Rheology of a Traditional Dairy Beverage from Colombian Caribbean

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Abstract

The aim of this research was to study the rheology of a traditional dairy beverage from the Colombian Caribbean. A completely randomized single-factor design was performed with two percentage levels of cassava starch and a control treatment. The dairy beverage “peto” with the addition of whole corn grains was produced following the traditional methodology for this product. Then, viscoelastic measurements were made to determine the storage module (G‘) and loss module (G¨) and the tangent values of the phase angle (Tan δ), as a function of the deformation frequency. It was observed that the elastic behavior prevailed over the loss modulus in the whole frequency range studied, being the most rigid gel when the highest percentage of cassava starch was used. Knowing the viscoelastic measurements of this study may be promising for industrializing the peto at the industrial level.

Keywords: Rheology; Traditional dairy beverage

1. Introduction

Dairy manufacturers have long used ingredients such as stabilisers to improve the kinetic stability of food emulsions. The selection of a particular type of stabilizer
depends on aspects such as the functional properties, the effect or mode of action of the stabilizer and the function of the stabilizer. One of the most promising stabilizers is cassava starch, which is added as a thickener in dairy beverages to improve texture and is also very inexpensive compared to other hydrocolloids [1]. In recent years, health concerns and changes in consumer preferences towards functional foods have led to extensive research on the development of healthy foods [2].

Among the healthy food category, there has been a greater demand from consumers for functional beverages with high acceptance and functionality, with corn being one of the most widely used raw materials to develop healthy beverages. It contains a vitamin complex B1 (thiamin), B2 (niacin), B3 (riboflavin), B5 (pantothenic acid) and B6, which makes it recommended for hair, skin, digestion, heart and brain. It contains vitamins A and K along with a large amount of β-carotene. It has a higher protein and fat content compared to other cereals. It is a powerful antioxidant that protects the body from damage caused by free radicals responsible for cell damage and/or cancer [3].

On the other hand, nutritionists have recognized the biological importance of milk and its value as an essential nutrient in a balanced diet [4]. Milk and dairy products provide the source of calcium in relation to its cost, providing the highest proportion of protein per calorie, compared to other foods. One of these foods is the peto, a traditional dairy beverage to the Caribbean Region, which is currently handcrafted and sold in the streets of the villages at night. It is important to perform rheological studies because there are no studies on the viscoelastic behavior of this beverage, also presents a rapid growth in consumer demand. Getting peto in a packaged form could be the result of lifestyle changes and produce high expectations in the marketplace.

Knowledge of beverage rheology is a valuable tool in the process of making and quality control of liquid foods [5]. Rheology plays an important role for food scientists in the development of food products, sensory quality, design and evaluation of process equipment [6, 7]. Its importance in product development in the food industry has been widely discussed in the literature [8]. It has been recognized that measurement of rheological parameters is necessary to provide fundamental knowledge of the structural organization of food and plays an important role in fluid flow and heat transfer [1]. The viscosity of food products cannot theoretically be predicted due to the complicated physical and chemical structure. Variations in the viscosity of liquid foods affect the energy use of a processing plant. Viscosity can become an important factor during the concentration of fluid foods such as the dairy corn beverage "peto", especially in the production of high density concentrates, due to the inefficiency of the operation when the product becomes highly viscous viscoso [1].
In addition, the optimum consistency for a good mouthfeel is a desired quality criterion in the "peto". Due to the fact that liquid foods are subject to different temperatures and concentrations during processing, storage, transport, marketing and consumption, rheological behaviour is important for understanding the functional relationship of viscosity to temperature and concentration [9]. Taking into account the above, the objective of this research was to study the rheology of peto as traditional dairy beverage from the Colombian Caribbean.

2. Methodology

2.1 Raw material

Cassava starch (*Manihot esculenta*) from Distribolívar S.A was purchased. The milk, corn and other inputs were obtained in supermarkets in the city of Cartagena de Indias (Colombia).

2.2 Experimental design

A completely randomized unifactorial design with two levels for the percentage of cassava starch (1% and 3%) was performed. Two formulations were made with the addition of cassava starch and a control treatment without the addition of the latter. The analyses were performed in triplicate, expressed with their mean and respective standard deviation. Descriptive statistics were used to determine the mean value and standard deviation for each parameter evaluated.

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Treatments</th>
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<tbody>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>Corn (g)</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Water (L)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Cassava starch (%)</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Milk (L)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cinnamon (mg/kg)</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Sodium chloride (%)</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Sugar (g/L)</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
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</tbody>
</table>

2.4 Elaboración de peto

It was taken 300g of corn, soaked for 12 h in 500mL of water. Then it was washed, and the impurities were removed. The corn was immediately placed in a cooking set for two hours in 3 L of water with cinnamon and sodium chloride at a
temperature of 100 °C. When the corn reached the conditions, sugar and milk were added, lowering the temperature to 70°C for 20 min with constant agitation.

2.5 Viscoelastic characterization

Samples of 10g were taken from each peto treatment. Viscoelastic measurements were made on a TA AR 1500® (TA Instruments Ltda.) rheometer using 40 mm concentric plates. All samples were left at rest for 15 min to allow them to relax prior to testing. The different peto treatments were subjected to deformation sweeping tests in order to choose the deformation value (in the linear viscoelasticity range), at which frequency sweeping was performed in the range from 0.1 to 100 Hz. The temperature of the samples was maintained at 25±0.1°C. The tests were automatically controlled by the TA Universal Analysis Version 5.2® program connected to the rheometer. Rheology data analysis was performed using Rheology Advantage Data Analysis Version 5.7® software. With the oscillatory tests, the storage (G’) and loss (G’’) modulus and the tangent values of the phase angle (tan δ) were determined as a function of the deformation frequency.

3. Results and discussions

Figure 1 shows that the storage modulus (G’) dominated the loss modulus over the entire frequency range studied. The dungarees with the highest percentage of yucca had a higher elastic or stiffness behavior and were also more viscous than the other two treatments. The peto control treatment showed the lowest elastic component, forming weak gels in the structure of the drink. The addition of cassava starch improved the viscosity and rheological properties of the peto, favoring texture and consistency, which was observed at the end of the finished product.

Starch acts as a thickener, forming stronger bonds than the other treatments, presenting greater rigidity of the material. The same results were reported by Lobato-Calleros et al., [10] (2014) in yogurt formulations with added starch. Regardless of the storage time characterized, they observed a slight increase of G’ over G’’ at all frequencies, behavior that is expected of a tangled network-like system, indicative of values that correspond to a weak gel structural network. They also claimed that the control treatment was yogurt that showed less elastic behavior than starch formulations.
Oscillating rheological data from a yogurt beverage revealed that the viscous component predominated over the elastic module, which exhibits the behavior of non-Newtonian elements. On the other hand, dairy beverages that are not exposed to a fermentation process, such as flavoured milks, are beverages that have been corrected in their fat content or in the amount of nutrients and formulated in order to make the intake of milk more attractive and tasty. These dairy beverages are formulated with ingredients such as milk, sucrose, cocoa powder and some hydrocolloids that are added to improve consistency [11].

Aguilar-Raymundo and Vélez-Ruiz [12] reported that the storage modulus was larger than the loss modulus in a milk-based dessert, which is characteristic of viscoelastic materials such as dispersions and gels. The elastic response dominated the viscose, resulting in a gelatinous response. They also stated that the values of Tan δ, which represents the ratio $G''$ and $G'$, were lower in formulations containing raw flour than in samples containing cooked flour.
As expected in Figure 3, it is shown that control treatment was the formulation with the lowest tangent loss reported, which relates the energy dissipated as heat to the energy stored elastically during sinusoidal deformation. Treatment 3, on the other hand, showed a higher Tan δ, indicating that the elastic component in the designed peto was predominant.

Considine et al., [2] reported that the incorporation of starch from different sources induces a large effect on the microstructure of dairy systems. All the yogurts they formulated showed values of Tan δ lower than the unit, confirming that the elastic properties prevailed over the viscous properties. The values of the Tan δ for all yogurt variations remained almost constant at the high frequency values for low-fat yogurts and only slightly increasing for non-starch yogurts. These results indicated that the addition of starches to low-fat yogurts contributes to the formation of more stable dispersed acidification in gelled systems.

![Figure 3. Phase angle tangent values (δ) as a function of frequency](image)

**Conclusion**

The elastic component prevailed over the viscous component throughout the frequency range studied. The peto, which in its formulation had the highest content of cassava starch, obtained the highest storage modulus, with the hydrocolloid acting as a thickener and stabilizer, which favored the consistency of the finished product. Knowing the viscoelastic measurements of this study may be promising for industrializing the petro at the industrial level.
References


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