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Physicochemical, sensory and stability properties of a milk caramel spread sweetened with a glucose-galactose syrup from sweet whey

Propiedades fisicoquímicas, sensoriales y de estabilidad de un dulce de leche con adición de sirope glucosa-galactosa de lactosuero dulce

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ABSTRACT

Whey is a dairy industry by-product with an adverse environmental impact; therefore, obtaining sweeteners from it promote a circular economy and is an alternative to mitigate the environmental problems. The aim of this research was to evaluate the effect of different inclusions (10%, 20%, and 30%) of Glucose-Galactose syrup (GGS), obtained from whey, on the physicochemical, sensory, and stability properties of a milk caramel spread. Results showed that the syrup has a significant effect on the techno-functional properties of the final product since it turns into a darker color when the concentrations of syrup increased. Besides, the yield of the product was higher (41.4%), providing a higher volume. In a replacement of 30% GGS, the milk caramel spread at a lower amount of soluble solids achieved a texture similar to the other inclusions. At a sensory level, consumers accepted all formulations with an acceptance higher than 90%. During the storage time (60 d), different evaluated parameters increased.

Keywords:
Milk caramel spread
Sensory analysis
Sweeteners
Texture
Whey

RESUMEN

El lactosuero es un subproducto de la industria láctea con alto impacto ambiental, por ello, obtener edulcorantes a partir de este promueve una economía circular y es una alternativa para mitigar el problema ambiental. El objetivo de esta investigación fue evaluar el efecto de diferentes inclusiones (10%, 20% y 30%) del sirope glucosa-galactosa (SGG), obtenido a partir de lactosuero, sobre las propiedades fisicoquímicas, sensoriales y de estabilidad en un dulce de leche. Los resultados mostraron que el sirope tiene un efecto significativo en las propiedades tecno-funcionales del producto final, el cual presenta un color más oscuro a medida que se aumenta su concentración. Además, el rendimiento del producto fue mayor (41,4%) proporcionando un mayor volumen. Cuando se logra un reemplazo del 30% de SGG, se obtiene una característica de textura similar a las demás inclusiones a menos sólidos solubles. A nivel sensorial, los consumidores aprobaron todas las formulaciones con una aceptación superior al 90%. Durante el tiempo de almacenamiento (60 d) los diferentes parámetros evaluados aumentaron.

Palabras clave:
Dulce de leche
Análisis sensorial
Edulcorantes
Textura
Lactosuero

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Milk caramel spread is a dairy product obtained generally by evaporation of milk at atmospheric pressure with the addition of sucrose until reaching 70% of total solids (Berwerth, 2006). In this process, sucrose is partially replaced usually by glucose syrup to avoid its crystallization, besides it participates as reducing sugar in the Maillard reactions (Moro and Hough, 1985). Besides, sodium bicarbonate is used as an ingredient to prevent the coagulation of proteins and help to get the golden color characteristic of this product. Milk caramel spread represents an important market to explore and promote because the increase in the average world consumption has been higher than 40% since 1990 (SENATI, 2011).

Usually, glucose syrup is used as a partial substitute for sugar during the preparation of milk caramel spread; being essential for its sweet flavor, contributing to the total solids of the product, and providing shine and texture (Garitta e*t al.*, 2004).

Whey is a dairy industry by-product produced during cheese making, 90% of the total volume of milk used for its manufacturing becomes whey (Prazeres *et al*., 2012). Additionally, it has nutrients such as serum proteins, lactose, and minerals; where the lactose is present in greater quantity and has a greater polluting level (Beltran and Acosta, 2012). A sweetener like glucose-galactose syrup (GGS) could be obtained from sweet whey; it has lactose, glucose, and galactose in its composition, being able to provide characteristics similar to the glucose syrup (Somov *et al*., 2015). The GGS is used as a sweetener that could substitute sucrose, not only in the manufacture of milk caramel spread but also as an ingredient in other products, reducing the whey environmental impacts.

Different authors have reported the use of sweetening agents in milk caramel spread, highlighting the addition of sucrose, invert sugar, polydextrose, fructose, and sorbitol, mainly because of their sweetness attributes (Queiroz *et al*., 2009; Valencia *et al*., 2008; Valencia and Millán, 2008). Other studies have evaluated the effect of incorporating flours (Lopes *et al*., 2015) for the functionality and stability they can confer to this product. The addition or modification of raw materials in this type of products has different effects on their quality characteristics, the most important being texture, pH, moisture content, viscosity, and general acceptability of the product over time (Andrade *et al*., 2009).

The purpose of this study was to evaluate different inclusions of GGS regarding the physicochemical, sensory, and stability properties of a milk caramel spread during storage at environmental conditions.

MATERIALS AND METHODS

Raw material

GGS (68-72 °Brix) was obtained by evaporating an enzymatic hydrolyzate from a lactose concentrate. The concentrated lactose was obtained employing the membrane filtering process (ultrafiltration and nanofiltration) of sweet whey, in a 100 L capacity filter pilot plant with a ceramic membrane and cut-off size of 100 Da. The operating conditions used for the nanofiltration process were: Temperature of 23 °C, concentration factor of 5, an inlet pressure of 31.5 bar and stage pressure of 2 bar. This lactose concentrate was hydrolyzed with β-galactosidase (1.2 mL L^{-1}) at a temperature of 36 °C for 3 hours (Perez-Escobar *et al*., 2020). This product was stored under refrigeration temperature (4 °C) until preparation of the milk caramel spread. Sucrose was purchased from a local supplier.

Characterization of raw materials

The GGS was characterized by measuring the following properties: pH (AOAC 945.10), acidity for lactic acid (AOAC 945.64), moisture content (AOAC 925.45), total solids (AOAC 925.45), soluble solids (AOAC 932.14), proteins (AOAC 991.20), minerals (AOAC 985.35), and ashes (AOAC 923.03). The apparent viscosity measurement was stablished at 4 °C using a Brookfield DV-III rheometer and concentric cylinder geometry. Lactose, glucose, galactose, and lactic acid were quantified by High-Performance Liquid Chromatography (HPLC), using an AGILENT 1200 series chromatograph, with an AMINEX HPX-87H ion-exchange column (300×7.8 mm), the concentration of the standards (lactose, glucose, galactose, and lactic acid) were from 1 to 5 g L^{-1}, and as mobile phase a solution of H_2SO_4 0.008 N at a constant flow of 0.6 mL min^{-1}. The sweetening power was determined through a sensory test per multidimensional approach with a three-trained panel. This test was performed according to Colombian Technical Standards NTC 3501 and NTC 3915.

Whole milk was used for making milk caramel spread and the following characteristics were determined: Content of total solids (NTC 4979), proteins (AOAC 972.16), fat (AOAC 989.04), acidity as a percentage of lactic acid (NTC 4623), density (Quevenne lactodensimeter), cryoscopic point (DE568) and pH (NTC 4592).

Milk caramel spread preparation

A final sweetness of 17% was proposed for the milk caramel spread during its formulation. Sodium citrate, at 0.1% of the total mixture, was added to the previously filtered milk. Milk heating was started with continuous agitation when it reached a temperature of 30 °C, sugar and powder milk were added. The sweetener was neutralized with sodium bicarbonate ($NaHCO_3$) to achieve 0.12% lactic acid since, without this pre-treatment, the milk caramel spread generated a sandy texture. Immediately, when this mixture reached a concentration of 40 °Brix, the previously treated sweetener (GGS) was added, and the evaporation processing was continuously running until reaching a concentration of 70 to 75 °Brix. The milk caramel spread was poured into the containers, allowed to cooling at room temperature; finally, it was stored.

Physicochemical analysis of milk caramel spread

The pH was determined using an OHAUS STARTER 3100 pH-meter potentiometer (NTC 4592). The color was evaluated through the tristimulus colorimetry technique with the Konica Minolta CR-400 series colorimeter. Total solids (measured as degrees Brix, °Brix) were measured with a gravimetric method (AOAC 925.45); determination of viscosity was achieved using a Brookfield DV-III rheometer with an RV7 spindle, measurements were performed at 25 °C and 10 rpm (Andrade *et al.*, 2009). Fat content was measured through the modified Babcock method. Protein was determined by the Kjeldahl method (AOAC 991.20-23). Soluble solids were evaluated by means of a digital refractometer (HI 96801) (Baldasso *et al.*, 2011). Water activity was measured by the dew point method with the Aqualab 4TE series equipment (AOAC, 2000, 2007). Moisture content was obtained using a Memmert vacuum stove (AOAC 977.21). Minerals were determined through atomic absorption spectrophotometry (NTC 5151). The spreadability analysis was carried out with a conical perspex probe 30P/30C in a texturometer TA-TX2, with a pre-test speed of 10 mm s^{-1}, test speed of 3 mm s^{-1} and a distance of 30 mm. The yield of the process was determined as follows where W_i is the initial weight and W_f is final weight:

$$Y(\%) = \frac{W_i - W_f}{W_i} \times 100$$

Sensory evaluation of milk caramel spread

The intensity attributes of milk caramel spread were evaluated following the Colombian technical standard NTC 2680. This panel was comprised of 20 expert technicians belonging to the Laboratory of Dairy Products of the Universidad Nacional de Colombia - Sede Medellín. In the sensory testing, the intensity of characteristics as texture, color, aroma, crystallization, and spreadability on a structured scale of 10 points was considered. Acceptability tests were carried out with 100 consumers for the different samples of milk caramel spread 24 hours after its preparation. Consumer perception regarding the general acceptability was evaluated in a structured hedonic scale of 9 points.

Product stability

The pH, apparent viscosity, color, water activity, and moisture content were evaluated over a period of 60 days under storage conditions (Temperature of 25 °C and relative humidity of 60%) using a Memmert ICH 260 climatic chamber. Milk caramel spreads were packaged in polypropylene bags.

Statistical analysis

A randomized experimental factorial design with four factors determined by the substitution (in relation to sweetness) of 0%, 10%, 20%, and 30% of sucrose for GGS (72 °Brix) was established, for a total of 12 experiments. The experimental data of the response variables were analyzed by ANOVA and Fisher's LSD method at a 5% significance level.

RESULTS AND DISCUSSIONS

Table 1 shows the physicochemical properties of GGS, indicating an acid raw material, dense with low humidity, yellow-green color due to the content of vitamin B2 (Arndt and Wehling, 1989), together with a high amount of minerals and a sweetening power of 50% regarding the sucrose value. In addition, the GGS is a non-Newtonian pseudoplastic fluid according to its rheological properties. Milk showed high-quality characteristics according to the NTC 399.

Table 1. Physicochemical characterization of the GGS and cow's milk used as a raw material for the preparation of milk caramel spread.

Property	Mean Value
GGS	
Acidity (% Lactic acid)	1.250±0.088
pH	4.850±0.073
Density (Kg m^{-3})	1370±12
Moisture (%)	24.24±2.62
Water activity	0.73±0.026
Soluble Solids (°Brix)	72.51±1.85
n-Fluency index	0.848±0.071
k- consistency index (Pas^{n})	1.416±0.224
Color	L*: 35.18±1.85 a*: -3.35±0.95 b*: 16.89±1.96
Protein (% w/w)	<2.5%
Calcium (% w/w)	0.26±0.04
Phosphorus (% w/w)	0.38±0.04
Magnesium (mg Kg^{-1})	834±60
Potassium (% w/w)	0.98±0.13
Ashes (% w /w)	3.45±0.26
Lactose (Kg m^{-3})	192.85±4.97
Glucose (Kg m^{-3})	392.86±10.84
Galactose (Kg m^{-3})	297.51±11.62
Lactic acid (Kg m^{-3})	52.80±18.68
Sweetening power	0.5
MILK	
Density (Kg m^{-3})	1031.3±0. 4
pH	6.68±0.04
Acidity (% Lactic acid)	0.17±0.01
Fat (%)	3.7±0.1
Protein (Kg m^{-3})	3.25±0.06
Non-fatty solids (%)	8.70±0.08
Total solids (%)	12.37±0.13
Cryoscopic point	0.514±0.003

Physicochemical properties of milk caramel spread

The pH value showed a statistical significance (P<0.05) among samples with addition of GGS, where pH decreased at the highest level of GGS inclusion even after neutralization, due to the presence of syrup, with values close to the reported by Novoa and Ramírez-Navas (2012) (Figure 1A). Hence, as a result of this low sweetening power, it should be added in greater quantity than sugar. This decrease in pH by increasing the GGS level was also related to the Maillard reactions because there is an interaction between the amino groups of milk proteins and reducing sugars such as glucose, galactose, and lactose. As there are a greater number of molecules of nitrogen interacting with sugars, the pH will be lower since these amino groups help to have alkaline pH and when reacting, acid groups predominate causing a decrease in pH (Belitz *et al.*, 2012).

The moisture content was similar for 10 and 20% of GGS inclusion, whereas, for 30%, there was significantly different (*P*<0.05). This change is due to the process was stopped at lower soluble solids because it achieved the appropriate texture at a shorter evaporation time. Since the evaporation time was shorter than the other treatments, more water remained inside the product. The moisture content was close to the defined in the Colombian technical standard NTC 3757. Also, these values coincided with the reported by Andrade *et al.* (2009), where values of 22% of moisture content for a milk caramel spread from buffalo milk were found.

For soluble solids, results indicated a statistically significant effect (*P*<0.05) for GGS inclusion (Figure 1B).

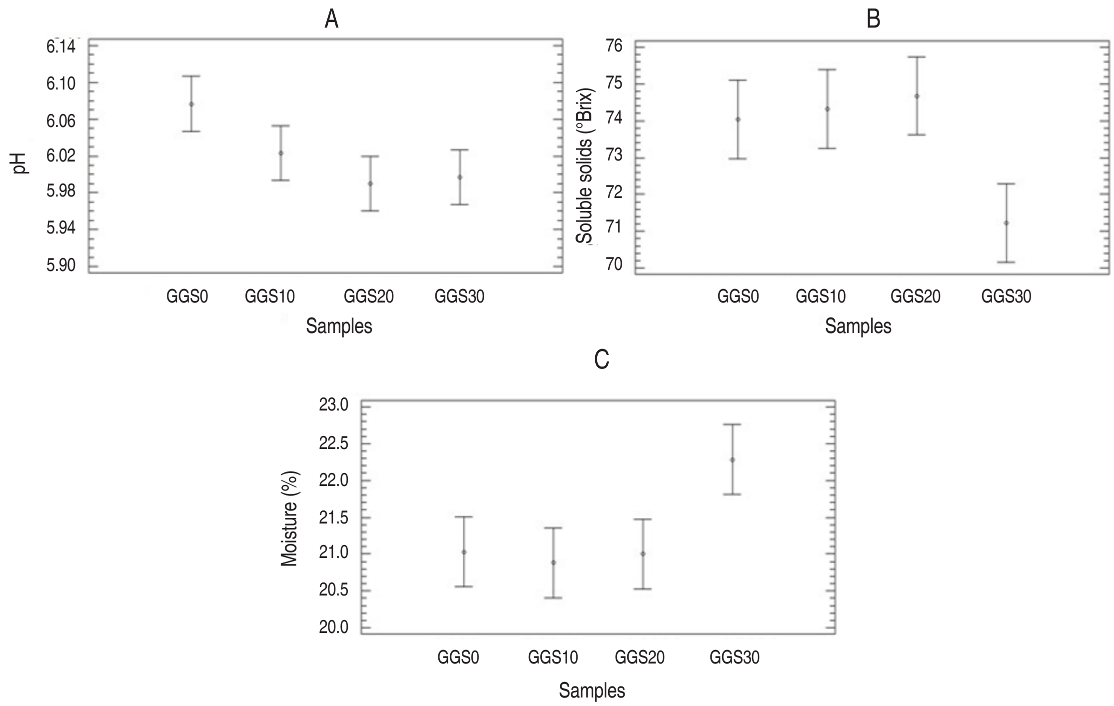

Figure 1. Physicochemical parameters of milk caramel spread with different contents of GGS. A. pH; B. soluble solids; C. moisture content.

Thus, to reach the desired texture, about 74 and 75 °Brix were required when adding up to 20% of sweetener; while when 30% of the syrup was added, this texture was achieved at soluble solids of 70.5 °Brix. This result could be explained by the cause of the contribution of soluble solids of GGS in such quantity. Additionally, soluble solids were within the ranges reported by Novoa and Ramírez-Navas (2012) for commercial milk caramel and milk caramel spread from buffalo milk reported by Andrade *et al.* (2009).

The GGS did not present statistically significant differences in the viscosity of the milk caramel spread (Table 2). However, it is a type of product that diminishes the apparent viscosity as deformation rate increases, presenting characteristics of a pseudoplastic or thixotropic fluid (Andrade *et al.*, 2009; Pauletti *et al.*, 1990; Rovedo *et al.*, 1991).

Textural parameters as adhesiveness, maximum force, and energy did not show statistically significant differences

(*P*>0.05) with the inclusion of GGS (Table 2). The differences in texture are due to the variations of pH in the different sweetened milk caramel spread, when by varying the pH, the electrical charges of the proteins are distributed heterogeneously, improving interactions between them (Valencia and Millán, 2008). The experimental values reported by Valencia *et al.* (2008) in terms of adhesiveness were lower than those of the present research. This fact was due to the soluble solids were lower (60 °Brix) and moisture content greater than 30% providing softer textures in the final product. However, the study reported by Valencia *et al.* (2008) coincided with those reported in the present work.

Table 2. Average values (± standard deviation) of the physicochemical parameters of the milk caramel spread with GGS in different concentrations.

Parameter	GGS (%)			
	0	10	20	30
Adhesiveness (J)	-1.423 (±2.150)	-2.654 (±1.557)	-2.410 (±0.462)	-1.228 (±0.737)
Force (N)	3,981 (±0.135) a	4,419 (± 0,117) a	4,306 (±0.146) a	4,218 (±0,165) a
Energy (J)	19.051 (±0.189) a	19.012 (±0.153) a	19.032 (±0.195) a	19.023 (±0.119) a
Apparent viscosity (mPa s)	55,167 (±1579) a	44,187 (±1719) a	66,700 (±1258) a	53,613 (± 2458) a
Water activity (A_w)	0.7993 (±0.0073) a	0.7923 (±0.0048) ab	0.7897 (±0.0240) ab	0.8223 (±0.0153) a
Fat (%)	8.1 (±0.3) a	7.6 (±0.4) a	7.6 (±0.5) a	7.6 (±0.5) a
Total Solids (%)	78.9713 (±1.370) a	78.502 (±0.2451) a	79.0007 (±0.6252) a	77.7167 (±0.4753) a
Protein (% w/w)	7.8 (±0.5) a	7.3 (±0.9) a	8.0 (±0.2) a	7.3 (±0.4) a
Calcium (% w/w)	0.25 (±0.02) a	0.26 (±0.01) a	0.27 (±0.02) a	0.25 (±0.04) a
Phosphorus (% w/w)	0.23 (±0.02) a	0.25 (±0.02) a	0.26 (±0.01) a	0.25 (±0.03) a
Magnesium (mg kg^{-1})	262.3 (±7.8) a	342.3 (±13.0) a	381.3 (±12.8) c	401.3 (±12.7) a
Potassium (% w/w)	0.48 (±0.03) a	0.63 (±0.07) a	0.63 (±0.02) c	0.72 (±0.04) c
Ashes (% w/w)	2.16 (±0.07) a	2.39 (±0.06) a	2.63 (±0.08)	2.66 (±0.06) c
Yield (%)	37.4 (±0.11) a	38.5 (0.057) a	39.6 (±0.26) c	41.4 (±0.45) d

Average values with the same lowercase letters in the same row denote that there were no significant differences according to Fisher's test (*P*<0.05).

Concerning water activity (A_w) and fat content, Table 2 shows that the GGS incorporation level did not show a significant effect (*P*>0,05). This result could be explained because of the water activity of the product is very similar to the syrup, both subjected to evaporation. Additionally, previous research reports that in the whey permeate there is less than 1 g L^{-1} of fat (Atra *et al.*, 2004). Therefore, this sweetener obtained a low fat due not only to the previous processing by which fat globules should be removed before subjecting the whey to ultrafiltration but also by the ultrafiltration and nanofiltration technologies, to which it was subjected. The values were within the range allowed by the NTC 3757, that mentions it should be between 6 and 9%, and it is validated by Andrade *et al.* (2009), who reported values of 7.95 for a caramel made of buffalo milk.

Protein did not present statistically significant differences between samples; it ranges from 7.3 to 8.0% (Table 2) values analogous to those reported by Garitta *et al.* (2004) and Sousa *et al.* (2002) who found values between 7.81 and 10%.

Two minerals (Magnesium and potassium) were evaluated in the milk caramel spread showing a statistically significant effect (*P*<0.05) by including GGS (Table 2). The results showed an increase in these minerals when more syrup was added; this same tendency was presented in ashes content. Besides, Calcium and Phosphorus minerals did not present statistically significant differences reaching values from 0.25 to 0.27% and between 0.23 to 0.26% w/w, respectively.

The CIELab color space in the final product indicated that GGS addition had a statistically significant effect (*P*<0.05). The lightness (L*) decreased as GGS content increased (Figure 2A), while value a* showed an adverse effect, as seen in Figure 2B. In consequence, the product turns darker brown as the syrup percentage increases. This color changes could be related to Maillard reactions because syrup containing reducing sugars such as lactose, glucose, and galactose. Besides, a higher level of GGS (monosaccharides) inclusion in addition to low pH favors this reaction producing a caramel color. Novoa and Ramírez-Navas (2012) reported the color of different milk caramel where L* ranged from 42 to 45, a* between 13.7 and 15.8, and b* ranges from 31.3 to 37.06, which according to the CIELab coordinates shows a lighter color than the milk caramel spread produced in this research. The ranges of CIELab values for Argentine milk caramel found by Castañeda *et al.* (2004) were L* (26.36 to 41.31), a* (14.72 to 17.09), and b* (26.37 to 31.49); being the color of milk caramel spread analyzed in the current work close to these values.

Nutritionally, the milk caramel spread with GGS contains a greater amount of minerals necessary for the proper functioning of the human body. Additionally, the GGS is understood to have galactooligosaccharide from the enzymatic hydrolysis of lactose (Neri *et al.*, 2009; Rodriguez-Colinas *et al.*, 2014), providing a prebiotic function at the nutritional level.

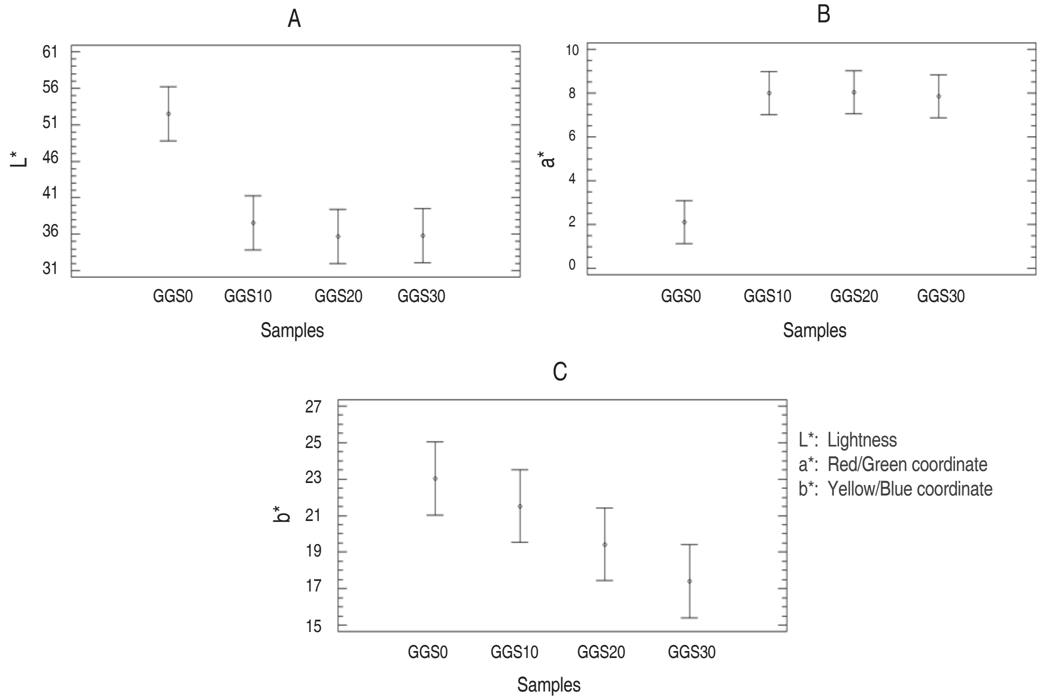

Figure 2. Color parameters of the milk caramel spread with different contents of GGS. A. lightness (L*); B. red to green (a*); C. yellow to blue (b*).

Sensory evaluation of milk caramel spread

Different factors were evaluated in the sensory test: Texture, color, aroma, crystallization, and spreadability (Figure 3A). The texture perception was qualified more fluid for the 10% GGS inclusion, while the other two inclusions (20% and 30%) perceived them a little dense. The color had the same tendency observed in the physicochemical analysis when increasing the addition of GGS, the darker the rating. The three inclusions were qualifying close to 5 (amber color), but the tendency demonstrated that when darker, the expert technicians could perceive this condition in every sample. In the perception of aromas, the evaluators rated them as "very nice." Additionally, spreadability was evaluated in the central line, but tending a little towards intense. Crystallization had a low rating, which means they did not perceive the crystals, sugar, or sandiness in any case.

Sensory analysis of the products through the acceptance test with 100 consumers for each sample is shown in Figure 3B. All the inclusions had a very good acceptance, where more than 90% of the consumers described them from "I like it lightly" to "I like it very much", having the highest acceptance the 10% of inclusion, which did not have an unfavorable rating, nevertheless replacements of 20% and 30% remained close to the replacement of 10%.

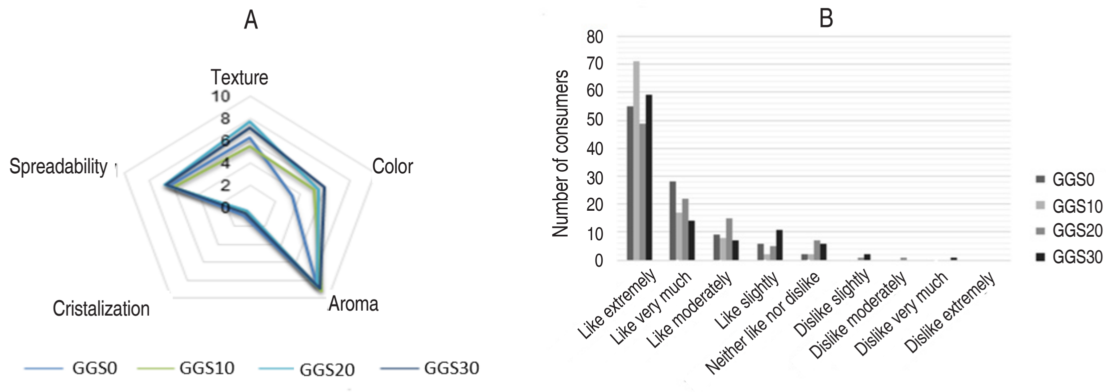

Figure 3. Sensory tests for milk caramel spread: Sensory descriptors (A); General consumer acceptance test for the different inclusions of GGS (B).

Stability of milk caramel spread

The pH presented statistically significant differences ($P<0.05$) for all samples during storage time; this value rose gradually with time and was greater at the end of the storage time (Figure 4). This behavior was also reported by other authors (Valencia and Millán, 2008). The apparent viscosity had the same behavior related to the interaction of the proteins during the stability study (Valencia and Millán, 2008).

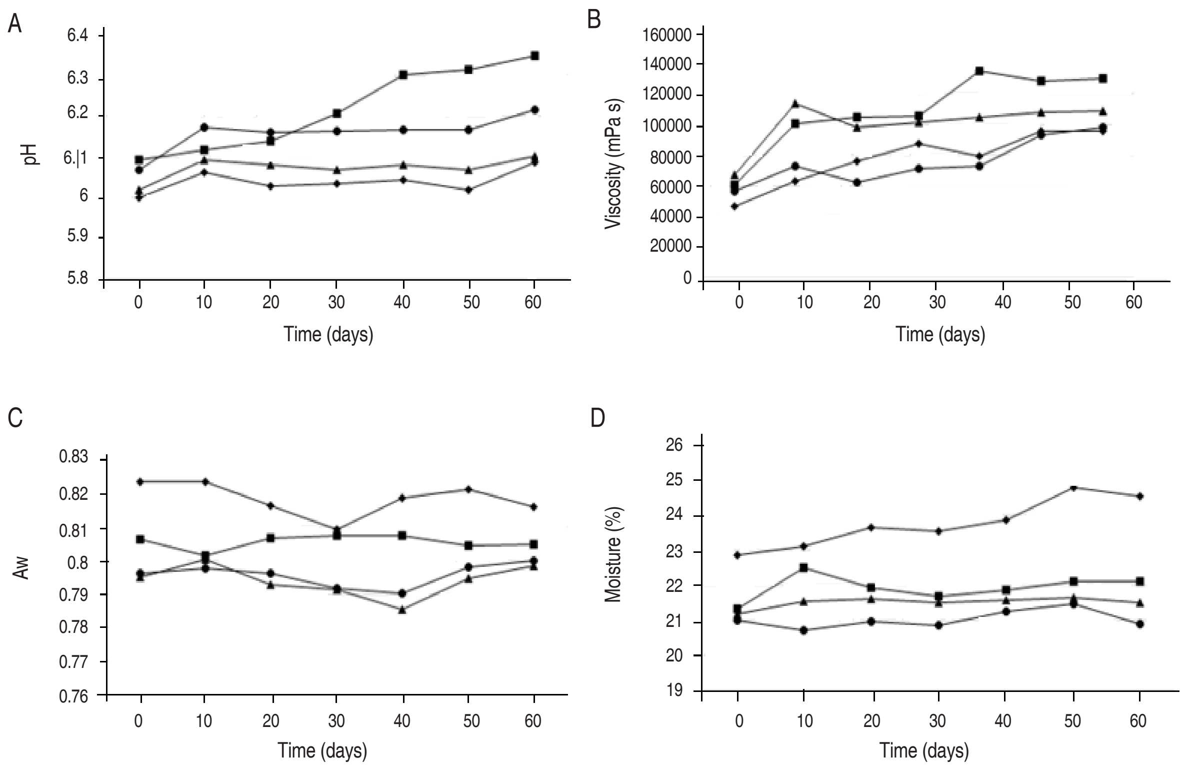

Figure 4. Stability properties of milk caramel spread sweetened with GGS at different concentrations during 60 days of storage under environmental conditions. 0% GGS (■), 10% GGS (●), 20% GGS (▲), 30% GGS (♦). A. pH; B. Apparent Viscosity; C. Water Activity; D. Moisture Content.

It was observed that the values of water activity (A_w) changed from 0.8013 to 0.8072 for the sample without GGS, 0.7904 to 0.8000 for the addition of 10% GGS; in the case of 20% GGS, it was from 0.7855 to 0.8002, and finally between 0.8091 and 0.8233 for the 30% substitution. Although in several cases, there were significant differences (*P*<0.05), the results did not show a defined behavior. The moisture content increased with time (*P*<0.05); that is, during the storage time at room temperature, the product was able to capture moisture from the environment because the milk caramel spread was not hermetically sealed with an aluminum film although it is noted that on day 60, it did not reach the maximum value allowed by NTC 3757 reported at 30%.

The average values for the CIELab color parameters in different formulations of milk caramel spread with GGS are given in Table 3. The L* value significantly increased in formulations of milk caramel spread of 10% GGS and 20% GGS at the end of the storage period, while 0% GGS and 30% GGS decreased. The values a* differ significantly (*P*<0.05) among the different formulas of milk caramel spread, a measure that elapsed the storage time; there was an increase in this parameter for all samples, becoming browner (Table 3). This characteristic of color in milk caramel spread could be associated with the possible presence of compounds derived from the Maillard reaction. The b* value also presented statistically significant differences (*P*<0.05) at the end of the 60 days of storage, this value is lower on the last day for the sample of 0% GGS and 30% GGS; on the other hand the samples with 10 and 20% GGS showed an increase, this phenomenon is also explained by the possible presence of derivatives of the Maillard reaction because this sweetener has reducing sugars and undergoes high temperatures during its preparation.

Table 3. CIELab color parameters of the milk caramel spread containing GGS at different concentrations for 60 days of storage at 25 °C and 60% of relative humidity.

CIELab Parameter	Time (d)	Sample			
		0GGS	10GGS	20GGS	30GGS
L*	0	54.66 (±0.90) a	38.28 (±0.02) a	34.85 (±0.05) a	36.24 (±0.03) a
	10	46.81 (±1.97) b	40.05 (±0.19) ab	37.71 (±2.74) b	33.96 (±1.35) ab
	20	45.99 (±0.84) bc	35.27 (±0.39) c	32.55 (±1.36) ac	30.48 (±2.11) c
	30	51.39 (±1.08) a	41.90 (±1.40) b	34.17 (±1.43) Acd	31.64 (±1.57) bcd
	40	46.69 (±1.79) bcd	38.31 (±0.22) abd	33.20 (±2.17) acde	31.48 (±1.20) bcde
	50	39.50 (±2.60) e	36.23 (±0.72) c	34.05 (±0.59) acdef	34.24 (±3.24) abdef
	60	47.04 (±3.04) bcd	39.34 (±2.27) abd	35.63 (±1.12) abdef	34.01 (±0.86) abdef
a*	0	1.98 (±0.05) a	6.84 (±0.02) a	7.47 (±0.02) a	7.94 (±0.05) a
	10	2.28 (±0.08) b	7.78 (±0.09) b	8.35 (±0.50) b	8.81 (±0.24) b
	20	2.50 (±0.04) c	6.85 (±0.06) a	7.66 (±0.17) ac	7.58 (±0.36) ac
	30	2.66 (±0.07) d	8.61 (±0.37) c	8.14 (±0.05) acd	8.09 (±0.04) acd
	40	2.85 (±0.09) e	8.05 (±0.19) bd	8.48 (±0.38) bde	8.00 (±0.32) acde
	50	3.26 (±0.03) f	7.61 (±0.17) b	8.72 (±0.25) be	7.28 (±0.54) c
	60	3.04 (±0.15) g	8.18 (±0.23) d	8.11 (±0.33) bcd	8.36 (±0.17) abde
b*	0	24.15 (±0.80) a	19.62 (±0.01) a	17.25 (±0.02) a	16.22 (±0.02) a
	10	19.20 (±0.17) b	21.92 (±0.19) b	19.01 (±1.95) ab	18.30 (±1.03) b
	20	19.28 (±0.42) bc	17.39 (±0.25) c	16.40 (±0.63) ac	14.32 (±0.89) c
	30	21.58 (±0.77) d	24.13 (±1.37) d	18.29 (±0.08) abd	15.94 (±0.24) ad
	40	19.46 (±0.48) bc	21.33 (±0.62) be	18.49 (±0.84) abde	15.05 (±0.43) acde
	50	17.82 (±0.89) e	19.37 (±0.65) a	19.12 (±0.82) bde	13.46 (±1.04) c
	60	21.35 (±1.17) d	21.26 (±0.23) be	17.25 (±1.37) abcde	15.67 (±0.38) ade

Average values with the same lowercase letters in the same column indicate that there are no significant differences between different formulations based on Fisher's test (*P*<0.05).

CONCLUSIONS

The glucose-galactose syrup can be used as a sweetener for the elaboration of milk caramel spreads considering the sensory, physicochemical, and stability analysis. The maximum recommended level is 30% of inclusion concerning the sweetness. GGS syrup influences the increase in the levels of magnesium and potassium. The texture was also achieved at lower soluble solids, increasing the product yield as the percentage of inclusion increases; therefore, it is important for cost reduction. In GGS, the content of reducing sugars significantly influenced the Maillard reactions altering the color and pH of the product, causing a darker brown color. During the storage period, milk caramel spreads have a shelf life of at least 60 days.

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