Abstract

Sugarcane juice (SJ) is a popular refreshing drink and an excellent source of energy. Though the juice offers numerous health benefits, it suffers from discoloration, off flavour development and short shelf life owing to enzymatic browning and microbial fermentation. In order to address the problem of SJ spoilage, two non-thermal techniques, viz., ultrafiltration (UF) and ozone treatment (OZ) (both as individual processes and in synergy) are attempted in this study. The experimental plan included the synthesis of functional composite polymer (CPY) and selection of CPY concentration (0.25, 0.5 and 1 wt%) for polymer blend preparation, study of membrane surface modification via polymer blending and evaluating its impact on membrane properties, and studying the effects of membrane operating conditions, viz., transmembrane pressure (TMP) 35-138 kPa and cross flow rate (CFR) 10-30 l/h on flux, juice properties and anti-fouling characteristics. In ozone treatment of raw SJ, optimization of gas flow rate (GFR) 3-10 l/min, ozone concentration (OC) 2-8 ppm and exposure time (ET) 5-20 min was carried out based on their effects on juice parameters and kinetic behaviour of enzyme and microbial inactivation was also studied by model prediction. Similarly, optimization was done for ozone treatment of ultrafiltered SJ considering GFR (4-8 l/min), OC (2-6 ppm) and ET (5-12 min). Further, individual UF and OZ processes and the combined UF+OZ technique were compared. The bioactive characterization and sensory evaluation of processed juice were done and then it was subjected to a storage study of 15 weeks under refrigeration and its shelf life was assessed. The results showed the superior anti-fouling properties, antimicrobial action and long run performance of the modified hollow fibre membrane prepared using polymer composition (18% polysulfone + 1% polyethylene glycol-200 + 0.5% CPY) compared to the unmodified one. The optimum condition for ozone treatment of raw SJ was obtained as gas flow rate (GFR) 5.6 l/min, ozone concentration (OC) 7.2 ppm and exposure time (ET) 18.5 min. From kinetic model prediction, it was found that, peroxidase (POD) enzyme was more sensitive to ozone action than polyphenoloxidase (PPO) as indicated by scale parameter of the best fitted Weibull model. The most resistant microorganism was *S. cerevisae* followed by coliforms and *L. mesenteroides* as revealed by predictive model parameters. The optimum conditions identified by multi-objective genetic algorithm were GFR 4.6 l/min, OC 3 ppm and ET 8.2 min for ozonation of ultrafiltered SJ. Cumulative enzyme and microbial inactivation effects were obtained by combining the processes (UF + OZ) providing about 85% PPO, 91% POD, 7 log bacteria and 5.2 log yeast and mould inactivation. Furthermore, when ultrafiltered SJ was used for ozonation, the applied ozone dose was minimized by 6.4 times compared to raw juice that resulted in reduced degradation of phenolic compounds and slight increase in antioxidant capacity. The hurdle technology apart from facilitating synergic inactivation effect reduced the process severity as well and therefore, it was adopted for preserving sugarcane juice. Multivariate techniques efficiently distinguished the stored samples and showed the dissimilarities in quality characteristics after 12 weeks of storage. The microbial stability and sensory acceptability analyses confirmed that the ultrafiltered ozonised sugarcane juice could be safely stored up to 90 days under refrigeration. The economic feasibility of process was ascertained by sensitivity analysis.

Keywords: Sugarcane juice; Preservation; Ultrafiltration; Membrane modification; Ozone treatment; Process optimization; Kinetic models; Shelf life prediction