1,100 MPN*/g	28 MPN/g	>1,100 MPN/g
Mold and yeast count	18,000 CFU#/g	120 CFU/g	960 CFU/g
Mold count	5,100 CFU/g	10 CFU/g	820 CFU/g
Yeast count	14,000 CFU/g	110 CFU/g	160 CFU/g
Aerobic plate count	9.2 MPN/g	630,000 CFU/g	7,600,000 CFU/g

Table 2. Microbiological properties of the raw *Gracilaria* Treated with sodium metabisulfite and powdered *Gracilaria*

Test method	Treated with sodium metabisulfite	Powdered *Gracilaria*
Escherichia coli count	28 MPN/g	<10
Mold and yeast count	120 CFU/g	<10
Mold count	10 CFU/g	
Yeast count	110 CFU/g	
Aerobic plate count	630,000 CFU/g	<10

Table 3. Proximate composition of raw and powdered *Gracilaria*

Test method	Raw *Gracilaria*	Powdered *Gracilaria*
Moisture content %	86.89g%	12.61%
Crude protein	1.14g/100g	14.58 g/100g
Crude fat	0.10g/100g	3.31g/100g
Ash	5.84g/100g	6.92g/100g
Iodine	-	12.00 g/100g
Dietary fiber	27.48	60.64 g/100g
Iron	15.20 mg/100g	95.93 mg/100g
Calcium	429.11 mg/100g	615 mg/100g
Sodium	290.89 mg/100g	647.34 mg/100g

The shelf-life or sensory changes in a food product can also be predicted using this method (Salami *et al.*, 2022). That is why Treatment 2 was chosen to be the pre-treatment method to be used in washing the *Gracilaria sp.*

Microbiological properties of the raw and powdered Gracilaria sp.

After determining the best pre-treatment and raw *Gracilaria* was turned into powder, the powdered *Gracilaria* sample was submitted at ChemPro Analytical Services Laboratories, Inc, Shaw Blvd, Orambo, Pasig City. Table 2 shows below that when the Raw Gracilaria was processed into powder the microbial load decreased. It showed that applying heat to the *Gracilaria* sp. can lessen the microbial load compared to the initial microbial load.

Proximate composition of the raw and powdered Gracilaria sp.

As shown in Table 3 below, after processing the raw *Gracilaria* into powdered *Gracilaria*, the moisture content decreased from 86.89% to 12.61% which is stable. Because according to the Aquaculture Extension Manual of the Southeast Asian Fisheries Development Center (SEAFDEC), Moisture content (MC) of 35-39% is the most stable. >40% MC undergo degradation during storage, 25-35% MC is relatively stable for periods in excess of 12 months (efficient for baling), and 15-25% MC is extremely stable, but thalli may be too brittle; resists pressure or snap bailing. Lastly, <15% MC is stable.

Also, there is an increased protein content because according to studies, it is determined that the protein molecule expands slightly (0.4% per 100 K) with increasing temperature and that this expansion is linear. The expansion is due primarily to subtle repacking of the molecule, with exposed and mobile loop regions exhibiting the largest movements. Individual atomic Debye-Waller factors exhibit predominantly biphasic behavior, with a small positive slope at low temperatures and a larger positive slope at higher temperatures. The break in this curve occurs at a characteristic temperature of 180-200 K, perhaps indicative of fundamental changes in the dynamical structure of the surrounding protein solvent. The distribution of protein Debye-Waller factors is observed to broaden as well as shift to higher values as the temperature is increased (Tilton *et al.*, 1993). It can also be observed in the Table 3 that the Ash content of powdered *Gracilaria* slightly increased because ashing at 600 °C for 6 h or 550 °C overnight (roughly 16 hours) produced results that were comparable to overnight ashing at 600 °C, but ashing at 550 °C for 6 hours resulted in higher ash content than other combinations (Liu, 2019).

Additionally, the Iodine content of powdered *Gracilaria* is considerably high at 12.00g/100g because dried seaweed or seaweed extracts are often found in foodstuffs, and recommendations for safe levels of iodine vary from 20 mg/1000g in Germany to 500 mg/1000g in the USA and a maximum tolerable level of 100 mg/1000g dried weight in Australia (Smyth, 2021). And in the Philippines, the Recommended Nutrient Intake per day for children ages 1-18 for male and female is from 90-150 µg. While for adults male and female is 150 µg.

Meanwhile, *Gracilaria* powder also contains enough Dietary Fiber at 60.64 g/100g, Iron at 95.93 mg/100g which is above the recommended Nutrient Intake per day, and Calcium at 615 mg/100g which is sufficient for the Calcium requirement of children ages 1-5 based on Recommended Nutrient Intakes.

The results in the Table 3 shows that according to Rohani-Ghadikolaei *et al.* (2012) that the concentration and composition of mineral in seaweeds are affected by location and species where seaweeds can selectively absorb minerals from the surrounding seawater and accumulated them in their thalli.

Descriptive attributes of Gracilaria powder

The descriptive attributes of *Gracilaria* powder were evaluated based on color, aromatics, and texture. Table 4 shows the raw scores of seven trained panelists who evaluated the *Gracilaria* powder. Overall, *Gracilaria* powder was dark brown, granulated, and with a perceptible seaweed aroma.

Table 4. Raw scores of the descriptive attributes of *Gracilaria* powder

Trained panelist	Color	Aromatics	Texture
1	130	100	110
2	130	100	110
3	130	100	110
4	130	110	110
5	120	100	110
6	120	100	110
7	120	100	110
Mean score:	125.71	101.43	110

Nutrient loss during the processing of raw Gracilaria sp. to powdered Gracilaria sp.

As shown in Table 2, there is no nutrient loss in terms of crude protein, crude fat, and ash. Rather due to processing some nutrients increased.

Production yield from fresh and powdered Gracilaria sp.

From 20 kilograms of Fresh seaweeds, the researchers obtained 1.185 kilograms of dried seaweeds.

Conclusion

Based on the findings of the study, washing *Gracilaria* with sodium metabisulfite can eliminate microorganisms into safe levels such as 28 MPN/g *Escherichia coli* count, 120 CFU/g Mold and Yeast Count, and 630,000 Aerobic Plate Count and can be further decreased when processed into powdered form. Also, *Gracilaria* powder has low water activity with 0.537 A_w at 24.70°C and has a considerable amount of 6.92% ash, 12.61% Moisture, 3.31 Crude Fat, 14.58% Crude Protein, 12.00% Iodine, 60.64% Dietary Fiber, 95.93 mg/100g, Calcium at 615.88 mg/100g and 647.34 mg/100g Sodium. As to sensory qualities, *Gracilaria* powder was dark brown, granulated, and with a perceptible seaweed aroma. Therefore, *Gracilaria* powder can provide enough nutrients and satisfy the Recommended Energy and Nutrient Intake for children and adults. But it is recommended that additional replicates for each treatment should be subjected to microbial testing to ensure the reliability of the data. Also, use a bigger drying tray or rack for larger-scale production.

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