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Consolidating the Feedstock Crops Cellulosic Biodiesel with Cellulosic Bioethanol Technologies: A Biotechnology Approach

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At present, the US is the largest producer of bioethanol (i.e. ethanol mostly produced from corn seed starch), and biodiesel (i.e. oil produced from oil seed crops). Considering controversies around whether governments should allow the conversions of food and feed into fuels or should they put a limit on such conversions, the future market potentials for crop vegetative wastes cellulosic bioethanol and cellulosic biodiesel is enormous.

The majority of crop lipids are in the seeds of oil seed crops. In certain cases such as in palm oil and olive trees, the majority of lipids are in the crop fruit. Lipids also exist in crop vegetative tissues including leaves, stems and husks. However, lipids of the vegetative tissues are at very low levels and mostly are in cell membranes and outside of the leaf epidermis in form of wax. For example, the lipids per dry weight of oil seeds and oil fruits could be as high as ~80-90%, while the vegetative tissues of normally contain less than 2-3% lipids. A couple of most recent review articles show that it is possible to increase the lipid contents of plants vegetative tissues via metabolic engineering. A couple of other scientific teams were recently able to produce high quantities (9.5 to 17% per dry matter) of high density oil in form of triacylglyceride (TAG) in sugarcane and tobacco (Nicotiana tobacum) leaves. The author's team also recently developed 3rd generation of metabolically engineered maize plants that are producing abundant oil droplets in their leaf cells (unpublished data). It is also possible to shift the fatty acid contents of cellulosic oil from biodiesel oil to vegetable oil by overexpressing of certain genes that are associated with lipid biosynthesis. The overexpression of certain other genes associated with lipid biosynthesis can result in productions of unusual fatty acids such as epoxy fatty acids, and fatty acids of acyl triglycerides, or can result in a shift of fatty acids from one type to another. Therefore, it is expected that biodiesel can be produced in crops vegetative biomass for extraction and use, and its fatty acid content be modified as might become needed.

On the other hands, cellulosic ethanol is produced through the use of microbial cellulases that convert crop cellulose into fermentable sugars and via pretreatment processes that either breakdown or remove the lignin component of lignocellulosic biomass to allow the exposure of cellulose of the lignocellulosic matter to cellulase enzymes. However, production of microbial cellulases and pretreatment processes of lignocellulosic matter are very expensive. To cut the costs of production of cellulosic ethanol, microbial heterologous cellulases have been produced within the crop vegetative biomass, specifically inside crops vegetative biomass sub-cellular compartments, including the apoplast (i.e. the free space outside of the plasma membrane and the cell wall), chloroplast, vacuole and mitochondria or within multiple number of sub-cellular compartments. In addition, lignin of crop vegetative biomass has been reduced via the RNA interference (RNAi) technology and the lignin structure has been changed in a manner that it can be broken down easily with minimum needs for pretreatment processes.

This Editor believes that it must be possible to produce high density lipids as biodiesel via metabolic engineering, extract the biodiesel oil and then convert the lignocellulosic residues into cellulosic ethanol. In fact the two biofuels production systems are well compatible with the existing cellulosic ethanol refinery. Such integrated technology can contribute towards replacing of the environmentally harmful and nonrenewable petroleum fuel to cellulosic biofuels without replacing of the food or feed for fuels. Technologies associated with cellulosic biofuels are not difficult and could be used around the globe especially in countries where abundant crop residues such as rice straws are burned to waste, creating environmental contaminations and human health problems including asthma.