EXPERIMENTAL INVESTIGATION ON SPECIFIC HEAT OF PSIDIIUM GUAIJAVA L (GUAVA FRUIT) AS A FUNCTION OF MOISTURE CONTENT AND TEMPERATURE

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ABSTRACT

Precise knowledge of Specific Heat of Guava fruit (PSIDIIUM GUAIJAVA L) cultivar (Rayalaseema area, AP, India) is one of fundamental importance to establish the design of process equipment, quantifying thermal processes and to understand its thermal behavior. A study of effect of Moisture content (MC) and Temperature on Specific Heat of Guava fruit are reported. The Specific Heat was evaluated for various MC 40% to 80% (wb) at two different densities. (Test samples were equilibrated to a given MC prior to use). The results reveal that the $C_p$ of Guava fruit increased with increase in moisture content and temperature and density in the range of 1.99 to 4.088 kJ / kg$^0$C. The experimental values were statistically analyzed and compared with standard (Dickerson and Siebel) models and were found in good agreement with predicted models. The analyzed data will help to enhance shelf-life and better control on both process and product of food industries and researchers.

Keywords: Density, Guava Fruit, Moisture Content and Thermal Conductivity.

1. INTRODUCTION

Guava (Psidium guajava L.) fruit is generally ovoid or pear shaped and depending on cultivar, their sizes vary from 2.5 to 10 cm in diameter and weight 50 to 500 g [1]. The flesh may be pink, white or yellow, either with seed or seedless [1]. Guava is a native to Mexico and it is also available throughout South America, Europe, Africa and Asia as it is able to grow in all subtropical areas [2].Guava is often marketed as "super-fruits" which has a considerable nutritional importance in terms of vitamins A and C with seeds that are rich in omega-3, omega-6 poly-unsaturated fatty acids and especially dietary fiber, riboflavin, as well as in proteins, and mineral salts. The high
content of vitamin C (ascorbic acid) in guava makes it a powerhouse in combating free radicals and oxidation that are key enemies that cause many degenerative diseases and that can be used to fortify children foods. The anti-oxidant virtue in guavas [3] is believed to help reduce the risk of cancers of the stomach, esophagus, larynx, oral cavity and pancreas.

The vitamin C in guava makes absorption of vitamin E much more effective in reducing the oxidation of the LDL cholesterol and increasing the (good) HDL cholesterol. The fibers in guavas promote digestion and ease bowel movements. The high content of vitamin A in guava plays an important role in maintaining the quality and health of eye-sight, skin, teeth, bones and the mucus membranes. Guava has excellent digestive and nutritive value, pleasant flavor, high palatability and availability in abundance at moderate price. The fresh fruit has limited shelf life therefore it is necessary to utilize the fruit for making different products to increase its availability over an extended period and to stabilize the price during the glut season. Guava can be consumed fresh or can be processed into juice, nectar, pulp, jam, jelly, and slices in syrup, fruit bar or dehydrated products, as well as being used as an additive to other fruit juices or pulps [4 and 5].

These products have good potential for internal as well as external trade. The utilization of guava for preparation of beverages and intermediates moisture products has not been explored much. Guava pulp can be used as base for the preparation of these products. In the food industry, knowledge of the thermo-physical properties of food is fundamental in analyzing the unit operations. They influence the treatment received during the processing and good indicators of other properties as well as the qualities of food. These benefit the producer, industry and the consumer [6]. Like many other fruits, guava is highly perishable. Drying is one of the methods used to prolong the shelf life of guava and prevent surplus of guava especially guava that is not satisfactory for other types of processing such as canneries. Various drying methods including hot air drying and lyophilisation [7] have been studied on guava.

Heating and cooling of food is one of the earliest methods of applying science to foods. A Thermal process is applied to any system in which heat energy is transferred to or from the product. The thermal properties of food are its ability to conduct, store and lose heat. Thermo-physical properties are indispensable in process calculations and quality optimization of foods that include freezing, heating, blanching and drying. It has been generally recognized that Thermo-physical properties of biological materials such as food stuffs are dependent on Temperature, Moisture content and composition. Therefore variability in composition and physical characteristics resulting from variations in soil, climatic conditions, irrigation techniques and fertilizer used would manifest themselves in measured thermo-physical properties [8].

The thermal properties of food establish how heat is distributed within a food sample. One among the thermal property i.e., Specific Heat, is the ability of a food product to store heat relative to ability to conduct (lose or gain) heat. It is strictly based on how much energy is needed not the rate at which it takes to raise the temperature. The specific heat (Cp) knowledge is essential for an efficient fruit pulp thermal processing [9].

2. MATERIALS AND METHOD

2.1 Sample preparation and moisture content

Freshly harvested, ripened desiree fruits of uniform shape, size and color were procured from the local orchard (Rayalaseema Area, A P, India) are washed in clean potable water, (The flesh of each fruit was observed to be pink and the central pulp contains seeds along with the peel is mashed in the form of paste(sample)) and allowed to equilibrate with room temperature prior to testing.

The moisture content of the fresh fruit samples was determined using a standard method AOAC (Association of Official Analysts and Chemists) [10] in a Vacuum oven at 70°C for 24 hrs with 03 replicates. To obtain samples with a range of moisture contents 40-80% (wb), the samples
were dried for various periods in an Experimental hot air drier at 55, 65 and 75°C. The partly dried samples were sealed in a polyethylene film and stored at a constant temperature (30°C) for 24 hours to ensure uniform moisture content throughout the sample.

2.2 Experimental Set up

A simple, inexpensive, laboratory apparatus was used for determining Specific Heat (C_p) as shown in the fig.1a. Specific heat has to be determined by circulating constant temperature hot water from controlled water bath.

Fig.1a Schematic diagram for the measurement of specific heat

The apparatus consisting of an Al test cylindrical capsule (Fig.1b) of 28.4 mm diameter and 104 mm long, a 33 gauge chromel wire as heating wire of length of 200mm positioned co-axially in the test cylinder with end covers. The top and bottom cover made of Teflon were used to minimize axial conduction of heat. An insulated Fe - constantan thermocouple is inserted through the top cover (Teflon) in to core of the sample to measure the temperature rise. The regulated DC power supply was connected to heater wire so as to supply constant power to it. The test cylinder outer surface is encircled by a tube network to maintain constant temperature bath and totally insulated to act as adiabatic container.

2.3 Methodology

The test cylinder is filled with predetermined mass and known Moisture Content mashed sample (pulp + peel) to obtain a uniform density from top open end and is sealed with polyethylene foil along with top cover (Teflon) to avoid any moisture loss. The temperature of the sample is equilibrated with the ambient temperature. When the sample reaches uniform targeted temperature by circulating controlled water bath through the encircled tube network, the power and stop watch are switched ON simultaneously. The time required for the every degree rise in temperature of the sample is recorded. The experiment is repeated for various MC samples and C_p is calculated by energy balance: Heat gained by the sample = heat supplied by the heater.

\[
C_p = \frac{V^*I^*t}{m^*(\Delta T)} = \frac{I^2 * R}{m^*(\Delta t)} \quad ------ (1)
\]

Where \( V \) = volts, \( I \) = currents (amps), \( R \) = resistance of heater (\( \Omega \) m\(^{-1} \)), \( t \) = time (sec), \( m \) = mass of fruit sample(kg), \( \Delta T = T_f - T_i \), \( T_f \) = Final temperature (°C), \( T_i \) = Initial temperature(°C).
a. Predicted Model: Dickerson [11] proposed modeling of Specific Heat equation to calculate the Specific Heat of unknown food product:

\[ C_p = 1.675 + 0.025M \quad \text{(2)} \]

Where, \( M \) = Moisture content of the material in % (wb)

b. Siebel [12] proposed the following equation to determine Specific heat of unknown food product:

\[ C_p = 0.8374 + 0.0335M \quad \text{(3)} \]

Where, \( M \) = Moisture content of the material in % (wb)

3. RESULTS AND DISCUSSION

3.1 Assay of Specific heat at Density \( D_1 = 911 \text{Kg/m}^3 \).

The effect of Moisture content on Specific Heat of Guava fruit (\( D_1 = 911 \text{ Kg/m}^3 \)) at different temperature is shown in Fig.2. The effect of temperature difference on Specific Heat of Guava fruit (\( D_1 = 911 \text{ Kg/m}^3 \)) at various moisture Content 40 – 80% (wb) is shown in Fig.3.

It is observed that the Specific Heat increases with increase in Moisture content due to presence of bound water molecules in the sample. The Specific Heat also increases with moisture content due to higher thermal contact between the particles of the sample but this increase may not be linear. For particular moisture content the Specific heat increases with increase in temperature difference as the sample has got tendency towards increase in the rate of heat transfer because of bound water present in the sample.

It is observed that Specific heat increases with increase in temperature difference in the moisture range of 40% to 80% (wb). The result reveals that, higher moisture levels of 70% and 80% (wb) specific heat increases with increase in temperature differences but this increase may not be linear. Temperature mainly influences the reduction in specific heat values due to formation of porosity [13].
3.2 Assay of Specific heat at Density $D_2 = 1062 \text{ kg/m}^3$

The effect of Moisture content on Specific Heat of Guava fruit ($D_2 = 1062 \text{ kg/m}^3$) at various temperature difference shown in the Fig.4. The effect of temperature difference on Specific Heat of Guava fruit ($D_2=1062\text{Kg/m}^3$) at various Moisture Content 40% to 80 % (wb) is shown in Fig.5.

![Graphs showing variation of Specific heat with Moisture content and Temperature difference](image)

**Fig.4 Variation of Specific heat with Moisture content**

**Fig.5 Variation of Specific heat with Temperature difference**

The Specific heat increases with increase in Moisture content with the minimum value of 1.68 kJ/kg$^0$C and maximum value of 4.038 kJ/kg$^0$C in the moisture range of 40% - 80%(wb) for density of 911 Kg/m$^3$(Fig.2 and Fig.3). Also a minimum value of 1.99 kJ/kg$^0$C and maximum value of 4.088 kJ/kg$^0$C in the moisture range of 40% - 80%(wb) for temperature difference of 5 to 15 $^0$C for density of 1062 Kg/m$^3$ (Fig.4 and Fig.5).

3.3 Assay of Specific heat at Density $D_1$ and $D_2$

![Graph showing variation of Specific heat Vs Time for different densities at 80% Moisture Content](image)

**Fig.6 Variation of Specific heat Vs Time for different densities at 80% Moisture Content**

It is also observed that at different bulk densities of 80% wb moisture content specific heat values increases with increase in time and corresponding increase in density as shown in Fig.6.
4. CONCLUSION

The effect of Moisture content (40-80% wb) and temperature difference (5-15°C) on Specific heat of fresh and dehydrated Guava fruit sample was investigated. The Specific heat increases with increase in density because of good thermal contact between the particles and decreases because of porosity. The increase in Specific heat is not linear because of particle size, its distribution, surface resistance and non homogeneity of the sample. The increase in specific heat at lower moisture content was relatively more than at higher moisture content. This is may be due to solid water interaction at lower moisture content.

The deviation of experimental results of Specific heat with the standard model [11] is in the range 8 to 14% for higher moisture content (60 to 80% wb) of the sample.

5. REFERENCES


