PRODUCTION OF 3RD GENERATION BIOETHANOL FROM MICRO AND MACROALGAL BIOMASS: A REVIEW

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The constant energy demand due to the continuous population increase clearly emphasizes the need to find additional energy sources. Fossil fuels are the main source of energy at the moment, however, their combustion leads to the release of emission gases that disrupt environmental stability. Researches have pointed out biofuels as complementary energy source. Bioethanol biofuel has emerged as an adequate replacement. Different substrates have been used for the production of bioethanol, such as different crops, agricultural waste, however, algae have proven to be the most efficient. Bioethanol production implementing algae as feedstock has appeared as effective way for bioethanol fermentation.

Bioethanol production with macro and microalgae biomass as raw materials represents a prospective biotechnological process since it can provide a constant and renewable energy source.

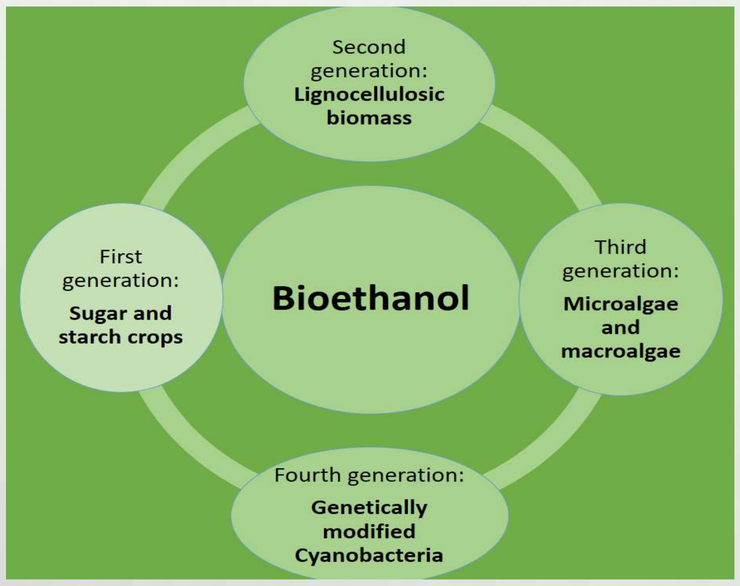

Figure 1. Bioethanol production generations

Bioethanol is a form of renewable energy that can be produced from different types of feedstock. There are 4 bioethanol generations. Algae represent raw material for third bioethanol generation. Algae are characterized by a high content of lipids and carbohydrates, as well as by low lignin and hemicellulose content, which is why they successfully compete with the previously mentioned raw materials. Algae are photosynthetic organisms and they absorb carbon dioxide, which directly affects the reduction of their emission.

was to examine the possibility of using algal biomass bioethanol production substrate.

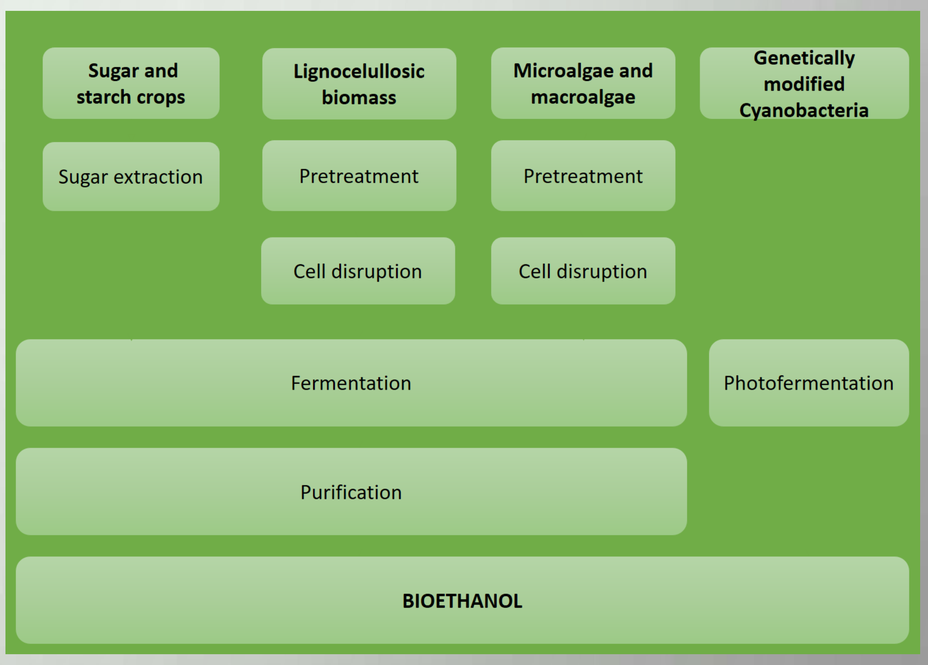

Figure 2. Bioethanol generations procedures

Based on the morphological structure, they are divided into microalgae and macroalgae. Algal biomass is capable of all-year-round production, harvesting and does not require herbicides or pesticides for its growth. They can survive extreme conditions and can be cultivated in different water environments. Algae do not require arable land and are not an obstacle for food production

Bioethanol production from algae feedstock depends on four operations, such as pretreatment, cell disruption, fermentation and purification. Each of the mentioned operations represents an equally important step necessary for bioethanol fermentation with sufficient yield and satisfactory quality. Algal biomass in normal conditions is not sufficient for bioethanol production why there is a need to cultivate biomass in high density..

Bioethanol fermentation is performed by producing microorganisms metabolic activity, such as bacteria, fungi and yeasts, among which the most commonly used are yeast *S. cerevisiae* and bacterium *Zymomonas mobilis*. *S. cerevisiae* has high carbohydrate conversion to alcohol and high fermentation speed which accomplishes significant bioethanol yield.

The aim of this review was to examine the possibility of using algal biomass as substrate for bioethanol production by systematization of data from available scientific literature. This review confirmed the possibility of using algal biomass as a substrate for bioethanol production. As interest in macro and microalgal substrates grows, it is very important to direct further detailed research towards the third generation of bioethanol.

Algae	Cell disruption	Fermenting microorganism	Bioethanol yield (g/g)	References
Scenedesmus bijugatus	Acid hydrolysis	*Saccharomyces cerevisiae*	0.158	Ashokkumar et al. 2015
Chlamydomonas reinhardtii	Enzymatic hydrolysis	*Saccharomyces cerevisiae* S288C	0.235	Choi et al. 2010
Chlorella vulgaris FSP-E	Acid hydrolysis	*Zymomonas mobilis*	0.233	Ho et al. 2013
Laminaria japonica	Enzymatic hydrolisis	*Saccharomyces cerevisiae*	0.291	Wargacki et al. 2012
Ulva lactuca	Acidic+enzymatic treatment	*E. coli* KO11	0.194	Kim et al. 2011
Gelidium amansii	Diluted acid	*B. custersii* KCCM11490	0.422	Park et al. 2012

Table 1. Achieved bioethanol yield based on micro and macroalgal feedstock

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