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Evaluation of Chocolate Milk Beverage Formulated with Modified Chitosan

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ABSTRACT

Chitosan is a polysaccharide derived from chitin by N-deacetilation, which has the property of gel formation. The objective was to develop a chocolate milk beverage using modified (hydrogel) chitosan as a thickening agent, and to make a sensory and rheological evaluation of this beverage. In the sensory evaluation an acceptability and comparative test with 50 local consumers was carried out, with the developed beverage and samples from the Brazilian market, with the attributes overall acceptability and viscosity. The hybrid hedonic scale was used. The rheological evaluation was carried out with a rotational rheometer (Rheotest) with the H1 probe. A controlled rate test – ramp (0- 500, and 500-0 L s^{-1}, 120 seconds, up and down), at 25ºC was used. There was no difference (P> 0.05) among the beverages in the overall acceptability. In spite of that, the developed beverage had a better score (7.12) in comparison with a market beverage (6.4). The beverages differed in viscosity (*P*< 0.05); the score of the developed beverage was 7.06 and the score of the market beverage was 5.87. The market beverage fitted to the Ostwald-de-Waele, Bingham, and Casson models, and the developed beverage fitted better to the Ostwald-de-Waele model. The consistence index (K) of the market beverage was 0.150 Pa s^n, while that of the developed beverage was 1.590 Pa s^n, showing a high difference in the consistence characteristic of the samples. The flow index (n) of the market beverage was 0.625 and that of the developed beverage was 0.435. All market beverages showed thixotropic behavior. The hydrogel chitosan was effective as a thickening agent and furnished a good acceptability of the beverage.

Keywords: Chitosan, Chocolate products, Food development, Food structure, Hydrocolloid.

INTRODUCTION

Many polysaccharides have the ability of gel formation (Yamaguchi *et al.*, 1981). Chitosan, which is derived from chitin by N-deacetylation and is present in some crustaceans, mollusks and fungi, has received attention because of its extraordinary properties (biocompatibility, solubility in various media, solution, viscosity, ability to form film, fungistatic) and because of its abundant sources and low cost (Prashanth *et al.*, 2001; Dutta *et al.*, 2004). Chemical modification is one of the methods proposed to improve functional properties of proteins and other substances in the food industry (El-Adawy, 2000). Researchers have been studying a manner of making chitosan soluble in neutral and alkaline pH (it is soluble in acid pH only). Chemical treatment of chitosan with succinic anhydride increases its solubility in neutral and alkaline media. Therefore, it is possible to use chitosan as a thickening agent. Shrimp-derived chitosan is a substance Generally Recognized as Safe (GRAS), as well the succinic anhydride is listed as an Indirect Additives Used in Food Contact Substances (Food and Drug Administration, 2013). The choice of stabilizer depends upon the type of heat treatment used. For

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pasteurized products starch, gelatin and alginates are used;

for UHT-products, mainly carrageenan are used; and sterilized product can use cellulose derivatives such as carboxymethylcellulose. Many polysaccharides have the ability to form gel, which indirectly reflects its function in natural systems, as N-succinyl chitosan (Eduardo, 2006; Damin *et al.*, 2009).

Chocolate beverage can also be classified as a dairy beverage. According to Brazilian legislation, dairy beverage is a dairy product resulting from the mixture of milk (*in natura*, pasteurized, sterilized, UHT, reconstituted, concentrated, powder, whole, defatted or partially defatted) and whey (liquid, concentrated, powder), with or without added products (vegetable fat, fermented milk, yeast). The dairy basis may represent less than 51% (w/w) of the total product ingredients (Damin *et al.*, 2009). Chocolate dairy beverages are basically formulated with milk, sugar, cocoa powder, and some types of hydrocolloids, which are added to improve the consistency and to avoid the settling of cocoa particles. Milk solids can also be included. The characteristics of these ingredients (fat content, alkalinity and color of cocoa powder, hydrocolloid type) should produce differences in the final composition and in physical and sensorial properties of formulated products. The liquid state of this chocolate dairy beverage brings out almost instantaneously the compounds with pure cocoa flavor, contributing to the big popularity of this product around the world. Saunders (2011) suggested evidence that CHO+Pro (carbohydrate and protein coingestion) beverages may positively influence recovery under some exercise conditions, and chocolate milk is likely a good recovery beverage for lactose-tolerant endurance athletes.

The aims of this work were to develop a chocolate milk beverage using modified chitosan, as a thickening and functional agent, in order to introduce a new option of product to the food industry; to realize rheological and sensory evaluation, comparing the developed beverage with a similar one from the market; and to evaluate some Brazilian market chocolate beverages with respect to rheological characteristics.

MATERIALS AND METHODS

Samples

Chocolate Dairy Beverage Formulation

Chocolate dairy beverage (chocolate beverage with modified chitosan) was prepared using N-Succinil Chitosan hydrogel produced in Chemical-Pharmaceutical Technology Laboratory (Pharmaceutical Sciences School, University of Sao Paulo).

The beverage was prepared with 1.5% cocoa powder (Garoto-Brazil), 8.72% whole milk powder (Nestlé-Brazil), 7% refined sugar (União-Brazil), 0.25% chocolate powder flavor (Duas Rodas-Brazil), 0.03% chocolate and vanilla powder flavor (Duas Rodas-Brazil), 82% distilled water, and 0.5% N-Succinil Chitosan hydrogel (2% solution). The beverage was prepared as the following:

-Milk power reconstitution in water (50°C) → Addition of cocoa powder, sugar, and flavors (mixing) → Addition of chitosan hydrogel until concentration of 0.5 % and homogenized → Filling glass bottles → Pasteurization (sample at 65°C for 30 minutes), the batch method used a vessel pasteurizer, which consisted of a vessel surrounded by circulating water (lab scale) → Shutting and cooling.

Market Samples

Nine commercial samples (Eight chocolate beverages in UHT package: Samples B to I, and One in glass bottle package: Sample A) were obtained from Brazilian market.

Sensory Evaluation

Sensory evaluations, overall acceptability and comparative test (in respect to viscosity attribute), with 50 local consumers (students, professors, and employees of the São Paulo University), at 10°C, were carried out with the developed beverage, 35 mL in a plastic cup, and sample A from the Brazilian market. The hybrid hedonic scale, based on equal interval which is important in the assignment of numerical values to the response choices (From 1= "Dislike extremely" to 10= "Like extremely") was used (Villanueva *et al.*, 2005). Tests were performed in Sensory Laboratory of Pharmaceutical School/University of Sao Paulo, and approved by Research Ethics Committee of the Institution.

Rheological Evaluation

The rheological evaluation was carried out with a rotational rheometer Rheotest RN 3.1 (Rheotest, Germany), with the H1 probe (Concentric cylinder-R $_{(radius)}$= 36 mm and Height= 70 mm) plus a cup (R $_{(radius)}$= 38 mm), with 35 mL sample. A controlled rate test (ramp) -up and down (0-500, and 500-0 L s^{-1}, 120 seconds), at 25ºC, was used. The data were captured by the program "Rheotest", and the values obtained were evaluated by Ostwald-de-Waele, Bingham and Casson rheological models, in order to verify which ones best fit to the product.

Solid Soluble Content

Measurements of total soluble solids were obtained in Shibuya refractometer (Japan) through the refractive index, and the results were expressed in Brix degrees, at 25°C.

Statistical Analysis

All analyses were carried out in triplicate and results were expressed as mean±standard deviation (SD). Statistical analysis was done by using the Statistic software package version 5.0 (StatSoft. Inc. Tulsa, UK). Differences between means were first analyzed by ANOVA test and then Least Significant Difference (LSD) test ($P< 0.05$). Data were subjected to Pearson correlations.

RESULTS AND DISCUSSION

Rheology

Elastic behavior of many fluid food is small or can be neglected, leaving the viscosity function as the main area of interest which involves shear stress and shear rate, with the relationship between them established based on experimental data. Behavior of the materials is visualized as a plot of shear stress versus shear rate, and the resulting curve is mathematically modeled using various functional relationships (Steffe, 1996). Table 1 presents the results of the rheological evaluation using Ostwald-de-Waele, Bingham and Casson models. Pseudoplasticity of some samples could be due to some aggregates of carrageen, casein, that rise the viscosity of the product (Yanes *et al.,* 2002a). All analyzed samples presented pseudoplasticity ($n< 1$) (Table 1). The thinning behavior is characterized by decreasing the strength of the material to flow with increasing speed of deformation. At rest, these materials exhibit a reticular structure, which may consist clusters of molecules that attract or network of entangled polymer chains. The "structure" is destroyed by the action of a force, resulting in pseudoplastic behavior. Yanes *et al.* (2002b) observed the flow behavior of carrageen solutions and alginate in water and milk, verifying that they adapted to Ostwald-de-Waele model. The aqueous solutions showed thinning behavior with values between 0.71 and 0.98. When the carrageen concentration was lower, the milk solutions showed values next to the aqueous ones, and when it was higher, the samples showed values of flow index varying from 0.56 to 0.68. Chocolate beverage prepared at the laboratory using 0.5% chitosan hydrogel had higher value of consistency index (K), from Power Law equation, compared to the

Table 1. Rheologycal parameters of *Ostwald-de-Waele*, Bingham, and Casson models of market chocolate drinks, chocolate drink with modified chitosan, hydrated milk powder, and hydrogel chitosan.

	Ostwald-de-Waele			Bingham			Casson		
Samples	K (Pa s^n) [a]	N [b]	R^2 [c]	τ_0 (Pa) [d]	η (Pa s) [e]	R^2	τ_0 (Pa)	η (Pa s)	R^2
Market beverages									
A	0.150	0.625	0.964	1.117	0.013	0.979	0.369	0.009	0.978
B	0.791	0.432	0.955	2.813	0.026	0.828	1.223	0.015	0.884
C	0.789	0.421	0.974	2.553	0.025	0.915	1.203	0.014	0.952
D	0.701	0.430	0.956	2.057	0.026	0.972	0.974	0.015	0.988
E	0.763	0.385	0.943	2.120	0.020	0.994	1.200	0.009	0.990
F	0.565	0.402	0.893	1.267	0.020	0.996	0.623	0.011	0.990
G	0.867	0.419	0.976	2.933	0.026	0.892	1.410	0.014	0.934
H	0.710	0.459	0.956	2.670	0.028	0.880	1.197	0.016	0.935
I	0.329	0.538	0.901	2.557	0.014	0.761	1.087	0.009	0.868
CBMC [f]	1.590	0.435	0.902	5.120	0.064	0.740	2.680	0.032	0.754
MCS [g] 0.5% w/v	0.587	0.547	0.973	1.600	0.063	0.979	0.660	0.039	0.985
HMP [h] 13% w/v	0.773	0.277	0.851	1.630	0.009	0.981	1.16	0.003	0.944

[a] Consistency index (Pa s^n); [b] Flow behavior index (dimensionless); [c] Coefficient of determination; [d] Yield value (Pa); [e] Apparent viscosity (Pa s); [f] Chocolate Beverage with Modified Chitosan; [g] Modified Chitosan Solution, [h] Hydrated Milk Powder.

market beverages. The pseudoplasticity also had occurred due to the chitosan hydrogel that showed the values of consistency index (K) of 0.587 Pa s^n and flow index (n) 0.547 (Table 1). Beyond pseudoplasticity, the hydrogel chitosan 5% showed to be adapted to Bingham and Casson models, with yield stress of 1.600 and 0.660 Pa, respectively. It presented also thixotropic behavior (Figure 1).

Hydrogel chitosan is a polymer that can be in the form of an entangled polymer network, whose structure suffers a breakdown with the shear, resulting in a pseudoplastic behavior (Figure 2) (Chaplin, 2012). During the flow, the pseudoplastic materials may exhibit three distinct regions: a lower Newtonian region, where the apparent viscosity, called the limiting viscosity at zero shear rate, is constant with changing shear rates; a middle region, where the apparent viscosity is changing (decreasing for shear-thinning fluids) with shear rate and the power law equation is a suitable model for the phenomenon; and an upper Newtonian region, where the slope of the curve, called the limiting viscosity at infinite shear rate, is constant with changing shear rates. The middle region is most often examined when considering the performance of food processing equipment. The lower Newtonian region may be relevant in problems involving low shear rates, such as those related to the sedimentation of fine particles in fluids (Steffe, 1996). Pseudoplastic fluids lower the viscosity, or resistance to flow, with the increase of the velocity gradient. This shows a structural change that occurs with the application of force (Rao, 1977; Steffe, 1996). The progressive increase of shear rate destroys the arrangement of long-chain molecules, thereby helping to overcome the resistance to intermolecular flow (Holdsworth, 1993). These materials instantly decrease viscosity with increasing shear rate and are therefore easier to be pumped and mixed. The thinning allows for easy pumping of the final product and also the thick products

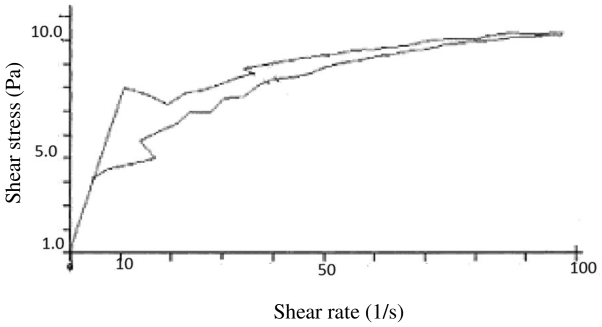

Figure 1. Thixogram of the chocolate beverage with hydrogel chitosan 0.5% at 25°C.

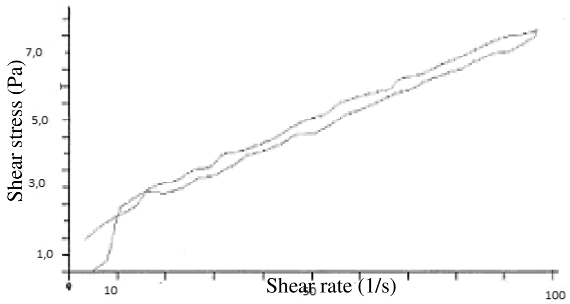

Figure 2. Thixogram of the hydrogel chitosan 0.5% at 25°C.

which are easily applied by spray (Singh and Heldman, 1993; Chaplin, 2004).

Samples A, C, D, and E were fitted to three models: Ostwald-de-Waele, Bingham, and Casson, with R^2> 0.915. Sample F was fitted preferable to Bingham and Casson models. The Casson fluid characteristics can be explained by presence of disperse particles, as this model is used to classify food dispersions. The yield stress of sample F was 1.267 Pa. Samples G and H were fitted to all models, except to the Bingham model, presenting pseudoplasticity (n < 1) and characteristics of the Casson fluid with yield stress 1.41 and 1.197 Pa, respectively. When a preparation displays flow from a minimum stress, it presents plastic behavior. At rest, these materials behave as solids due to particle-particle association. The external force must overcome the forces and destroy the internal structure of the material. The critical shear stress required to produce the flow is called yield stress (yield value). Above this value, the material begins to show liquid behavior. This feature is very important in the design process and quality assurance of some products such as butter, yogurt, and soft cheeses (Steffe, 1996; Rao, 1999).

Yanes *et al.* (2002a) realized rheological analysis of chocolate beverages from Spanish market and the samples fitted Newton, Ostwald-de-Waele, and Bingham models, the flow behavior being qualitatively similar to the milk. Although the milk is classified many times as a Newtonian fluid, its behavior is complex and strongly dependent on the temperature, shear rate, concentration, and physical state of the disperse phase, which is due to the hydrodynamic volume of the casein micelles and of the fat content (Van Vliet and Walstra, 1980). Depending on the conditions of the experiment (shear rate and temperature) and the type of the viscometer used (capillary, rotational, or controlled stress), the flow of the milk has been characterized as Newtonian, pseudoplastic, or Bingham plastic (Kristensen *et al.*, 1997; Phillips, *et al.*, 1995; Wayne and Shoemaker, 1988). Whole milk has adapted better to the Bingham and Casson models, with yield stress 1.630 and 1.160 Pa, respectively (Table 1). The milk flow curve is presented in Figure 3. Therefore, thinning of the chocolate beverage with hydrogel chitosan was not due to milk, but due to the presence of the thickener. Quantitative differences of the rheological parameters between the milk and the chocolate beverages were due to the addition of sugar, cocoa powder, and hydrocolloids. The milk type (defatted or

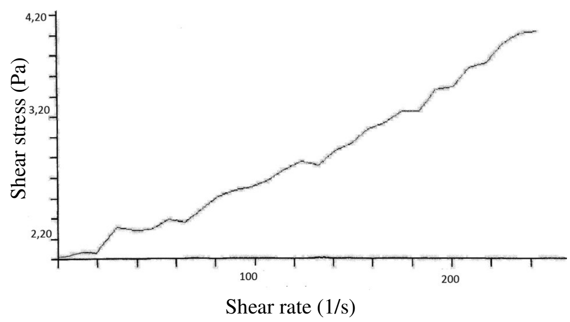

Figure 3. Rheogram of the reconstituted powder milk at 25°C.

whole), the hydrocolloid type and its concentration, and the possible reaction between the hydrocolloid and the casein micelles also can lead to the differences in flow behavior of these products. Dogan *et al.* (2013) studied the use of some gums in prebiotic chocolate beverage and found a good combination of 59% xanthan gum with 41% locust bean gum, and Ostwal-de-Waele model best fitted to the flow behavior of the samples.

All samples of chocolate beverages presented thixotropy, i.e. it was observed that the values of the readings for the ascending and descending curves were not identical. The thixograms of the chocolate beverages and hydrogel chitosan are presented in Figures 1-2 and Figures 4-12. In thixotropic materials, the apparent viscosity varies with the shear stress and with the applied time (Lewis, 1993). The time dependency is related to the structural changes caused by deformation in the material. If the shear rate is interrupted, the

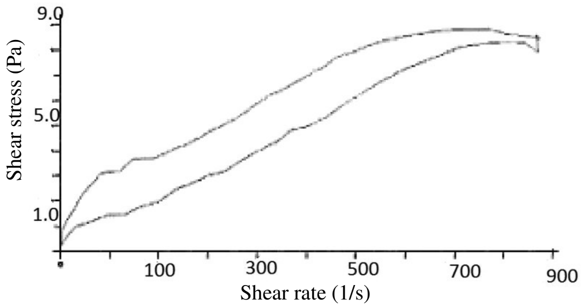

Figure 4. Thixogram of the chocolate beverage of Brazilian market (sample A) at 25°C.

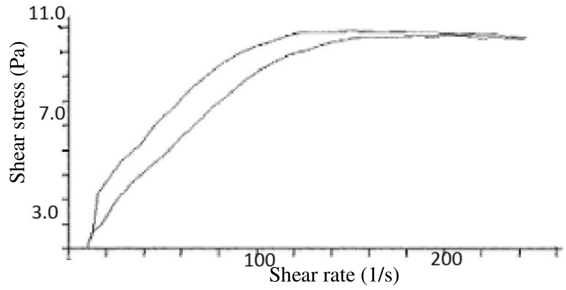

Figure 5. Thixogram of the chocolate beverage of Brazilian market (sample B) at 25°C.

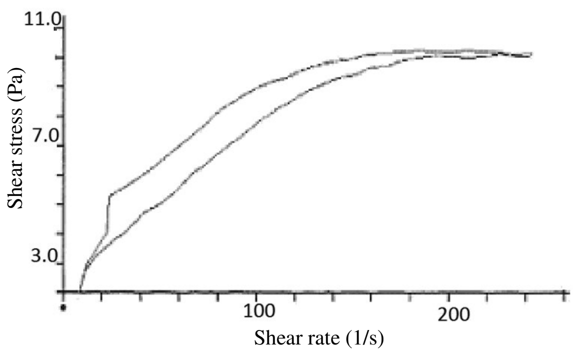

Figure 6. Thixogram of the chocolate beverage of Brazilian market (sample C) at 25°C.

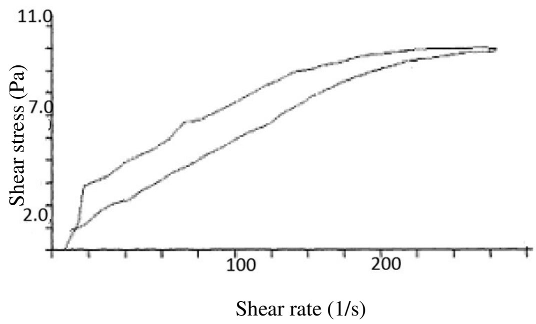

Figure 7. Thixogram of the chocolate beverage of Brazilian market (sample D) at 25°C.

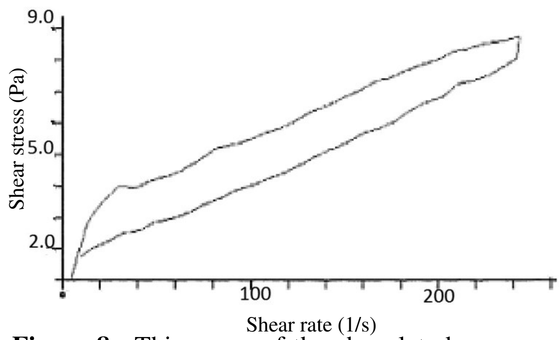

Figure 8. Thixogram of the chocolate beverage of Brazilian market (sample E) at 25°C.

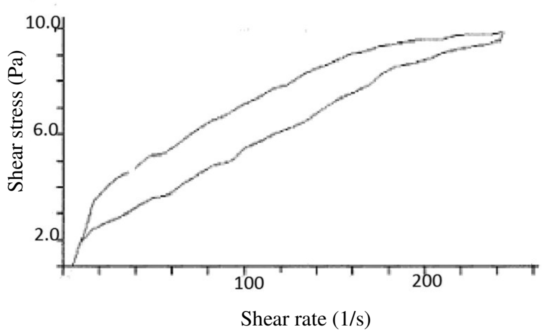

Figure 9. Thixogram of the chocolate beverage of Brazilian market (sample F) at 25°C.

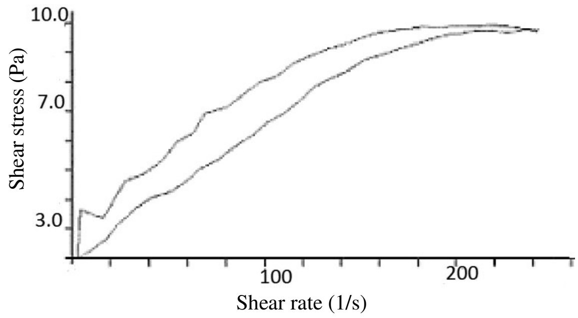

Figure 10. Thixogram of the chocolate beverage of Brazilian market (sample G) at 25°C.

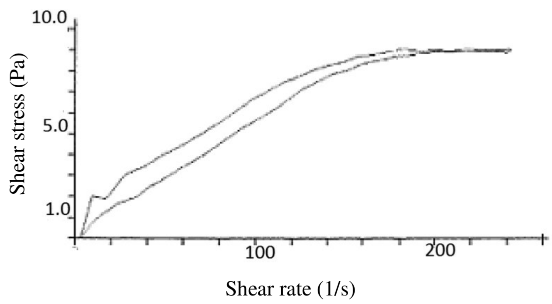

Figure 11. Thixogram of the chocolate beverage of Brazilian market (Sample H) at 25°C.

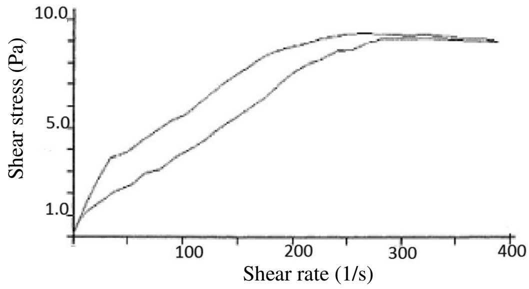

Figure 12. Thixogram of the chocolate beverage of Brazilian market (sample I) at 25°C.

viscosity can reach again the initial value due to the recovery of the structure; and this process is reversible (Ramos and Ibarz 1998; Miquelim and Lannes, 2009). However, in some products, the structure is irreversibly broken (Holdsworth, 1993). The defined area between the ascendant and descendant curves of the thixograms of a time dependent fluid represents the quantity of the required energy to eliminate the time influence; also, it characterizes the broken grade of the internal structure that occurred in the product, that is, when the structural breakdown occurred, the curves were not coincident, creating the hysteresis cycle (Halmos and Tiu, 1981). Thixotropy in many food fluids can be described in terms of the phenomenon of sol-gel transition. This terminology can be applied to baby foods containing starch or yogurts. After production and keeping in container, these foods slowly develop a tridimensional structure and can be described like gel. When submitted to the shear (in pipes and rheological tests), the structure is broken and the material reaches the minimal thickness, which could be described as a sol state. In foods that show reversibility, the structure is rebuilt and the gel state is obtained again. If the phenomenon is irreversible, the material remains in a state of sol (Steffe, 1996). The occurrence of thixotropy implies that the history of material flow should be taken into account when predicting flow behavior. For example, the flow of a thixotropic material for a long pipe is complicated by the fact that the viscosity changes along the pipe (Barnes *et al.* 1989).

Classifying fluids is an affordable way to conceptualize their behavior, however, it does not mean that the existing types of behaviors are unique. A material showing an elastic behavior, for example, can be simultaneously pseudoplastic and time-dependent. Other factors such as aging may also influence the rheological behavior. Ketchup, for example, can be described as time-independent, pseudoplastic, but aging the material generally provides a weak gel structure, leading to the product showing thixotropic behavior when used by the consumer. This explains why the stirring ketchup tube makes the product more fluid (Steffe, 1996).

Toker, *et al.* (2012) investigated the fuzzy modelling of the effect of the swelling power (SP) of starch and water absorption capacity (WAG) of gum on rheological behavior of the model. Six different starches and six different gums having different SP and WAG were used in the instant hot chocolate formulation model for this aim. All of the samples were fitted to Herschel Bulkley model within the R^2 values that ranged between 0.996 and 0.999. The consistency index (K), flow behavior index (n), and yield stress values (sigma (0)) of the samples varied between 2.30 and118.20 mPa s^n, 0.587-1.095 and 33-186.8 mPa, respectively. In addition, an adaptive neuro-fuzzy interference system was used to model and identify the sigma (0), *K*, and *n* based on SP of starch and WAG of gum. Fuzzy modeling technique yielded a very satisfactory prediction accuracy of 99% for each parameter.

Solid Soluble Content

Soluble solids of a beverage consist mainly of sugars dissolved in the system, which could be sucrose added or sugar found in milk, and also from cocoa solids. It can be noticed that the chocolate beverages from market and with hydrogel chitosan showed no difference related to the soluble solids, showing some standardization in the content of some ingredients such as sugar, milk, and cocoa powder (Table 2). Yanes *et al.* (2002a) analyzed the content of soluble solids of nine chocolate drinks of the Spanish market and found that it varied from 16.3 to 18.4 ºBrix, showing values close to those found in this work. Yanes *et al.* (2002b) found that the soluble solid solutions of alginate and carrageenan in skim milk, without sugar, were 10 to 10.5 ºBrix. Therefore, about 6-8 °Brix of sucrose were added to the resulting chocolate beverage.

Table 2. Soluble solid content of chocolate beverages.

Samples	Soluble Solid Content (ºBrix)±SD[a]
A	17.6 ± 0.01
B	20.8 ± 0.02
C	18.8 ± 0.02
D	19.6 ± 0.03
E	19.4 ± 0.01
F	20.0 ± 0.02
G	18.0 ± 0.02
H	20.0 ± 0.01
I	17.8 ± 0.01
CBMC[b]	18.6 ± 0.03

[a] Standard Deviation, n= 3, [b] Chocolate Beverage with Modified Chitosan.

Sensory Evaluation

Chocolate beverage A was chosen for comparative purposes, because it was similar to the chocolate beverage developed in despite of the appearance and package (glass bottle).

Overall Acceptability

According to statistical analysis (t-test) there was no significant difference (P> 0.05) between the mean overall acceptability of the sample A and the sample with hydrogel chitosan, as the $t_{calculated}$ (1.802) was lower than $t_{critical}$ (2.009). In spite of that, the developed beverage had a better score (7.12) in comparison with the market beverage (6.4). Figure 13 shows the frequency distribution of the scores obtained in the overall acceptability of the samples A and formulated with hydrogel chitosan. In general, as it is possible to observe, the formulated beverage with hydrogel chitosan had a good acceptability in comparison to sample A, which had a good acceptability at the Brazilian market.

Viscosity

According to statistical analysis (t-Test) there was significant difference (P< 0.05) between the mean of acceptability related to viscosity of the sample A and the sample with hydrogel chitosan, as the $t_{calculated}$ (2.755) was larger than $t_{critical}$ (2.009). The beverages showed difference (P < 0.05) on the viscosity. The score of the developed beverage was 7.06 and the score of the market beverage (sample A) was 5.87. The frequency distribution of the scores is shown in Figure 14.

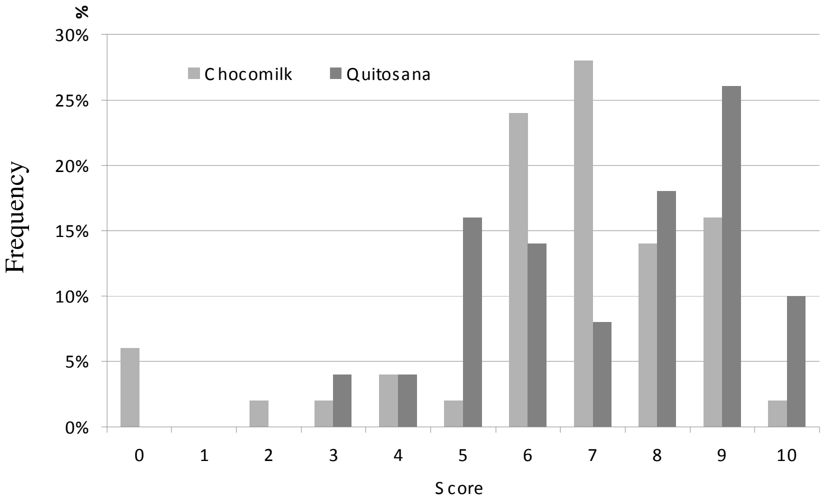

Figure 13. Frequency distribution of global acceptance scores obtained by sample A and the chocolate beverage developed with hydrogel chitosan.

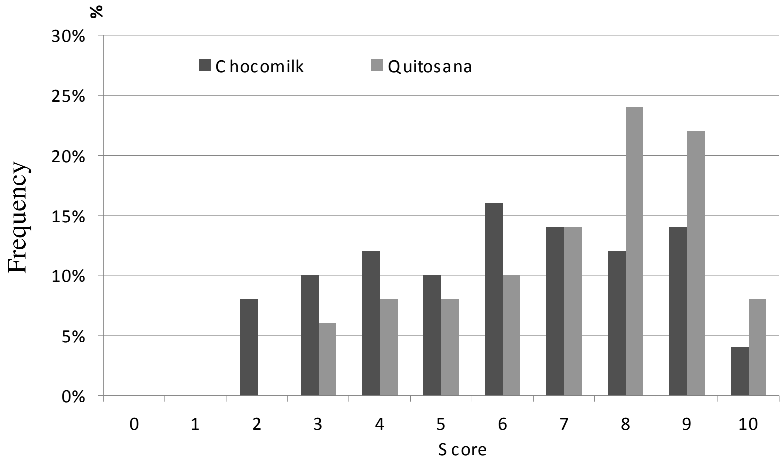

Figure 14. Frequency distribution of viscosity scores obtained by sample A and chocolate beverage developed with hydrogel chitosan.

Hydrogel chitosan is a polysaccharide which has the ability to form gel in neutral and alkaline pH media, forming viscous solutions at low concentrations. The hydrogel chitosan 0.5% used in the beverage had satisfactory viscosity and creaminess, leading the product to have better acceptability in comparison to the market product (sample A). Sample A, according to its label, contained starch as a thickener and was less viscous, and no taste of creaminess. The viscosity of sample A was 0.013 Pa s, and that of the formulated beverage was 0.064 Pa.s (Table 1). Révérend *et al.* (2009) studied 28 commercial hot coffee beverages aiming to obtain fundamental knowledge on hot beverage mouthfeel by investigating the potential correlations between sensory characteristics and rheological behavior, and also understand the functionality of different thickener systems in warm beverages. The texture perception in coffee beverages was resulting from a combination of various parameters, and was explained partially by flow behavior. Pflanzer *et al.* (2010) analyzed sensory profiles of three commercial brands of milk chocolate beverage using the Quantitative Descriptive Analysis (QDA) (twelve descriptive terms). An acceptability test was also performed to evaluate the samples thoroughly in terms of the intensity of the ideal sweetness and buying intention. All brands presented high acceptability, and there was no significant difference between them.

CONCLUSIONS

The present research was related to a manufacturing process and formulation of chocolate beverage using chemically modified chitosan. Formulations were characterized by the good result of the physical and sensory analyses performed, an important factor to be obtained for a product with distinctive characteristics. All samples showed pseudoplastic behavior, due to hydrocolloid and lipid present in these products. Although these products were traditionally pseudoplastic, some samples preferably adapted to other models, as Bingham and Casson. This is accepted because the existing behaviors were not unique. All samples, except the reconstituted powdered milk, showed thixotropy. Chocolate beverage developed with hydrogel chitosan 0.5% showed a consistency index (K) higher than that of the market samples. Although there was no significant difference (P> 0.05) between the overall acceptability of the chitosan beverage and the market sample, with respect to viscosity, the beverage formulated with hydrogel chitosan was better accepted than the market sample. This indicated consumer preference for more full-bodied beverage.

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بررسی نوشیدنی شیرشکلاتی دارای کیتوزان اصلاح شده

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چکیده

کیتوزان یکی از پلی ساکاریدهای مشتق شده از کیتین با روش ان- دی استیله شدن(N-deacetylation) است که خصوصیت تشکیل ژل دارد. هدف از این پژوهش تولید نوشیدنی شیر شکلاتی قوام یافته با کیتوزان اصلاح شده (دارای خصوصیت تشکیل دهنده ژل درآب) و ارزیابی خصوصیات رئولوژیکی و حسی آن بود. در آزمون حسی، خصوصیات قوام و پذیرش کلی نوشیدنی تولید شده به وسیله ۵۰ نفر ارزیاب با نوشیدنی موجود در بازار برزیل، مقایسه شد. برای ارزیابی حسی از یکی از معیارهای هدونیک استفاده گردید. برای ارزیابی خصوصیت رئولوژیکی نوشییدنی تولید شده، از گرانروی متر دورانی با پروب اچ۱(H1) استفاده شد. آزمون با سرعت کنترل شده افزایشی- کاهشی در دامنه صفر تا ۵۰۰ لیتر برثانیه و در زمان ۱۲۰ ثانیه(0- 500 L/s, and 500-0 L/s, 120 s) در دمای ۲۵ درجه سلسیوس انجام شد. اختلاف قابل تشخیصی در پذیرش کلی بین نوشیدنی ها($P > 0.05$) وجود نداشت. ولی امتیاز نوشیدنی تولید شده(۷/۱۲) از نوشیدنی موجود دربازار(۶/۴) بیشتر بود. گرانروی نوشیدنی تولید شده(۷/۰۶) از گرانروی نوشیدنی بازاز(۵/۸۷) بیشتر بود($P < 0.05$). مدلهای مناسب برای نوشابه بازار استوالد-ویل، بینگهام و کاسون(Ostwald-de-Waele, Bingham, and Casson models) و مدل مناسب برای نوشیدنی تولید شده استوالد- ویل(Ostwald-DE-Waele) بود. ضریب قوام(K) برای نوشیدنی بازار۰/۱۵۰پاسکال ثانیه ($Pa.s^n$) و برای نوشیدنی تولید شده۱/۵۹پاسکال ثانیه($Pa.s^n$) بود که نشان دهنده قوام خیلی بهتر نوشیدنی تولیدی است. اندیس رفتار جریانی(n) نوشیدنی بازار ۰/۶۲۵ و برای نوشیدنی تولیدی ۰/۴۳۵ بود. همه نوشیدنی های بازار دارای خصوصیت رئولوژیکی تیکسوتروپیک بودند. کیتوزان اصلاح شده به عنوان قوام دهنده نوشیدنی، دارای خصوصیت پذیرش کلی خوبی است.