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Valorization of milk whey as a dairy beverage adapted to processing in rural settlements

Valorização do soro de leite como bebida láctea adaptada para processamento em assentamentos rurais

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Abstract: Even though with an average productivity of 4,5 liters/animal/day, milk production is very common in the Brazilian rural area as a stable food subsistence and food security activities. Considering the difficulties of storage, milk is also used in the process of dairy, resulting in whey as its residue. This research aimed to valorize the products of family farming by developing and studying the shelf life of a dairy beverage based in mozzarella cheese whey. According to the Brazilian legislation, a milk beverage is a product derived from the blend of milk (at list 51% of the total ingredients) and whey, with others food ingredients. The whey used was collected in a commercial dairy installed in a rural settlement located 20 kilometers from the laboratory, and it presented the appropriate characteristics of use according to the Brazilian standards, with suitable physicochemical and microbial values. The formulation has been adjusted to suit production as an appropriate technology for small producers and to allow the beverage to be sold as school lunch. The organoleptic attributes allowed to select a formulation, flavored with passion fruit pulp and cooked cassava paste as a thickener ingredient, both easily found in rural settlements. The shelf life of the pasteurized and refrigerated beverage (5°C) was monitored for 21 days, with no significant variations in pH, acidity, total coliform, aerobic mesophilic, psychrotrophic and yeast/mold counts, and without fecal coliforms. In relation to its organoleptic attributes, the beverage obtained a total average of 7.4 with a good acceptance by the tasters, fact that can collaborate for sale in specific family farming Brazilian National School Feeding Program.

Keywords: Thickener, Agroindustry, Organoleptic attributes, Passion fruit, Cassava.

Resumo: Embora com produtividade média de 4,5 litros/animal/dia, a produção de leite é muito comum no meio rural brasileiro como atividade de subsistência e segurança alimentar. Em razão das dificuldades de armazenamento é também comum seu processamento em queijos, resultando o soro como resíduo. A pesquisa teve como objetivo o desenvolvimento e estudo de vida de prateleira de bebida láctea de soro de queijo mozarela, valorizando os produtos da agricultura familiar. De acordo com a legislação brasileira as bebidas lácteas são misturas de leite (pelo menos 51% do total de ingredientes) com o soro, com outros ingredientes adicionados. O soro foi coletado em laticínio comercial localizado em um assentamento rural a 20 km do laboratório e apresentou as características adequadas segundo a legislação brasileira, com adequados valores físico-químicos e microbianos. A formulação foi ajustada para adequar-se à produção em pequenas agroindústrias da zona rural de forma a permitir ser comercializado em merenda escolar. Os atributos organolépticos permitiram selecionar uma formulação, saborizada com polpa de maracujá e massa de mandioca cozida como espessante, ambos os ingredientes facilmente encontrados em assentamentos rurais. A vida de prateleira da bebida pasteurizada e refrigerada (5°C) foi acompanhada por 21 dias, sem que fossem observadas grandes variações do pH, acidez ou na contagem de coliformes totais, aeróbios mesófilos, psicrotróficos e leveduras/bolores, sem contagem para coliformes fecais. Nos atributos organolépticos a bebida obteve a média geral de 7,4, com boa aceitação por parte dos provadores, o que poderá colaborar para venda em programas de apoio à agricultura familiar como o Programa Nacional de Alimentação Escolar.

Palavras Chave: Espessante, Agroindústria, Atributos organolépticos, Maracujá, Mandioca.

Introduction

In Dairy farms, whey is obtained at the proportion of 1 liter per 9 kilograms of cheese mass, which turns it the main byproduct of this activity. Whey is composed of 93.6% of water and, 0.55% of protein, lactose, and minerals (Robins et al., 1996). Its composition maintains a good proportion of the milk nutrients, such as 5.0% lactose and 0.9% proteins of high biological value, characterizing an excellent source of low-cost proteins (MAWSON, 1994).

Despite this, in Brazil, the whey obtained from cheese production is still not properly used.

Thus, a large volume remains without adequate treatment, ending up being wasted as a liquid effluent, creating social, economic and environmental damages (OLIVEIRA, 2006). For this reason, small dairies and producers face difficulties with the excess of whey produced (ANDRADE; MARTINS, 2002).

The National Commission of Milk Livestock reports that in the Brazilian states of Mato Grosso do Sul and Ceará, the price paid per liter of milk to the producers do not cover the total production costs. Since the producers' income is lower than the total production cost, small dairies are unable to replenish the machinery and improve their production, having difficulties to cover the costs of labor, food, inputs, medicines, and other items. Some issues are also found in milk storage, for instance, the production of milk in settlements, where it is common several families to store their product in only one shared cooler. The main problem related to this fact is that in the dry months when the milk production is lower than in the rainy season, this cooler may need to be shut down because there is not enough milk production (CORRÊA et al., 2010).

The Brazilian Ministry of Agriculture and Livestock states that milk must be cooled to a temperature of 4 ° C or less no more than three hours after the end of milking. This limiting requirement reduces the time that producers have to deliver milk to dairy and forces many of them to opt for cheese production, which is a way of adding value to milk and reducing its perishability (BRASIL, 2011).

In Brazil, the production of dairy beverages is one of the main options for the use of whey. Among the most commercialized products are the fermented milk drinks, which present sensorial characteristics similar to yogurt and unfermented ones (CAPITANI et al., 2005).

The Brazilian legislation defines a milk beverage as the product resulting from the mixing of milk and whey, added or not with food grade ingredients such as vegetable fat, fermented milk, selected milk ferments and other dairy products. The milk fraction may be *in natura*, pasteurized, sterilized, UHT, reconstituted, concentrated, powdered, whole, semi-skimmed or partly skimmed and skimmed. The whey fraction can be liquid, concentrated and powdered. The milk base should represent at least 51% by weight of the beverage total ingredients. As supplements, the beverage can contain optional non-dairy ingredients, such as sugars, maltodextrin, sweeteners, fruit cuts/pulp/juice, honey, cereals, vegetables, vegetable fats, chocolate, dried fruit, coffee, spices, natural or innocuous flavorings and/or flavors, modified starches or starches, gelatin or other components (BRASIL, 2005).

Food additives are ingredients intentionally added to foods, not intended for nourishment, but for the purpose of modifying their physical, chemical, biological or sensory characteristics. Among these additives, the thickeners are used as a way to increase the viscosity of a food (ANVISA, 1997). They are widely used in the food industry because thickening or increasing viscosity can promote emulsion stabilization, particle suspension, crystallization control, inhibition of syneresis, encapsulation and film formation (PENNA, 2002). For instance, the starch extracted from cassava has specific properties, which makes it preferred in various food processes, where its properties are attributable to the amylose/amylopectin ratio, glycosidic linkages, and granular structure. Another thickener commonly used in industries is cellulose (FONTAN, 2008).

Consumers demand healthier, innovative, safer and more practical products, and the combination of dairy products and with a healthy image has led to growth in this food sector, chiefly because of the consumption increase of the dairy beverages, which have become popular (ACHANTA et al., 2007).

The Brazilian National School Feeding Program (PNAE) aims to improve public health and food security, mainly by stimulating new markets and food supply policies, becoming an ally in the formation of new eating habits. At the same time, this program also aims to stimulate rural development, contributing in some municipalities to increase school meals and encourage the production of local family farming (REAL e SCHNEIDER, 2011)

The production of a milk whey drink could be a solution that adds value to this byproduct and can increase the income of small farmers. It is a drink with a high nutritional value very used in the feeding of children, with the potential to be included in school meals.

Hence, the research aims to valorize whey cheese by developing a dairy beverage and establishing its shelf life by using soft technology level processing.

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Material and methods

Whey collection

200 liters of fresh whey were collected in a commercial dairy with the capacity to process 3 to 4 thousand liters/day and transform this amount in mozzarella cheese. This dairy is a family farming property located in the Settlement Conquista, in the city of Campo Grande, Mato Grosso do Sul, about 20 km far from the laboratory where all analyses were carried out. The whey was collected and immediately brought to the laboratory. A sample was collected for analysis and the remainder stored under freezing at -15 ° C until the time of the beverage formulation.

Beverage formulation

To comply with the legislation (BRASIL, 2005), the milk beverage consisted of 40% reconstituted milk powder standardized at 3% fat and 26% whey. To this base, 13% of fresh passion fruit pulp, 13% of cooked yellow pulp cassava roots and 8% of sugar were added. The formulation was prepared in an industrial blender where all ingredients were blended together for 3 minutes. Then the mixture was packed in 250ml glass bottles and pasteurized as described by Agricultural Research Company of Minas Gerais (EPAMIG). The bottles were immersed in a water bath (Fisatom) and heated until the center of the bottle reached 90 ° C, remaining at that temperature for 5 minutes. Subsequently, it was stored in a refrigerator at 5 ° C (EPAMIG, 2010) until the evaluation of its shelf life and organoleptic attributes.

The pasta obtained from cooked cassava roots was used as a thickening ingredient due to its availability in the rural environment, also helping to accentuate the drink final color due to its yellow flesh. The tastant selected by previous acceptance test was the fresh yellow passion fruit pulp (*Passiflora edulis*) because it has a persistent aroma and improves the appearance of the drink. According to Faleiro (2016), this passion fruit is a common product of family farming, usually in organic production.

Physicochemical analysis

The whey was characterized for pH, titratable acidity expressed as lactic acid, DORNIC acidity, moisture, ash and protein contents (Micro-Kjedahl Method) as (HORWITZ, 2005). The fat was obtained by the Bligh-Dyer Method (BLIGH and DYER, 1959) and the carbohydrates as total reducing sugars by the Somogyi-Nelson method (SOMOGYI, 1945; NELSON, 1944). The milk beverage was characterized using the same methods as required by Brazilian legislation (BRASIL, 2005). All analyses were performed in triplicate.

Microbial analysis

The microbial analysis of whey and milk drink followed the methodology established by APHA - American Public Health Association (RICE, 2012), with all counts made in triplicate at each dilution, for the following groups: counting of thermotolerant coliforms at 45 ° C using the Most Probable Number (MPN) method in three tube series, inoculating 1 ml of the dilutions 10^{-1}, 10^{-2} and 10^{-3}. For yeasts and molds and mesophilic microorganisms, surface plating was performed, expressing the count in Colony Forming Unit (CFU / ml). For the microbial control in the milk beverage in the shelf life study, the count of psychrotrophic microorganisms was realized by surface plating. For the microbial control in the milk beverage in the shelf life study, the count of psychrotrophic microorganisms was realized by surface plating. In the whey, the presence of Lactobacillus was verified using the plating in depth and, for its confirmation, Gram staining and characterization under the optical microscope were used.

Sensory analysis

The evaluation of the organoleptic attributes of the beverage was performed as a tool to monitor the characteristics necessary to establish the palatability of the product but without the intention of establishing market acceptability. It was performed by 10 trained tasters, who evaluated the general acceptance of the beverage, using the hedonic scale of nine points, with the extremes: (1) for extremely displeased and (9) greatly enjoyed. Color, flavor, texture, aroma, and appearance were also evaluated, as a way to validate the instrumental analyses, but without intention to establish consumption intensity. All the tasters were volunteers in the research and signed a consent term, agreeing to carry out the evaluation of the drink.

Shelf-life

The shelf-life of the beverage evaluated the variation of the physicochemical and microbial characteristics at 0, 7, 14 and 21 days after production, under storage in domestic

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refrigeration at 5 ° C (OLIVEIRA, 2006). In the storage, the values of pH and acidity in lactic acid were recorded according to the norms of the HORWITZ, (2005). The counts of mesophilic microorganisms, psychrotrophs, yeasts and molds, and coliforms were based on the methods cited by Rice, (2012) and expressed in Colony Forming Units (CFU/ml). The average validity of a milk beverage with these characteristics is a maximum of 30 days (EPAMIG, 2010).

Statistical analysis

From the results in triplicate, the mean and standard deviation (σ) were calculated. A comparison of means of the characteristics of the whey used as raw material and the dairy beverage was performed through the Tukey's test at 5% probability, using the statistical program Statsoft 13.3 (2016). The same procedure was applied to the analysis of the beverage shelf life, including analysis of variance. The average of the sensorial analysis scores from all tasters for each organoleptic attribute was calculated by the same program.

Results and discussion

The characterizations of the whey used and of the final beverage are compared in Table 1. The results show that all the characteristics increased significantly in the dairy beverage as a result of the inclusion of ingredients in the whey, except the moisture. The addition of milk in the beverage formulation increased the amount of lactic acid present, which consequently increased the DORNIC acidity, and also contributed to protein and fat content increases. The added ingredients caused a slight increase in pH, while the addition of sugar in the formulation caused an accentuated increase in the total carbohydrates content in the final dairy beverage.

Table 1. Physico-chemical characteristics of whey compared to the freshly prepared dairy beverage.

Analysis	Unities	Whey	Dairy beverage
Moisture	(%)	93,25±0,05 $_a$	75,08±0,44 $_b$
pH	-Log [H+]	3,62±0,02 $_b$	3,87±0,02 $_a$
DORNIC acidity	(°D)	87,00±1,00 $_b$	130±0,00 $_a$
Lactic acid	(%)	0,56±0,004 $_b$	1,54±0,00 $_a$
Ash	(%)	0,54±0,01 $_b$	0,76±0,01 $_a$
Fat	(%)	0,58±0,04 $_b$	0,82±0,02 $_a$
Protein	(%)	0,83±0,00 $_b$	2,33±0,02 $_a$
Total carbohydrates	(%)	4,97±0,40 $_b$	21,01±0,35 $_a$

Averages in a row with equal letters did not differ significantly ($p < 0.05$).

The amounts of each main component used in the formulation (21.01 g carbohydrate, 2.33 g protein, and 0.82 g fat) allow estimating the nutritional value of the milk beverage in 100.74 kcal or 1 kcal.g -1, when calculated using food composition tables (FRANCO, 2007).

The mean values for whey are similar to those found by Pelegrine (2008), which characterized the whey obtained from cheese processing, using it to enrich protein drinks. The values of pH and fat of the dairy beverage are similar to those found by Santos (2008) for a fermented beverage with umbu (*Spondias tuberosa* sp.) pulp, also formulated with whey from the mozzarella cheese production, which was fermented with a thermophilic culture for yogurt. The mean values of pH and fat found by the author were respectively 3.67 ± 0.35 and 0.78 ± 0.39.

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The whey characterization confirms it as an acidic product with mean pH values of 3.62 and acidity of 86.33 ° D, probably an indication of natural fermentation. Martin et al. (2016) also observed a decrease in pH in whey that was exposed to a temperature in the range of 20°C to 50°C, which allowed the growth of fermentative microorganisms. In our research, the whey was also exposed to room temperature, although for a short period of time what should have stimulated a natural fermentation.

In the whey analyzed by an optical microscope, it was observed the presence of lactic bacteria, which confirms the natural fermentation, by the microorganisms present in it, making the use of milk ferments unnecessary in the beverage formulation, which is an advantage in the case of production in rural areas.

Microbial analyses of whey and dairy beverage show that both met the hygiene standards selected by the Brazilian law (BRASIL, 2005). The coliform count at 45 ° C expressed in NMP/ml indicated a value lower than 3 coliforms/ml, for both the milk beverage and whey, within the maximum limit allowed by the dairy beverage legislation, which is 100 coliforms/ml. In the mesophilic microorganisms count, the presence of mobile *Bacillus* sp. hampered plate counting. There was no yeasts and molds in the whey and in the dairy beverage.

The results of acidity expressed as lactic acid during the storage period at 5°C showed no significant difference over the storage time but when expressed as pH the values varied over 21 days, initially with increases, followed by fall and finally ending with an increase, as can be observed in Table 2.

Table 2. Variation of pH and acidity expressed as lactic acid of the dairy beverage sample for 21 days of storage at 5 ° C.

Days	pH	Acidity expressed as lactic acid (%)
0	3,87±0,020 $_{bc}$	1,0629±0,008 $_{a}$
7	3,91±0,020 $_{ab}$	1,0775±0,009 $_{a}$
14	3,84±0,011 $_{c}$	1,0839±0,006 $_{a}$
21	3,94± 0,005 $_{a}$	1,0785±0,062 $_{a}$
CV%	1,06	3,66

Averages in a column with equal letters did not differ significantly ($p < 0.05$).

From the results obtained it can be stated that the microbial content did not change during 21 days of storage, with the total number of coliforms stabilized in the same range of the microbial analysis performed when the beverage was prepared, as well as psychrotrophic microorganisms and yeasts and molds. Mesophilic aerobes occurred in both whey and dairy beverage but their counting was impaired by the misshapen colonies.

The organoleptic attributes presented a small variation of 0.6 points in the mean scores of each attribute, as can be observed in Figure 1, but the same did not occur in relation to the evaluation of the tasters, where a three-point variation was observed in all attributes, with the lowest score of six and the highest of nine points.

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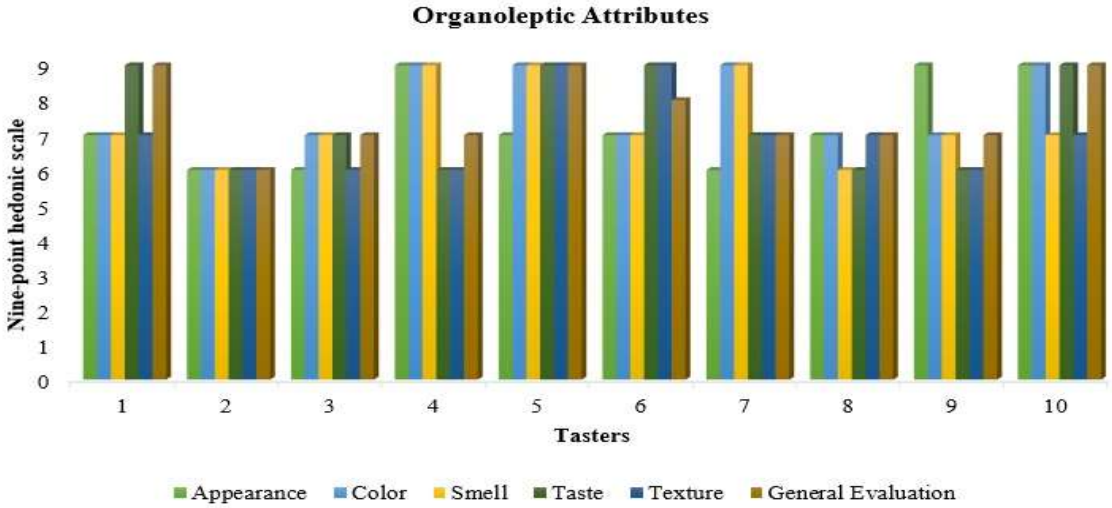


Figure 1: Scores attributed to dairy beverage, according to the nine-point hedonic scale as given by the 10 tasters.

The control analyses showed that the beverage could be consumed in up to 21 days, a much longer time than expected for an appropriate technology, authorizing its consumption within the Brazilian standards, which is a positive factor to its commercialization in the National School Feeding Program.

Conclusion

The results allowed to conclude that it is possible to obtain a dairy beverage with good organoleptic characteristics, using as raw material reconstituted milk powder, naturally fermented cheese whey, yellow passion fruit pulp, sugar and cooked yellow pulp cassava. The control analyses showed that the physicochemical, centesimal and microbial characteristics and caloric value of the final drink are within the parameters of the current legislation of identity and quality of milk drink, authorizing its consumption under refrigeration for up to 21 days.

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