ABSTRACT

An environment control chamber was designed and fabricated to control air temperature, relative humidity and flow rate as required for withering, oxidation and drying of tea leaves for black tea manufacturing. The device consists of a spray chamber for humidification of air, an air heater, a blower and a chamber to accommodate the leaves. Also, there is provision for recirculating part of exhaust air during drying. The device could maintain air temperature within ± 0.2 ^{o}C and relative humidity within ± 2% of the set value during experiments. Withering of leaves of TV25 were carried out at different air temperatures (25, 30, 35 ^{o}C) and relative humidities (60, 75, 85%). During withering, with increase in air temperature polyphenoloxidase (PPO) enzyme specific activity decreased and peroxidase (PO) specific activity was enhanced. Both PPO and PO specific activity decreased with reduction in relative humidity of air. Process parameters for withering were optimized using an Artificial Neural Network model for prediction and Genetic Algorithm to maximize enzyme activity and reduce moisture content to desired range for CTC and orthodox black tea production. The optimized parameters are: CTC – temperature: 29.13 ^{o}C, RH: 79.58%, duration: 11.41 h; Orthodox – temperature: 33.04 ^{o}C, RH: 77.27%, duration: 10.60 h.

Mass diffusivities and mass transfer coefficients for the exchange of O_2 and CO_2 during oxidation of macerated CTC and orthodox leaves were found to fit to exponential relationships. Initial values of mass diffusivity of O_2 were found to be 1.159×10^{-8} m^2/s and 6.019×10^{-10} m^2/s for CTC and orthodox leaves, respectively. Mass diffusivity of CO_2 was 5.191×10^{-7} m^2/s and 2.383×10^{-8} m^2/s for CTC and orthodox leaves, respectively at the beginning of oxidation.

Macerated CTC and rolled orthodox leaves of TV25 were oxidized at different air temperatures (20, 25, 30 and 35 ^{o}C) in the environment control chamber varying the thickness of oxidizing leaf bed (2 cm and 5 cm). The rate of depletion of individual catechin (EGCG, ECG, EGC, EC) during oxidation was modeled using Michaelis-Menten equation. Michaelis-Menten constant and reaction rate constant were determined for each catechin and activation energy for change in reaction rate constant with temperature according to Arrhenius plot were calculated. The depletion of di-hydroxylated catechins (EC, ECG) was found to be more affected by change in air temperature than the tri-hydroxylated catechins (EGC, EGCG). The individual theaflavins (simple TF, TF3MG, TF3'MG and TFDG) were formed and depleted at different rates depending on the temperature of oxidation. Theflavin (TF) graph reached maximum amount after longer duration of oxidation for lower air temperature. Amount of maximum total TF at different temperatures was in the range of 1.19 – 1.3 % for CTC macerated leaves and 0.33 – 0.43 % for rolled orthodox leaves. In total TF, amount of individual theaflavins were in the order of TFDG>TF3MG>TF3'MG>simple TF for oxidation of both CTC macerated and rolled orthodox leaves. Thearubigin (TR) content increased with duration of oxidation, air temperature and bed thickness. The ratio of TF:TR when total TF content was maximum was found to be 1:10.07 for CTC and 1:13.94 for orthodox tea. Quadratic and linear regression equations were developed to model the change in TF and TR content respectively, with air temperature, oxidation duration and bed thickness in CTC macerated and rolled orthodox leaves. ANOVA of the models revealed that bed thickness does not have significant effect on TF content in both macerated CTC and rolled orthodox leaves.

Keywords: black tea, environment control chamber, withering, polyphenoloxidase, peroxidase, oxidation, optimization, gas diffusivity, Michaelis-Menten constant, catechin, theaflavin, thearubigin.