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Using Metabolic Engineering to Make Cheaper Biofuels

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Abstract

This paper attempts to find if metabolic engineering can be applied to more than one aspect of the biofuel production process and significantly reduce costs enough to make biofuels a viable replacement for petroleum. To explore this possibility, this paper analyzed three meta-analysis reviews on lignocellulosic biomass pretreatments and changing plant metabolism, one meta-analysis on the prospects of changing metabolism of the bacteria used in lignin processing, three experimental papers on the potential of changing bacterial processing metabolism, and one experimental paper relating lignin mass to biomass yields. Metabolic engineering can make biofuel production most cost effective by changing the biosynthetic pathways of the actual biomass to make it less lignin dense, to have more biomass, or to change the structure lignin to make it more easily broken down. It can also be achieved by altering the metabolic pathways of yeasts that convert cellulose in biomass to ethanol and other fuel sources. These findings show that it is possible to make lignocellulosic biofuel production less costly, but reveal that the extent of this cost reduction is largely unquantified and must be further researched.

Introduction

Biofuels are one of the most promising sources of alternative energy because they are easily transported and they can be more fuel efficient than traditional petroleum fuels, thus releasing fewer greenhouse gases. It is especially important to invest in biofuels because our supply of crude oil is quickly dwindling and is expected to run out within the next 100 years. However, the most commonly used biofuels today are usually derived from corn, which is both is both energy inefficient and a threat to the global food economy. In contrast, grass based ethanol, which is comprised of lignocellulosic biomass is more energy efficient, does not threaten food economy and can utilize byproducts of agriculture to reduce commercial waste. However, this process is expensive because grass is dense in lignocellulosic material and lignin, which require high cost pretreatments to break down in order to access energy rich cellulose. These pretreatments are not only expensive, but can be energy intensive and harsh, thus negatively impacting the environment. Metabolic engineering of biosynthetic pathways has the potential to reduce costs significantly, and thus make biofuels more appealing to industry as an energy source because it can essentially change any part of the production process that is biological. Although lignocellulosic bioprocessing methods are currently too expensive to be viable in commercial application, metabolic engineering of the biosynthetic pathways of biomass and pretreatments may offer a way to make ethanol production cheaper through a collaboration of changes in biosynthetic pathways, such as changing lignin structure and substrate use efficiency.

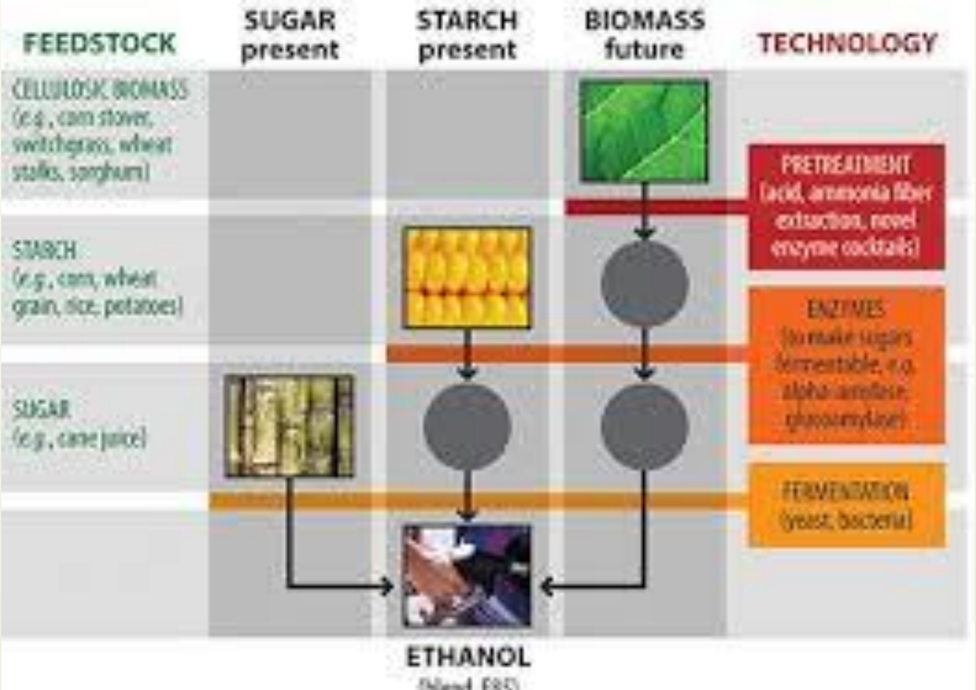
Results/Discussion

Decreasing lignin in plant biomass: It is possible to decrease the amount of lignin in plant biomass by down regulating the major enzymes in the lignin biosynthesis pathway. In fact, decreasing lignin was found to lead to a shift in energy that produced more cellulose. However, it was found that decreasing lignin in plants may lead to dwarfism and weakened defense systems, although this has been shown to be unlikely.

Changing the structure of lignin in plant biomass: Changing lignin structure in a way that makes it more susceptible to pretreatments requires further study, but it was found that there are many potential ways to do this such as modifying phenylpropanoid pathways and producing alternative monomers. However, there are so many potential alternative monomers that more research must be done to narrow the candidate pool.

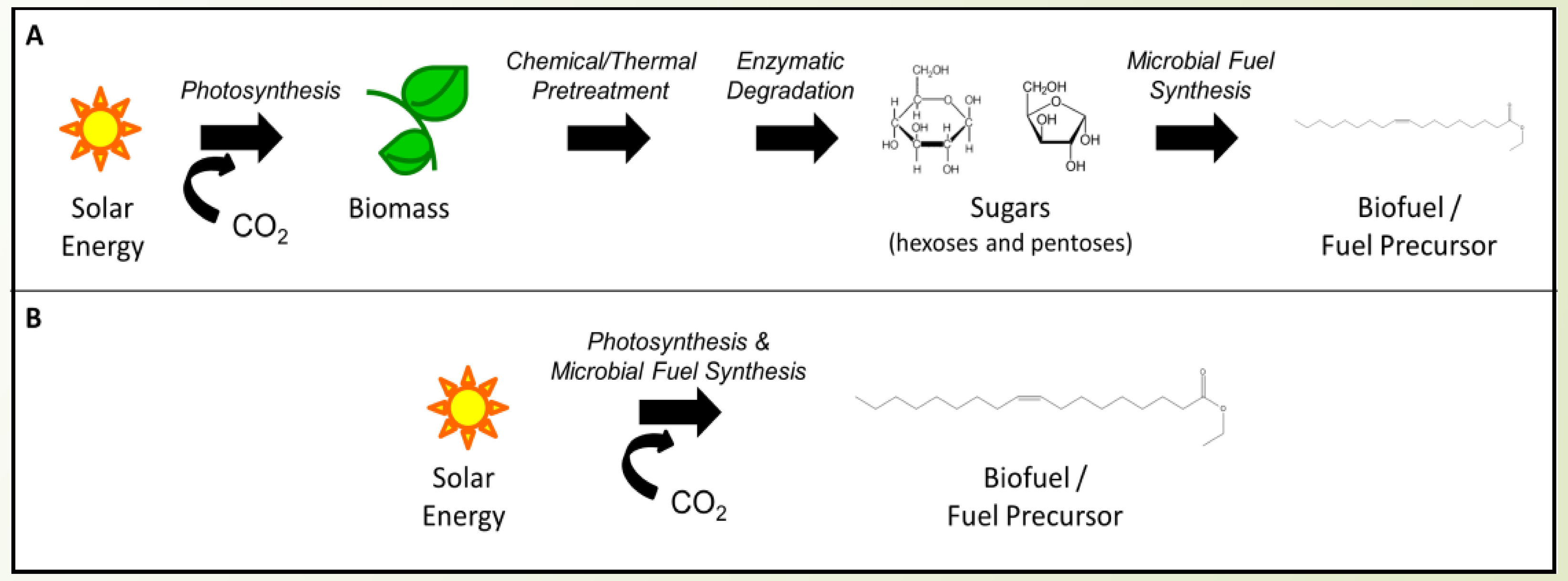
Consolidated bioprocessing: Consists of taking an organism that is efficient at producing ethanol and making it cellulolytic or taking an organism that is cellulolytic and making it highly efficient at producing ethanol. There are many potential organisms (both eukaryotic and prokaryotic) for this method and all have benefits and drawbacks to using, therefore extensive research must be done to make this a viable option.

Changing conversion bacteria metabolism to use fermentable sugars more effectively: Adaptive evolution due to improved pentose pathways and overexpression of phosphate pathway genes were able to increase xylose consumption and ethanol production.



Conclusion

Based on this research, it was found that there has been success in changing amounts of lignin in plant biomass and changing conversion bacteria metabolism to use fermentable sugars more effectively, while consolidated bioprocessing and changing the structure of lignin in plant biomass still require extensive research before they can be applied as viable ways to make ethanol production from lignocellulosic biomasses cheaper. The implication of these findings is that there is no single, freestanding way to make cellulosic bioprocessing more cost effective through metabolic engineering. Instead, it be applied to multiple aspects of the production process in order to be effective. If these methods are applied, then corn could be eliminated as a fuel source, thus solving a global food crisis as well as leading to fewer carbon emissions. However, before this can be applied on a commercial scale more research must be done to create a standard combination of techniques, as well as on the extent of cost reduction from their applications.



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