Dairy Products Production with Buffalo Milk

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Abstract

This research was carried out to evaluate the physical-chemical and sensorial characteristics of dairy products (yogurt and ice cream) elaborated with buffalo milk. Five formulations were developed and the treatments were: F1 = cow milk (100%); F2 = cow milk (50%) + buffalo milk (50%); F3 = cow milk (30%) + buffalo milk (70%); F4 = cow milk (70%) + buffalo milk (30%); F5 = buffalo milk (100%). For cow and buffalo milk, it was determined the acidity (°D), density at 15°C, fat and protein contents and viscosity. The dairy products were evaluated on: pH, acidity, percentages of fat and protein, viscosity and sensorial acceptance test with nine points hedonic scale and purchase intent. The obtained results, submitted to Anova and Tukey Test with significance level of 5% revealed that partial replacing cow milk by buffalo milk is suitable, for yogurt. For ice cream, the entire replacing is viable.

Keywords: buffalo milk, yogurt, ice cream, sensorial acceptance, physical-chemical

1. Introduction

Buffalo milk constitutes over 12% of the global milk production (FAO, 2013), and it provides more energy per unit volume than provided by cow's milk due to its higher fat and protein content. Besides, if compared with cow's milk, buffalo milk is richer in fat and produces a milk with a higher percentage of proteins (Cunha Neto et al., 2005; Guerra et al, 2005;Vieira et al, 2008; Rodrigues et al., 2008; Buzi et al., 2009).

The lower heat capacity and the higher thermal conductivity and thermal expansion of buffalo milk clearly indicate that a lower amount of heat energy is required to achieve certain desired heat effects in buffalo milk as compared to cow's milk. Therefore, time–temperature combinations for its heat processing may have to be standardized and suitably modified to get the desired effect. (Sindhu and Arora, 2011).

Although Mozzarella cheese is the main product, buffalo milk is well used for fluid milk supply, fermented products (like yogurt), fat-rich dairy products (like cream and butter), heat desiccated and acid-coagulated products (casein, and caseinate), ice cream, and dairy whitener, due to total solids higher content, and larger size of the casein micelles and fat globules (Teixeira et al, 2005; Andrighetto et al, 2005; Lopez, 2005; Czerwenka et al, 2010; Dalmasso et al, 2011; Vieira, 2011). For these manufactured products, the basic raw material is the raw buffalo milk, which is used in the unit operations, such as pumps, agitation, heat exchanger and separations.

For such industrial processes to be technically and economically feasible, it is important to have the knowledge of the physical–chemical properties.

Among these properties, the rheological behavior is one of the most important, being useful not only as quality measure, but also in projects, evaluation and operation of the process equipment (Ibarz et al., 1996; Nindo, 2007). Most fluid foods do not have the simple Newtonian rheological model; in other words, their viscosities are independent of shear rate or shear stress and not constant with temperature. Therefore, it is necessary to develop more complex models to describe their behavior (Holdsworth, 1971). Some of the most widely used rheological models are the Power Law with two parameters, the Casson with two parameters plus the yield stress, and the Mizrahi–Berk (M–B) with three parameters and yield stress (Pelegrine et al, 2002).

This research was carried out to evaluate the applicability of the buffalo´s milk in order to develop dairy products (yogurt, cheese and ice cream), as well to analyze the physical-chemical and sensorial characteristics of these products.

2. Method

Dairy products were prepared using buffalo and cow's milk in several proportion, lactic culture (in yogurt case), strawberry flavor and stabilizers (for ice cream). The milk samples were analyzed through physicochemical analysis of pH (Adolfo Lutz, method N. 4.7.1), acidity (Adolfo Lutz, N.4.7.2°D), density at 15°C (A.O.A.C., 1980 – Method 16196), fat content (Bligh and Dyer, 1959), protein content (A.O.A.C., 1980 – Method 380120) and viscosity (Singh and Heldman, 2003), in a capillary viscometer (model LV).

For yogurt processing, the milk samples, composed by whole cow milk and buffalo milk in different proportions, were added with sucrose (7 g/100 mL), stirred and heated to 43° C in water bath (Tecnal, Dubnoff). Once reached this temperature value, the milk was inoculated with 1.5g/100 g of the lactic culture (composed by *Streptococcus salivarius subsp. thermophilus*and *Lactobacillus delbrueckii subsp. Bulgaricus*, conceded by Rhodia), in order to start the fermentation process. Then, passed 30 minutes, the bath temperature was adjusted to 40ºC and the heating process discontinued when observed a compact coagulum, without becoming serous. The yogurt formulations were added with strawberry flavor, in 1% proportion of the total mass.

For ice cream process, the milk samples were mixeds with sucrose, butter oil, stabilizers (neutral alloy and emulsion forming) and strawberry flavor, in following proportion: milk sample (65%), sucrose (17%), butter oil (16%), lecithin (1%) and neutral alloy (1%). The ingredients were homogenizeds in industrial blender (Metvisa, LQ-25) during 5 minutes and stored under refrigeration in a soft ice cream machine (Brasfrio).

The dairy products were evaluated on pH (Adolfo Lutz, method N. 4.7.1), acidity (Adolfo Lutz, N.4.7.2°D), density at 15°C (A.O.A.C., 1980 – Method 16196), fat content (Bligh and Dyer, 1959), protein content (A.O.A.C., 1980 – Method 380120) and viscosity (Singh and Heldman, 2003), in cylindrical Brookfield viscometer (model LV). The products were also evaluated on sensorial acceptance test with nine point hedonic scale and purchase intent; the samples were served in codified (with three numeral) discardble white glass and sensorial attributes evaluated were: flavor, color, appearance and texture. The results were submitted to Anova and Tukey Test with significance level of 5%.

3. Results and Discussion

Physico-chemical properties of cow and buffalos milk, as well as for yogurt formulations are presented in Table 1.For ice cream formulations, these results are in Table 2; these analyses were all carried out in triplicate. Each value expressed Tables 1 and 2 represent the repetitions average, and the values in parentheses are the standard deviation, for each analysis.

Table 1: Physicochemical Characteristics of Cow Milk, Buffalo Milk and Yogurt Samples

Product	Cow milk	Bufalo milk	yogurt				
			F.I	F.II	F.III	F.IV	F.V
pH	6.82 (0.02)	6.89 (0.01)	5.31 (0.02)	5.35 (0.05)	5.28 (0.03)	4.80 (0.03)	5.01 (0.00)
Acidity (%)	1.78 (0.11)	1.81 (0.09)	0.54 (0.03)	0.52 (0.00)	0.53 (0.04)	0.59 (0.01)	0.68 (0.02)
Density (g/mL)	1.027 (0.08)	1.035 (0.06)	--	--	--	--	--
Fat content (%)	2.71 (0.20)	5.99 (0.17)	3.33 (0.17)	4.40 (0.21)	5.32 (0.09)	4.66 (0.13)	5.88 (0.11)
Protein contents (%)	2.29 (0.07)	3.84 (0.09)	2.61 (0.16)	2.79 (0.30)	3.18 (0.13)	2.98 (0.23)	2.71 (0.24)

F1 = cow milk (100%); F2 = cow milk (50%) + buffalo milk (50%); F3 = cow milk (30%) + buffalo milk (70%); F4 = cow milk (70%) + buffalo milk (30%); F5 = buffalo milk (100%).

Table 2: Physicochemical Characteristics of Cow Milk, Buffalo Milk and Ice Cream Samples

Product	Cow milk	Bufalo milk	Ice cream				
			F.I	F.II	F.III	F.IV	F.V
pH	6.82 (0.02)	6.89 (0.01)	5.88 (0.06)	5.38 (0.07)	5.37 (0.08)	4.93 (0.03)	5.24 (0.08)
Acidity (%)	1.78 (0.11)	1.81 (0.09)	0.48 (0.06)	0.51 (0.05)	0.49 (0.02)	0.51 (0.00)	0.63 (0.04)
Density (g/mL)	1.027 (0.08)	1.035 (0.06)	--	--	--	--	--
Fat content (%)	2.71 (0.20)	5.99 (0.17)	4.00 (0.02)	4.86 (0.08)	5.89 (0.11)	4.97 (0.10)	6.00 (0.08)
Protein contents (%)	2.29 (0.07)	3.84 (0.09)	2.99 (0.10)	3.02 (0.28)	3.89 (0.08)	3.26 (0.37)	3.01 (0.14)

F1 = cow milk (100%); F2 = cow milk (50%) + buffalo milk (50%); F3 = cow milk (30%) + buffalo milk (70%); F4 = cow milk (70%) + buffalo milk (30%); F5 = buffalo milk (100%).

It can be noted, by Tables 1 and 2, that the fat and protein average content in buffalo and cow´s milk were superior, respectively, in 121% and 67.7%. These results are in agreement with the results obtained by Verruma and Salgado (1994) and Wong et al. (1996). The dairy products with higher content of buffalo milk showed reduced pH and higher acidity, according with the results obtained by Minhas et al (2002).

Shear stress, shear rate and absolute viscosity values, for cow and buffalo´s milks, are in Tables 3.

Table 3: Viscosity Data for cow and Buffalo´s Milk

τ (PA)	γ (S^{-1})	μ (PA.S)	γ (S^{-1})	μ (PA.S)
1.77	1327.58	0.0134	1491.78	0.001852
2.00	1472.40	0.00136	1410.14	0.00178
2.28	1628.95	0.00140	1294.24	0.001726
2.53	1793.91	0.00141	1171.23	0.001671
2.76	1908.67	0.00145	1034.44	0.001625

It can be observed, from Table 3, that the viscosity values, for each shear stress value didn´t varied significantly, for both, which can be concluded that both raw milk behaves as a Newtonian fluid. Similar results were observed by Changani et al (1997) and Morison et al (2013).

The values of yogurt and ice cream´s apparent viscosity can be visualized in Figures 1 and 2.

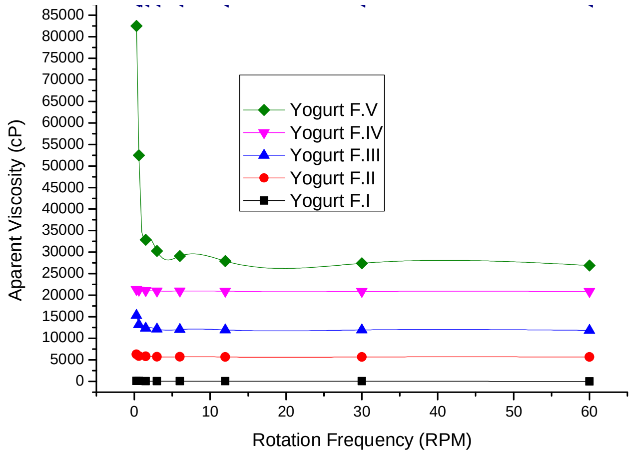

Figure 1: Rheological Properties of Yogurt Samples, Elaborated with Buffalo Milk

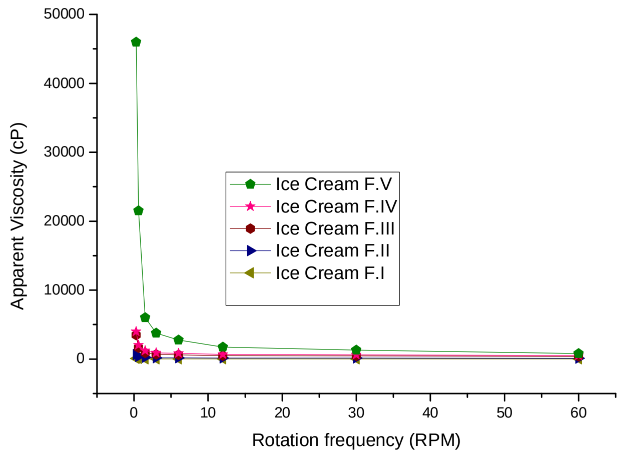

Figure 2: Rheological Properties of Ice Cream Samples, Elaborated with Buffalo Milk

The results, expressed in Figures 1 and 2, show that, for both products, the apparent viscosity decreases with increase in rotation frequency (this property directly proportional to the shear rate), denoting pseudoplastic behavior, conforming Minhas et al (2002), Gomes et al (2009), Lee and Lucey (2010) and Rossa et al (2011). The yogurt, despite the pseudoplástic behavior, presented certain thixotropy, since the apparent viscosity decreased, for the same formulation, between the three subsequent measurements; this thixotropy is, probably, due to suspended particles sedimentation. Mathias et al (2011) also achieved this conclusion when analyzed rheological behavior in coffee-flavored yogurt with different types of thickener.

Tables 4 and 5 presents the sensory evaluation results

Table 4: Sensory Evaluation of Yogurt Samples, Elaborated with Buffalo Milk

	F.I	F.II	F.III	F.IV	F.V
Color	5.73^a	4.27^a	4.87^a	4.83^a	3.63^a
Appearance	6.17^a	4.23^b	4.90^a	5.37^a	3.46^b
Flavor	6.27^a	4.53^a	4.83^a	5.17^a	3.23^a
Texture	6.30^a	4.40^a	4.97^a	5.23^a	3.40^b

Table 5: Sensory Evaluation of Ice Cream Samples, Elaborated with Buffalo Milk

	F.I	F.II	F.III	F.IV	F.V
Color	7.87^a	7.43^a	7.86^a	7.70^a	7.90^a
Appearance	7.73^{ab}	7.30^a	7.70^{ab}	7.50^a	8.23^b
Flavor	7.77^a	7.20^a	7.70^a	7.47^a	8.20^a
Texture	7.87^{ab}	7.20^a	7.86^{ab}	7.47^a	8.23^b

Table 4 denotes that, for color, flavor and texture, there was no statistical difference observed between the formulations I, II, III and IV. Regarding with appearance, the formulations I, III, and IV, presented best acceptance and were statistically equal. Up to the sample with 70% of buffalo milk resulted in statistically equal to organoleptic characteristics of cow's milk. Thus, replacing cow milk by buffalo milk in yogurt samples can be partially, but not entirely, on product nutritional enrichment.

Regarding ice cream, results in Table 5 show that the sample prepared only with buffalo milk (F.V) had higher approval, although no statistical difference observed, with respect to color and flavor. For appearance and texture, this sample also was the most accepted, but differed from the others. Consequently, for ice cream producing, buffalo milk can substitute entirely cow milk, for all attributes.

Thus, the samples selected for purchase intention analysis were: with buffalo milk 70% (F.III) for yogurt and 100% buffalo milk (F.V) for ice cream. Figure 3 presents purchase intent results, for these samples.

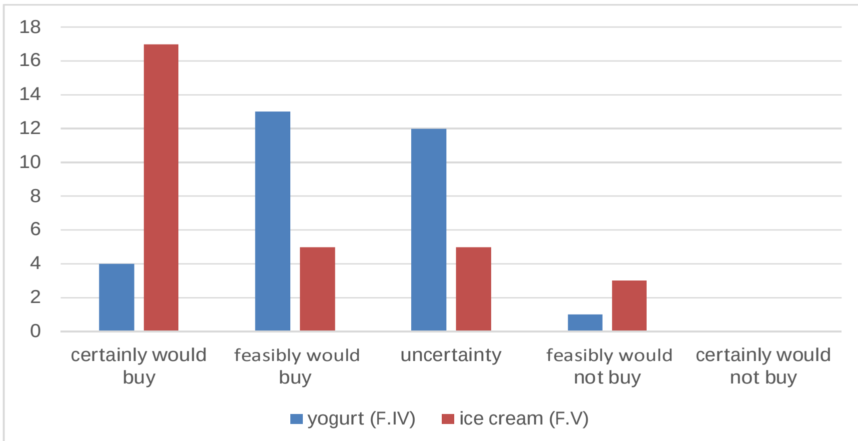

Figure 3: Purchase Intention Histograms of Rheological Properties of Yogurt and Ice Cream Samples

It can be noted, from Figure 3, that ice cream presented best acceptance, since 73% of tastes certainly or feasibly would by the product, in comparison with yogurt, such acceptance resulted in 57%.

4. Conclusion

From results presented in previous items, it could concluded that, according with Changani et al (1997) and Fox et al (1998), buffalo milk presents higher fat and protein content than cow's milk. Respecting rheological behavior, even cow as buffalo´s milk showed Newtonian behavior, once the viscosity values remained constant, for all shear stress values.

On other hand, all samples (yogurt and ice cream) presented pseudoplástic behavior and, for yogurt samples, showed some thixotropy. Many researchers achieved same conclusions in analyzing dairy rheogocial behavior that, according Singh and Helman (2003), present shear thinning behavior because are liquids that appear homogeneous, but actually contain microscopic particulates submerged in it. When these liquids are subjected to a shear, the randomly distributed particles may orient themselves in the direction of flow.

Relating sensory analysis results, Tables 4 and 5 shows that nutritional enrichment in partial (but not entire) replacing cow milk by buffalo milk is viable, on yogurt preparing is viable. For ice cream, buffalo milk can become a good cow milk substitute, once its acceptance sensorial was higher of the same product drawn from cow's milk.

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