Frozen yogurt from sheep milk

Elisangela de Abreu[1], *Jamile Zeni*[2], *Clarice Steffens*[2*], *Juliana Steffens*[2]

10.1590/0034-737X201663050003

ABSTRACT

The aim of this work was to develop frozen yogurt formulations from powdered yogurt of sheep milk, through an experimental design of 2², with a triplicate at the central point. The variables studied were emulsifier/stabilizer (0.50%, 0.75%, and 1.00%) and powder for cream (2.75%, 3.00% and 3.25%). The parameters evaluated were sensory characteristics, texture, and microbiological counts. The results showed that the formulations had counts of *S. aureus* and fecal coliforms at 45 °C, lactic acid bacteria and *Salmonella* sp within the limits established by legislation. Instrumental analysis of texture-related parameters (firmness, cohesiveness, adhesiveness, and consistency) of the formulations with different concentrations of emulsifier/stabilizer and cream powder showed no significant differences (p > 0.05). In sensory analysis, Formulations 3 and 4 with lower concentrations of emulsifier/stabilizer scored the highest values, thus indicating good acceptability.

Key words: emulsifying, stabilizing, sensorial analysis, texture.

RESUMO

Frozen yogurt a partir de leite de ovelha

Este trabalho teve como objetivo desenvolver formulações de *Frozen Yogurt* a partir do iogurte em pó de leite de ovelha por meio de planejamento experimental 2², com triplicata no ponto central. As variáveis estudadas foram emulsificante/estabilizante (0,50%, 0,75% e 1,00%) e pó preparo para creme (2,75%, 3,00% e 3,25%) e as respostas foram em termos de características sensoriais, microbiológicas e análise instrumental de textura. Os resultados mostraram que as formulações apresentaram contagem de *S. aureus*, coliformes termotolerantes a 45 ºC, bactérias láticas e *Salmonella* sp de acordo com os limites estabelecidos pela legislação. Em relação a análise instrumental de textura todos os parâmetros avaliados (firmeza, coesividade, adesividade e consistência) nas formulações com diferentes concentrações de emulsificante/estabilizante e o pó preparado para creme não apresentaram efeito significativo (p > 0,05). Por meio da análise sensorial as formulações 3 e 4 com menor concentração de emulsificante/estabilizantes foram as que apresentaram maiores pontuações para aceitação global, assim apresentando uma boa aceitabilidade.

Palavras-chave: emulsificante, estabilizantes, Análise sensorial, Textura.

Submitted on June 23th, 2015 and accepted on June 10th, 2016.

[1] SENAI, Florianópolis, Santa Catarina, Brazil. elisangela@sc.senai.br
[2] Universidade Regional Integrada do Alto Uruguai e das Missões, Departamento de Ciências Agrárias, Programa de Pós-Graduação em Engenharia de Alimentos, Erechim, Rio Grande do Sul, Brazil. jamilezeni@uricer.edu.br; clarices@uricer.edu.br; julisteffens@uricer.edu.br
*Corresponding author: clarices@uricer.edu.br

INTRODUTION

Interest in frozen yogurt consumption has been on the increase because of its nutritional properties. Furthermore, it is an alternative to ice cream for people who suffer from obesity, cardiovascular disease, and lactose intolerance because of its low fat and lactose content compared to ice cream (Pinto *et al.*, 2012).

Frozen yogurt is manufactured by subjecting milk to lactic acid fermentation using *Lactobacillus bulgaricus* and *Streptococcus thermophiles* cultures, with or without the addition of other foodstuffs, followed by aeration and freezing (Brasil, 2005). This product combines the cooling sensation of ice cream with the nutritional value of yogurt (Tamime & Robinson, 2007). However, yogurt is highly susceptible to microbial growth because of the ease of degradation. One way to extend the shelf life is dehydration, which drastically reduces the water activity and prevents the growth of microorganisms.

Lyophilization and atomization are the processes used for yoghurt dehydration. It is essential to study the viability of the beneficial bacteria in yogurt powder to assess the damage caused by the drying process and to establish drying temperature, to optimize the drying conditions (Mishra & Kumar, 2004). Yogurt powder has the advantage of longer shelf life without refrigeration and can be used later for the development of frozen yogurt formulations.

Adding value to a traditional product along with making use of a different raw material such as sheep milk, gives special characteristics to frozen yogurt, because sheep's milk contains high concentration of total solids (Mckusick *et al.*, 2002), including lipids and casein. Therefore, the aim of the present study was to develop frozen yogurt formulations using yogurt powder from sheep milk, characterize it microbiologically and sensorily, and assess the product texture.

MATERIALS AND METHODS

Preparation of yogurt powder

Ten liters of pasteurized whole milk from sheep of the Lacaune race, produced at Cabanha Chapecó, located in Chapecó / SC, Brazil, was used to produce the yogurt. The yogurt was prepared in accordance with the methodology of Tamime & Robinson (2007), with modifications. The milk was heated to 45 °C, inoculated with 2% mesophilic thermophilic starter *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (CHR-HANSEN) and kept in 2 L terephthalate containers for 5 h in a water bath at 45 °C. During the fermentation, the pH was monitored using a pH meter (Micronal) and maintained at 4.6, which is the isoelectric point of casein. The yogurt was cooled in a chamber (Sotronic) at 4 °C. Subsequently, the sheep milk yogurt was distributed in plastic trays of 200 g capacity and frozen (Consul) at -18 °C for 24 h. The trays were removed and placed in a lyophilizer (Edwars) at -40 °C for 48 h, following the procedure by Mishra & Kumar (2004). The resulting yogurt powder was packed in metal containers with sealing wax, stored at room temperature for further development of frozen yogurt formulations.

Development of Frozen Yogurt

The frozen yogurt formulations were developed using a central composite design 2^2 with triplicate at central point, to determine the emulsifier/stabilizer concentration (0.5 to 1%) and cream powder (2.75 to 3.25%) variables. Although these two components are added in minimal amounts relative to the other ingredients, these are crucial to obtain a suitable texture.

The formulations were prepared by reconstituting yogurt powder with mineral water in the proportion of 77.25% yogurt to 22.75% water (homogenized for 2 min in an industrial mixer (Caicara)), until complete dissolution. Next were added sugar, glucose powder, natural yogurt flavor, emulsifier/stabilizer, and cream powder and homogenized for 1 min, according to the methodology described by Gonçalves & Eberle (2008) and Alves *et al.*. (2009). The mixtures were placed in ice cream maker (Maqsoft) and stir/freeze during 5 min at -10 °C. The frozen yogurt was packaged in terephthalate containers (2L) and frozen in cold chamber (Solid) at -18 °C for 24 h.

Microbiological analysis

The sheep milk yogurt was assessed for total coliforms at 30 °C, thermotolerant coliforms at 45 °C, lactic acid bacteria, yeasts and molds, and *Salmonella* sp. The sheep milk yogurt powder was evaluated for thermotolerant coliforms at 45 °C, lactic acid bacteria, *Bacillus cereus*, *Staphylococcus aureus*, and yeasts and molds. *Frozen Yogurt* formulations were assessed for thermotolerant coliforms at 45 °C, lactic acid bacteria, yeasts and molds, *Staphylococcus aureus* and *Salmonella* sp. All analyses were performed in triplicate.

The total coliform count at 30 °C was performed according ISO 4832 (2006). Serially diluted samples were inoculated into sterile petri plates and plating in depth with the addition of crystal violet neutral red bile agar (Acumedia), with slow mixing of the inoculum using a horizontal circular motion. After the culture medium solidified, the plates were incubated at 30 ± 1 °C in an incubator (Binder) for 24 ± 2 h.

The thermotolerant coliform count at 45 °C was determined as described by IN Nº. 62 (Brazil, 2011). The method was based on presumptive evidence and involved inoculation of the sample diluted with violet red bile agar - VRBA (Acumedia). The suspected colonies were submitted to confirmatory test, and inoculated in *Escherichia coli* - EC (Merck) broth, and incubated at 45 °C in a water bath with shaking (Marconi) for 48 h.

Lactic acid bacteria count was determined using ISO 7889 (2003) method. Serial sample dilutions were inoculated in sterile petri plates. *Lactobacillus delbrueckii* subsp. *bulgaricus* count was conducted by plating in depth with MRS agar (Acumedia) and *Streptococcus thermophilus* count by in depth plating with M17 agar. The inoculum was mixed slowly with a circular motion. After the culture medium solidified, the plates with *Lactobacillus delbrueckii* subsp. *bulgaricus* were incubated inverted in an anaerobic jar at 37 °C in an incubator (Binder) for 72 h and *Streptococcus thermophilus* plates were also incubated in a 37 °C incubator (Binder) for 48 h.

The yeast and mold counts were carried out according to ISO 6611 (2004) method. Serial sample dilutions were inoculated into sterile petri plates, held in depth with the plating agar containing Yeast extract / dextrose / oxytetracycline (OXOID), mixing the inoculum slowly with circular motion. After solidification, the plates were incubated at 25 °C in an incubator (Tecnal) for 5 d.

The *Bacillus cereus* count followed the methodology described by ISO 7932 (2004). Serial dilutions were inoculated into sterile petri plates by surface plating on MYP Agar (Acumedia), carefully spreading the inoculum with Drigalski handle. The plates were incubated at 30 ± 1 °C in an incubator (Binder) for 24 h.

Staphylococcus aureus count was performed according to ISO 6888-1 (1999). Serial dilutions were surface-plated in sterile petri dishes containing Baird-Parker agar (Acumedia). The plates were incubated at 37 ± 1 °C in an incubator (Binder) for 48 h.

The analysis of *Salmonella* sp. was performed using VIDAS equipment according to the methodology described by AOAC (2011). Samples were pre-enriched and incubated at 35 ± 1 °C in an incubator (Binder) for 22 h. After the pre-enrichment, Rappaport Vassiliadis broth with soy - RVS (Merck) and selenite cystine broth (Merck) were added. The RVS medium was incubated at 41.5 ± 1 °C in a water bath with shaking (Marconi) for 24 h and the selenite cystine medium in an incubator (Binder) at 37 ± 1 °C for 24 h, after which the VIDAS test® was performed.

Sensory analysis

The sensory analysis of the frozen yogurt was performed with 50 untrained tasters, to assess the global acceptance and buying intention. These tests were approved by the ethics committee of the Universidade Regional Integrada do Alto Uruguai e das Missões- URI-Erechim - registry by the number of N°: 37328314.3.0000.5351, and a written consent was signed by all participants.

The global acceptance evaluation was performed using a 9-point hedonic scale anchored with: 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely; and purchase intention was anchored with 1 = buy, 2 = would not buy, 3 = may buy.

Instrumental Analysis of Texture

Frozen yogurt formulations were also evaluated for the parameters of firmness, adhesiveness, cohesiveness, and consistency. The texture properties were determined by Texture machine TA-XT2 Plus (SMS), using a cylindrical stainless steel probe of 6 mm diameter (POR / 6), pretest speed 2.0 $mM.s^{-1}$, test speed of 2.0 $mM.s^{-1}$, post-test speed of 2.0 $mM.s^{-1}$, in 5 s with 20 mm distance.

Statistical analysis

The results of the physico-chemical analyses were subjected to Tukey's test at 5% significance for comparison between the means. All statistical analyses were performed using Statistic 8 0 (StatSoft Inc®, USA) software.

RESULTS AND DISCUSSION

Microbiological characterization

Sheeps milk yogurt

The sheep milk yogurt was characterized with respect to total coliform count at 30 °C, coliforms at 45 °C, lactic acid bacteria and yeasts and molds, as specified by the Normative Instruction N° 46, which establishes the Technical Regulation of Identity and Quality of Fermented Milks, MAPA (Brazil, 2007). The *Salmonella* sp. detection standards are provided by Technical Regulation of Microbiological Standards for Food, established by Resolution RDC Nº 12, of Brazil (2011). The results of the microbiological characterization of the sheep milk yogurt are shown in Table 1.

For the fermented milk to be considered as yogurt by IN Nº. 46 of MAPA (Brazil, 2007), the lactic acid bacteria count must be at least 10^7 CFU/g. Thus, the sheep milk yogurt prepared in this study was in accordance with the regulation, which had a count of 2.0×10^9 CFU/g. Lower values (5.8×10^7 CFU/g) were obtained by Finco *et al.*, (2011) in cow milk yogurt after a day of processing. These high values are important because the lactic acid bacteria act by competitive exclusion and synthesis of antagonistic substances such as organic acids, diacetyl, hydrogen peroxide, and bacteriocins, which inhibit or retard the proliferation of spoilage bacteria and pathogens (Alexandre *et al.*, 2002; Chesca *et al.*, 2009).

The total coliform count at 30 °C, thermotolerant coliform count at 45 °C, and yeasts and mold count in the yoghurt were within the limits established by the legislation, indicating that the yogurt has been prepared under hygienic conditions.

The *Salmonella* sp analysis is a qualitative assay that indicates the absence or presence of *Salmonella*. The RDC Nº 12 (Brazil, 2001) standard requires the absence of this microorganism. The yogurt prepared in this study conformed to the parameters established by the Brazilian legislation.

Sheep milk yogurt powder

Table 2 presents the microbiological characterization of the yogurt powder made from sheep milk. The limits established in the DRC Nº 12 (Brazil, 2001) for *Bacillus cereus*, coliforms at 45 ° C, *Staphylococcus aureus*, and coagulase-positive *Salmonella* sp. are 5×10^3 CFU/g, 10 CFU/g, 10^2 CFU/g, and absent, respectively. The results for the yogurt powder as shown in Table 2 are in accordance with the limits established by the DRC.

The lactic acid bacteria count in yogurt powder (Table 2) was 2 logs lower, compared to sheep milk yogurt (Table 1). This reduction may be associated with the low temperature used during the drying process (lyophilization at - 40 °C), which affects the survival of the bacteria.

Sheep milk yogurt powder produced by the lyophilization method had 4.0×10^7 CFU/g lactic bacteria, which is in conformance with the minimum requirement of 10^7 CFU/g lactic acid bacteria as specified by IN Nº 46 MAPA (Brazil, 2007). Similar values were found by Krasaekoopt & Bhatia (2012), who obtained 5.6×10^7 CFU/mL of lactic acid bacteria in cow milk yogurt powder produced by foam layer drying.

Frozen Yogurt

Table 3 shows the results for microbiological analyses of frozen yogurt formulations obtained by central composite design 2^2 with triplicate at central point.

The microbiological standards established by RDC Nº12 (Brazil, 2001) for iced milk are a maximum of 5×10^1 CFU/g, 5×10^2 CFU/g and 0/25g, for coliform, *Staphylococcus aureus*, and *Salmonella* sp, respectively. All frozen yogurt formulations developed in this study have values below those specified in the legislation, thus meeting the recommended microbiological requirements.

Lactic acid bacteria count declined by 2 logs when the sheep's milk yogurt was dehydrated to yogurt powder, from 10^9 CFU/g to 10^7 CFU/g. Frozen yogurt also had 10^7 CFU/g lactic acid bacteria, similar to that of sheep milk yogurt powder. Corte (2008) found 2.2×10^8 CFU/g to 1.2×10^9 CFU/g lactic bacteria in frozen yogurt made from cow milk yogurt supplemented with prebiotic (inulin), calcium caseinate and probiotics. Isik *et al.*, (2011) found a count of 8×10^8 CFU/g in cow milk yogurt fortified with inulin and isomalt. Thus, it can be seen that frozen yogurt prepared from sheep milk yoghurt powder manufactured by a dehydration process, retained a count of 2×10^7 CFU/g. The presence of viable lactic acid bacteria in fermented milk products has a beneficial effect on the health of the consumers. However, the effects can be realized only when the count per gram is maximum. According to Penna (2002), for a probiotic product to have beneficial effect, the minimal count of viable beneficial bacteria must be 10^6 CFU/g. Thus, the frozen yogurt formulations developed in this work have beneficial effects on consumer health.

Instrumental Analysis of Texture

The texture analysis may be performed using appropriate equipment (instrumental) or sensorially. According to the ISO standard (1992), texture is the set of mechanical properties, geometry, and surface detectable by mechanical and touch receptors and possibly by visual and auditory receptors. The food texture is sometimes the deciding factor for consumer acceptability, in addition to flavor and aroma. Thus, evaluation of the product texture serves several purposes for the food industry, which

Table 1: Microbiological characterization of sheep's milk yogurt

Analysis	Sheep's milk yogurt	Legislation
Total Coliforms at 30 ºC (CFU/g)	< 1.0 x 10	10^2
Thermotolerant coliforms at 45 ºC (CFU/g)	< 1.0 x 10	10
Lactic Bacteria (CFU/g)	2.0×10^9	$>10^7$
Yeast and molds (CFU/g)	< 1.0 x 10	2×10^2
Salmonella sp. (Absence/25g)	Absence	Absence

Table 2: Microbiological characterization of sheep's milk yogurt powder

Analysis	Sheep's milk yogurt powder
Bacillus cereus (CFU/g)	3.7×10^2
Thermotolerant coliforms at 45 ºC (CFU/g)	< 1.0 x 10
Staphylococcus aureus coagulase positive (CFU/g)	< 1.0 x 10
Lactic bacteria (CFU/g)	4.0×10^7
Salmonella sp. (Absence/25g)	Absence

include the control of raw material and the manufacturing process, changing ingredients or equipment when required, quality control of finished product, development of new products, and making changes to formulation (Alves *et al.*, 2009; Souza *et al.*, 2010). The instrumental texture analysis includes the evaluation of consistency, firmness, adhesiveness, and cohesiveness.

Table 4 shows the results of instrumental analysis of texture of the frozen yogurt formulations manufactured according to central composite design 2^2, with triplicate at central point. Different formulations scored similar values for cohesiveness. However, formulations with higher concentration of emulsifier/stabilizer scored higher for consistency and firmness (Formulation 1). Stabilizers are macromolecular compounds that are hydrated thoroughly with water and form colloidal solutions. The formation of a three-dimensional network and hydrogen bonds prevents water mobility (Early, 2004), thus yielding higher values, as in Formulation 1.

It was found that the lowest quantity of emulsifier/stabilizer and powder cream in the formulations resulted in higher stickiness (Formulation 3).

Table 3: 2^2 matrix of the central composite design and the response of the microbiological analysis of the frozen yogurt

Formulations	Independent Variables*		Dependent Variables			
	X_1	X_2	*S. aureus* (CFU/g)	Thermotolerant coliforms at 45 ºC (CFU/g)	Lactic bacteria (CFU/g)	*Salmonella* sp (Absence 25 g)
1	1 (1.00)	-1 (2.75)	1 x 10^2	1 x 10^1	2 x 10^7	Absence
2	1 (1.00)	1 (3.25)	1 x 10^2	1 x 10^1	2 x 10^7	Absence
3	-1(0.50)	-1 (2.75)	1 x 10^2	1 x 10^1	2 x 10^7	Absence
4	-1(0.50)	1 (3.25)	1 x 10^2	1 x 10^1	2 x 10^7	Absence
5	0 (0.75)	0 (3.00)	1 x 10^2	1 x 10^1	2 x 10^7	Absence
6	0 (0.75)	0 (3.00)	1 x 10^2	1 x 10^1	2 x 10^7	Absence
7	0 (0.75)	0 (3.00)	1 x 10^2	1 x 10^1	2 x 10^7	Absence

*Independent variables: X_1: Emulsifier/Stabilizing (%); X_2: Prepared powder to cream (%). Fixed variables: Sucrose (8%); Glucose powder (3%); Natural yogurt flavor (1%).

Table 4: 2^2 matrix of the central composite design and the response of the instrumental analysis of texture from the frozen yogurt

Formulations	Independent Variables*		Dependent Variables			
	X_1	X_2	Firmness	Stickiness (g.s)	Cohesiveness	Consistency (g.s)
1	1 (1.00)	-1(2.75)	12622.18	-2480.23	0.147	104132.29
2	1 (1.00)	1(3.25)	5565.41	-2462.71	0.137	40875.83
3	-1 (0.50)	-1(2.75)	3999.34	-2123.07	0.132	31113.38
4	-1 (0.50)	1 (3.25)	5008.93	-2640.22	0.166	38016.09
5	0 (0.75)	0 (3.00)	4312.74	-2349.08	0.111	36388.74
6	0 (0.75)	0 (3.00)	4340.35	-2310.67	0.120	37412.57
7	0 (0.75)	0 (3.00)	4402.91	-2204.80	0.120	37502.81

*Independent variables: X_1: Emulsifier/Stabilizing (%); X_2: Prepared powder to cream (%). Fixed variables: Sucrose (8%); Glucose powder (3%); Natural yogurt flavor (1%).

Table 5: 2^2 matrix of the central composite design and the response of the global evaluation and purchase intention of frozen yogurt

Formulations	Independent Variables *		Response**	
	X_1	X_2	Global evaluation	Purchase intention
1	1 (1.00)	-1 (2.75)	5.88[b]	3.04[b]
2	1 (1.00)	1 (3.25)	5.90[b]	3.46[b]
3	-1 (0.50)	-1 (2.75)	6.84[a]	3.96[a]
4	-1 (0.50)	1 (3.25)	7.06[a]	4.00[a]
5	0 (0.75)	0 (3.00)	5.24[c]	2.94[b]
6	0 (0.75)	0 (3.00)	5.26[c]	2.85[b]
7	0 (0.75)	0 (3.00)	5.32[c]	2.92[b]

*Independent variables: X_1: Emulsifier/Stabilizing (%); X_2: Prepared powder to cream (%);

**Means followed by the same lowercase letters on column no represents significant difference at 5% level (Tukey's test).

Firmness can be defined as the force required to resist strain, and indicates the structural stiffness of the product. Firmer the sample, greater is the force required to shear it (Tunick, 2000). None of the independent variables studied (emulsifier/stabilizer prepared and powder cream) had significant effect on the firmness of the frozen yogurt at 95% confidence level, as shown in Figure 1. These variables had no effect on the product because of the small quantities added to the formulation. Firmness is affected more by the composition, particularly the protein and sugar content, and the efficacy of the freezing process (Hartel, 2001).

Various studies have reported that the addition of purple rice bran oil had no effect on the firmness and texture of frozen yogurt prepared from cow milk (Sanabria, 2012). On the other hand, another study on cow milk frozen yogurt containing a carbohydrate fat substitute reported greater firmness, which was significant at 95% confidence level (Pinto *et al.*, 2012). The authors state that the fat substitute decreases the formation of ice crystals and promotes the formation of a gel network, thus enhancing the firmness of the product.

Adhesiveness is the work required to overcome the forces of attraction between the food product and other

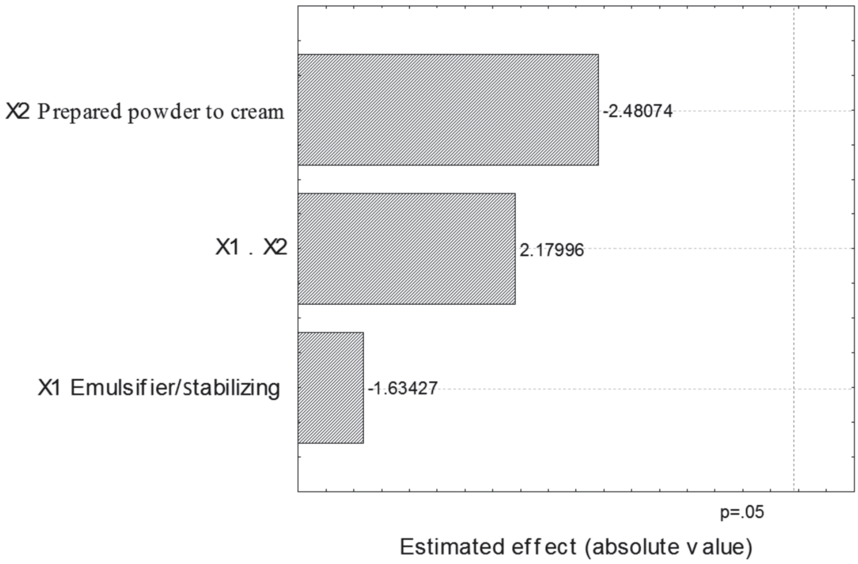

Figure 1: Pareto chart of the firmness of frozen yogurt

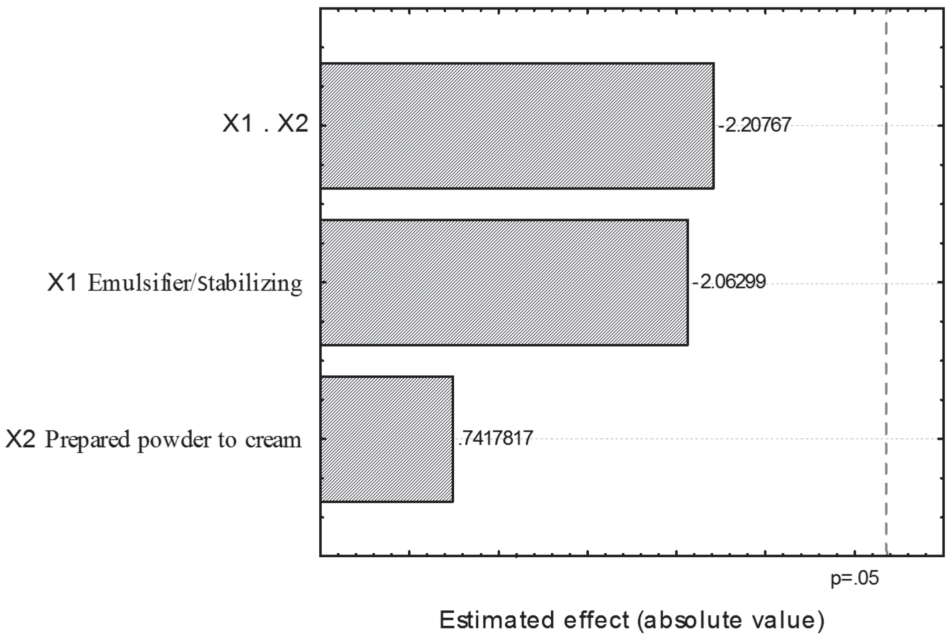

Figure 2: Pareto chart of the adhesiveness of frozen yogurt

surface, and often indicates stickiness (Alves *et al*., 2009; Souza *et al*., 2010; Sanabria, 2012) of the product. The increased adhesiveness is the result of the formation of a more viscous gel (Gel Nagar *et al*., 2002). The emulsifier/stabilizer variables and the prepared powder cream had no significant effect at a significance level of 95% (Figure 2) in the frozen yogurt formulations developed in this study.

Cohesiveness refers to the forces involved in the internal connections in the product (Antunes *et al*., 2004). It was observed that the cohesiveness was not significantly altered in frozen yogurt, as shown in Figure 3. These results demonstrate that the formulations have acceptable characteristics.

The independent variables studied had no significant effect on the consistency (Figure 4) of frozen yogurt at the 95% confidence level. This shows that the quantity of emulsifier/stabilizer added and powder cream are suitable for such formulations. Excessive amounts of these ingredients would make the product more viscous, sticky, and thicker. Another component that can affect the structural aspects of the product is fat. Excessive fat content affects the rheological and melting properties. An increase in the degree of fat clustering reduces the melting rate and increases the viscosity (Tharp *et al*., 1998).

Sensory analysis

The sensory analysis of food is of critical importance for defining the sensory quality of food, assessing consumer acceptance of the developed product, and maintaining consumer loyalty in an increasingly competitive market (Teixeira, 2009). Table 5 shows the 2^2 matrix of the experimental design and the responses to the overall evaluation and purchase intention for frozen yogurt.

In this overall assessment of the samples, the calculated F was 17.60, higher than the tabulated F of 2.13, indicating significant difference between the

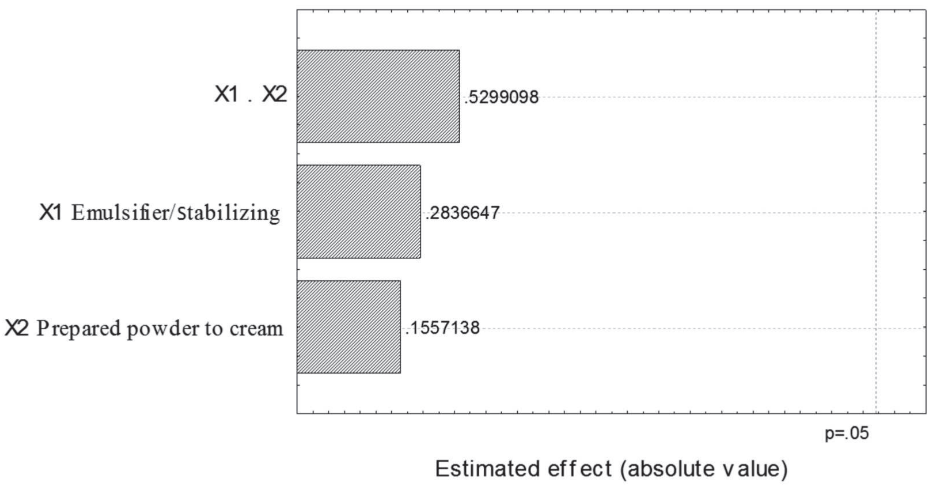

Figure 3: Pareto chart of the cohesiveness of frozen yogurt

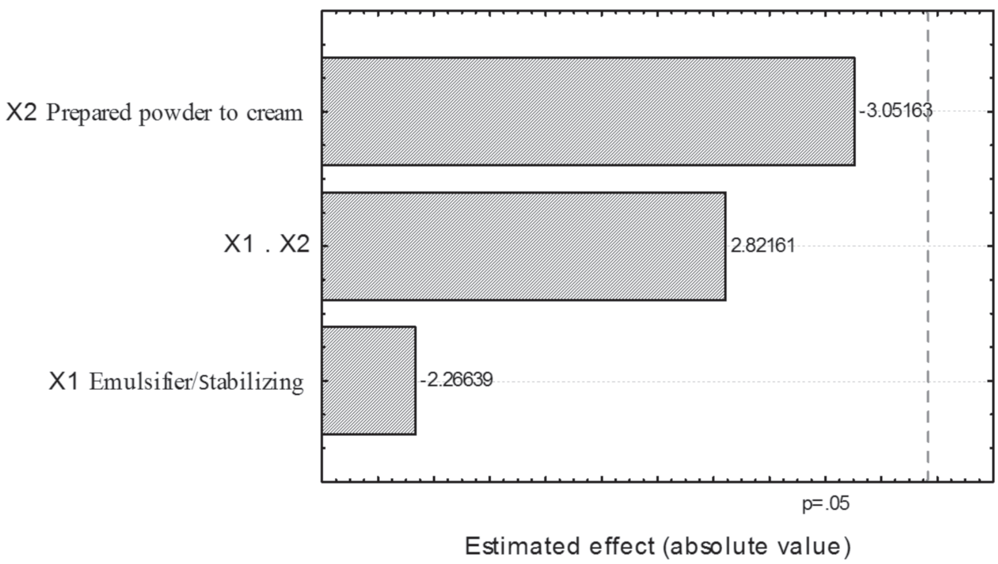

Figure 4: Pareto chart of the consistency of frozen yogurt

samples at a significance level of 5%. For tasters, the calculated F was 6.64, higher than the tabulated F of 1.40 also indicating significant difference between the samples at a significance level of 5%.

Formulations 3 and 4 scored moderately higher for global acceptance, indicating significant difference over other formulations at 95% confidence level, thus presenting good acceptability. These formulations were developed with lower emulsifier/stabilizer content and did not leave an aftertaste like the other formulations did, as reported by the panelists.

In purchase intent, the calculated F for the samples was 17.06, higher than the tabulated F of 2.13, indicating significant difference among the samples at a significance level of 5%. For tasters, calculated F was 2.16, higher than the tabulated F of 1.41, also indicating significant difference among the samples at a significance level of 5%.

Formulations 3 and 4 scored higher in buying intentions, with a significant difference over other formulations. Thus, these formulations (3 and 4) were the most accepted receiving the highest scores compared to the tasters.

CONCLUSIONS

The results of microbiological quality and sensory acceptance analyses demonstrate the feasibility of producing frozen yogurt from sheep milk yogurt powder. Firmness, cohesiveness, adhesiveness, and consistency were similar for all the variables studied (emulsifier/stabilizer and the prepared powder to cream) without affecting ($p > 0.05$) the formulation. In the global acceptance analysis, formulations 3 and 4 with lower concentrations of emulsifier/stabilizer scored the highest.

ACKNOWLEDGEMENTS

The authors thank CNPq, CAPES, FAPERGS, Senai and URI-Erechim for the financial support for this research.

REFERENCES

Alexandre DP, Silva MR, Souza MR & Santos WLM (2002) Atividade antimicrobiana de bactérias lácticas isoladas de queijo-de-minas artesanal do Serro (MG) frente a microorganismos indicadores. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 54:424-428.

Alves LL, Richards NSPS, Becker LV, Andrade DF, Milani LI, Rezer APS & Scipioni GC (2009) Aceitação sensorial e caracterização de frozen yogurt de leite de cabra com adição de cultura probiótica e prebiótico. Ciência Rural, 39:2595-2600.

Antunes AEC, Cazetto TF & Bolini HMA (2004) Iogurtes desnatados probióticos adicionados de concentrado proteico do soro de leite: perfil de textura, sinérese e análise sensorial. Alimentos e Nutrição Araraquara, 15:107-114.

AOAC International (2005). Official Method 996.08 Salmonella in Foods, Enzyme-linked immunofluorescent assay screening method (VIDAS Salmonella [SLM] Assay). 19th ed, p. 158-160. Chapter 17, 17.9.14A.

Brasil (2001) Resolução RDC Nº 12 de 2 de janeiro de 2001. Aprova o regulamento técnico sobre os padrões microbiológicos para alimentos. DOU, 02/01/2001, Seção 1, p.174.

Brasil (2005) Resolução RDC Nº 266 de 23 de setembro de 2005. Aprova o regulamento técnico para fixação de identidade e qualidade de gelados comestíveis e, preparados para gelados comestíveis, pós para o preparo e bases para gelados comestíveis. DOU, 23/09/2005, Seção 1, p. 370.

Brasil (2007) Instrução Normativa Nº 46 de 23 de outubro de 2007. Aprova o regulamento Técnico de Identidade e Qualidade de Leites fermentados. DOU, 23/10/2007, Seção 1, p.4.

Brasil (2011) Instrução Normativa Nº 62 de 29 de dezembro de 2011. Regulamento Técnico de Produção, Identidade e Qualidade do Leite tipo A, de Leite Cru Refrigerado, de Leite Pasteurizado e o Regulamento Técnico da Coleta de Leite Cru Refrigerado e seu Transporte a Granel. DOU, 30/12/2011, Seção 1, p.13.

Chesca AC, Castro HK, Silveira M & D'Angelis CEM (2009) Atividade Antimicrobiana de Bactérias Lácticas Isoladas de Queijos de Baixa Umidade Frente a *Staphylococcus aureus* ATCC6538 e *Listeria monocytogenes* ATCC7644. Higiene Alimentar, 23:123-128.

Corte FFD (2008) Desenvolvimento de Frozen Yogurt com propriedades funcionais. Dissertação de Mestrado. Universidade Federal de Santa Maria, Santa Maria. 100p.

Early R (2004) Tecnologia de los produtos lácteos. Zaragoza, Acribia. 459p.

Finco AMO, Garmus TT, Bezerra JRMV & Córdova KRV (2011) Elaboração de iogurte com adição de farinha de gergelim. Ambiência Guarapuava, 7:217-227.

Gel-Nagar G, Clowes G, Tudoricã CM & Kuri V (2002) Rheological quality and stability of yog-ice cream with added inulin. International Journal Dairy Technology, 55:89-93.

Gonçalves AA & Eberle IR (2008) Frozen yogurt com bactérias probióticas. Alimentos e Nutrição, 19:291-297.

Hartel RW (2001) Crystallization in Foods. Gaithersburg, Aspen Publishers Inc. 325p.

Isik U, Boyacioglu D, Capanoglu E & Erdil DN (2011) Frozen yogurt with added inulin and isomalt. American Dairy Science Association, 94:1647-1656.

ISO 4832 (2006) Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coliforms – Colony-count technique. ISO 4832:2006. International Standardization Organization ed., Geneva, Switzerland.

ISO 6611 (2004) IDF 94:2004. Milk and milk products – Enumeration of colony-forming unit of years and/or moulds – Colony-count technique at 25 degrees C. Disponível em: <http://www.iso.org/iso/catalogue_detail.htm?csnumber=40473>. Acessado em: 12 de Abril de 2016.

ISO 6888-1 (1999) Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) - Part 1: Technique using Baird-Parker agar medium. Disponível em: <http://www.iso.org/iso/catalogue_detail.htm?csnumber = 23036>. Acessado em 26 de Janeiro de 2016.

ISO 7889 (2003) Yogurt – Enumeration of characteristic microorganisms – Colony-count technique at 37 degrees C. Disponível em: <http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31880>. Acessado em: 12 de Abril de 2016.

ISO 7932 (2004) Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of presumptive Bacillus cereus – Colony-count technique at 30 degrees C. Disponível em: <http://www.iso.org/iso/catalogue_detail.htm?csnumber=38219>. Acessado em: 08 de Fevereiro de 2016.

ISO 5492 (1992) Sensory Analysis – Vocabulary. Disponível em: <http://www.iso.org/iso/catalogue_detail?csnumber=38051>. Acesado em: 08 de Fevereiro de 2016.

Krasaekoopt W & Bhatia S (2012) Production of yogurt powder using foam-mat drying. AU Journal Technology, 15:166-171.

McKusick BC, Thomas DL, Berger YM & Marnet PG (2002) Effect of milking intervals on alveolar versus cisternal milk accumulation and milk production and composition in dairy ewes. Jounal of Dairy Science 85:2197-2206.

Mishra NH & Kumar P (2004) Yoghurt power – a review of process technology, storage and utilization. Food and Bioproducts Processing, 82:133-142.

Penna ALB (2002) Probióticos: uma alternativa para o setor lácteo. In: 18º Congresso Brasileiro de Ciência e Tecnologia de Alimentos, Porto Alegre. Anais, SBCTA. p.4045-4050.

Pinto SS, Carlise BF-F, Muñoz IB, Barreto PLM, Prudêncio ES & Amboni RDMC (2012) Effects of the addition of microencapsulated Bifidobacterium BB-12 on the properties of frozen yogurt. Journal of Food Engineering, 11:563-569.

Sanabria LAA (2012) Development of a frozen yogurt fortified with a nano - emulsion containing purple rice bran oil. Doctoral Thesis. Louisiana State University, Baton Rouge. 85p.

Souza JCB, Costa MR, Rensis CMVB & Sivieri K (2010) Sorvete: Composição, processamento e viabilidade da adição de probiótico. Alimentos e Nutrição, 21:155-165.

Tamime AY & Robinson RK (2007) Tamime and Robinson's yoghurt: science and technology. 3ª ed. Cambridge, CRC Press. 791p.

Tharp BW, Forrest B, Swan C, Dunning LE & Hilmoe M (1998) Basic factors affecting ice cream meltdown. In: Proceedings of the International Symposium held in Athens, Belgium. p.54-64.

Teixeira LV (2009) Análise sensorial na indústria de alimentos. Revista Laticínio Cândido Tostes, 366:12-21.

Tunick MH (2000) Rheology of dairy foods that gel, stretch, and fracture. Journal of Dairy Science, 83:1892-1898.