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Standing stock and chemical composition of brown seaweed *Sargassum crassifolium* (J. Agardh) along the coast of Iligan Bay

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Abstract

S. crassifolium is one of the species of brown seaweeds occurring in abundance along the coast of Iligan Bay. Likewise, this species is a good source of proteins, carbohydrates and minerals in human nutrition, and one of the major sources of alginic acid and alginate. Due to the economic importance of alginic acid and its salts, and the high occurrence of this species in the locality, this study was conducted to determine the abundance, standing stock, nutritional composition, alginic acid and alginate content of *S. crassifolium* in Iligan Bay. Using the transect-quadrat method, the abundance and standing stock were determined in the intertidal flat of Barangay Calangahan, Lugait, Misamis Oriental, while the analysis of nutritional composition, alginic acid and alginate extraction was done using the standard methods. Results showed that the cover value of *S. crassifolium* was 86.80±34.43% and its standing stock was 3,157.80±1451.82 g wet wt m^{-2}. The nutritional composition represented by protein, fat, carbohydrate, ash and moisture content was within the values specified for seaweeds. The average alginic acid was 3.91±0.98% while the alginate was 2.14±0.36%. It was concluded that the wild populations of *S. crassifolium* in Iligan Bay were high based on its cover and standing stock, hence sustainable for commercial exploitation for alginic acid production. Moreover, its nutritional composition was in considerable quantities and within the values specified for seaweeds.

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Introduction

Sargassum crassifolium (J. Agardh) is one of the species of seaweeds occurring in abundance along the coast of Iligan Bay. A study conducted on community structure of macroalgae in selected intertidal sites of Iligan Bay revealed that *S. crassifolium* was the most dominant and abundant species (Echem and Metillo, 2010). This brown seaweed has flat or elliptical holdfast. The thallus could reach up to 40 cm or more and it has several branches which arise from the short, smooth and slightly twisted stipe. The color of the blade ranged from light to dark brown and the attachment was alternate. Each blade was embedded with cryptostomata; the apex was mostly obtuse and the base was unsymmetrical and has serrated blade margin. The gas bladder was green to brown in coloration; elliptical in shape; some with spines, flattened stalk, and several surrounded with blade-like structure (Trono, 1997).

Sargassum contains one of the most important seaweed products and its sodium and calcium salts. Alginic acid and alginates are used in dentistry for dentures and denture surfacing, in dyeing and water proofing of clothes, in the plastic industry, in paints and varnishes, in the making of gum and linoleum and wall paneling and even in the manufacture of artificial textile fiber called alginate rayon. Sodium alginate is used in forming gels in cosmetics and food, preparing films and coatings, transparent papers and textile sizes and as stabilizers in cosmetics, ice creams and salad creams. The use of calcium alginate, beryllium alginate for the manufacture of silks, offers enormous potentialities for the raw materials (Durairatnam and Grero, 1969).

In view of the commercial importance of alginic acid, it seems worthwhile to assess the content of this polysaccharide in *Sargassum crassifolium* found along the coast of Iligan Bay and its standing stock in the area. The information generated from this research is considered valuable because if alginic acid and its salts can be extracted from this brown seaweed even on small commercial scale, it may be enough to satisfy local demands and will be a source of employment for the local people.

Materials and methods

Plant collection

S. crassifolium plants were collected by hand during low tide at the intertidal flat of Barangay Calangahan, Lugait, Misamis Oriental (8° 22' 7.13" North Latitude and 124° 15' 40.05" East Latitude).

The area is composed of rocky substrates from intertidal to subtidal area which favor the growth of seaweeds especially brown seaweeds. Some seagrass were also found in the intertidal area (0-10 cm during low tide) and they are in patchy distribution. The area is highly fished and gleaned by people collecting fishes and invertebrates.

Abundance and standing stock of S. crassifolium

Sampling for abundance and standing stock estimation was carried out using the transect-quadrat method (English *et al.,* 1997). Harvested samples of *S. crassifolium* were sorted and washed thoroughly with tap water to remove rock debris and epiphytes and weighed. Abundance was expressed as percent cover (%) while standing stock was expressed as wet weight (g wet wt m^{-2}).

Protein, fat, carbohydrate, ash and moisture analysis

Cleaned samples of *S. crassifolium* were oven dried at 60°C to constant weight. After drying, the samples were ground into powder and were brought to the Chemical Testing Laboratory of the Department of Science and Technology, Cagayan de Oro City for analysis. Analysis of crude protein was done using Kjeldahl method, total fat by hydrolysis and solvent extraction method, ash content by dry ashing procedure, moisture content by air oven method, and total carbohydrate content by computational method [Carbohydrate = 100% - (% protein + % fat + % ash + % moisture)]. The method used for the analysis of crude protein, total fat, ash content and moisture content was based on OMA AOAC (2008) and the values were expressed as percentage on dry weight basis.

Alginic acid and sodium alginate extraction

The alginic acid extraction was done following the method of Torres *et al.* (2007) while the sodium alginate was extracted following the method outlined by Calumpong *et al.* (1999) with some modifications. The dried alginic acid and the sodium alginate yield were calculated based on the formula described by Hurtado-Ponce and Umezaki (1988):

$$Y = \frac{Wt_A}{Wt_S} \times 100$$

Where:

Y = % alginic acid yield

Wt_A = weight of dried alginic acid

Wt_S = weight of powdered seaweed (50 g)

Results and discussion

Abundance and standing stock

The abundance of *S. crassifolium* represented by percent cover was 86.80±34.43% and its standing stock was 3,157.80±1451.82 g wet wt m^{-2}, respectively (Table 1). This value was higher than the highest standing stock (~305 g wet wt m^{-2}) obtained for the same species harvested from Bolinao, Pangasinan, Philippines (Trono and Lluisma, 1990). This value seemed high for sustainable commercial exploitation for alginic acid and alginate production in this area.

Chemical composition

In this study, the carbohydrate content of *S. crassifolium* was 65.01±0.26% and higher than the value (46.59%) obtained in Kupang Bay, Indonesia (Salosso, 2019) and in Central Java, Indonesia [(56.25%; Handayani *et al.,* 2004)] for the same species (Table 1). Macroalgae possess high protein and carbohydrate content especially fiber (Pattara *et al.,* 2011; Kasimala *et al.,* 2015) and both the brown and red macroalgae contain large amounts of carbohydrates (Stiger *et al.,* 2016).

Table 1. Abundance (%), standing stock (g wet wt m^{-2}) and levels of carbohydrate, protein, total fat, ash, moisture content, alginic acid and alginate measured in *S. crassifolium* (mean ± SD). Values are presented as percent (%) dry weight for carbohydrate, protein, total fat, ash, moisture content, alginic acid and alginate.

Variables	Value
Abundance	86.80 ± 34.4
Standing Stock	3,157.80 ± 1451.82
Carbohydrate	65.01 ± 12.45
Protein	6.75 ± 1.45
Total Fat	0.82 ± 0.03
Ash	19.17 ± 4.38
Moisture	8.26 ± 2.37
Alginic acid	3.91 ± 0.98
Alginate	2.14 ± 0.36

The protein content was 6.75±0.09% and was higher than the value (5.19%) obtained in Central Java, Indonesia (Handayani *et al.,* 2004) for the same species and comparable to the same sample obtained from Kupang Bay, Indonesia [(8.06%); Solosso, 2019]. Seaweed protein is called complete protein with all the essential amino acids at levels close to that recommended by FAO/WHO (Wong and Cheung, 2000; Matanjun *et al.,* 2009). On the other hand, lipids in seaweeds are present in very small amounts ranging between 1 and 5% of dry seaweed matter (Miŝurcová, 2011). In this study, the lipid content was 0.82±0.03%. Also, the moisture content was 8.26±2.37% and within the recommended level of not more than 35% (Pellinggon and Tito, 2009). Moisture content is an important criterion in determining the shelf-life and quality of processed seaweed meals as high moisture may hasten the growth of microorganisms (Rohani-Ghadikolaei *et al.,* 2012). Moreover, the ash or mineral content was

19.17±4.38% and the value was higher than those specified for terrestrial counterparts with only 5% - 10% dry weight (USDA, 2001). Seaweeds are known as a significant source of minerals due to their capacity to absorb inorganic substances from the environment. This capability is regarded with the presence of polysaccharides in seaweed cell walls and also able to predestine a place of mineral storage in different parts of seaweed tissue (Kűpper *et al.,* 1998; Hashim and Chu, 2004).

The yield of alginic acid obtained from *S. crassifolium* was 3.91±0.98% while the sodium alginate was 2.14±0.36% (Table 1).

These values were relatively lower when compared to the previous studies (alginate: 37.9, 30.30 and 10.00%) done on the same species (Handayani *et al.,* 2004; Mushollaeni, 2011; Salosso, 2019), respectively. However, this result is similar to the study of Sivagnanavelmurugan *et al.* (2018) in which the alginic yield of *S. wightii* was 3.93±0.22%. Generally, the alginic content of different seaweeds would vary and likewise the alginates due to species differences and method of extraction (Larsen *et al.,* 2003; Chee and Wong, 2009). As an example, Chennubhotla *et al.* (1982) found that the yield of alginic acid was within the range of 22.3 to 30.8% in *S. ilicifolium* and from 15.9 to 34.5% in *S. myriocyslum.* Similarly, Davis *et al.* (2004) found that the yield was within the range of 21.1 to 24.5% in *S. fluitans* and 16.3 to 20.5% in *S. oligocystum.*

The season of harvest which might have affected the life cycle of *S. crassifolium* would be another factor (Draget *et al.,* 2000; Mirshafiey and Rehm, 2009). For example, in Puerto Rico the maximum amounts of alginic acid were observed during the vegetative and reproductive phase of the two *Sargassum* species such as *S. polyceratium* and *S. vulgare*, while the lowest values were associated with the old and decaying plants after the fruiting period (Aponte de Otaola *et al.,* 1983). Also, in the coast of Hikkaduwa, Sri Lanka, high alginic acid content occurred during the North East monsoon while low alginic content occurred in the South West monsoon. In the Philippines, *Sargassum* would achieve its highest growth (thallus) during the month of November especially for those found in the intertidal region, while it was in December for those in subtidal region. In contrast, the gradual death of *Sargassum* would occur from December to February and all plants would be on die-off stage in the month of May (Ortiz and Trono, 2000).

The observation of Ortiz and Trono (2000) can be related to the present study because *S. crassifolium* samples were harvested during the month of February which corresponds to its die-off stage hence produces low alginic acid and its salts.

Conclusion

The abundance and standing stock of wild populations of *Sargassum crassifolium* were high for sustainable commercial exploitation of this brown seaweed for the production of alginic acid and its salts in Iligan Bay. Likewise, its nutritional composition was within the values specified for seaweeds, hence there is a potential for this species to be used as raw material or ingredients in human diet and animal feed. Season of harvest should be considered in order to achieve higher yield of alginic acid.

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