THE PERFORMANCE OF AN AERATED STIRRED TANK REACTOR ON VHG BATCH FERMENTATIONS

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The quest for new and renewable energy sources has greatly increased due to the depletion of fossil fuels reserves. Agro-food wastes appear as a cheap and renewable energy source that can contain great amounts of carbon to be transformed in bioethanol that can be used as additive to gasoline. Industrial wastes of carob pod have a large content in carbohydrates that can be ferment into ethanol. *Saccharomyces cerevisiae* yeasts have been widely used in fermentation processes for bioethanol production because of its considerable tolerance to high concentrations of ethanol and sugar content and low pH values [1]. The scope of this study was to evaluate the performance of an aerated stirred tank reactor, when fermenting carob pod extract at high sugar concentration. Batch fermentations were carried out in a reactor with 2.4 l of carob syrup with 250 g/l in sugar content and supplemented with peptone and yeast extract at low concentrations, at two different aeration rates in order to verify the positive influence of different aeration flux, the tank geometry and mixing efficiency for high ethanol yields. Results showed that at a higher aeration rate, such as 0.63 vvm, ethanol production reaches its maximum of 70.7 g/l with a yield of 0.3 g of ethanol per g of substrate and *S. cerevisae* growth figured a specific growth rate of 0.1 h^{-1}. This production fell short of the expected and theoretical yield of 0.51 g ethanol/g substrate, while at 0.13 vvm of aeration rate ethanol production reached 110.6 g/l showing a yield of 0.45 g ethanol/g substrate.

Carob extract fed-batch fermentation was carried out, at 30 ºC, 250 rpm and 0.13 vvm of aeration rate, to improve ethanol production by addition of fresh medium and alleviate ethanol toxicity due to the dilution of the medium. At the first stage of this fermentation ethanol content reached 67.0 g/l with a yield of 0.48 g ethanol/g substrate and a cellular growth with a specific growth rate of

0.226 h^{-1} was noticed. After 20 hours of fermentation 0.75 l of carob extract medium was added providing more carbon source for ethanol production. Cells continued to grow at 0.079 h^{-1} and ethanol concentration reached 99.6 g/l after 50 hours of fermentation with a yield of 0.47 g ethanol/g substrate. After a second addition at 50 h, ethanol concentration increased and reached its maximum of 126.7 g/l at 120 hours with a yield of 0.50 g ethanol/g substrate. In this third stage, cellular growth was observed with a specific growth rate of 0.011 h^{-1}. During these three stages total sugar consumption increased progressively from 47.6 % to 52.0 %, reaching 61.8 % at the last stage, while at the batch fermentation 89.0 % of the available sugar was consumed. Ethanol productivity at the batch fermentation was 2.04 $g.l^{-1}.h^{-1}$ however, at fed-batch fermentation ethanol productivity reached 3.64 $g.l^{-1}.h^{-1}$ at the first stage, decreasing harshly within the next two stages achieving values of 0.65 $g.l^{-1}.h^{-1}$ and 0.69 $g.l^{-1}.h^{-1}$. These results show that carob pod was successfully used to produce bioethanol, using a STR and mild aeration. Major production occurs during exponential growth phase, but higher values of ethanol content it's possible at stationary phase. Although fed-bath fermentation has lower ethanol productivity, fresh medium addition showed to be an excellent way of enhancing ethanol production from 110.6 g/l to 126.7 g/l due to the decrease of ethanol toxicity and higher availability of total sugar.

High aeration flux promotes entrainment of ethanol in the gas stream of exhaust gases from the reactor. One way around this constraint is through the use of lower aeration flows, and the inclusion of an efficient condenser, with high capacity, in the exhaust gas output, minimizing losses evaporation. This design improvement, coupled with fed-batch operational mode, may improve substantially the fermentative performance of the ethanol production on VHG systems.

[1] Elke Nevoigt. *Progress in Metabolic Engineering of Saccharomyces cerevisiae*. Microbiology and Molecular Biology Reviews, 2008, 72(3): 379-412.

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