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Polysaccharides from Microalgae, What's Future?

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Opinion

Biopolymers are diverse, abundant and important for life. They exhibit numerous properties and are of increasing importance for various applications in industry. Among them, homo- or heteropolysaccharides exhibit a large variety of chemical structures based on glycosidically-linked combinations of up to 40-50 different monosaccharides (mainly hexoses and pentoses) including complex sugars. Various substituents such as acyl groups, amino acids or sulphates may be attached to this polysaccharidic backbone which may be linear or branched. This wide range of glycosidically-linked structures provides an extensive group of different architectures [1]. Polysaccharides from plants, macroalgae, microorganisms, fungi and animals are widely exploited in industry as hydrocolloids, biosourced materials, biological agents and other. Compared to polysaccharides from plants and macroalgae, the commercial success of microbial polysaccharides is relatively poor except for curdlan, xanthan, gellan, and curdlan in the food industry [2]. The pharmaceutical and cosmetic industries have promoted the development of polysaccharides with specific biological properties for use as elicitors, antiparasitic, anticoagulants or antimicrobial agents [3].

However, only a small number of polysaccharides have become well-established products at this time with little market niches. Many articles, reviews and books claim for the potential value of new microbial polysaccharides each month in academic literature but few contain realistic appraisals. Some success stories have been reported for new microbial polysaccharides with original properties such as bacterial hyaluronic acid, glucuronan, HE800 and others [4-7]. All of these successes are linked to the specific properties of these polysaccharides not described or identified in plants and macroalgae ones. All these "new microbial polysaccharides" are produced using non-photosynthetic microorganisms and mainly bacteria. So, microalgae have been very poorly investigated for their potential as producers of polysaccharides despite their diversity. Autotrophic microalgae are phylogenetically a heterogeneous group of photosynthetic microorganisms. They require only inorganic compounds (such as N, S, P, CO2) and light as energy sources for their growth and development and their taxonomic diversity corresponds to a high biochemical variety, making them attractive for potential exploitation as commercial sources of new polysaccharides. Indeed, even if a high number of structures of polysaccharides from non-photosynthetic microorganisms have been described in literature (probably more than several hundred), only polysaccharides produced by the unicellular red alga *Porphyridium* sp., *Porphyridium cruentum*, *Porphyridium aerugineum* and *Rhodella reticulata* have been the subject of in-depth characterizations leading sometimes to industrial applications [8,9].

Nevertheless, during the two last decades, the development of technologies for the production of microalgae biomass and its treatments using the concept of biorefinery has significantly decreased the cost of commercial products from microalgae and open the way to the cultivation of non-exploited microalgae. Numerous microalgae may excrete in their environment large amounts (up to 20g/L) of exopolysaccharides (EPS) sometimes as mucilages associated to cell envelopes (also called cell-bound polymers). Some EPS from microalgae and their production have been described in the literature. They are mainly heteropolysaccharides composed of glucose, galactose and xylose but included also significant amounts of other monosaccharides such as rhamnose, iduronic acid, methylated sugars, fucose and other [9]. Nonetheless the high number of sugars in their structure, the lack of repeating units, a nature often ramified, the presence of non-sugar substituents lead to very hard structural characterizations. The consequence is a very poor knowledge of polysaccharidic structures from microalgae with contradictory results which can be explained by the culture conditions of microalgae, the analytical methods and the origins of strains usually non axenic. The annual market of seaweed polysaccharides is around (90 000 tons) for hydrocolloids, cosmetic and pharmaceutic industries [10].

This market is not saturated and could integrated new biopolymers such as those produced by microalgae considering their original structures and recent progress for their production in photobioreactors. For that their averages prices have to be between 20 (low value market such as hydrocolloids) and 3000 (high value biological agents) US dollars per Kg. Indeed, the future challenges will be to increase the level of knowledge for new producers of polysaccharides growing in autotrophy, to reduce their costs of production and extraction and to characterize their structures and their rheological but also biological properties. This global strategy is applied in our laboratory (Institut Pascal-Clermont Auvergne University) in the "Polysalgue" French project which is a public-private partnership (2015-2019) of the 2015 French "Agence Nationale de la Recherche" Work Program.

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