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Simultaneous utilization of non-starch polysaccharides and starch and viscosity reduction for bioethanol fermentation from fresh *Canna edulis* Ker. tubers

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HIGHLIGHTS

- Non-starch polysaccharides and starch can be utilized simultaneously.
- Fermentation efficiency increased and viscosity reduced after CWDE treatment.
- After CWDE treatment, starch granules changed and fibers were disrupted.
- This process can efficiently produce bioethanol from *Canna edulis* Ker.

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ABSTRACT

Viscosity reduction and the effect of cell-wall degrading enzymes (CWDEs) were investigated using *Canna edulis* Ker. for bioethanol fermentation. The fermentation mash treated with CWDEs was much thinner (2.12 Pa s) than the control mash (8.42 Pa s), the fermentation efficiency was increased from 90.46% to 96.11%. HPLC analysis revealed that after treated with CWDEs, glucose and total sugar were increased by 28.07% and 7.60%, respectively. Changes in the starch granules were investigated by scanning electron microscopy (SEM), atomic force microscopy (AFM), and confocal laser scanning microscopy (CLSM). The results suggested that the reduction in viscosity was caused by changes in saccharide composition and physical changes of the starch granules. This present study is of significance that non-starch polysaccharides and starch can be simultaneously utilized for bioethanol production using roots and tubers as feedstock.

1. Introduction

Canna edulis Ker. is non-food biomass source that contains 12–19% starch and can be cultivated in marginal lands with low nutrient demands and in subtropical highlands. It is abundantly available (yearly output is approximately 4.5 kg/m^2) in southwest China in the Guizhou and Yunnan provinces (Wu et al., 2010). Thus, the fresh tubers of *C. edulis* Ker. are a potential source of low-cost feedstock for bioethanol production; however, using root and tuber mashes of high solid content is challenging, especially on an industrial scale. High viscosity syrup is difficult to transport in pipes, which seriously effects industrial production and increases energy consumption. Moreover, high viscosity can also reduce fermentation efficiency as starch is incompletely hydrolyzed to fermentable sugar and growth and metabolism of yeast are affected. The addition of water can reduce viscosity but decreases the concentration of fermentable total sugar and increases energy consumption for ethanol distillation.

A wide range of cell-wall degrading enzymes (CWDEs), including cellulase, xylanase, pectase, with the capability to deconstruct cell wall polysaccharides and change the rheological characteristics of the biomass have been widely applied to reduced viscosity of the mash. The appropriate viscosity has been achieved after the enzymatic treatment of sweet potato (Zhang et al., 2011), potato (Srichuwong et al., 2009), cassava (Sriroth et al., 2000) and sugar beet (Gibson et al., 2007). The enzymatic approach can potentially also be applied to *C. edulis* Ker.; however, as a monocotyledon, its

Abbreviations: SSF, simultaneous saccharification and fermentation; CWDE, cell-wall degrading enzyme; SEM, scanning electron microscopy; AFM, atomic force microscopy; Ra, average roughness; Rq, square root roughness; CLSM, confocal laser scanning microscopy.

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