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IMPROVED ORANGE PEEL WASTE PRETREATMENTS FOR BIOETHANOL PRODUCTION

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Abstract

Citrus fruits world production has been estimated to be over 88 million tons per year, and oranges alone account for about 55% of such amount. Orange peel waste (OPW) is the solid residue of orange juice production. It consists of peels, membranes, cores, juice sacs and seeds and represents over 50% of the processed fruits. Its commercial uses are limited and its disposal is of great concern from the environmental point of view.

In this study, second generation bioethanol production from OPW was investigated. The feedstock was chemically characterized and exhibited low phenols and lignin contents (1.19±0.01 and 1.9±0.08% w/w, respectively) and high cellulose and free glucose and fructose concentrations (26.11±2.12, 6.67±0.69 and 6.81±0.36% w/w, respectively): such properties made OPW a good putative candidate for bioethanol production.

The raw material was suspended in an aqueous solution of sulfuric acid (0.5% v/v) at a solid concentration of 160 g L^{-1} and pretreated in a novel lab-scale direct steam injection apparatus (DSIA), where different reaction temperatures (130 to 200 °C) and times (90 to 500 s) were tested. The resulting slurries were analyzed for the presence of degradation products, and further depolymerized in shaken flasks using a commercial cellulase preparation (Cellic C-Tec2, Novozymes). The clarified liquor was then fermented in shaken cultures, under repeated-batch conditions, using an industrial *Saccharomyces cerevisiae* strain.

It was found that pretreatments at 200 °C for 90 s and 180 °C for 150 s led to the highest glucose yield after enzymatic hydrolysis (52.30±0.34% w/w) and to the highest ethanol yield (50.35±0.89% w/w) and productivity (2.04±0.03 g L^{-1} h^{-1}) after fermentation. Since the latter pretreatment (180 °C for 150 s) led to a lower concentration of inhibitors (*i.e.* formic acid, phenols and 5-hydroxymethylfurfural), such condition was chosen for a scale-up experiment, in which solid concentration in the DSIA was tripled and the entire process feasibility was assessed at the bench-reactor scale. The scaling up was successful since both glucose yield (63.92±3.22% w/w) and ethanol productivity (5.61±0.08 g L^{-1} h^{-1}) were higher than in shaken flask experiments.

On the basis of a mass balance including all the hexoses released after pretreatment and enzymatic hydrolysis, the overall process yield at the bench-reactor scale would amount to about 140.13 L bioethanol per metric ton dry OPW.