CONCLUSION
Conclusion

In this study microbial treatment, using fungal isolates, was explored to treat agro residues like wheat straw, rice straw, rice husk and bagasse to facilitate the conversion into ethanol. The major conclusions are:

- Agro residues like wheat straw, rice straw, rice husk and bagasse were shown to give good reducing sugar and concurrently ethanol yield.
- Statistical analysis showed that the significant results were obtained from rice husk and bagasse.
- Fungal treatment of agro residues was found to be the best method of saccharification.
- Consortium of fungi was more effective (*Phanerochaete chrysosporium* with *Aspergillus niger* and *Phanerochaete chrysosporium* with *Trichoderma reesei*)
- *Phanerochaete chrysosporium* showed cellulase, xylanase and laccase activity which helped in removal of lignin barrier in the cellulose to ethanol path.
- Direct fungal treatment was found to give better yield of reducing sugars, because of synergy of enzyme systems, than the enzymatic hydrolysis of raw materials using enzyme concentrates.
- SSF method was found to be better with direct fungal saccharification whereas SHF was better for enzymatic hydrolysis.
- *Pichia stipitis* was found to give better ethanol yield after fermentation from the raw materials used, followed by *Saccharomyces cerevisiae*. 
Simultaneous Saccharification and cofermentation of bagasse treated with consortium of *Phanerochaete chrysosporium* with *Aspergillus niger* and *Phanerochaete chrysosporium* with *Trichoderma reesei* after cofermentation with *Pichia stipitis* and *Saccharomyces cerevisiae* gave the best yield of ethanol.

The study adequately described that the consortium of these fungi was found to show effective cellulase, xylanase and laccase activity which allowed the saccharification of the raw material leading to the highest release of sugars from the lignocellulosic material.

Cofermentation with *Pichia stipitis* and *Saccharomyces cerevisiae* showed utilization of both xylose and glucose for the ethanol production.

Production of ethanol from lignocellulose has the advantage of abundant and diverse raw material compared to sources like corn and cane sugars, but required a greater amount of processing to make the sugar monomers available to the fermenting organisms for the ethanol production. Microbial approach for the processing of agro residues helped in reducing the severity of pretreatments and potential advantage of fungal treatment was its effectiveness in improving cellulose digestibility to get good ethanol yield.

**Future Challenges**

In the course of this investigation, some of the areas have been identified that will need further scientific research and development. The residual solid (lignin) left after fermentation has many uses like use as solid fuel or use in production of silica and can be useful in other fields. One of the main remaining challenges of fungal pretreatment technology is to improve the selectivity for preferential lignin degradation thus preserving more cellulose and to shorten the pretreatment period.
However, further research is required so that the mechanism of delignification can be clearly understood. An in-depth understanding of the inhibitory mechanism of lignin derivatives on enzyme activity may help to develop approaches in order to effectively remove inhibitors thus improve the hydrolysis efficiency. A cost analysis will be critical for estimating the economics of an ethanol production process that employs this microbial pretreatment technology. Other challenges are the identification and isolation of effective microorganisms, capable of using all the sugars available in the lignocellulosic hydrolysates (like glucose, xylose, arabinose, mannose, and galactose). The development of single genetically engineered microorganism showing the cellulase, xylanase and laccase activity and at the same time having the ability of fermentation to produce ethanol has to be undertaken.