Research Article

Development and Characterization of a Milk Beverage (Yogurt-like) Oriented to People with Diabetes

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ABSTRACT

With the purpose of elaborate a milk product, yogurt like, (settled and drinkable) with nutritive and functional components, developed to help to people with Diabetes mellitus; a formulated beverage was prepared with different levels of some selected nutrients; the beverage was characterized, and analyzed in fresh also through storage. Diabetes mellitus is a common disease, in which habits and sedentary lifestyle are two important factors, among others, these habits may and should be modified. Institutions for health and education should encourage people, with and without this suffering, to understand the problematic of this illness and to modify their habits. Thus, the development of a new food, oriented to help people with diabetes, is a scientific challenge. Yogurt as a milk fermented beverage, has changed with time and there exist a diversity of presentations, in which the incorporation of new selected components to the original matrix, may generate changes, in both, structure and properties, that need to be known, analyzed, and studied.

INTRODUCTION

The development of new products on one side, and the needs for more nutritional and functional food items on the other, are very important aspects of the Food Science. A functional food may provide health benefits in addition to the nutritional input. Yogurt is a dairy product with good nutritional value and with increasing demand, in Mexico and over the world. Yogurt has changed with time and there exist a diversity of presentations, both settled and drinkable, including yogurt with reduced fat content, yogurt with higher calcium content, yogurt with specific probiotic microorganism, yogurt with prebiotic compounds, between other yogurt types and variants. The incorporation of new components to the original matrix, may generate changes, in both, properties and structure, that need to be characterized and studied [1-9]. Fermented milks, and particularly yogurt, are items of high consumption in the world, are foods with important nutritional value, they have been utilized as matrices to incorporate and to deliver several functional and nutritious components [10]. Different ingredients, such as antioxidants, dietary fiber, fruit and vegetable components, inulin, minerals, prebiotics. probiotics and vitamins, among others, may be incorporated in the yogurt or fermented milk matrix. And, as consequence of that incorporation, some of the original characteristics and properties can be modified, then the changes in the new formulated food items should be analyzed and studied [9,11-13].

Diabetes Mellitus (DM) is a common disease, it is associated with risk factors, such as age, diet, ethnicity, genetic, physical activity, race, and smoking. Some of them as diet and physical activity, among others, are considered reversible. Dietary habits and sedentary lifestyle are two important factors that may be modified, for a rapid incidence of this health problem in developing countries. Institutions for health and education should encourage people, with and without DM, to understand the problematic and to modify their habits [14]. Thus, the development of a new food, oriented to help people with diabetes, is very attractive, and it is a scientific challenge [15]. DM is "a metabolic disorder characterized by hyperglycemia resulting from either, a deficiency in insulin secretion or lack of action of the insulin". Furthermore, if this disorder is not controlled, it can lead to damage of some organs, such eyes, kidney, nerves and cardiovascular system. There are three types of DM, and the WHO [16] reported more than 300 million of persons with DM type 2, in addition there are more than 400 million, of people with lactose intolerance. Food scientist have tried to create and to develop a diversity of enriched foods, trying to help people with this suffering, by incorporation of antioxidants and phenolic compounds for instance [17-19].

People with DM 2 should eat foods, with particular and valuable, nutritive and functional components, the nutritious plan should be individualized as possible, in consideration of their lifestyles, cultural backgrounds, and socioeconomic factors. In our days, the diets for diabetics are based on clinical research and knowledge of the food components effects in this health disease. Therefore, the develop of a new food should include all these mentioned aspects and considerations. The objective of this work was to formulate a milk beverages or yogurt type, based on previous studies around the world and our knowledge, including three nutrients of different nature, such as calcium caseinate, inulin and whey protein at different concentrations, and probiotics.

MATERIAL AND METHODS

This research was completed in three stages. A first, in which the different yogurt-like systems were formulated, characterized, and studied, determining their physicochemical and physical properties and completed with a sensory assessment. Whereas in the second and longest part, a stability analysis was done, through twenty-eight days of storage. Finally, the third part included the characterization, stability, sensorial and clinical analysis with a selected and flavored beverage.

Materials

The following materials were used for the elaboration of the yogurt type beverage: pasteurized skim milk (Lala® México), semi-skim milk powder (Svelty of Nestlé, México). A lyophilized starter culture (with 50:50 mixture of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. bulgaricus (YO-MIX® 401, DANISCO, Germany) that was used at 0.02% w/v by direct inoculation. And other ingredients, such as agave inulin 90% purity (FRUCTAGAVE PR95®, Agaviótica, N.L., Mexico), calcium caseinate (Casec®, Nestlé, México), whey protein (Isopure Zero Carb®, Nature's Best® Inc, NY, USA) and frozen blackberry (Global Premier, Olagaray Group, Mexico), were also utilized to formulate the beverage systems.

Methodology

Beverage preparation and systems: The yogurt-like beverage was made (2L) using the method described by Tamime and Robinson [20], mixing liquid skim milk and liquid semi-skim milk powder to adjust the level of solids to 9%. The mixtures were pasteurized at 90°C during 30 min and then, cooled down to 42°C to inoculate the fermenting microorganisms. Table 1, shows the proportions of the selected nutrients and the specification of the ten systems to be characterized, including eight systems with different levels of inulin. caseinate and whey protein, and two beverages without these nutrients. All of them with a 16% of solids content, by the addition of the skim milk powder. The different formulations or systems were placed into the incubator, where they remained for 5.5 ± 0.5 h until reach a pH of 4.5 ± 0.1. The prepared beverage (yogurt type) was divided in two parts, one was used for preparation of settled type, whereas the other part was utilized for preparation of the drinkable type.

All samples were stored for 28 days at 4°C and the systems were subjected to physicochemical and physical analysis, using duplicates for each one. The tests were carried out at different days; day 0, day 7, day 14, day 21 and day 28.

Yogurt with blackberry: Following the same methodology, a settled yogurt beverage without and with blackberries puree was elaborated. The blackberry puree or concentrate, was previously prepared, by using a mixer device (Thermomix TM 31, Vorwerk, Germany), mixing the frozen fruits and water at 80°C through 30 min. That is a recommended process [15], as microbiological sure (no microorganisms) and also, physicochemically not harmful for the phenolic available compounds.

Physicochemical determinations: All samples or systems were analyzed at least by duplicate, the tests were applied to characterize the formulated beverages and to analyze the effect of the storage, following standard determinations. Moisture content was determined through water evaporation (method 990.20, [21]), with 10 g of sample during 25 min in a water bath, and lately dried in a laboratory oven at 102°C, up to reach constant weight.

Acidity was quantified by titration of 20 mL of sample with 40 mL of distilled water, using 2 mL of phenolphthalein and NaOH (0.1N) as neutralizer (method 947.023, [21]). Whereas the pH was measured by immersion with a digital potentiometer (Model 420, Orion Research Inc., Boston, MA, USA), previously calibrated (pH 4 and 7), at room temperature.

The color of the samples was measured in a color meter, Color Gard System/05 (Colorgard System, BYK Gardner, Inc., Silver Spring, Maryland, USA) previously calibrated (L = 92.90, a = −1.05, b = 0.82), and expressed by L*, a*, b* CIELAB parameters. The tests were conducted with samples of 20 g, and from the three parameters an additional term was calculated, the net color change taking the next equation [22]:

$$\Delta E = \sqrt{(L_i - L_0)^2 + (a_i - a_0)^2 + (b_i - b_0)^2}$$

(Eq. 1)

Where: L_i, a_i and b_i are the values for the sample with different formulations or storage times, and L_0, a_0 and b_0 are the values for the control or initial sample.

Density was determined by a gravimetric method [21], using Grease pycnometers (Fisherbrand, Ontario, Canada).

For water activity, a dew point hygrometer device (Aqua Lab CX-2, Decagon Devices Inc. Pullman, WA, USA) at 25°C, that was used with 1 mL of sample, and doing the lecture by triplicated [23]. Doing the previous calibration of the hygrometer. Syneresis of the samples was determined through a centrifugation procedure. Approximately 10 g of sample was transferred into a 50 mL glass tube and centrifuged in a Centrifuge (Clay Adams Inc., California, USA) at 5000 rpm for 20 minutes. The percentage of syneresis was calculated as the released whey over the original weight [24].

$$Syneresis = \frac{weight\ of\ supernatant}{weight\ of\ sample} * 100$$

(Eq. 2)

Viscosity and rheological parameters

Flow properties determinations were performed in a Brookfield DV-I and DVI-III viscometers (Brookfield Engineering Laboratories Inc., MA, USA) using the small sample adapter (10 mL) and two needles, S27 and S31. Shear stresses (τ) were determined at the correspondent shear rates (γ) obtained in a range of 2 to 100 rpm at 20°C for samples of low viscosity (LV) and applying the relationships from the manufacturer [25].

$$\gamma = \frac{2\ wR_c^2\ R_b^2}{R_b^2\ (R_c^2 - R_b^2)} \quad \tau = \frac{M(\frac{torque}{100})}{2\ \pi\ R_b^2\ L}$$

(Eqs. 3 and 4)

Where: γ is the shear rate, w is the angular velocity, Rc is the cup radius, Rb is the bob or needle radius, τ is the shear stress, M is the portion (0-100) of the applied torque, and L is the length of the needle.

The experimental data were fitted by two mathematical models: the Power Law (PL, Eq. 5) and the Herschel and Bulkley (HB, Eq. 6).

LP $\tau = K\dot{\gamma}^n$ (Eq. 5)

HB $\tau = \tau_0 + K\dot{\gamma}^n$ (Eq. 6)

Where: τ is the shear stress (Pa), K is the consistency coefficient ($Pa{\cdot}s^n$), $\dot{\gamma}$ is the shear rate (s^{-1}), n is the flow behavior index (dimensionless), and τ_0 is the yield stress (Pa).

Four parameters, τ_0, n, K and apparent viscosity (η) of these rheological models were used to characterize the flow behavior of the samples. In which, RMSE (root mean square error, Eq. 7) was used as goodness test, to determine which one of the two models did the best fitting [8,26].

$$RMSE = [\frac{1}{n_e}\sum_{i=1}^{n_e}[(\tau_{exp} - \tau_{pred})^2]]^{1/2}$$

(Eq 7)

Where: n_e is the number of experimental data, τ_{exp} is the experimental shear stress; and τ_{pred} is the predicted shear stress (obtained from the mathematical model).

Texture. The texture profile analysis (TPA) was carried out with a texture meter TA.XT2 (Scardale, NY, USA) and using the software Texture Expert (version 1.22) for data, obtaining five texture parameters: hardness, adhesivity elasticity, cohesivity and gumminess. 150 mL of sample, with a penetration of 5 cm, and a stainless steel probe,

4.4 cm diameter, 8.0 cm long, and 1 mm/s were used [27].

Sensory evaluation

In order to determine the acceptance level of the yogurt-type beverages, each formulation was exposed to an analytical ordering in accordance to Wittin de Penna [28] with a panel of 20 non-trained individuals. Sensory attributes of flavor, aroma, texture and overall acceptability, were evaluated.

Glycemic analysis

A clinical test with 20 diabetic persons was carried out supplying two beverages, one sample of manufactured yogurt beverage with blackberry and one sample of settled yogurt.

Statistical analysis

All systems were analyzed after preparation at the corresponded day of storage. The response variables identified as physicochemical and flow properties were statistically examined with the Minitab software (v.16, Minitab Inc., Pennsylvania, USA). Statistical analysis was performed by using an analysis of variance (ANOVA). Also, a Tukey test was applied for multiple comparisons of the mean values.

RESULTS AND DISCUSSION

Two yogurt-like beverages were prepared, settled and drinkable, then their characteristics, results and discussions are presented in different sections, next.

Fresh yogurt systems

Settled yogurt characterization: The five formulated and prepared settled systems, in which inulin was a constant ingredient and with different content of C and W, were identified, based on their composition, as S-3C, S-4C, S-3W, S-4W and SC (Table 1), exhibited different physicochemical properties.

Table 1: Formulation in percentage of the milk beverages or systems.

Identification Code	Standardized Milk	Inulin	Calcium Caseinate(C)	Whey Protein (W)
S3C	93	4	3	-
D3C	93	4	3	-
S4C	93	3	4	-
D4C	93	3	4	-
S3W	93	4	-	3
D3W	93	4	-	3
S4W	93	3	-	4
D4W	93	3	-	4
SC	100	-	-	-
DC	100	-	-	-
BSY*	83.7	2.7	3.6	-

*Prepared as settled yogurt with incorporation of blackberry puree: 10%

Five physicochemical characteristics (solids content, acidity, pH, density and syneresis) of the fresh settle yogurt, are included in Table 2. The solids contents may be considered as normal and as function of the formulation, there is an expected range of contents (15.5-16.1%), and resulting higher than those (13-13.5%) reported by Macit and Bakirci [13], but lower than those (17.4-22.6%) reported by Curti et al. [10], and in agreement with other works [29]. Acidity and pH, typically correspond to this milk product, in agreement with Lee and Lucey [30], influenced of course, by the presence of the added components (caseinate, inulin and whey protein) used in our prepared yogurt systems. Acidity is in the range allowed by the Mexican norm [31] for yogurt.

Table 2: Physicochemical characteristics of fresh settled yogurt.

Yogurt System	Total Solids (%)	Acidity (%)	pH	Density (kg/m^3)	Syneresis (%)
SC	15.51±0.2^a	0.58±0.3^a	4.67	1168±14^{Aa}	45±3^a
S3C	16.06±0.1^a	0.42±0.2^a	4.68	1083±63^{Aab}	55±2^a
S4C	15.82±0.1^a	0.44±0.2^a	4.62	1079±57^{Aba}	45±2^a
S3W	15.90±0.1^a	0.44±0.2^a	4.65	1011±5^{Ba}	56±2^a
S4W	15.91±0.1^a	0.47±0.2^a	4.52	964±56^{Ba}	65±2^a

C: Calcium caseinate; W: whey protein.

Being density and syneresis, the properties with more variability, than may be attributed to the composition of each yogurt system. Density corresponded to this type of beverage items, and in agreement, with those (1047-1089 kg/m^3) reported by Hernández [22], Ramírez-Sucre and Vélez-Ruiz

[7], and Aguilar-Raymundo and Vélez-Ruiz [9]. The syneresis is high (45-65%), being higher to those values reported by Brennan and Tudorica [32] for low fat yogurt added with inulin; although is lower in comparison with a yogurt prepared with oat bran and chia seeds [19]. Yogurt with whey protein exhibited higher syneresis than yogurt with caseinate. The presence of inulin has been reported as a factor that favors the decreasing of the serum separation, but in the studied systems of this work, it was not the case, the ingredient did not have a significant effect on syneresis decreasing. In general, the analyzed yogurt beverages showed significant differences, as a function of composition or formulation. Additionally, other properties were also measured. Color parameters of the studied systems are presented in Table 3.

High luminosity (>90), with tendency to the green tone and yellow color was observed for the five systems, in general, the color varied between white color and light yellow.

Higher luminosity (> 97) was measured in the control and caseinate yogurts, whereas yogurt with whey protein recorded 90% of luminosity; thus, both components (C and W) had a significative effect on L*, inulin did not have influence ($p < 0.05$). Contrary to luminosity, the green color was higher in yogurt with whey protein (- 2.67, and - 3.73) than the other three yogurts (- 2.05, - 2.06, and – 2.3). And for the yellowness parameter, higher tone (12.74) was measured in yogurt S4W, whereas resulted almost the same (11-04-11.40) for three systems, control and with caseinate (SC, S3C and S4C), and the lowest (10.3) was detected for the S3W yogurt-like system. Then, an important effect of composition was observed on color parameters.

Table 3: Color parameters of fresh settled yogurt.

Yogurt system	Luminosity (L*)	Redness (a*)	Yellowness (b*)
SC	97.84 ± 0^{Aa}	-2.05 ± 0.02^{Aa}	11.04 ± 0.30^{Aa}
S3C	97.63 ± 0.03^{Aa}	-2.29 ± 0.02^{Ba}	11.19 ± 0.07^{Aa}
S4C	97.84 ± 0^{Aa}	-2.06 ± 0.02^{Aa}	11.40 ± 0.30^{Aa}
S3W	90.16 ± 0.6^{Aa}	-3.73 ± 0.01^{Ca}	10.35 ± 0.90^{Ba}
S4W	90.69 ± 0.3^{Aa}	-2.67 ± 0.10^{Da}	12.74 ± 0.40^{Ca}

C: Calcium caseinate; W: whey protein.

With respect to rheological behavior, the systems exhibited a typical flow curve, in which the viscosity decreased with shear rate for a non-Newtonian fluid, pseudoplastic type, as expected. This response has been reported for yogurt systems. From the flow curve two rheological models were applied, Power Law and Herschel and Bulkley equations; and taking the RMSE (root mean square error) as a criterium of fitting, resulted that the best model was the second one. The correspondent flow parameters for the studied yogurt systems, are included in Table 4.

Being a pseudoplastic nature with yield stress the generalized response, in agreement with data reported by Keogh and O´Kennedy [33], Aportela-Palacios et al. [4], Brennan and Tudorica [32], Ramírez-Sucre and Vélez-Ruiz [6,7], and Aguilar-Raymundo and Vélez-Ruiz [9], among others.

Although flow curves showed the decreasing in viscosity, some irregularities were observed. At low shear rates for the caseinate systems (S3C and S4C), and contrary to the expected, the yogurt with higher content of caseinate (S4C) had lower apparent viscosity than the system S3C.

Table 4: Rheological parameters of fresh settled yogurt.

Yogurt system	Flow index (n) (dimensionless)	Consistency coefficient (K) ($Pa\ s^n$)	Yield stress (τ_0) (Pa)	Apparent viscosity at 20 s^{-1} (mPa s)	RMSE
SC	1.00^{Aa}	0.144^{Aa}	0.278^{Aa}	126^{Aa}	0.18
S3C	0.57^{Ba}	14.561^{Ba}	22.43^{Ba}	7942^{*Ba}	1.66
S4C	0.61^{CBa}	10.482^{Ca}	18.15^{Ca}	4554^{**Ca}	0.39
S3W	0.74^{Ca}	0.657^{Aa}	0.356^{Aa}	320^{Da}	0.07
S4W	0.76^{Ca}	0.575^{Aa}	1.138^{Aa}	367^{Da}	0.18

C: Calcium caseinate; W: whey protein; *at 10 s-1; **at 17 s-1; Different letters indicate significant differences ($p < 0.05$).

The control yogurt (SC) was identified as Newtonian, and the non-Newtonian response was more notable (lower flow index) in systems with caseinate, and the yield stress was very high (22.4 and 18.1 Pa) in comparison with the other yogurts. Very good fittings (RMSE < 2) were obtained for the HB equation, that is a model that includes the yield stress. A structured gel may be visualized in both yogurt systems with caseinate and whey protein. Although it was more detectable in caseinate yogurts, due to higher magnitudes in yield stress (18.15 and 22.43 Pa) and apparent viscosity at low shear rates (4554 and 7942 mPa s). It was a significant effect of composition on flow properties.

For textural assessment, a TPA test allowed the evaluation of five parameters: hardness, adhesivity, elasticity, cohesivity and gumminess of the settled yogurt, they are included in Table 5.

Table 5: Textural parameters of fresh settled yogurt.

Yogurt system	Hardness (N)	Adhesivity (N s)	Elasticity (dimensionless)	Cohesivity	Gumminess
SC	0.284^{Aa}	-0.664^{Aa}	0.767^{ABa}	0.978^{Aa}	28.97^{Aa}
S3C	0.751^{Aba}	-2.693^{Aa}	0.800^{Aa}	0.755^{Aa}	57.80^{Ba}
S4C	1.082^{Aa}	-4.023^{Aa}	0.867^{Aa}	0.713^{Aa}	78.68^{BAb}
S3W	0.227^{Aa}	-0.282^{Aa}	0.533^{Ca}	0.979^{Aa}	22.64^{Aa}
S4W	0.262^{Aa}	-0.332^{Aa}	0.633^{BCa}	0.965^{Aa}	25.73^{Aa}

C: Calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$)

Hardness showed important differences, being significantly affected by yogurt composition, and being consistent with flow parameters in which the yogurt with caseinate had higher values, 0.75 and 1.08 N for 3 and 4% of this ingredient, that contributed to a more structured gel. Adhesivity was similar, to hardness, being the highest value for yogurt with 4% of caseinate, followed by yogurt 3% of caseinate and the other three systems. The elasticity exhibited magnitudes lower than 1.0, and it was significant difference as a function of components, but the values had a short range of variation, 0.53 to 0.87. Yogurt systems with whey protein and control, showed more cohesivity. Whereas the gumminess was higher for yogurt with caseinate. In general, the textural parameters, were affected by composition.

Finally, a sensorial assessment was completed with a non-trained panel of 20 individuals (students and workers), evaluating the four mentioned parameters.

The obtained results are included in Table 6, being 43 and 71 the computed extreme values, in according to the followed methodology of Witting de Penna [28], indicating significant differences. In it, a surprising result was obtained for the overall acceptability, in which the control yogurt was the less acceptable (33), whereas the yogurt with 4% of caseinate was the most acceptable (78). This difference in acceptability of the five systems may be attributed to the presence of the added components, inulin, caseinate and whey protein favoring this sensory parameter, doing yogurt-like systems with good acceptability. Something similar, was recorded for other three texture parameters, with particular differences between them.

In general, the best evaluated was the S4C, followed by the S3C, that was better in texture; next in sensory evaluation, was the S3W and S4W, being this last better in aroma; and the last position was for the control system with sensorial mean magnitudes in the side of rejecting.

Table 6: Sensorial parameters of fresh settled yogurt and their perception by 20 persons.

Yogurt system	Aroma	Flavor	Texture	General acceptability
SC	39^{a}	34^{a}	32^{a}	33^{a}
S3C	62^{b}	66^{b}	86^{b}	66^{b}
S4C	69^{b}	74^{c}	75^{b}	78^{c}
S3W	48^{b}	60^{b}	50^{c}	62^{b}
S4W	52^{b}	50^{b}	42^{c}	46^{b}

C: Calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$)

Also, a significant difference ($p < 0.05$) is observed between control yogurt and added yogurt systems. Thus, a positive effect of the ingredients on sensory was observed, in addition to the desirable functionality on this yogurt-like beverage.

Drinkable yogurt systems

The formulated and prepared yogurt-like drinkable systems, were previously mentioned (Table 1), including the same ingredients at the same concentration, varying only the Preparation process, in which the breaking of the gel is an important step in drinkable type elaboration. The measured five physicochemical characteristics of the drinkable yogurt are included in Table 7. The solids percentage (15.58 as mean value) and constant water activity (0.991), corroborate the analogy of both yogurt types. Certainly, there were differences in the other properties, acidity, color, density, and syneresis with respect to the settled yogurt type; small differences than may be attributed to the manufacturing process, being the mechanical agitation the cause of physical effects on components, gel structure and microorganisms. No differences were observed between drinkable systems, for acidity, density and syneresis.

Table 7: Physicochemical characteristic of fresh drinkable yogurt.

Yogurt system	Total solids (%)	Acidity (%)	pH (kg/m^3)	Density	Syneresis (%)
DC	15.61±0.2^a	0.56±0.3^a	4.67	1063±10^{Aa}	52±3^a
D3C	15.79±0.2^a	0.41±0.2^a	4.55	1071±32^{Aa}	58±2^a
D4C	15.49±0.6^a	0.58±0.2^a	4.63	1073±59^{Aa}	50±2^a
D3W	15.20±0.6^a	0.50±0.2^a	4.60	1064±55^{Aa}	68±2^a
D4W	15.91±0.2^a	0.54±0.2^a	4.61	1054±53^{Ba}	66±2^a

C: Calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$).

Color parameters for this type of yogurt, are presented in Table 8. A generalized similarity may be observed in these parameters for both types of yogurts, as expected. High luminosity, green and yellow tones are characteristics for the color of the five drinkable yogurt systems. Similarly, to settled systems, drinkable yogurts were significantly affected by composition.

Table 8: Color parameters of fresh drinkable yogurt systems.

Yogurt system	Luminosity (L*)	Redness (a*)	Yellowness (b*)
DC	97.53±0.1^{Aa}	- 2.63±0.04^{Ca}	10.45±0.04^{Aa}
D3C	97.97±0^{Aa}	- 2.24±0.01^{Ba}	10.38±0.04^{Aa}
D4C	97.83±0.3^{Aa}	- 1.84±0.10^{Ca}	10.94±0.60^{Aa}
D3W	89.54±0.7^{Ca}	- 3.64±0.02^{Dab}	11.17±0.50^{Aa}
D4W	96.50±0.7^{Ba}	- 2.72±0.07^{Ca}	12.20±0.10^{Aa}

C: calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$).

As expected, the flow behavior of drinkable systems showed observable and clear differences, the flow parameters and the apparent viscosity were of lower magnitudes. Even though they exhibited the same non-Newtonian nature with yield stress and pseudoplastic behavior, the magnitude of the parameters are included in Table 9. This flow response is related with the components, in which inulin and the other two ingredients contribute to the molecular interaction, that is reflected by the presence of yield stress and flow index below 1.0; certainly, the recorded consistency coefficient and yield stress were of notable lower value. The yield stress was in a range of 6.4 to 321 mPa for drinkable yogurt systems, and 28 to 22432 mPa for settled yogurt for instance. The flow behavior was well fitted, also, by the Herschel-Bulkley model, due mainly to the yield stress presence.

Table 9: Rheological parameters of fresh drinkable yogurt systems.

Yogurt System	Flow index (n) (dimensionless)	Consistency coefficient (K) (Pa s^n)	Yield stress (τ_0) (Pa)	Apparent viscosity at 20 s^{-1} (mPa s)	RMSE
DC	0.67^{ABa}	0.015^{Aa}	0.0064^{Aa}	5	0.01
D3C	0.69^{ABa}	0.154^{Ba}	0.321^{Ba}	77	0.03
D4C	0.92^{Ca}	0.142^{Ba}	0.262^{BCa}	70	0.01
D3W	0.60^{Bab}	0.037^{Aa}	0.100^{Da}	15	0.01
D4W	0.85^{Ca}	0.038^{Aa}	0.214^{Ca}	27	0

C: calcium caseinate; W: whey protein; * at 10 s^{-1}; ** at 17 s^{-1}.
Different letters indicate significant differences ($p < 0.05$).

For the textural parameters of this yogurt, the TPA tests served, also, for the quantification of the adhesivity, cohesivity, elasticity, gumminess, and hardness, that are included in Table 10. Lower magnitudes were determined for four textural parameters of this type of beverage with exception of cohesivity. Although the yogurt with whey protein, exhibited light higher textural parameters in comparison with the settled systems, expressing an homogeneous consistency (adhesivity and cohesivity) favored by the agitation. The texture was significantly affected by composition, similarly than for settled yogurt.

Table 10: Textural parameters of fresh drinkable yogurt systems.

Yogurt system	Hardness (N)	Adhesivity (N s)	Elasticity	Cohesivity (dimensionless)	Gumminess
DC	0.260^{Aa}	- 0.269^{Aba}	0.633^{Aa}	0.956^{Aa}	25.39^{Aa}
D3C	0.296^{Aa}	- 0.365^{Aa}	0.667^{Aa}	0.948^{Aa}	28.58^{Aa}
D4C	0.293^{Aa}	- 0569^{ABa}	0.700^{Aa}	0.925^{Aa}	27.67^{Aa}
D3W	0.264^{Aa}	- 0.463^{ABa}	0.733^{Aa}	0.989^{Aa}	26.61^{Aa}
D4W	0.303^{Aa}	- 0.766^{Ba}	0.833^{BCa}	0.985^{Aa}	30.44 ^{Aa}

C: calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$)

The correspondent sensory evaluation for drinkable yogurt systems, may be appreciated in Table 11, in which is very interesting to observe how the preparation process of the milk beverage affected the perception of the panel. Drinkable yogurt was better accepted, and none of the mean values for the sensorial parameters was lower than 43, and with only two of them (flavor and general acceptability) with a value of 71 for the system with 4% of caseinate.

Yogurt system	Aroma	Flavor	Texture	General acceptability
DC	69^{a}	51^{a}	54^{a}	49^{a}
D3C	62^{b}	54^{b}	62^{b}	61^{a}
D4C	59^{a}	71^{b}	65^{a}	71^{b}
D3W	45^{a}	52^{a}	56^{a}	58^{a}
D4W	50^{a}	57^{a}	46^{a}	45^{a}

Table 11: Sensorial parameters of fresh settled yogurt and their perception by 20 persons.

C: calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$).

Based on this comparison, in which a non-trained panel was utilized; it may be concluded that drinkable yogurt, was more accepted than settled one, even though the composition is the same, but the preparation was different.

Stability study

The same characterized yogurt systems, five settled and five drinkable, were prepared to analyze their response through a storage period of 28 days. The main results and observations are presented next, in a summarized form.

Storage of settled yogurt: As expected, solids content, density and water activity showed light changes at the settled yogurt systems through the storage period, main changes were recorded in acidity, and pH, due to physicochemical and metabolic changes, in which the storage time affected these properties, significantly, pH decreasing as expected, and inversely related to acidity, was more notable in the first week than the rest of the storage time, whereas acidity increased steadily during the four weeks. The acidity of systems with caseinate recorded the lowest acidity values and also, they exhibited the lowest increasing in this physicochemical parameter. In general, both parameters were inside the Mexican norm [31]. The evolution of both parameters through storage are showed by Figures 1a and 1b. Syneresis augmented little, but with significant effect through the four weeks of storage, attributed to the overall modifications in the yogurt systems, both physical and physico-chemical. Four of the five determined values for solids separation are included in Table 12, as representative values at the storage of this beverage, in which a range of increasing was between 8 and 13%, corresponding to the day 0 and the end of the storage.

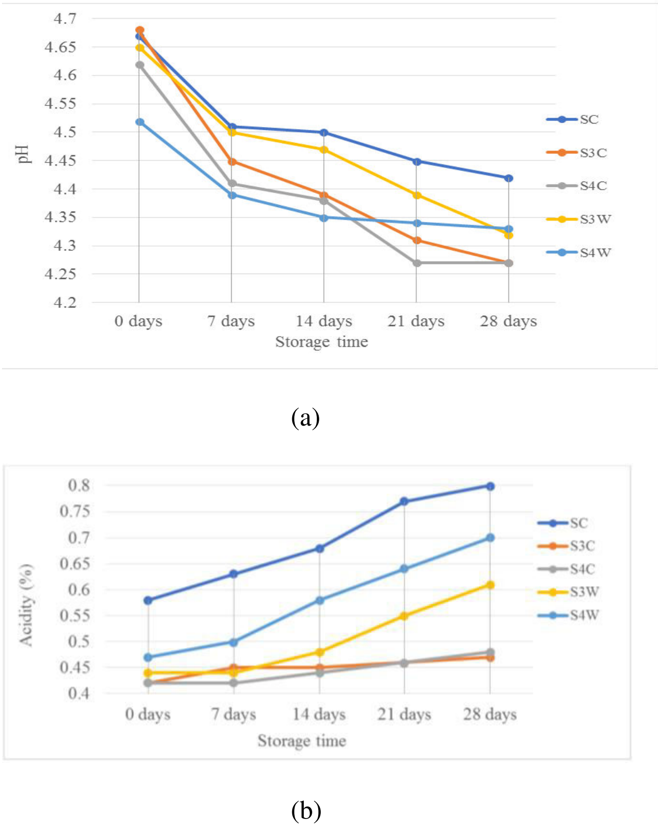

Figure 1: a) pH evolution and, b) acidity evolution, through 28 days of storage for settled yogurt systems.

Color was also affected by time, with decreasing in luminosity, from 90.1-97.8 as the range for fresh samples, to 89.5-91.3 range at the fourth week, for settled yogurt-like systems. Green tone augmented little, from – 2-05 to – 3.7 for the initial day, to a range of – 2.7 to - 3.7 at the last day, with only one system (S3W) showing a small decrease (-3.73 to -3.65). The yellow color also exhibited a small augment, from a range of 10.3-12.7 for fresh systems, to a range of 11.6-14.1 for stored yogurts, with only one system (S4W) showing a decreasing pf 12.74 to 12.43.

A general change from white-cream color in fresh systems to white-yellow color, was observed through the storage in which a significant effect of time was detected. The net change of color is expressed in Table 12, with magnitudes from 2.4 to 8.9, expressing low overall color changes through the 28 days of storage, in which the system with the highest value was for the control yogurt, and the lowest change was for the S3W yogurt.

Table 12: Syneresis and change of color for settled yogurt systems through storage.

Yogurt system	Syneresis (%)				Net change of colour
	at 0	at 7	at 14	at 28 days	
SC	43	50	52	54	8.87 ± 0.08[a]
S3C	56	59	60	65	6.41 ± 0.06[b]
S4C	46	53	56	58	7.16 ± 0.10[b]
S3W	57	60	66	70	2.38 ± 0.07[c]
S4W	64	64	67	72	7.51 ± 0.05[ab]

C: calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$)

The rheological response through the storage period was varied (Table 13), the systems exhibited a different evolution, in which the model of Herschel and Bulkley also, fitted very well the experimental values, in general.

Table 13: Flow parameters for settled yogurt systems through storage.

Yogurt system	n (dimensionless)			K (Pa s^n)		
	at 7	at 14	at 28 days	at 7	at 14	at 28 days
SC	0.71[Ab]	0.64[Abc]	0.58[Ac]	0.285[Ab]	0.235[Ac]	0.158[Ac]
S3C	0.77[Aa]	0.79[ac]	0.85[ABa]	8.895[Bb]	4.546[Bc]	0.996[Bd]
S4C	0.81[Ab]	0.90[Ab]	1.14[ABc]	4.340[Cb]	3.253[Bc]	1.124[Bd]
S3W	0.70[Ab]	0.64[Ac]	0.64[Ac]	0.659[Aa]	0.481[Ab]	0.199[Ad]
S4W	0.67[Aab]	0.64[Ab]	0.64[Bb]	0.229[Aab]	0.116[Ab]	0.105[Ab]

Yogurt system	τ_0 (Pa)			η (mPa s)		
	at 7	at 14	at 28 days	at 7	at 14	at 28 days
SC	0.141[Ab]	0.426[Ac]	1.12[Ae]	0.117[Aa]	0.111[Aa]	0.096[Aa]
S3C	12.27[Bb]	9.30[Bb]	1.32[Bc]	8.358[Ba]	8.201[Ba]	3.102[Ba]
S4C	12.31[Bb]	12.86[Bb]	5.58[Cc]	5.460[ABa]	5.365[ABa]	3.159[Ba]
S3W	0.218[Ab]	0.469[Ac]	0.417[Be]	0.266[Ab]	0.169[Ac]	0.087[Ae]
S4W	0.561[Ab]	0.508[Ab]	0.390[Bb]	0.284[Ab]	0.121[Ac]	0.080[Ac]

C: calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$).

Observing that the control yogurt followed a different evolution, an increasing for n and τ_0, a decreasing in K and η; in comparison with the other four systems. Whereas for yogurt with caseinate, an increasing for n, and a decreasing in K, τ_0 and η, was observed. On the other side, a decreasing at n, K, and η was measured for yogurt with whey protein, but not for τ_0. Some data of flow parameters, taken as representatives, are included in Table 13.

The decreasing in most of the flow properties is a consequence of changes in gel structure, due to physical changes through storing of the yogurt systems.

For texture evolution, followed through TPA tests (data non shown), hardness showed a small increasing in the first week, but it was stable the rest of the storing; not significant changes were computed for this parameter through the storage. The same stable response was observed for cohesivity and gumminess, without significant changes during the four weeks. Adhesivity, in which yogurts with 4% of caseinate and 4% whey protein were the most adhesives, they exhibited small changes, not significant during the shelf life. Elasticity was stable for three yogurts and only those prepared with whey protein had a significant increasing through storage.

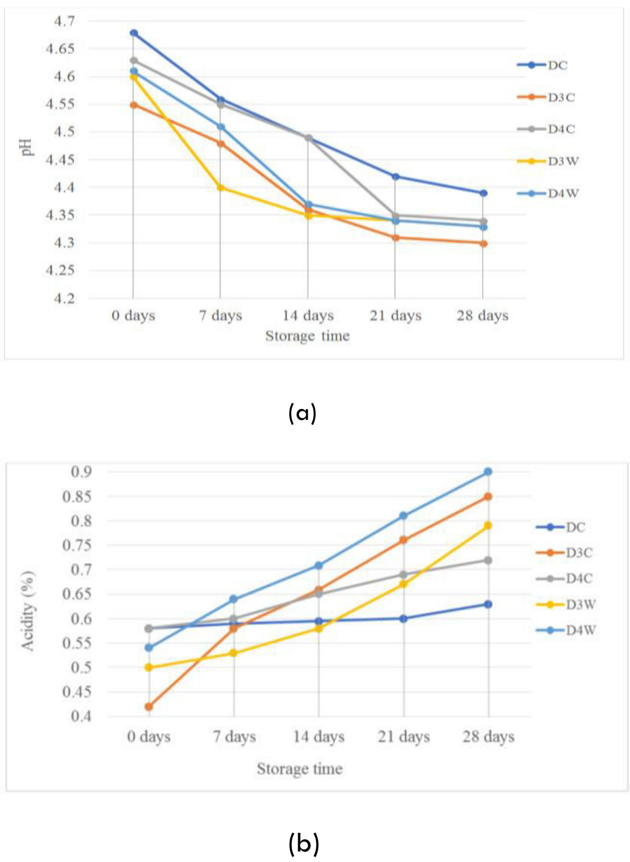

Figure 2: Evolution of (a) pH and (b) acidity in drinkable yogurt systems through 28 days of storage.

4.4. Storage of Drinkable Yogurt

As expected, the physicochemical changes of this type of yogurt were analogous to the settled one. Total solids, although recorded some variations, showed stability through storage, and did not were significantly affected by time. The water activity that was 0.991 at the beginning, exhibited a range of 0.987 to 0.990, after 28 days of storing pH as one of the important physicochemical parameters, exhibited a decreasing during the store (Figure 2a), being the control yogurt the sample with highest pH (4.39) at the last day, and the yogurt with 3% of caseinate, was the sample with the lowest pH (4.29); all the five systems were inside the Mexican norm (181-SCFI-2010), until the second week of storage. The decreasing in the magnitude of this parameter, during the 28 days, was an average of 0.28 for the five settled yogurt systems; yogurt with 4% of whey protein decreased pH from 4.61 to 4.33, for instance. On the other side, acidity with higher values, in comparison with the settled systems, augmented following almost a linear trend (Figure 2b) in which yogurt systems with 4% of whey protein and 3% of caseinate reached the highest values (0.90 and 0.85%). And being the lowest, the augment corresponding to the control yogurt. A significative influence of storage time was recorded on acidity of drinkable yogurts.

Syneresis augmented very little, from 53-68% to 59-70%, through the four weeks of storage, attributed to light physical and physicochemical modifications in this type of yogurt systems. This augment was similar than those syneresis results exhibited by settled yogurt systems, as expected. The results of syneresis for drinkable yogurts, corresponding to the first, second, third, and final storage days are included in Table 14. Control yogurt had the lowest loss of water and yogurts with whey protein showed the higher magnitudes of syneresis, but with small increasing. Color (data non shown) was also affected by time, with a decreasing in luminosity, from 89.5-98.0 as the range for fresh samples, to 87.7-91.5 for samples at the fourth week, with significant effect of storage time. Green tone (a*) augmented just a little, from – 1-84 to – 3.64 for the initial day, to a range – 2.6 to - 3.7 at the last day, with only one system (D3W) having a small change (-3.64 to -3.72), also showing significant effect of storage time. And the yellow color (b*) also exhibited a small augment, from a range of 10.4-12.2 for fresh systems, to a range of 10.9-13.8 for stored yogurts; this color parameter did not exhibit significant effect of storage time. A general change from white-cream fresh systems to white-yellow color in systems, was observed through the storage, in which, a significant effect of time was detected.

The recorded changes in color parameters of drinkable yogurts were analogous to those observed in settled systems. These small modifications in color of yogurt, both, settled and drinkable, are attributable to the presence of the added proteins in the formulation. The overall change of color is expressed in Table 14, with magnitudes from 1.5 to 10.4, expressing low changes, in which the system with the highest value was the control yogurt and the lowest change was for the D3W yogurt.

Table 14: Syneresis and change of color for drinkable yogurt systems through storage.

Yogurt system	Synerēsis (%)				Change of color
	at 0	at 7	at 14	at 28 days	
DC	53	53	54	59	10.36 ± 0.10[a]
D3C	58	58	62	65	6.59 ± 0.10[b]
D4C	50	54	54	58	6.66 ± 0.30[b]
D3W	68	68	69	70	1.51 ± 0.07[c]
D4W	66	66	67	70	6.82 ± 0.09[ab]

C: calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$)

And even though, changes in color of both yogurts, settled and drinkable, were recorded, the changes are comparable, 2.3-8.9 for settled and 1.5-10.4 for drinkable systems, indicating a desired stability through storage, in this quality parameter that favors the consumer acceptability, as it was observed in the sensorial assessment.

In relation to the rheological behavior, the flow curves of the drinkable yogurt-like systems showed a non-Newtonian response with a yield stress attributable to the presence of the added inulin and the two proteins. The Herschel and Bulkley model fitted very well the flow response, part of the results obtained of this fitting are presented in Table 15, including the four parameters (flow index, consistency coefficient, yield stress and apparent viscosity at three of four weeks of storage. A generalized decreasing in the flow index with storage, with exception of yogurt S4W, was observed; also, an increasing in the consistency coefficient trough three weeks with decreasing at the fourth week of storage, and an increasing in yield stress, was measured for these drinkable systems. Changes in the measured apparent viscosity for each system, are obviously related to the mentioned three flow parameters.

And clearly the magnitude of the flow parameters (consistency coefficient, yield stress and apparent viscosity) for drinkable systems, are notable lower than those obtained for the correspondent to settled yogurts.

Similarly, to the settled yogurt, the texture evolution followed through TPA determinations (data non shown), exhibited that hardness had a small increasing through the storing, without significant effect of storage time; for instance: 0.293 N at day 0 and 0.371 at day 28 for system D4C. Adhesivity of systems, also exhibited small increasing through storage, in general. System D4C had – 0.569 at the beginning and - 0.776 N-s at the end, although an exception was observed in yogurt-like D4W, with - 0.766 N-s at day and -0.447 N-s at day 28.

Table 15: Flow parameters for settled yogurt systems through storage.

Yogurt system	n (dimensionless)			K (Pa s^n)		
	at 7	at 14	at 28 days	at 7	at 14	at 28 days
DC	0.69^{Aab}	0.65^{ABab}	0.56^{Ab}	0.022^{Aa}	0.038^{Ab}	0.127^{Ad}
D3C	0.62^{Ab}	0.63^{ABb}	0.59^{Ab}	0.266^{Bb}	0.275^{BCb}	0.255^{Bb}
D4C	0.70^{Ab}	0.59^{Bb}	0.61^{Ab}	0.397^{Cbc}	0.429^{Cc}	0.317^{Cb}
D3W	0.63^{Aa}	0.55^{Bb}	0.72^{Ac}	0.041^{Aa}	0.051^{Aa}	0.028^{Da}
D4W	0.76^{Aa}	0.76^{Aa}	0.73^{Aa}	0.035^{Aa}	0.031^{ABa}	0.030^{Da}

Yogurt system	τ_0 (mPa)			η (Pa s, at $20s^{-1}$)		
	at 7	at 14	at 28 days	at 7	at 14	at 28 days
DC	25.73^{Aa}	29.39^{Aa}	258.9^{Ae}	0.009^{Ab}	0.013^{Ac}	0.042^{Ae}
D3C	1085^{Cb}	1572^{Cc}	1778^{Ad}	0.140^{Bb}	0.171^{Bcd}	0.164^{Bc}
D4C	1496^{Db}	1635^{Cb}	2659^{Ac}	0.190^{Cb}	0.210^{Cc}	0.235^{Ce}
D3W	142.9^{Ba}	143.3^{Ba}	152.5^{Aa}	0.021^{Db}	0.020^{Db}	0.020^{Db}
D4W	108.5^{ABb}	100.2^{ABb}	94.08^{Ab}	0.015^{Bb}	0.014^{Ab}	0.016^{Db}

C: calcium caseinate; W: whey protein.
Different letters indicate significant differences ($p < 0.05$)

The same light increase was detected for elasticity, cohesivity and gumminess, for three systems (control and with caseinate); whereas the other two systems, with whey protein showed a variable response, with small increasing's and decreasing's through the storage. For instance systems D3W exhibited 0.733, 0.800, 0.767, 0.800 and 0.901 (dimensionless) for elasticity, at 0, 7, 14 , 21, and 28 days of storage.

And then, to finish this stage, the sensory evaluation of the drinkable systems was carried out, following the same procedure, evaluating four sensorial attributes. Good acceptances were recorded for the five systems. No one of the grades given by the panel, was out of the range of 43-71, indicating good acceptability, in general. Aroma was 45-69 (57 average), flavor ranged 51-71 (61 average), texture recorded 46-65 (55.5 average), and acceptability was 49-71 (60 average). A correlation in values for flavor and acceptability, given by the sensory panel, was observed for the five yogurt systems.

Blackberry yogurt for diabetic people

Based on results of the characterization and mainly on the stability response of the yogurt systems, particularly those results in acidity, color, flow response, pH and syneresis, the settled yogurt with 4% of caseinate was selected to complete this study. Thus, taken the yogurt-like system, settled type, formulated with 4% of caseinate as the sample with "better" characteristics and good acceptability, a sample of beverage was prepared, incorporating fresh blackberry at 10%, into the formulation. Therefore, the composition of the yogurt with blackberry puree, is included in Table 1 as BSY, in which the percentages of the main components are modified, due to the presence of the blackberry. For characterization and stability analysis, two systems of settled yogurt were prepared, the selected yogurt with inulin and caseinate (S4C), and the same yogurt beverage added with the fruit (BSY). Thus, both yogurt systems were characterized in fresh and during 28 days of storage. Those results considered as most important are discussed next.

Characteristics of two yogurt systems (BSY and S4C):

As expected, the solids content and water activity, were very similar and they exhibited Light changes after 28 days; being 15.95% (+ 0.3) of solids with 0.991 (+ 0) of water activity for the settled yogurt, and 15.82% (+ 0.3) with 0.991 (+ 0) of solids content and water activity, for the flavored sample, respectively. Acidity, being higher in the flavored system, augmented 0.05% and 0.1% with storage, for flavored and settled yogurts, respectively. Syneresis, being lower in the beverage with blackberry, increased 8% and 12%, respectively in settled and flavored systems. Whereas pH, being lower in settled yogurt, decreased with storage, from 4.63 to 4.27 in correlation with acidity. The evolution of these three properties, and the variation of the color parameters, of the flavored yogurt, are presented in Table 16; following a normal evolution, with differences attributed to their composition and with significative effect of storing time. For the yogurt-like sample BSY, the color was importantly influenced obviously by the incorporation of blackberry, affecting the three parameters since the fresh yogurt determination. Some values for the three parameters of color and how they changed with time, are included in Table 16. For BSY, the luminosity was low due to the presence of fruit components, it was stable through storage. Redness and yellowness were contrary to the scale recorded in settled and drinkable sample, values of redness were positive (red tone), whereas yellowness was negative (blue tone), as effect of the presence of pigments from blackberry; a* showed a small decrease, and b* also diminished a little more. These two changes, in a* and b* are due to the loss of intensity in the color of the blackberry as a natural response to the atmospheric effect during the storing. The color parameters of the selected settled yogurt are in the previous sections.

Table 16: Evolution of four physicochemical properties for settled and flavored yogurts, through storage.

Acidity (%) in yogurt system	at 0	at 7	at 14	at 21	at 28 days
S4C	0.40	0.41	0.45	0.48	0.50
BSY	0.63	0.61	0.65	0.69	0.68
Syneresis (%) in yogurt system	at 0	at 7	at 14	at 21	at 28 days
S4C	46	52	56	58	58
BSY	37	40	41	42	45
pH in yogurt system	at 0	at 7	at 14	at 21	at 28 days
S4C	4.63	4.41	4.37	4.27	4.27
BSY	4.75	4.67	4.53	4.45	4.42
Luminosity (L*) in yogurt system	at 0	at 7		at 21 days	
BSY	66.65 ± 0.06^a	67.45 ± 0.10^b		67.74 ± 0.06^c	
Redness (a*) in yogurt system	at 0	at 7		at 21 days	
BSY	19.63 ± 0.03^a	18.01 ± 0.10^b		16.17 ± 0.10^d	
Yellowness (b*) in yogurt system	at 0	at 7		at 21 days	
BSY	- 1.27 ± 0.05^a	- 0.66 ± 0.01^b		- 0.24± 0.02^d	

Different letters indicate significant differences ($p < 0.05$).

Even though there were measurable variations in the three color parameters, with respect to the yogurts without blackberry, the net change of color for flavored yogurt was very low (1.23 + 0.02), indicating an overall stability of this flavored system.

For the flow response of this yogurt system with fruit, that was fitted with the same models, an important difference was found with respect to both studied yogurt systems, settled and drinkable. The best fitting now, was reached with the Power Law model, indicating the absence of the yield stress (Table 17), that may be attributed to the incorporation of the fruit puree components in the proteinic matrix. Low flow behavior indices ($n < 0.45$) were obtained, and high consistency coefficients (> 9.6 Pa s^n) were computed, that were notable higher, than those of the settled beverages, as consequence of the major interaction between solids inside the yogurt-like.

Table 17: Flow parameters from Power Law model for settled yogurt with blackberry (BSY).

Storage time	n (dimensionless)	K (Pa s^n)	η_{ap} (Pa s)
Day 0	0.415^{ab}	16.799^a	2.615^a
Day 7	0.392^b	14.403^b	2.136^b
Day 14	0.443^a	9.696^c	1.684^{cd}
Day 21	0.401^b	10.525^c	1.625^d
Day 28	0.352^c	14.450^b	1.907^c

Different letters indicate significant differences ($p < 0.05$).

Sensory assessment and clinical analysis

Finally, a sensory evaluation and a clinical analysis of glycemic index were carried out, in which three blackberry yogurt-like samples were prepared, using stevia as natural sweetener. Following the results and recommendations of Cardello et al. [34]; in which, they reported a quantity of 0.092 g of stevia to sweet 100 g of an acid solution (pH 3.0). Then, for the sensory assessment, three batches (1 kg each) of blackberry yogurt, with 0.92 (BSY1), 1.38 (BSY2) and 1.80 g (BSY3) of stevia as sweetener, were elaborated and a group of 29 persons evaluated the three beverages, applying a hedonic scale. From the sensory evaluation, the response was of good acceptance, the sample with 3% of stevia (BSY3) was better evaluated (7.2 ± 1.8 average), that could be considered as logic, being sweeter than the other two, being the main difference between them; with average mean values of 5.9 ± 1.3 for BSY1, and 5.4 ± 1.9 for BSY2. With a mean acceptability for them (BSY1, BSY2, BSY3), of 6.17, that is a good score.

Yogurt with the highest level of sweetener was the best evaluated, showing significative difference with respect to the other two samples and then, being this yogurt, the used for the clinical study. Yogurts BSY1 and BSY2 although exhibited almost one point of difference in the acceptation test, they did not show significant difference, between both.

On the other side, the clinical analysis was carried out with 20 persons at a Hospital, 10 diabetic people and 10 persons, without this illness. It was necessary to select a commercial yogurt with the same flavor (Santa Clara, SCSY) with similar composition (taken from the nutritional label), in addition to the yogurt selected in this study (BSY3). Both beverages (SCSY and BSY3) were supplied, 50 g for diabetic and 100 g for non-diabetic people, measuring the glucose level to each person, before breakfast and 30, 60, 90 and 120 min, after they ingested the sample beverage; the results are briefly presented in Table 18.

Table 18: Determination of capillary glucose (mg/dL) in a group of 20 persons, divided in two groups.

Group:	Time (min)	Sample BSY3	SCSY (mg/dL)
Diabetic people	0	105.871^{Aa}	115.571^{Aa}
	30	115.714^{Aa}	133.857^{Ab}
	60	109.571^{Aa}	122.571^{Aa}
	90	103.429^{Aa}	125.000^{Aa}
	120	97.857^{Aa}	123.429^{Aa}
Non-diabetic people	0	93.714^{Aa}	85.571^{Ba}
	30	105.571^{Aa}	127.714^{Ab}
	60	102.857^{Aa}	95.000^{Aa}
	90	99.857^{Aa}	85.517^{Ba}
	120	98.714^{Aa}	89.285^{Ba}

BSY3: yogurt with blackberry; SCSY: commercial yogurt.
Different letters indicate significant differences ($p < 0.05$).

Important differences were observed, people without diabetes, did not exhibited significant differences between both beverages and with the test time of 120 minutes. Contrary to the other group, diabetic people showed a significant increase in the glucose level, after the minute 30, for commercial beverages, attributed to the composition of the yogurts.

CONCLUSIONS

Eight yogurt-like systems and two control yogurts were prepared, characterized, and stored, studying five settled and five drinkable samples. Physicochemical and physical properties were measured in fresh systems of both yogurts, finding similarities in solids content, acidity, pH and water activity, and notable differences in flow response, syneresis and texture properties. Sensory evaluation were also completed, with good acceptability, 46-78 for settled systems and 45-71 for drinkable samples. The evolution through storage of all systems, was variable and a function of the composition, thus from the stability in storing, one settled yogurt-like was selected (S4C) to complete the research. Therefore, two systems were prepared, settled with 4% caseinate and settled with 4%caseinate added with blackberry fruit, analyzed in fresh and stored, showing clear differences in color, acidity, syneresis, pH, and flow properties. The research was finished with a sensorial of three flavored settled yogurt-like systems in which the incorporation of a sweetener favored the good acceptability by a sensory panel; and including clinical evaluations of glucose in diabetic and non-diabetic people, with good results in the clinical test for the blackberry beverage. From the sensory viewpoint, the settled yogurt-like with blackberry and three percent of sweetener was the preferred milk beverage.

A yogurt-like food was developed, characterized, and analyzed through storage, finding good physicochemical properties, good acceptability and good functional properties. With this study, in which a milk beverage was prepared and studied, people may elaborate a yogurt-like with desired characteristics, depending of the final objective. Such was the case in our research, of the yogurt-like with blackberry for diabetic people.

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