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RESEARCH ON INDUSTRIALIZATION IN OBTAINING BIOFERTILIZERS AND BIOFUELS FROM SEAWEED

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ABSTRACT

Obtaining biofertilizers and biofuels from organic products has been of great interest in recent years and is an important step in combating pests and reducing soil chemicals. Seaweed is an great agent in reduction pollution, in the textile industry, in the manufacture of pulp and paper, in distillation, in petrochemistry, metallurgy, chemistry, food, pharmaceuticals, as well as in agriculture as biofertilizers.This article presents stages of research worldwide on the potential of industrialization in obtaining biofuels and biofertilizers from seaweed.The paper highlights technologies and processing methods in obtaining future biofertilizers and biofuels with a low impact on new climate change felt strongly on agriculture.

INTRODUCTION

Obtaining biofertilizers and biofuels from organic products has been of great interest in recent years and is an important step in combating pests and reducing soil chemicals. Therefore seaweed is a very versatile product widely. It is also an ingredient for the global food and cosmetics industries and is used as fertilizer and as an animal feed additive. Fertilizer uses of seaweed date back at least to the nineteenth century.

Macroalgae represent a diverse group of eukaryotic, photosynthetic marine organisms. Unlike microalgae, which are unicellular, the macroalgal species are multicellular and possess plant-like characteristics. They are typically comprised of a blade or lamina, the stipe, and holdfast for anchoring the entire structure to hard substrates in marine environments (Figure 1). The general features of these structures are very diverse in the various taxa comprising macroalgae (Figure 1).

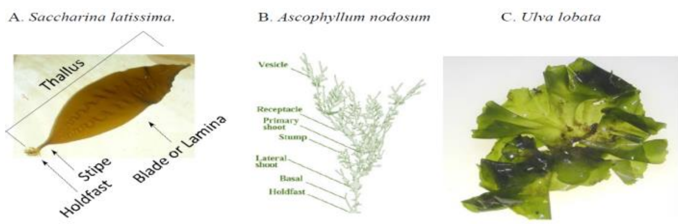

Figure 1. Differite speacies seaweeds

There are forms whose primary feature is that of long blades, forms that are branched, and others that are leafy and form mats. Moreover, some forms possess air bladders that act as flotation devices that enable some species to stand upright or occur free-floating on ocean surfaces.

The high fibre content of the seaweed acts as a soil conditioner and assists moisture retention, while the mineral content is a useful fertilizer and source of trace elements. In the early twentieth century, a small industry developed based on the drying and milling of mainly storm-cast material, but it dwindled with the advent of synthetic chemical fertilizers. Today, with the rising popularity of organic farming, there has been some revival of the industry, but not yet on a large scale; the combined costs of drying and transportation have confined usage to sunnier climates where the buyers are not too distant from the coast. There are several species of algae worldwide, with different properties and widespread use. In 1974, the American Gas Association decided to look for a renewable source of methane (natural gas) and sponsored a project to produce seaweed on farms in the ocean, harvest it and convert it to methane by a process of anaerobic fermentation. The project was divided into two parts: one the production and harvesting of the seaweed (biomass), the other the conversion of the biomass to energy (methane, that could be burned to produce energy). The results were not as expected as a result and research and development have been stopped. In 1980 Chapman et al conducted many studies on the production of biofertilizers and their effects on their application in agriculture and the food industry. Thus making a table with a statistic of studies made on the effectiveness of seaweed extractsBlunden (1991) describes an interesting application of Ascophyllum as a soil conditioner in controlling losses of topsoil. For example showed that the granular product composted in seaweed form contains 20-25% water and can be easily stored and used in this form. He applied this product on steep slopes prone to massive landslides, as well as difficult to cultivate with conventional equipment. By spraying such slopes with composted algae (eg Ascophyllum species) it gave good results, even on bare rock. The plants grow quickly and the topsoil is formed after a few years. The spray is thixotropic, ie it is fluid when a force is applied to spread it, but it attaches to a weak gel when it stays for a while and sticks to the inclined surface. Keep any soil in place and retain enough moisture to allow the seeds to germinate.

Seaweed extracts have given positive results in many applications. There are probably other applications where they have not made significant improvements, but these receive less, if any, publicity. However, there is no doubt that seaweed extracts are now widely accepted in the horticultural industry. When applied to fruit, vegetable and flower crops, some improvements have included higher yields, increased uptake of soil nutrients, increased resistance to some pests such as red spider mite and aphids, improved seed germination, and more resistance to frost. There have been many, many controlled studies to show the value of using seaweed extracts, with mixed results. For example, they may improve the yield of one cultivar of potato but not another grown under the same conditions. No one is really sure about why they are effective, despite many studies

having being made. The trace element content is insufficient to account for the improved yields, etc. It has been shown that most of the extracts contain several types of plant growth regulators such as cytokinins, auxins and betaines, but even here there is no clear evidence that these alone are responsible for the improvements. Blunden (1991) summarizes the situation when he says “there is a sufficient body of information available to show that the use of seaweed extracts is beneficial in certain cases, even though the reasons for the benefits are not fully understood”.

MATERIAL AND METHOD

Due to the fact that in the raw state the seaweed weigh a lot, the transport and processing cannot be done very far from the source (sea, ocean, etc.). Generally drift seaweed or beach-washed seaweed is collected. In Cornwall (United Kingdom), the practice was to mix the seaweed with sand, let it rot and then dig it in. For over a few hundred kilometres of the coastline around Brittany (France), the beach-cast, brown seaweed is regularly collected by farmers and used on fields up to a kilometre inland. Similar practices are performed in several countries around the world. For example in Puerto Madryn (Argentina), large quantities of green seaweeds are cast ashore every summer and interfere with recreational uses of beaches. Part of this algal mass has been composted and then used in trials for growing tomato plants in various types of soil. In all cases, the addition of the compost increased water holding capacity and plant growth, so composting simultaneously solved environmental pollution problems and produced a useful organic fertilizer. After the seaweeds are processed (collected, dried, shredded) in a very large proportion, the brown ones they are sold as soil additives and function as both fertilizer and soil conditioner. They have a suitable content of nitrogen and potassium, but are much lower in phosphorus than traditional animal manures and the typical NPK (ratios in chemical fertilizers).

In addition to fermentation technologies, a number of non-fermentation options for energy production using macroalgae are also available. These include direct combustion to produce heat energy and gasification using pyrolysis where the biomass is converted to gas or liquid (tar) before further downstream processing. The products of such systems can be either utilized in engines or turbines for electricity production or as biofuels for transportation and in bio-refineries to produce high value products (Bruhn et al., 2011). Compared to traditional biomass (such as wood and straw), the thermo-chemical conversion of aquatic biomass is less studied and thermal behavior of macroalgae for combustion and pyrolysis has been described for a few species of brown algae only, primarily *Laminaria* and *Fucus* (Ross et al., 2008; Ross et al., 2009; Bruhn et al., 2011). It was found that ash and alkali contents of macroalgae (such as *U. lactuca*) are the main challenges in the direct combustion. However, application of a bio-refinery concept and integrated systems could increase the economic value of the *U. lactuca* biomass as well as improve its suitability for bioenergy production (Bruhn et al., 2011).

RESULTS AND DISCUSSIONS

Although liquid biofuels are mainly used for transportation yet gaseous fuels (natural gas) are also an alternative fuel option for vehicles (Smyth et al., 2010). Macroalgae can be converted to biofuels by various processes including thermal treatment and fermentation (Lam et al., 2010) but the most direct route to obtain energy from macroalgae is via its anaerobic digestion (AD) to biogas (~ 60% methane). The biochemical conversion pathway is an anaerobic digestion of biomass (usually in the form of liquid or paste-like substrates) by methanogenic bacteria, producing a mixture of gases containing approximately two-thirds CH4, one-third CO2, water vapors and some impurities. This process is well established and is commercially available (Demirbas, 2009; Ryckebosch et al., 2011). Regarding the utilization of algae, it is possible to use it as a substrate because feeding wet biomass to digestion is the one general advantage in using algae as a substrate. Thus, algal biomass is required to concentrate only instead of complete drying out but in wet-fermentation systems concentrations should not exceed 5% on DM biomass basis. It has shown that digestion of algae for biogas production is suitable and the yield depends on the selected algal strain and the method of pretreatment chosen (Mussgnug et al., 2010; Kroger and Franziska, 2012).

Co-digestion of algae together with other substrates is another perspective and the biogas yield may be enhanced using this integrated approach (Yen and Brune, 2007). Because, sometimes protein content of the algae used may be higher leading to production of high ammonium concentrations in the biogas sludge and may lead to toxicity inhibition to reactions

(Salerno et al., 2009). So, this problem could be overcome by adding organic substrates with low protein content (Mann et al., 2009). However, the daily and seasonal fluctuations of the (phototrophic) algae production is a drawback of this combined application to the biogas production on sustained basis. The C:N ratio is also an important factor and the argument for the co-digestion of seaweeds with other more N-rich substrates, for instance waste food or agricultural slurries. Biogas yield also depends on wide range of other variables such as inoculum, digester system and feed stock composition. Overall, the biogas production process has an advantage in the utilization of the whole algal cell and algal blooms from polluted or wastewater (Kroger and Maller-Langer, 2012).

Anaerobic digestion of *U. lactuca* to methane seems more suitable and yields have been reported in the range of 180–330 mL CH4 g-1 of Volatile Solids (VS) depending on the treatment procedure (Bruhn et al., 2011). In 2006, the most realistic estimate of industrial potential of methane production using macroalgae as feedstock was studied (Lewis et al., 2000). A commercial scale 4 stage anaerobic digester was used in this study for over 150 days, with a daily input between 0.2-1.0 tonnes of seaweed and a retention time of 15 to 25 days. An average production of 22 m3 of methane per tonne wet weight of brown seaweed (*Laminaria* sp.) was measured (Lewis et al., 2000). However, recent studies suggest that there is still potential for further optimization of co-digestion of macroalgae with a more nitrogenous substrate, manipulation of the microbial composition of the inoculums (Xu and Mi, 2011; Hsu and Robinson, 2006; Huber et al., 2007), suitability of the selected strain and improved pretreatment technologies (Kroger and Maller-Langer, 2012).

CONCLUSIONS

The marine alga *Ulva* sp. demonstrates a high biomass yield and a high photosynthetic efficiency compared to terrestrial crops but the use of the biomass for combustion represents few challenges due to high contents of moisture, ash and alkali. Anaerobic digestion of the wet biomass to produce methane seems more promising but further improvement in this conversion technology is desired. The economic and environmental sustainability of using seaweed for production of bioenergy would benefit for the bioremediation as well as extracting of high-value products from the biomass prior to energy production. Large scale cultivation and biofuels production plants should be designed in different zones of the world using native strains to fully understand the impacts and performance of native macroalgae.

Biofuels are considered as promising alternative liquid fuels in recent global energy scenario. Food crops and ligno-cellulosic plant biomass have been widely studied as an alternative feedstock for biofuels production. After decades of research, the competition of fuel with food and recalcitrant nature of plant biomass, these feed stocks are losing their popularity. Marine macroalgae have come forward as another potential feedstock for biofuels production. Marine algae have several advantages over the traditional energy crops including absence of lignin, higher growth rates and no competition with human food. Moreover, along with several environmental benefits, they can be grown using saline and waste water and have higher abilities to sequester the atmospheric CO2 than traditional energy crops. Although there are several challenges associated with the algal biomass conversion to bioenergy yet these problems can be overcome using integrated biorefinery approach. The biogas was mixed with city natural gas to power a gas engine power generator with a capacity of using one-metric ton macroalgae per day to provide the electricity and heat requirements of the production plant (Figure 2). *Saccharina* and *Ulva* were the macroalgal taxa used as feedstock in this demonstration.

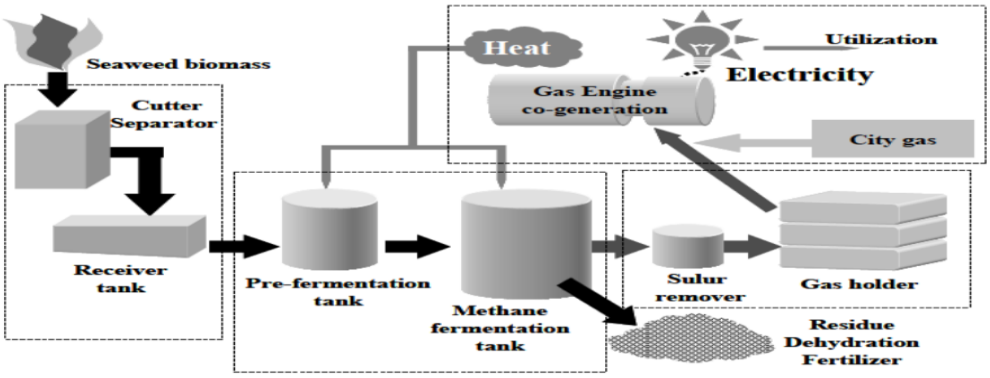

Figure 2. Seaweed processing plant for production of methane and electricity (Matsui et al., 2006)

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