Cyprus University of Technology

Faculty of Geotechnical Sciences and Environmental Management

Doctoral Dissertation

Development of a citrus peel waste biorefinery for the production of high added-value commodities and biofuels

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Limassol, December 2019

ABSTRACT

Citrus fruits constitute one of the most highly utilized food products worldwide. The production of citrus fruits reaches over 124×10^6 t per year, while citrus juice manufacturing generates 25×10^6 t. During the processing of the fruit, half of its mass is converted into citrus peel waste (CPW) consisting of peels, seeds and segment membranes. Current management practices include the use of CPW as animal feed or disposal in landfills. However, CPW is composed of pectin, cellulose, hemicellulose, soluble sugars and essential oils, components that constitute CPW as a promising feedstock for extraction and production of added-value products and biofuels through the biorefinery platform.

The proposed biorefinery of this work combines physicochemical and biological treatments for extraction of essential oils and pectin as well as for production of succinic acid (platform chemical), ethanol and methane (biofuels) and a fertilizer. The first step employed distillation for extraction and collection of essential oils where the yield reached 0.43% and 0.24% (v/w) for "Mandora" and household citrus waste respectively. The next step of the proposed biorefinery included acid hydrolysis, where the optimized conditions comprised 116 ^{o}C for 10 min using 5% (w/v) of dry raw material for both materials. Afterwards, the extraction of pectin, which reached 30.5% (w/w), was separated from the hydrolyzate generated through addition of ethanol. Subsequently, following ethanol removal, the hydrolyzate was microbially fermented to succinic acid or ethanol. Succinic acid production was enhanced with the addition of corn steep liquor in fermentations, while the addition of vitamins increased the production rate. A fed-batch experiment was also conducted and resulted in slight increase of both the final concentration of succinic acid as well as the product yield. Moreover, ethanol production was studied using *P. kudriavzevii* KVMP10, a newly thermotolerant yeast which was compared against two major industrial yeasts (*S. cerevisiae and K. marxianus*) and found to be a more efficient ethanol producer through use of CPW hydrolyzates. Finally, solid biorefinery residues were tested in anaerobic digestion for the production of biomethane and in agricultural applications as fertilizer targeting the development of a zero-waste process.

Keywords: Biorefinery, Succinic acid, Bioethanol, Biomethane, Fertilizer