

Effects of ripening on rheological properties of avocado pulp (*Persea americana* mill. Cv. Hass)

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Abstract. Avocado (*Persea americana* Mill) Hass variety is the most planted in Chile with a greater trade prospect. The aim of this study was to investigate the effect of maturity on rheological properties of Chilean Avocado Hass pulp. Fresh unripe avocados were washed and peeled, cut and stored at 3 different times; a portion was treated at 5°C and the other was treated at 20°C until it reached 2 lb puncture pressure. During maturation changes would develop due to temperature and time, with internal cellular structure changes. Preliminary results of the rheological characteristics of avocado puree show a Bingham plastic behavior.

1. Introduction

Avocado (*Persea americana* mill. c.v. Hass) industry is a very important export agribusiness in Chile, with sales over US\$ 250 million and an important rural employment source. Exports represent 60% of the total production, mainly to the U.S. However, the increasing of plantations in Chile and from other producing countries, it is expected production increase and prices decrease, which will generate a high availability of raw material for domestic consumption and for the production of avocado oil which will result in an increase of their waste. For the latter, it is important for domestic producers to optimize the avocado industry and use their left overs.

Characterization of raw materials is of economic significance and has become very important for the development of innovative technological applications in various agro-productive areas. One of the most important factors that have a direct impact on the quality characteristics (color, texture, taste, palatability, etc.) is the avocado ripening process developed during postharvest storage, which indirectly depends on the harvesting season and biochemical changes that occur during fruit storage at a given temperature and time. It is interesting to characterize the intrinsic attributes of avocado, especially since the literature reports mainly chemical and textural characterization (Wang et al, 2010; Landahl et al, 2009). Related to flow and viscoelastic rheological properties, Tabilo-Munizaga (2005) characterized avocado pulp treated by high pressure (UHP) observing that did not show the behavior expected by the authors, defined by the Herschel-Bulkley model for flow properties and, on the other hand, it was determined that the UHP treatment resulted in a variation of the typical viscoelastic behavior of vegetable pulps obtained by monitoring storage (G') and loss (G'') modules. Logaraj and Bhattacharya (2007) performed rheological analysis in model systems using avocado oil emulsions,



determining a pseudoplastic behavior for emulsions. However, these authors did not consider the actual rheological behavior of avocado pulp which corresponds to complex matrix interactions of macronutrients influenced by the fruit maturity evolution. Industrially, green avocado is cooled at 5°C to minimize the effects of ripening and then after sale is kept at room temperature to reach the optimum ripening temperature. In this work, the rheological behavior of avocado pulp at different maturity stages during storage at 5°C and 20°C is characterized, which are actual conditions used by the industry.

2. Materials and methods

2.1. Samples preparation

Raw materials. Fresh unripe avocados (*Persea americana* mill. cv. Hass) were obtained from INIA-La Cruz, Valparaíso- Chile. Avocados were harvested on November 26, 2012 and stored in 3 different times (T0 = 0 days; T1, T2 = 20 and 40 days respectively), a portion of the batch was treated at 5°C and the other batch portion was treated at 20°C until it reached 2 lb puncture pressure. For T0 it took 10 days to reach this pressure; it took four days for condition T1; and 5 days for condition T2.

2.2. Equipment.

A Haake rheometer (Thermo Scientific™, RheoStress 1 Germany) which was operated from a computer loaded with the software package (HAAKE RheoWin version 4.30.0016), with cylindrical geometry (Ti DIN cup 40.1 ml) was used. Avocado puree temperature was controlled to $25 \pm 0.1^\circ\text{C}$ by a water bath (ThermoFisher SC 100). To determine mechanical ripeness a penetrometer (Durometer Gy-3 Fruit Scleromete) was used.

2.3. Preparation of avocado puree.

Fresh unripe avocados were washed and peeled by hand. Avocado was sliced and placed in a food processor (Braun, 4162 model, 450 watts) using speed "Hi" to obtain a homogeneous paste or puree, using 5 minutes for non-mature or "hard" fruits, and 3 minutes for ripe fruit. See Figure 1.

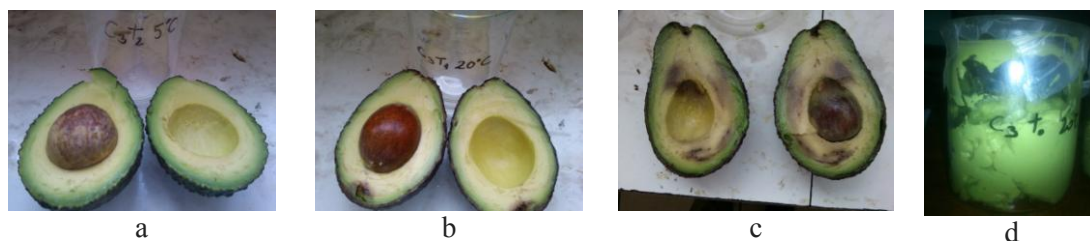


Figure 1. Avocado a.- stored at T0; b.- stored at T1;c.- stored at T2; d.- pulp

2.4. Rheological measurements

2.4.1 Sample preparation.

Pulp was mixed with 1.5% (w/w) sodium chloride and a citric acid: ascorbic acid ratio (3:1) to reduce the initial pH to 4.1. Approximately 150 g of avocado puree were poured into plastic whirl-pack bags, heat sealed and maintained under refrigeration no longer than 3 h until rheological tests were performed.

2.4.2 Rheological tests.

2.4.2.1 Steady tests.

Tests were carried out using a cone and plate geometry. Six intervals spanning from 0.1 to 100/s, increasing and decreasing in a lineal ramp, were performed on each avocado puree sample. Data was plotted and analyzed for different rheological models.

2.4.2.2 Oscillatory tests.

Viscoelastic properties of avocado purees were analyzed using small amplitude oscillatory shear; lineal viscoelastic region was determined at 10 Hz using an amplitude sweep for torque from 1 to 50 mNm. Data was collected with Rheowin 4 Job Manager. Five repetitions were used.

3. Results and Discussion

3.1. Apparent viscosity and flow properties

Figures 2, 3 and 4 show the data obtained for apparent viscosity and flow properties, respectively. Apparent viscosity changes for avocado pulp stored at 0; 20 and 40 days at 5°C and the time for subsequent aging at 20°C (10; 4 and 5 days) are shown in Figure 1. For maturation at 5°C it was observed that the apparent viscosity decreases after 40 days from 6332 to 1146 Pas, according to the advance of maturity, indicating that there was a change in the avocado pulp rheological properties resulting in increased flowability of avocado pulp. For maturation at 20°C, generated by sampling (T0, T1 and T2) of the fruit previously stored at 5°C it was observed that the time to maturity of consumption (given by a texture equivalent to 2 lbf) were 10; 4 and 5 days resulting in a decrease in apparent viscosity in relation to the counterpart at 5°C, which reached similar values which varied between 758 and 988 Pas.

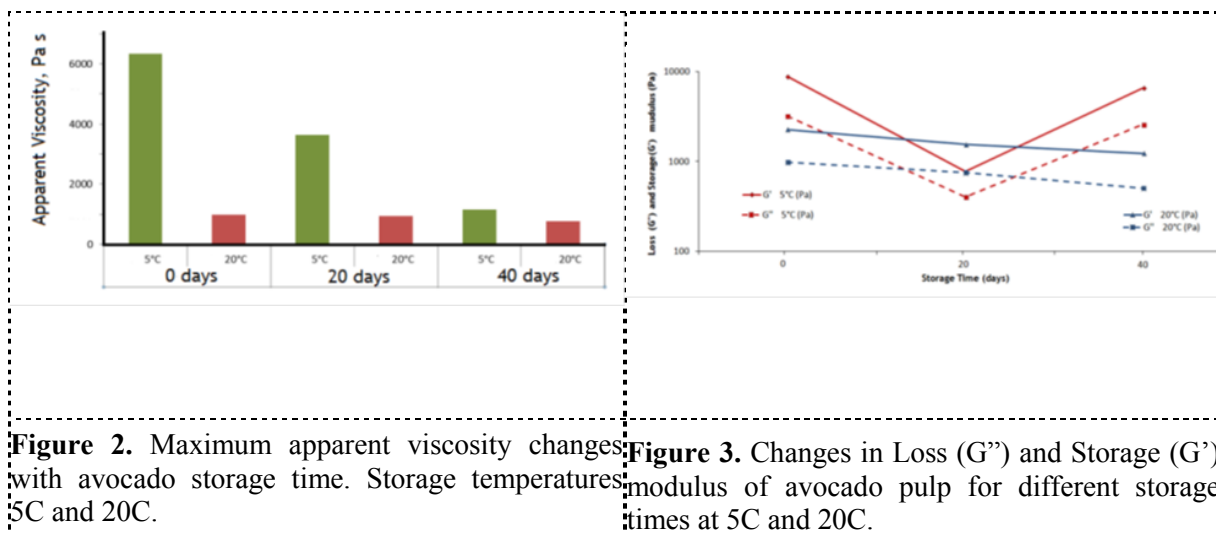


Figure 2. Maximum apparent viscosity changes with avocado storage time. Storage temperatures: 5C and 20C.

Figure 3. Changes in Loss (G'') and Storage (G') modulus of avocado pulp for different storage times at 5C and 20C.

From Figure 3 it appears the behavior of the pulp to be Bingham plastic, the model has only been recognized by the shape of the curves obtained, but it could not be confirmed by the equation because more tests are needed to make a conclusive statement.

Figure 4 shows that in the frequency range studied (between 1 to 10 Hz), that samples behave more solid-like than liquid-like, because the elastic module is above the viscous modulus, behavior that is maintained over the progress of avocado ripening.

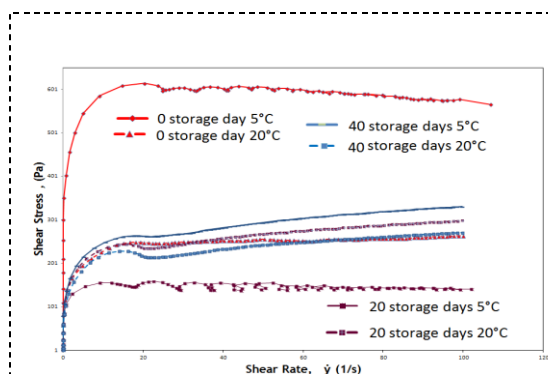


Figure 4. Shear stress versus shear rate for avocado pulp at different storage times at 5°C and 20°C.

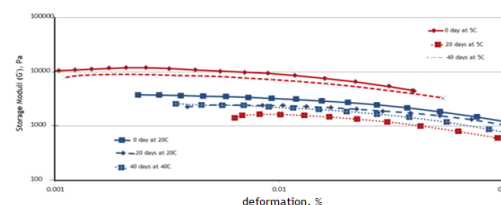


Figure 5. Changes in Storage (G') modulus for different storage times of avocado pulp at 5°C and 20°C at different deformations

4. Conclusion

The changes in the viscoelastic behavior of the samples of avocado pulp is dependent on phenomena related to the damage of the cell structure produced by the maturation on both at cold storage at 5°C and at the consumption temperature at 20°C. During maturation changes would generate due to temperature and time, which modify the internal cellular structure of the fruit and its associated composition to physical changes produced on its components.

Preliminary results of the rheological characteristics of avocado puree show a Bingham plastic behavior.

Acknowledgements

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