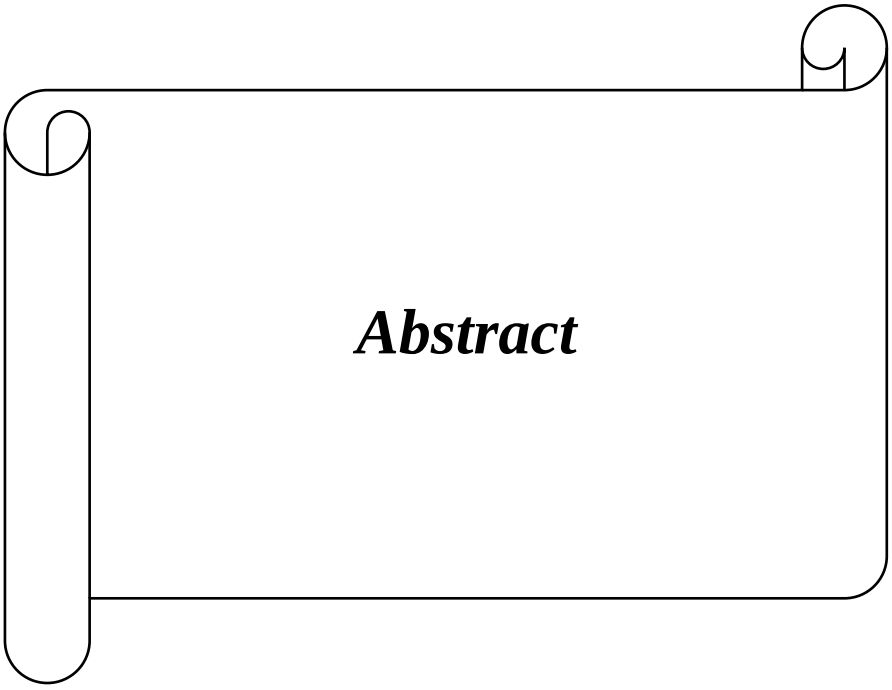
Abstract

Ohmic Heating as an Alternative Thermal Processing Method of Mango Puree

ABSTRACT

Ohmic heating (OH) appears to offer an attractive alternative to the conventional thermal processing by keeping food material in between two electrodes to raise its temperature rapidly and volumetrically by joules effect. Conventionally thermal processing is used for the processing of mango (*Mangifera indica L.*) at commercial scale. Therefore, the present research was formulated with five objectives. The first objective was to design and development of lab scale OH setup and its performance examination. Further, the mango puree was characterized and OH processing parameters were optimized on the basis of certain important responses. Kinetic study of enzyme and microbial inactivation and change in color (ΔE) was performed. However, the effects of OH and conventional heating on mango puree and its storage study were conducted.

The OH setup consists of 50 mL Teflon made a heating cell, disc shape platinized titanium electrodes (2 No.), variac transformer (1φ-430 V) and a data logging assembly. Five different food materials viz. Tomato, Watermelon, Pineapple, Litchi juice and Mango puree were tested for the performance evaluation. The rate of OH increased with the EFS and the OH behavior of food samples varied due to the compositional differences. The electrical conductivity (EC) of the samples had an important role in OH at all the EFS levels, whereas at higher EFS (30-40 V/cm), the consistency also was observed to affect the OH behavior. The efficiency of the OH process was achieved near 90 %. However, it can be increased further by appropriate equipment design and insulation of the heating chamber.

The physico-chemical characteristics of the food material had a major role in OH behavior; therefore, the characterization of mango puree was performed on the basis of acid and sugar (TSS) content. Soluble sugar and acid content causes changed the water activity of the mango puree, the change in acid content by 0.12g/100g increased water activity from 0.983 to 0.990. The flow and textural characteristics were affected considerably by the soluble solids and acid content. The interaction of sugars and acid

with other components such as water, pectin and cell wall material at the molecular level could be the reason for the changes in physico-chemical properties. The onset and peak temperatures of phase change in the mango puree were ranged in between 65-70 °C and 95-105°C, respectively, as the acid content increasing and 70-90°C and 105-110°C, respectively, as the TSS increasing from 20 to 24°B. The enthalpy of fusion was lower at 24 °B and higher at the lower TSS content, such behavior may be related to the inferring effect of sugar on fusion of other species present or it can be related to the lower mobility of the sugar in the higher TSS content. The mango puree exhibit visco-elastic nature and the addition of acid caused a slight increase in storage modulus (G') and loss modulus (G'') at 30 °C, whereas at 90 °C, relatively higher increase 782 and 129 Pa was observed in G'' and G' respectively. The change in total soluble solids from 20 to 22 °B increased the G' and G'' at 30 as well as 90 °C, however, further increase in TSS from 22 to 24 °B resulted in the reduction in the value of G' and G''. The ohmic heating (OH) behavior of the mango puree gets affected by electric field strength; however mango puree can be heated instantly by OH at 20-40 V/cm. At 40 V/cm the heating rate of 1.71 and 4.70 °C/s was observed at 0.50 and 0.62 g/100g acids respectively, whereas increasing TSS from 20 to 24 °B caused a reduction in heating rate from 2.24 and 1.71 °C/ s.

The optimization of the process parameter, EFS (15-30 V/cm), Temperature (85-95 °C) and time (1-2 min) was considered as independent variables and residual activity of PPO and POD, ΔE and reduction of the bacterial count were taken as dependent parameters. The experiments were planned as per the 3-level factorial design. The optimized conditions were found to be OH at 95 °C for 115 s using EFS of 15 $V.cm^{-1}$ as the best condition with 0.794 desirabilities for treating the mango puree. Generally, it is adopted that enzyme inactivation follows first order pattern which is based on the assumption that the break of a single bond or a structure is sufficient to inactivate the enzyme; however, it is known that the process is much more complex. Therefore, the detailed kinetic study suggested that the PPO follows Distinct isozyme whereas POD inactivation followed the Weibull distribution, with R^2 of 0.978-0.999 and 0.992-0.999 respectively. Decimal reduction time (D-value) of the labile fraction was calculated to be extremely lower than the stable fraction of PPO, and it reduced with increasing the EFS for both the isozyme fractions. The bacteria reduced exponentially, both the temperature

and EFS were found to have a positive relationship with the rate of bacterial reduction. The reduction of constant 'k' increased from 1.826 to 2.162 min^{-1} at 80 °C and 2.142 to 3.318 min^{-1} at 95 °C when EFS was enhanced from 15-30 V/cm. The change in color (ΔE) was changing linearly with the treatment time during all the OH conditions, the temperature and EFS were amplifying the value of ΔE.

The mango puree contained 151±4.35 μg/100 mL, 116.9±3.37 mg/100 mL and 24.33±0.03 mgGAE/100 mL β–carotene, Vitamin C and total phenols respectively. Ohmic heating and Hot water heating (HWH) at optimized condition were compared for their effects on various physico-chemical parameters and bioactive components of mango puree. The mango puree was found to be shear thinning in nature; both the treatment caused slight changes in its rheology. β–carotene, Vitamin C and total phenols degradation were witnessed during heating as well as holding in both OH and HWH treatments. However, vitamin C and total phenols were retained to a greater extent in OH treatment comparatively whereas higher degradation of β carotenes resulted in OH with respect to that of HWH. During the storage of 3-months at ambient conditions, vitamin C, total phenols and β carotene showed a decrease with the storage time. Microbial growth was relatively restricted by OH treatment than by HWH treatment, total bacteria population was found to increase from 1.73 to 2.60 log CFU/mL and 1.46 to 2.84 log CFU/mL in OH and HW treated respectively during three months storage. The possible reason for restricted microbial growth OH would be due to the electric effects of the OH process. In summary, the OH process can be proved to be an energy efficient, convenient method of mango puree processing. Additionally, OH would be helpful in the retention of quality parameters, thus, it is recommended that the OH process has great potential as an alternative thermal processing method for mango puree.