Lipid production by Cryptococcus curvatus on hydrolysates derived from corn fiber and sweet sorghum bagasse following dilute acid pretreatment

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BACKGROUND

There is an international demand for and concern for an alternative fuel and energy source, due to the fact that natural resources such as petroleum are being rapidly depleted. As it stands, current efforts towards a sustainable resource are being directed towards ethanol production. Ethanol production appears to be an economically efficient solution as an alternative fuel source. It utilizes corn fiber, which is produced in mass quantities by the corn industry, but not suitable for animal feed. This minimizes agricultural waste. Ethanol may be a good initial attempt at producing an alternative fuel source; however it is not the solution to the problem.

ETHANOL PRESENTS MANY PROBLEMS

In terms of high water solubility, flammability, and low energy content. It is difficult to transport and use in engines to be practical. In order to produce gasohol. Therefore, this is not a sustainable solution. A promising resolution, as an alternative to ethanol, is the production of biodiesel. Biodiesel is a better option as an alternative to ethanol. It has a higher energy density and the opportunity to be very cost efficient. Cellulose is an important component of the biocatalytic process. Cellulose can be found in lignocellulosic materials, combined along with other two carbon substrates, carbohydrates and lignin. For this reason, lignocellulosic materials are the target choice for substrates.

DISCUSSION

Theoretically, severe pretreatment tends to disrupt the lignocellulosic structures more than those done under mild conditions. But severe pretreatment may also lead to degradation of released sugars from cellulose and hemicellulose. As indicated by Fig. 2 (not included), most of TRS was released during the first 24 h. Samples with SF of 1.87 had the highest TRS release compared with those with SF of 1.2 and 1.89. Thus, for SSF, the lowest severity treatment resulted in maximal release of sugars. In this case, a fast and simple dilute acid pretreatment (0.5% sulfuric acid) at 121°C for 1 h is enough to release more than 96% of potentially available sugars from SSF. The remaining material which includes unhydrolyzed cellulose, hemicellulose, and lignin can be processed further through thermomechanical processes to produce bio-crude.

The lowest SF for corn fiber of 1.05 resulted in a recovery of 83.2% of theoretically available sugars just by pretreatment. Pretreatment of corn fiber with SF of 1.84 and 2.24 led to sugar yield of 80.7% and 67.5%, respectively. Pretreatment having the highest SF had the lowest sugar yield. For corn fiber, pretreatment at 121°C for 1 h using 5% or 7.5% of sulfuric acid is enough to unlock most sugars out of the feedstock.

Hydrolysates which were the supernatant of slurries after pretreatment and centrifugation of those derived from the two lower SFs for SSF and corn fiber were used to ferment C. curvatus. In this study, no detoxification of any hydrolysates were carried out. Once yeast cells were added to the hydrolysates, they started to grow immediately with rapid growth rate. After 4 days, the dry cell weight content was measured to be 40%. With regard to hydrolysates derived from corn fiber, no significant cell growth was detected though nutrients in a mineral medium and a spore’s solution were provided (data not shown). For this hydrolysate, detoxification may be needed to remove any non-sugar compounds to yeast fermentation.

Regarding the non-sugar compounds that were also identified... For SF 1.02, among the non-sugar compounds, HMF had the highest concentration of 1.5 g/l which is lower than the threshold of 3 g/l above which significant inhibition on C. curvatus growth and lipid production will take place. However, though HMF was consumed by C. curvatus in our study, this chemical remained unchanged at a concentration around 0.4 g/l throughout the 7-day fermentation period using the same yeast strain (Yu et al., 2011). Kind of chemicals were observed in hydrolysates from SSF with SF of 1.84.

Comparing sugars in hydrolysates of SSF obtained from SF of 1.02 and 1.87. Concentrations of glucose and arabinose were basically the same. Concentration of xylose in hydrolysates from SF = 1.87 was 41.2% of that from SF = 1.02. Thus, it indicated that severe pretreatment degraded xylose. As a result of this degradation, higher concentration of formic acid (1.6 g/l) was measured in hydrolysates of SSF from SF of 1.87 than that of (0.1 g/l) from SF = 1.02. In addition to formic acid, hydrolysis from SF of 1.84 contained levulinic acid at a concentration of 5.0 g/l which was much higher than that of SF1.02. The concentration of formic acid and levulinic acid may play important role in the inhibition of C. curvatus. Thus, it is apparent that pretreatment increased the concentration of non-sugar compounds which could inhibit growth of C. curvatus. But the exact reason for why C. curvatus did not grow on corn fiber hydrolysates is not certain at this point since other chemicals that were not detected and quantified by HPLC could result in growth inhibition. In this case, to utilize corn fiber hydrolysates as substrates for cultivating C. curvatus, non-sugar compounds, detoxification through overliming and/or absorption is needed.

CONCLUSION

Pretreatment of corn fiber and SSF through use of dilute sulfuric acid at mid conditions to high sugar recovery and low concentration of non-sugar compounds. Hydrolysates of SSF derived from pretreatment with the lowest SF supported growth of C. curvatus which reached a cell density of 10.8 g/l with a lipid content of 40% in 6 days. C. curvatus was able to consume all major monosaccharides and non-sugar chemicals in the hydrolysates. Corn fiber hydrolysates, however, did not result in significant cell growth even with the supplementation of nutrients. Follow up studies have included the down stream processes of the most efficient way to convert the lipids into usable biodiesel, exploring thermal liquefaction of sweet sorghum bagasse.

REFERENCES


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