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Rheological and heating properties of cassava starch, glycerol and acerola pulp blends

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1 Introduction

Starch has been considered the most promising material for varied application for the future, because relatively low price, abundance and thermoplasticity (Chivrac et al., 2010) and cassava starch has been extensively used to produce biodegradable materials as starch films (Kechichian et al., 2010) and known use in food applications as thickness agent. Usually, the second major component of a starch based film is the plasticizer. Plasticizing agents are commonly used for thermoplastic starch production, which include water and glycerol (Alves et al., 2007) and also other polyols.

The use of glycerol is strategically interesting, as one of the main co-product of biodiesel production (around 30% of the crude oil). By finding new alternatives for using this co-product collaborates to the development of sustainable practices. The hydroxyl groups present in glycerol are responsible for inter and intramolecular interactions in polymeric chains, providing films with a more flexible structure (Souza et al., 2010). In this way, the association of cassava starch with plasticizers as glycerol can promote alterations in the materials, justifying the study of these additives to develop a potential and ecological alternative to the synthetic plastic.

In order to form films, starch needs to be gelatinized in presence of heat and excess of plasticizer. This process known as gelatinization is important to form films. During this process, the addition of other plasticizers such as glycerol and even other components may interfere with film formation and the rheological properties which is the aim of this study. Moreover, the addition of other interesting additives or ingredients such as fruit and vegetable juices has been going particularly as edible films (Farias et al., 2012).

The aim of the study was to investigate the gelatinization of cassava starch in presence of glycerol and acerola pulp using the Rheoscope (Thermo Haake, Kalrshure, Germany).

2 Materials and Methods

2.1 Materials

Cassava starch, also known as polvilho doce (Yoki, Brazil), acerola pulp (Doce fruta, Goiás, Brazil), glicerina P.A. (Vetec, Brazil) were acquired in the local market of Rio de Janeiro.

2.2 Methods

Cassava starch (0,5% w/w, d.b) and glycerol (50%) were suspended in acerola pulp or water and analysed during gelatinization process. The samples were: (T1) cassava starch and water, (T2) cassava starch, acerola pulp and glycerol, (T3) cassava starch and acerola pulp, (T4) acerola pulp, (T5) acerola pulp and glycerol.

The profiles of starch suspensions at concentration of 0.5% and components were measured using Rheoscope (Thermo Haake, Karlsruhe, Germany) fitted with 20x lens attached to MARS Rheometer (Thermo Haake, Karlsruhe, Germany). This system combines a viscometer with an optical microscope and digital video camera. The microscope and the camera are located embedded beneath the glass plate in the bottom of the viscometer.

The Rheoscope was coupled to a DC30 Phoenix water bath (Thermo Haake, Karlsruhe, Germany), allowing for heating and cooling ramp of test fluid during the measurements. A reflective parallel plate geometry of 60 mm in diameter with gap size of 0.2 mm, running at shear rate of 100 s^{-1} was used. The temperature profile followed the methodology described by Tan et al. (2008) with modifications and described as follow: held at $50 \text{ }^\circ\text{C}$ for 2 min, heated up to $90 \text{ }^\circ\text{C}$ over a period of 14 min, held at 90°C for 8 min, cooled back to $73 \text{ }^\circ\text{C}$ for 14 min, giving a total period of 40 min.

The sample viscosity, shear rate, temperature and digital images were recorded and analyzed to determine changes in the starch granules and their interactions at different times.

3. Results e Discussions

The viscosity flow behavior of the samples under varied temperature condition is displayed in Figure 1. In the presence of glycerol (T2 and T5), the viscosity increased over the first 5 min ($55 \text{ }^\circ\text{C}$) and decreased when the temperature increased to $83 \text{ }^\circ\text{C}$, after 30 min reading, showing slight recover as the temperature decreased. This effect probably appeared as a result of an initial organization of polymeric chains under shear.

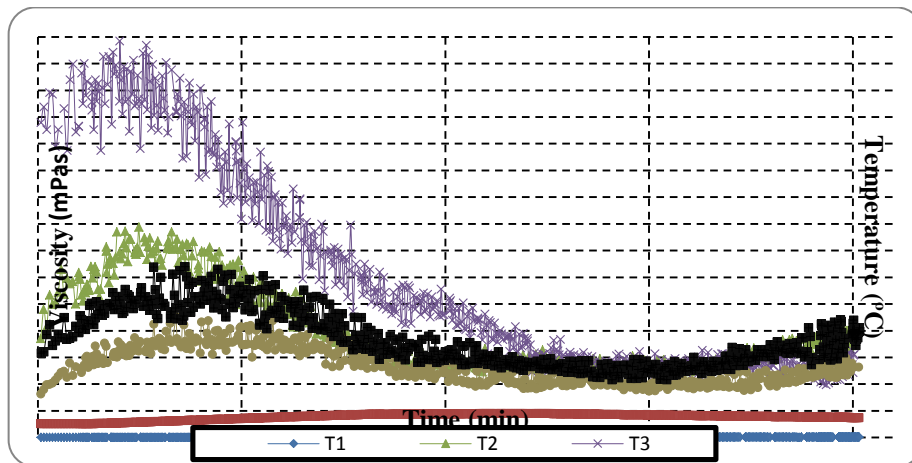


Figure 1: Time *versus* Viscosity curve for cassava starch solutions with acerola pulp and glycerol: (T1) cassava starch and water, (T2) cassava starch, acerola pulp and glycerol, (T3) cassava starch and acerola pulp, (T4) acerola pulp, (T5) acerola pulp and glycerol

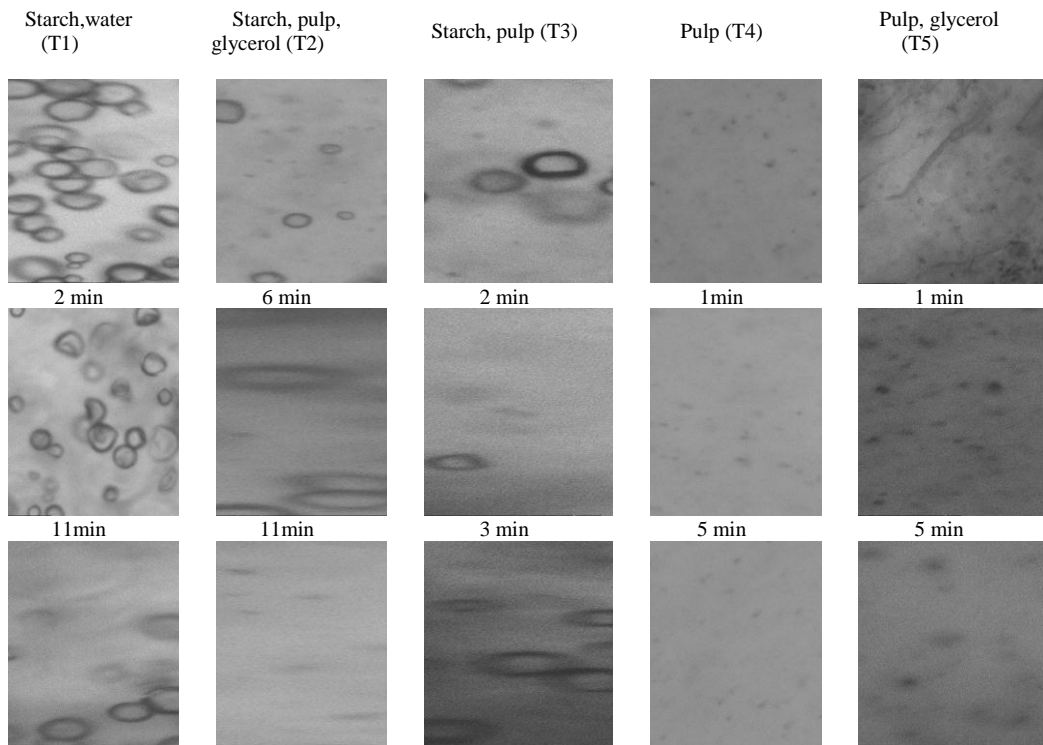
Samples without glycerol (T3 and T4) showed similar behavior, however lower viscosity was observed particularly in the beginning of the analysis. Only sample T1 (cassava starch and water) presented very low viscosity throughout the temperature profile.

It is possible to say that occurred a synergistic effect between starch and glycerol that promoted an increase on apparent viscosity in the beginning of the analysis.

Acerola pulp contain substantial concentration of hemicelluloses (Farias et al., 2012) which has contributed to increase the viscosity at low temperature study. It is known that hemicellulose like pectin is used as thickness agent as its long molecules can entangle at low temperature (BeMiller, 2001). According to Torley and van der Molen (2005) different sugars differ in their effect on starch gelatinization, and their mixtures have an effect that is largely proportional to the concentration of the sugars present. It seems that vitamins and hydrocolloids from acerola pulp may affected the starch gelatinization. This effect was reduced by the presence of glycerol that can form strong bonds with water molecules prevents the solubilization of hydrocolloids.

The images of starch gelatinization of all five samples are presented in Figure 2. Starches were characterized by the presence of round contrasting shapes (granules) in the beginning of the analysis, particularly when processed with water. Probably due to the dilution, starch shapes were scarce when mixed with glycerol and acerola pulp. No clear shapes were observed for pulp and water, whereas when glycerol was added pronounced long and fine structures were seem, probably due to the presence of fibers (hydrocolloids) optically enhanced by glycerol.

By continuous heating and shearing, starches granules swelled until their shape disappeared after 15-20 min, depending on the plasticizer. Similar work was conducted by Tan et al (2008) with cereal starches. They observed that large granules absorb plasticizer prior to smaller granules, but it was clearly observed in this work.



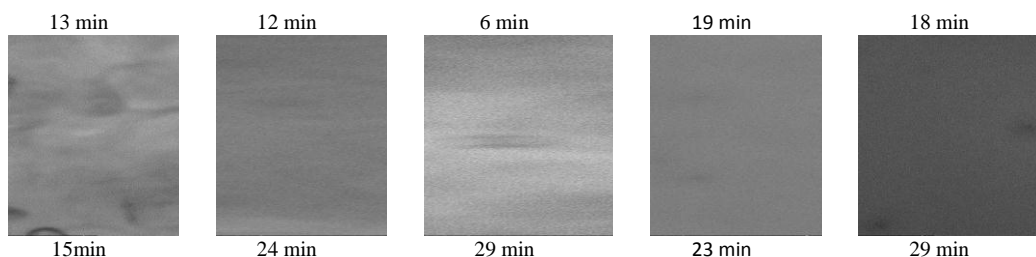


Figure 2: Images of the gelatinization of cassava starch and interactions with acerola pulp and glycerol

5 Acknowledgements

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