Abstract

Citrus fruits, a most traded horticultural crops grown worldwide, are well-accepted by consumers all over the world due to their attractive colours, flavour, aroma, nutritional and health-promoting values. The main setback of citrus juice processing industry is development of bitterness which brings limitation in acceptability and commercialization. Assam lemon (*Citrus Limon* L. Burmf) is an important variety of Assam, North-Eastern region of India and totally unexplored for commercialization.

Firstly, in the present study an attempt was made to debitter the Assam lemon juice through the enzymatic approach. A maximum bitterness removal of 38.95±3.27% was found at 37 °C after 2 h of reaction with 1% (v/v) enzyme (30 IU/ml). Enzyme treatment of juice reveals an increment of reducing sugar and total sugar by 37.51 and 48.50%, respectively along with antioxidant activity by 15.30% than untreated juice. No significant changes in elemental and sensory properties was found.

Further work was carried out in the valorization of Assam lemon waste in a close loop approach. Enzymatic approach coupled with hydrodistillation was yielded 4.19±0.11% (v/w) essential oil and 12.67±0.42% (w/w) pectin. Maximum ethanol production from Assam lemon waste through partial simultaneous saccharification and co-fermentation (PSSCF) was 12.16±0.15% (v/v) in optimized condition. Mass flow analysis demonstrated 69.17% overall process efficiency when compared to the theoretical ethanol yield.

After ethanol production fermented waste was further valorized through anaerobic digestion (AD) by inoculating mixed anaerobic consortia (MAC) and using graphene oxide (GO) to maintain stable and fast direct interspecies electron transfer (DIET). A maximum yield of 243.23±1.99 ml/g VS_{fed} biomethane was achieved when the solid loading was kept at 25 g TS/L and incubated for 30 days at 37 °C when GO was added as 0.06% (w/v) and accounted for 70.88% process efficiency.

Finally, digested biomass was used for N enrichment and bioavailability of P, K through *Fischerella muscicola* for biomanure production. N, P and K were enriched by 2.88, 2 and 2.16 folds compared to the initial content. Combine application of biomanure and inorganic

fertilizer on mung bean cultivation reveals an increment of yield by 2.02 folds with maintain good soil health.

Keywords: Assam lemon, Debittering, Valorization, Biorefinery, Biofuel, Biomanure, Mung bean