ENHANCING INDUTRIAL VINEGAR PRODUCTION FROM COFFEE PULP: ROLE OF AERATION RATE ON ACETIC ACID FORMATION

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Abstract

Coffee pulp, a major by-product of coffee processing, represents an underutilized biomass with potential for value-added fermentation products. This study investigated the effect of aeration rate on acetic acid production during vinegar fermentation from coffee pulp using *Acetobacter pasteurianus* TISTR 102 in a stirred-tank bioreactor. Aeration rates of 0.5, 1.0, and 1.5 vvm were evaluated in a 10-L bioreactor to determine their influence on acetic acid formation, viable cell growth, and fermentation kinetics. Among the tested conditions, 1.0 vvm provided the optimal balance between oxygen availability and microbial stability, resulting in the highest acetic acid concentration (5.12%), maximum viable cell density (14.2934 log CFU/mL), and shortest fermentation time (144 h). The logistic growth model effectively described microbial growth behavior, yielding a high coefficient of determination (R^2 = 0.9975) with low error indices (χ^2 = 0.3587, RMSE = 0.5821, and MBE = 0.3388). Lower aeration (0.5 vvm) caused oxygen limitation, whereas excessive aeration (1.5 vvm) promoted over-oxidation and shear stress, reducing process efficiency. Scale-up validation in a 100-L fermenter under the optimized condition achieved 4.48% acetic acid, satisfying food safety standards for vinegar production. These findings demonstrate that aeration control is a critical engineering parameter for efficient vinegar fermentation and confirm the industrial feasibility of converting coffee pulp into a sustainable value-added product.

Keyword: coffee pulp, vinegar fermentation, aeration rate, kinetic modeling, acetic acid production.