DEVELOPMENT, RHEOLOGICAL AND SENSORY CHARACTERIZATION OF FERMENTED MILK DRINK ADDED WITH CHIA FLOUR (*SALVIA HISPANICA* L.)

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Abstract: **As a healthy and nutritious option emerges the chia seed, provided with high oil content and natural antioxidants important to the human diet. This work aimed at evaluating the rheological and sensory characteristics of fermented milk drinks incremented with chia flour in three different concentrations. Were developed three treatments: without chia flour; adding of 0.5% of chia flour and with 1.0% of chia flour. Rheological measures were applied after storing the milk drinks under refrigeration through a rotational rheometer of concentric cylinders. The milk drinks were submitted to sensory analysis (appearance, taste, texture, viscosity, global impression), by a team of 65 non-trained tasters. The numbers for rheological analysis highlighted a pseudoplastic non-Newtonian behavior, being that treatment with 0,5% of chia flour had higher shearing tension rates and a slight change in viscosity than treatment with 1,0% of chia flour. The assigned treatment without chia flour stood out in all sensory attributes: appearance, taste, texture, viscosity and global impression. Therefore, the milk drink treatment with 0,5% of chia had the highest values for rheological analysis, while the treatment without chia flour had the best sensory acceptance.**

Keywords: Milk drinks, Chia flour, Physicochemical, Rheology, Sensory.

INTRODUCTION

There is a direct relationship between foods consumed by people and quality of life, that is, balanced eating habits may decrease risks of diseases such as cancer, hypertension, diabetes, arthritis and heart diseases. Thus, the development of products with natural ingredients increases the amount of health-related products.

The chia (*Salvia hispanica* L.) is an oilseed plant native to Mexico which is widely cultivated and commercialized because of their benefits to human health. They are provided with high oil content (32%), being that 60% consist of alpha-Linolenic acid, a fatty acid designed as Omega 3 associated with several benefits to the consumers' health [1]. The seed is also plentiful in antioxidants, fibers and other nutrients [1,2,3].

The concept of rheology in foods is defined as the understanding of food structure as a response to force or deformation [4]. According to [5], rheological studies on milk drinks are available in literature, though the effect of chia flour, regarding rheological parameters, has not been studied yet.

According to [6], sensory analyses are used to measure, analyze, and interpret the reactions to the characteristic of products, the way they are perceived by sight, smell, taste, touch and hearing. It is a science that aims, primarily, at studying the consumer's perceptions, sensations and reactions to the product's characteristics, including their acceptance and rejection.

This work aimed at evaluating, rheological and sensory characteristics of fermented milk drinks added with chia flour in three different concentrations.

MATERIAL AND METHODS

The manufacture of fermented milk drinks were made in the dairy pilot plant. Rheological and sensory analyses were evaluated in the Laboratory of Food Refrigeration, both located in the Department of Food Science, at Federal University of Lavras, Minas Gerais state.

Raw material

Among the raw materials used for formulating the milk drinks, were used pasteurized milk, whey, granulated sugar, chia flour, carrageenan (thickening agent), lactic culture containing *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus*, strawberry pulp and cochineal carmine (artificial colorant).

Treatments

In order to elaborate the milk drinks, were used three formulations with different concentrations of chia flour. These dinks were assigned the following names: T1 - Treatment without chia flour; T2 - Treatment with 0.5% (m/v)

of chia flour and T3 - Treatment with 1.0% (m/v) of chia flour, as it is shown in Table 1. Nevertheless, for definition of these three milk drink formulations were made a pre-test in the dairy pilot plant, evaluating rheological and sensory characteristics.

TABLE 1. Formulation of milk drinks

Ingredients (10^3 kg/m³)	Formulation T1	Formulation T2	Formulation T3
Whey	49	49	49
Pasteurized milk	51	51	51
Chia flour	0	0.5	1
Carrageenan (thickening)	0.005	0.005	0.005
Modified starch	0.005	0.005	0.005
Sugar	9	9	9
Strawberry pulp	10	10	10

Rheological analysis

The treatments were submitted to rheological measures after storing the milk drinks under refrigeration. To calculate their shear rate and apparent viscosity were used a rotational rheometer with concentric cylinders (Brookfield DVIII Ultra®), an adapter for small samples 13R/RP (19.05 mm of diameter and 64.77 mm of depth) and a sensor for coaxial shearing SC4-31 (11.76 mm of diameter and 25.15 mm of length). An ultra-thermostat bath was connected to the rheometer in order to control the sample's temperature (24 ± 2 ºC).

The samples were described and adjusted by Herchel-Bulkley model (equation 1), using software Reocalc (version V.3.1, Brookfield Engineering Laboratories Stoughton, USA®) to capture data.

$$\tau = \tau_o + k\gamma^n \qquad (1)$$

Where:
τ = shearing tension (Pa),
τ_o = initial shearing tension (Pa),
k = consistency index (Pa.s),
γ = deformation rate (s-1),
n = flow index.

Sensory analysis

The milk drinks were submitted to sensory analysis by a team of 65 non-trained tasters, which were recruited among visitors, students and employees from the Department of Food Science at Federal University of Lavras - UFLA. Were evaluated the acceptance of appearance, taste, texture, viscosity, global impression, using a 9-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much; 1 = dislike extremely). The samples were served refrigerated (8 to 12ºC) in 50 mL white pots coded with random numbers, in individual booths, in the Sensory Analysis Laboratory.

Statistical Analysis

The results of the sensory measures were submitted to analysis of variance (ANOVA) and the differences in average were compared by Tukey test at the level of 5% of significance, by means of software SISVAR 5.0 [7].

RESULTS AND DISCUSSION

Rheological analysis

The results for rheological parameters were adjusted by Herschel-Bulkley model, pointing out that all treatments tested had a pseudoplastic behavior (n<1), characterizing behavior non-Newtonian (Table 3). The rheological charts that relate Shear rate *vs.* Deformation rate and Apparent viscosity *vs.* Deformation rate of the treatments elaborated are represented by Figures 2 and 3, respectively.

TABLE 3. Rheological parameters of milk drinks, as obtained by Herschel-Bulkley model ($\tau = \tau_o + k\gamma^n$)

Tratamento	Farinha de chia (%)	n¹*	K²** (Pa.s)	R² ³***
T1	0	0,41	0,266	99,97
T2	0,5	0,36	0,448	99,77
T3	1	0,43	0,307	99,57

¹*n – Flow index; ² **k – consistency index; ³ ***R²- Coefficient of determination.

In Fig. 2 is presented the rheological chart that relates Shear rate (mPa) and Deformation rate (1/s) of the milk drinks. The Treatment T1 had the lowest shear rate (maximum of 3.19 mPa), followed by treatment T3 (maximum of 3.95 mPa) and T2 (maximum of 4.22 mPa), i.e., the increase in soluble solids in the milk drink did not provide a harmonic increment to shear rate. According to [8], certain products, when submitted to deformation, show residual tension and mollification, apparently due to structure breaking.

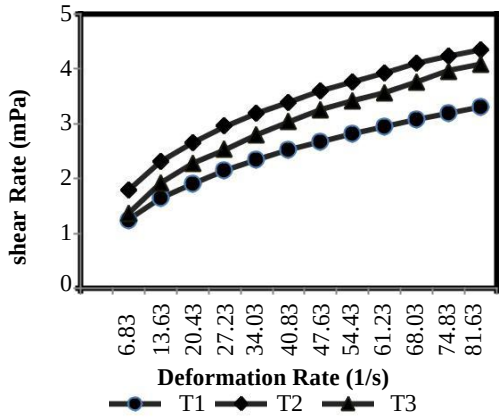

Fig. 2. Relation between Shear rate and Deformation rate of milk drinks incremented with different concentrations of chia flour.

In Fig. 3 is displayed the rheological chart that relates Apparent viscosity (mPa.s) and Deformation rate (1/s) of the manufactured milk drinks. For this analysis, were not considered the first result obtained to get the model adjustment, because with numbers close to zero, no model could adapt within acceptable parameters.

There was no great difference among the curves for apparent viscosity of treatments T3 and T2, though the latter had initial viscosity slightly superior to T3 (with 1.0% of chia flour).

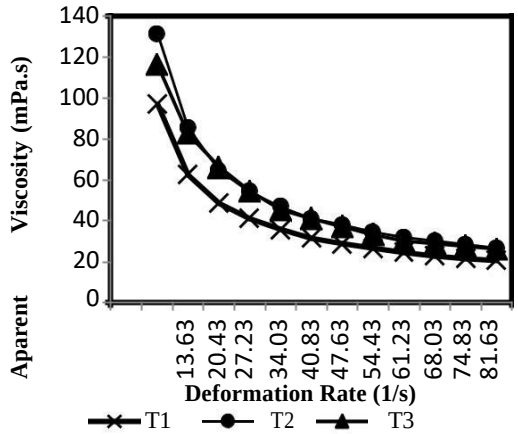

Fig.3. Relation between Apparent viscosity and Deformation rate of milk drinks incremented with different concentrations of chia flour

Sensory analysis

Among the manufactured milk drinks, treatment T1 had a better sensory acceptance as for all evaluated attributed, followed by treatments T2 and T3, which showed no significant differences, according to Table 4.

TABLE 4. Average values for appearance, taste, texture, viscosity and overall impression of manufactured milk drinks obtained by test of acceptance with 9-point hedonic scale

Features	Treatments		
	T1	T2	T3
Appearance	7.0[a]	5.12[b]	4.98[b]
Taste	6.06[a]	4.92[b]	5.05[ab]
Texture	6.35[a]	5.03[b]	4.78[b]
Viscosity	6.25[a]	5.01[b]	4.94[b]
Overall impression	6.37[a]	5.14[b]	5.09[b]

[ab] Averages in the same lime and with the same letters did not differ significantly by Tukey test ($p<0.05$), n = 65 on-trained tasters.

The development of a new product, evaluating consumers' acceptability is something fundamental to predict its behavior in market [9]. Generally, the average values for the features analyzed varied from 4.78 to 6.37 points.

The results obtained in the evaluation for taste varied from 4.92 to 6.06 points, being that treatment T1 had the highest acceptance. The Treatments T2 and T3 did not differ statistically and had the lowest score for taste, most likely due to the low homogenization between chia flour and milk drinks and a possible residual taste in treatment T3.

Grades for texture ranged between 5.03 and 6.35 points, being that T1 had the highest score. The milk drink without chia flour stood out from the others treatments due to the best creamy and thick aspects. When evaluating texture, should be considered the product's body; but clot with lumps

and weak body are problems that may cause consumers' rejection [10].

As for viscosity, the grades varied from 4.94 and 6.25, the treatment T1 had the highest score, while T2 and T3 had no significant differences. According to [10], low viscosity may be caused by low concentrations of total solids, thermal treatment and insufficient homogenization, improper handling and low incubation temperature. During rheological analysis, the drinks were measured at a different temperature from the sensory analysis and also had problems in homogenization process of lumps of chia flour for data capture by the rheometer. It can explain the fact that treatments T2 and T3 had higher viscosities.

The values obtained for overall impression varied between 5.09 and 6.37 points, with a significant difference among the treatments. The Treatment T1 had the highest score (6.37 points) points) followed by treatments T2 and T3, which did not differ statistically.

CONCLUSION

The Addition of chia flour to fermented milk drinks did not cause statistic differences ($p<0.05$) among the treatments, regarding physicochemical parameters. The rheological analysis had a pseudoplastic non-Newtonian behavior, being that treatment T2 had the highest shear rate and a slight increase in viscosity, when compared to treatment T3. However, as for sensory features, the treatment T1 had the best acceptance, differing significantly from the other treatments. Nevertheless the addition of chia flour in dairy products can be an alternative to increase the milk drink nutrition values and further studies will be necessary.

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