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# A review on delignification of lignocellulosic biomass for enhancement of ethanol production potential

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ABSTRACT

In the recent past, significant research has been made by thermal, mechanical, chemical and microbial pretreatments in the process of delignification. Production of ethanol from the lignocellulosic material has been done in three major steps: (i) delignification; (ii) depolymerization and (iii) fermentation. Pretreatment has been one of the most expensive processing steps in cellulosic biomass to fermentable sugar conversion. Present review article presents recent advances in the field of delignification. Research article also comprehensively discusses the different pretreatment methods along with effect of delignification on ethanol production and the uses of lignin in different industries. It has been found out that; pretreatment methods have significant impact on production efficiency of ethanol from biomass. This further signifies that, the pretreatment results must be balanced against their impact on cost of the processing steps and the trade-off between operating costs, capital costs and biomass cost.



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## 1. Introduction

Conversion of abundant lignocellulosic biomass to ethanol as a transportation fuel presents an important opportunity to improve energy security, reduce the trade deficit, reduce greenhouse gas emission and improve price stability [1]. In last few decades several ways of utilizing biomass and associated waste for energy production in different forms e.g., biogas, bio-diesel, pyrolytic bio-oil, etc. have been envisaged thoroughly by researchers worldwide [2–6]. It becomes imperative to explain in beginning why lignocellulosic biomass should be converted to ethanol in comparison to other biofuels such as bio-diesel, pyrolytic oil, bio-gas and many others. This can be explained simply because of these main reasons delignification of lignocellulosic biomass becomes so lucrative and important for ethanol production because of its abundance and low cost. Also low oil content in lignocellulosic biomass makes it useless for bio-diesel production. Along with this other technologies e.g., biogas can mainly be used for electricity or thermal energy and not as a vehicle fuel. The designing and operation of a biomass gasification plant involves a number of factors and most of these are critical that may increase the chances of malfunctioning of the plant [5]. Another main energy conversion technology is biodiesel; it is produced from vegetable oils and animal fats through the process of trans-esterification. Mostly, it is obtained from *Pongamia, Jatropha* and other crops such as mustard, jojoba, flax, sunflower, palm oil, coconut etc. Several researchers have used crops such as rubber seed [7], jatropha [8,9], mahua [10], tobacco seed [11], castor [12], *Eruca sativa* [13] and pongamia [14]. Major lignocellulosic biomass does not contain oils which are essential for the production of biodiesel and some crops such as mustard which contain oils are consumed as animal feed. Moreover, the viscosity of neat vegetable oil (range of 28–40 $mm^2/s$) is high due to which its direct use has led to diesel engine problems such as deposits formation and injector coking arising from poor atomization [15]. In India, the recent studies have reported that the present economics of molasses-based ethanol production is not in the favor of commercial blending of ethanol in petrol. The study has indicated that if the government is targeting to bring into effect 10% blending by the year 2016–2017, as planned in the National Biofuel Policy, production of approximately 736.5 million t of sugarcane with area coverage of 10.5 million ha would be required [16] which is not feasible solution and will require huge investment. Moreover, it would be highly unsustainable to extend the sugarcane area beyond a certain limit, as the sugarcane is a highly water-intensive crop with water requirement of 20,000–30,000 $m^3$/ha/crop [16]. Therefore, it is necessary to find out an alternative way for the production of ethanol. Lignocellulosic substances such as cereal straws are available in large quantities and can be easily fermented to produce ethanol, which can be used either as a motor fuel in pure form or as a blending component in gasoline. Otherwise, farmers burnt these straws openly for clearing the field that led to the air pollution and emission of greenhouse gases. [17].

There are so many lignocellulosics agricultural waste available for ethanol production such as sugarcane baggase, rice hull, timber species, willow, salix, switch grass, softwood, rice straw, wheat straw etc. (Fig. 1.).

In agricultural dominating countries like India the crop residue and waste have great potential for ethanol production. Table 1 shows total crop residue production and their availability for ethanol production in India.

One can see there is significant increase in the availability of crop residue for ethanol production; it may be due to increased

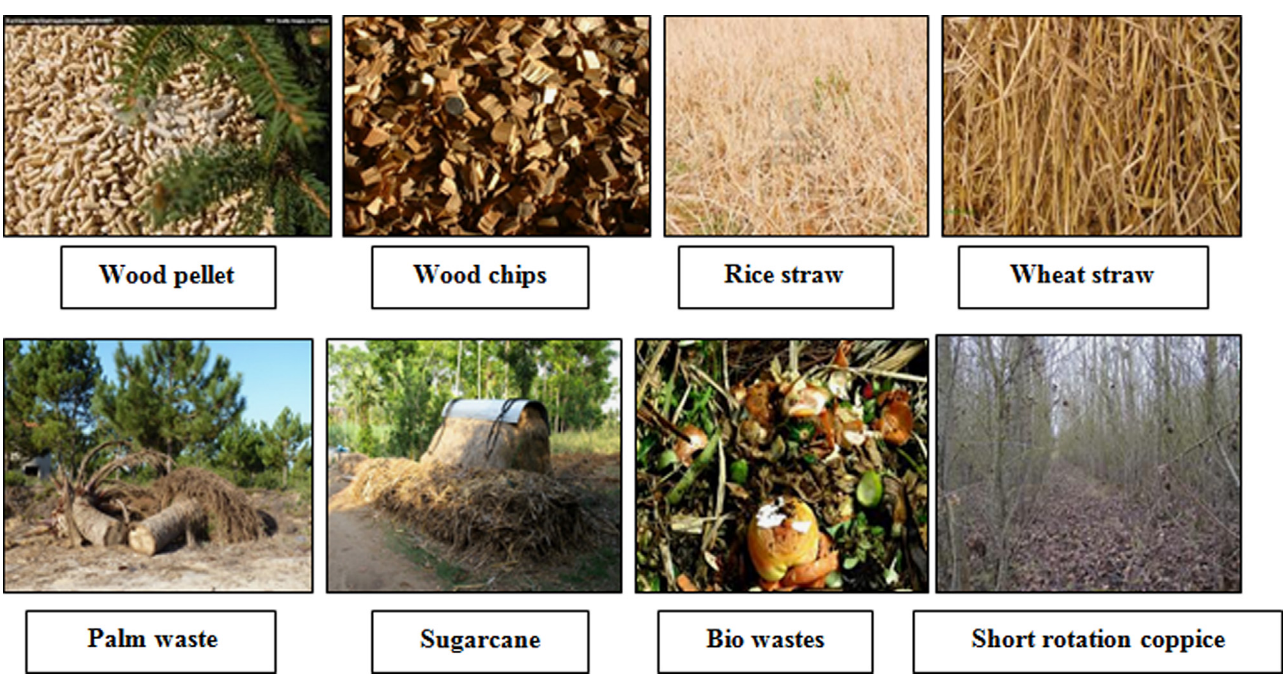


**Fig. 1.** Various lignocellulosic agricultural waste and crop for ethanol production.
*Source:* Adapted from [18].