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Carbohydrate of the Brown Seaweed, *Saccharina latissima*: A Review

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***Abstract* - *Saccharina latissima* is one of the potential seaweed sources because of its high carbohydrate content. The interest of farming of macroalgae has increased in European countries. Abundant research results have provided data for the biochemical composition of *S. latissimi*. This paper collects and summarize data on carbohydrate content of *S. latissima* from scientific articles published all around the world. The content of polysaccharides in *S. latissima* range from 30 to 50% dw. These polysaccharides include alginate, fucoidan, laminarin and mannitol. Information of the carbohydrate content of *S. latissima* will be needed for further developments, such as use in biofuel, food or health industries. It may also increase the interest of cultivation of *S. latissima*. As a result, *S. latissima* may become an important commodity in aquaculture.**

Keywords: Carbohydrate, Saccharina latissimi, seaweed

I. INTRODUCTION

Seaweed farming mostly undertaken in Asian countries. Recently, it also conducted in some African, American and European countries. It is a relatively new industry in North America and Europe[1]. The production has grown by 119% since 1984[2], showing an increased interest of seaweed cultivation. The large increase of seaweed production from 1984 to 1994 includes chlorophytes, rhodophytes and phaeophytes, with increase value of 376%, 167% and 97% respectively[2]. The global production of seaweed in 2016 dominated by *Euchema* spp, *Laminaria japonica*, *Gracilaria* spp., *Undaria pinnatifida*, *Kappaphycus alvarezii*, and *Porphyra* spp. [3].

Seaweed are cultivated both as a raw material for seaweed industries and for human food. Seaweed biomass has a potential as a source for producing biofuels [4]; nutraceuticals or functional food [5, 6]; pharmaceutical or medical [7-9] and food [2, 10-12]. The utilization of seaweed has also increased for environmental purpose. Studies on macroalgae farming close to fish farms have revealed that seaweed has the potential for bioremediation services [13, 14].

The high use of seaweed inseparable from its nutritional content, which may up to 50% for the carbohydrate content [15]. Beside direct consumption, seaweed are also extracted for agars, carrageenans and alginates content. *Gracilaria* and *Gelidium* are the principal source of agar[16, 17], *Kappaphycus* and *Eucheuma* are the main sources of carrageenans [18], while brown seaweed (class Phaeophyceae and orders Laminariales and Fucales) have large contents of alginate (up to 55% dw) [19]. *Alaria esculenta* and *Saccharina latissima* are the potential brown seaweed species most suited for cultivation in Europe [13, 20] because they hold valuable nutritional content [21]. The objective of this paper is to provide detailed information on the carbohydrate composition of *S. latissima*. We believe that the information provided here will give the advantages for the industrial uses of this and other macroalgae.

II. CARBOHYDRATE OF *Saccharina latissima*

Total carbohydrate of *S. latissima* range from 30 to 50% dw[22]. The most abundant carbohydrate in sugar kelp (*S. latissima*) is alginate that constitutes up to 40% [23]. Handå *et al*. found that the alginate content of sugar kelp was in the range between 6 and 27%[13]. Alginate content of *Laminaria saccharina* from Barents Sea were found to be 34.5±1.00% dw[24], and Shiener *et al*. notified an average alginate content of 28.5±3.9% of the dry weight for *S. latissima* from Scottish waters [25]. Alginic acid distributed universally among the Phaeophyta [26]. Jard *et al*. suggested that *S. latissima* is the best algae suited for alginate extraction[27]. It is also a key species for the food industries, and *S. latissima* is therefore a main candidate for seaweed aquaculture. Total alginate of *S. latissima* is lower than that of *Himanthalia elongata* (Table 1), but the thickening properties of alginate from *S. latissima* is better than that of other brown algae mentioned [27].

TABLE I
TOTAL ALGINATE OF THE SELECTED BROWN SEAWEED*

	Brown seaweed species				
Total alginate (x1.18 uronic acid) (g/kg TS)	*Undaria. pinnatifida*	*Saccorhiza. polyschides*	*Sargassum. muticum*	*Saccharina. latissima*	*Himanthalia. elongata*
	222	192	160	243	350

*[27]
**total alginate contents were obtained from corresponding references.

Subsequent to alginate, laminaran comprise up to 35% dw of brown seaweed [15, 28]. Laminaran, together with fucoidan, are primarily found in species of *Laminaria* and *Fucus* [26]. Laminaran from *S. latissima* was found around 3%-9% in the vicinity of salmon farm in Norway [13]. The content of laminaran from the fronds of *L. saccharina* at sheltered area has been found to be below 26% dw [29]. Studies on the laminaran content of *L. saccharina* from Barents Sea showed that the content of Laminaran were 11.6±2.65% dw [24]. Comparison of laminaran content of *S. latissima* by Black (1950) suggested that laminaran was higher in plants grown in the sheltered zone than in more exposed plants [29].

Another commercial carbohydrate of brown seaweed is fucoidan, which may present contents up to 15% of dw [30]. The maximum and minimum fucoidan value of 6.2±0.06 and 2.3±0.04 % of DM, respectively, was observed in *S. latissima* grown in Danish waters [31]. The highest contents of fucoidan has been found in *L. saccharina* from the Barents Sea, with fucoidan contents of 8.8±0.9% dw [24].

L. saccharina also contains up to 14% of the polysaccharide mannitol [30]. Other study publish mannitol values of 15.04±2.03% dw were found in *L. saccharina* grown in the Barent Sea [24]. Values from the Island of Frøya in Norway has shown mannitol content of 2.05%-15.84% DM [32]. The average mannitol content S. latissima from Scottish waters of 18.6±4.7% are reported was [25]. The higher mannitol on *L. saccharina* are underneath 24% dw reported from British Laminariaceae [29]

III. POTENCY OF COMMERCIAL PRODUCTION OF SEAWEED BIOMASS

The worldwide aquaculture production of aquatic plant dominated by macroalgae showed production yields above 30 million tonnes in 2016 [3]. The average world yield of macroalgae is higher than those of wheat, maize, sugar beet and sugar cane [33]. This makes seaweed available as an industrial raw material for commercial product, and it is suggested that marine sources has the largest biomass potential compare to other sources [34]. In addition to that, huge biomass required for the industrialization of seaweed may reach through aquaculture.

S. latissima, as a potential species for seaweed aquaculture, is one of the fastest growing species of kelp in European waters [35, 36], and the species show good growth performance [37]. In Norway, the procedure for seedling production of *S. latissima* has been established through research activities [36], and further farming activities is initiated. Through the MACROSEA project (https://www.sintef.no/projectweb/macrosea/), we will also contribute to provide a knowledge platform for industrial macroalgae cultivation.

IV. CONCLUSION

S. latissima has a relatively high content of total carbohydrates. The carbohydrate includes of alginate, fucoidan, laminarin and mannitol, components that can be used for production of biofuel, food and health products. Protocol for the aquaculture of *S. latissima* has also established in Norway.

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