MARKET RESEARCH AND DEVELOPMENT OF BUFFALO MILK YOGURT IN RIO GRANDE DO SUL, BRAZIL

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ABSTRACT

Interest in dairy products made from buffalo milk has increased in recent years. This study aimed to understand market trends and develop a buffalo milk yogurt. To this end, questionnaires were administered via Google Forms, covering the state of Rio Grande do Sul, Brazil: Questionnaire 1 assessed consumer knowledge about buffalo milk and its derivatives, while Questionnaire 2 evaluated public interest in consuming a product made from this milk. The sampling method used was non-probability sampling, specifically convenience sampling, as participants voluntarily

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responded to the questionnaires distributed online. Based on the research results, a buffalo milk yogurt was developed, and its microbiological, physicochemical, and sensory characteristics were evaluated. Questionnaire 1 had 138 respondents, with 87.7% indicating an interest in buffalo milk derivatives. Questionnaire 2 received 155 responses, with 95.5% of participants expressing interest in buffalo milk yogurt, and 58.7% selecting vanilla as their preferred flavor for the product. The milk was analyzed by Standard Plate Count (SPC), yielding 3.6 x 10^5 CFU/g. The buffalo yogurt exhibited a pH ranging from 4.71 to 4.77, protein content between 4.15 and 4.39 g/100 g, and fat content ranging from 3.4 to 3.9 g/100 g. For the Lactic Acid Bacteria (LAB) count, 4.7 x 10^7 CFU/g was obtained; for the mold and yeast count, <1.0 x 10^2 CFU/g was recorded; and for the coliform count, <1.0 x 10^2 CFU/g was recorded. In the sensory analysis of vanilla-flavored buffalo milk yogurt with 91 participants, the overall acceptance score was 7.8, indicating «liked very much» on the hedonic scale. This study highlights the population's interest in consuming buffalo milk and its derivatives, particularly yogurt. Microbiological analysis confirmed that the product met the microbiological standards required by legislation for fermented milk, and this food can be considered safe for human consumption.

Key words: Brazilian market analysis, lactic acid bacteria, dairy industry, buffalo milk, dairy products, sensory quality

RESUMEN

El interés por los productos lácteos a base de leche de búfala ha aumentado en los últimos años. Este estudio buscó comprender las tendencias del mercado y desarrollar un yogur de leche de búfala. Para ello se aplicaron cuestionarios en Google Forms que abarcaron el estado de Rio Grande do Sul, Brasil: el Cuestionario 1 evaluó el conocimiento del consumidor sobre la leche de búfala y sus derivados, mientras que el Cuestionario 2 analizó el interés de la población en el consumo de un producto elaborado con esta leche. Se utilizó un muestreo no probabilístico, específicamente un muestreo por conveniencia, ya que los participantes respondieron voluntariamente a los cuestionarios distribuidos en línea. Con base en los resultados de la investigación se desarrolló un yogur de leche de búfala y se evaluaron sus características microbiológicas, fisicoquímicas y sensoriales. El cuestionario 1 tuvo 138 respuestas, de las cuales el 87,7% manifestó interés en derivados de leche de búfala. El cuestionario 2 obtuvo 155 respuestas, en el que 95,5% de los encuestados indicaron interés en un yogurt de leche de búfala, siendo el 58,7% de los encuestados favorecedores del sabor vainilla. La leche fue analizada mediante el recuento estándar en placa (CPP), obteniendo 3,6 x 10^5 UFC/g. El yogur de búfala presentó un pH entre 4,71 y 4,77, proteínas de 4,15 a 4,39 g/100 g y grasas entre 3,4 y 3,9 g/100 g. Para el recuento de bacterias de ácido láctico (BAL), se obtuvo 4,7 x 10^7 UFC/g; para el recuento de mohos y levaduras, se registró <1,0 x 10^2 UFC/g; y para el recuento de coliformes, se registró <1,0 x 10^2 UFC/g. En el análisis sensorial del yogur de leche de búfala sabor vainilla, con 91 participantes, la puntuación media de aceptación fue de 7,8 puntos, indicando «me gustó mucho» en la escala hedónica. Este estudio muestra el interés de la población en el consumo de leche de búfala y sus derivados, destacándose el yogur. El análisis microbiológico confirmó que el producto cumple con los estándares microbiológicos requeridos por la legislación para la leche fermentada, al tiempo que este alimento puede considerarse seguro para el consumo humano.

Palabras clave: análisis del mercado brasileño, bacterias ácido-lácticas, industria láctea, leche de búfala, productos lácteos, calidad sensorial

RÉSUMÉ

L'intérêt pour les produits laitiers à base de lait de bufflonne a augmenté ces dernières années. Cette étude visait à analyser les tendances du marché et à développer un yaourt à base de ce lait. Pour cela, des questionnaires ont été appliqués via Google Forms, couvrant l'État du Rio Grande do Sul, au Brésil : le premier évaluait les connaissances des consommateurs, et le second mesurait leur intérêt pour ce type de produit. La méthode d'échantillonnage utilisée était un échantillonnage non probabiliste, spécifiquement un échantillonn age de convenance, car les participants ont répondu volontairement aux questionnaires distribués en ligne. Sur la base des résultats de la recherche, un yaourt au lait de bufflonne a été développé et ses caractéristiques microbiologiques, physicochimiques et sensorielles ont été évaluées. Le questionnaire 1 a recueilli 138 réponses, dont 87,7 % ont exprimé un intérêt pour les produits dérivés du lait de bufflonne. Le questionnaire 2 a eu 155 répondants, dont 95,5 % ont manifesté un intérêt pour un yaourt

au lait de bufflonne, et 58,7 % ont préféré la saveur vanille. Le lait a été analysé par la méthode de la Compte Standard en Plaque (CSP), avec un résultat de 3,6 x 10^5 UFC/g. Le yaourt de bufflonne a présenté un pH compris entre 4,71 et 4,77, une teneur en protéines de 4,15 à 4,39 g/100 g et une teneur en graisses de 3,4 à 3,9 g/100 g. Pour le comptage des bactéries lactiques (LAB), 4,7 x 10^7 UFC/g ont été obtenus ; pour le comptage des moisissures et des levures, <1,0 x 10^2 UFC/g a été enregistré ; et pour le comptage des coliformes, <1,0 x 10^2 UFC/g a été enregistré. Lors de l'analyse sensorielle du yaourt au lait de bufflonne saveur vanille, réalisée avec 91 participants, la note d'acceptation globale a été de 7,8 points, indiquant «beaucoup aimé» sur l'échelle hédonique. Cette étude montre l'intérêt de la population pour la consommation de lait de bufflonne et ses dérivés, en particulier le yaourt. L'analyse microbiologique a confirmé que le produit répondait aux normes microbiologiques requises par la législation pour le lait fermenté, et cet aliment peut être considéré comme sûr pour la consommation humaine.
Mots-clés : analyse du marché brésilien, bactéries lactiques, industrie laitière, lait de bufflonne, produits laitiers, qualité sensorielle

RESUMO

O interesse por produtos lácteos a partir de leite de búfala tem aumentado nos últimos anos. Este estudo buscou entender tendências de mercado e desenvolver um iogurte de leite de búfala. Para isso foram aplicados questionários no Google Forms que abrangem o estado do Rio Grande do Sul, Brasil: o Questionário 1 buscou avaliar o conhecimento do consumidor sobre o leite de búfala e seus derivados e o Questionário 2 procurou verificar o interesse da população no consumo de um produto fabricado a partir deste leite. A amostragem utilizada foi não probabilística, especificamente amostragem de conveniência, uma vez que os participantes puderam responder voluntariamente aos questionários distribuídos online. A partir dos resultados das pesquisas, um iogurte de leite de búfala foi desenvolvido e suas características microbiológicas, físico-químicas e sensoriais foram avaliadas. O questionário 1 teve 138 respondentes onde 87,7% responderam possuir interesse em derivados de leite de búfala. O questionário 2 teve 155 respondentes e 95,5% informaram possuir interesse em um iogurte de leite de búfala e 58,7% escolheram o sabor baunilha para o derivado. O leite foi analisado pela Contagem Padrão em Placa (CPP), na qual obteve-se 3,6 x 10^5 UFC/g. O iogurte de búfala apresentou pH em torno de 4,71 e 4,77, proteína de 4,15 a 4,39 g/100 g e gordura entre 3,4 a 3,9 g/100 g. Para a contagem de bactérias ácido-lácticas (BAL), obteve-se 4,7 x 10^7 UFC/g; para a contagem de fungos e leveduras, registrou-se <1,0 x 10^2 UFC/g; e para a contagem de coliformes, registrou-se <1,0 x 10^2 UFC/g. Na análise sensorial do iogurte de leite de búfala sabor baunilha, com 91 participantes, a nota geral de aceitação foi de 7,8 pontos, indicando 'gostei muito' na escala hedônica. Com este estudo pode-se observar o interesse da população no consumo de leite de búfala e seus derivados, destacando-se o iogurte. Através da análise microbiológica, o produto apresentou-se dentro dos Padrões Microbiológicos exigidos pela legislação para leite fermentado, podendo considerar esse alimento seguro para o consumo humano.
Palavras-chave: análise de mercado brasileiro, bactérias ácido lácticas, indústria de laticínios, leite bubalino, produtos lácteos, qualidade sensorial

1. INTRODUCTION

The domestic buffalo (*Bubalus bubalis*), originally from Asia, was introduced to Brazil in 1890 on Marajó Island–in the state of Pará, through the importation of Carabao breed animals from French Guiana and in 1895 through the importation of animals from Italy (Silva & Ribeiro, 2021). The global buffalo population is estimated to be approximately 204 million head, with 98% of the world's herd concentrated in Asia (FAO, 2024). Currently, Brazil has a herd of 3 million buffalo (ABCB, 2024), making it the largest producer in the Americas. Consequently, buffalo farming has gained significant prominence in recent decades.

Initially, buffalo farming focused on meat production, but from the 1980s onwards, there was a growing interest in milk production (Bernardes, 2007). Buffaloes have a long productive life, ranging from nine to ten lactations, and can produce an average of 7 to 11 liters of milk per day. Approximately 7% of the milk consumed worldwide is of buffalo origin, making it the second-largest source of global milk production (Godinho *et al*., 2020). In Brazil, in 2018, more than 87 thousand tons of buffalo milk were produced (Minervino *et al*., 2020). This raw material has garnered increased attention due to its higher levels of fat, protein, minerals, and total solids compared to cow's milk, as well as its elevated lactose content (Ricci & Domingues, 2012). Furthermore, it has a sweet flavor and a white color, which are attributed to a low concentration of carotenoid pigments and the absence of â-carotene in its composition (Cavali & Pereira, 2020). The differences in the percentages of fat, protein, and total solids, in comparison to cow's milk, confer a distinctiveness to buffalo milk, both in terms of its production and the yield and quality of its derivatives (Ferreira *et al*., 2021). The main derivative of this milk is mozzarella cheese, which is particularly sought after for its softness and mild flavor. Other derivatives, in addition to buffalo mozzarella, include ricotta, dulce de leche, and yogurt, which have also gained popularity among consumers.

Yogurt is a product resulting from fermentation that occurs in milk at a temperature of 45 ºC, facilitated by two species of thermophilic bacteria: *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. According to Addeo *et al*. (2007), buffalo yogurt is free from artificial thickeners due to its higher concentration of casein compared to cow's milk yogurt. It also contains higher levels of calcium and protein, and lower levels of cholesterol. It is important to note that buffalo milk yogurt possesses beneficial nutritional properties and is experiencing growth in the market. In this context, the objectives of this study were to analyze market trends, assess consumer preferences, and characterize the properties of yogurt produced with buffalo milk.

2. MATERIALS AND METHODS

2.1. DEVELOPMENT AND APPLICATION OF QUESTIONNAIRES: CONSUMER MARKET X BUFFALO MILK AND DAIRY PRODUCTS

A market survey was conducted on the consumption of milk and its derivatives, with a focus on those derived from buffalo milk. Two questionnaires were prepared using Google Forms: Questionnaire 1 (Q1), titled 'Survey on Interest in the Consumption of Buffalo Milk and Its Derivatives' (Table 1), and Questionnaire 2 (Q2), titled 'Survey on Interest in the Consumption of Buffalo Milk Yogurt' (Table 2). Both questionnaires were available for responses for 15 days to the population of the state of Rio Grande do Sul, Brazil. The

Table 1
Questions asked in Questionnaire 1 (Q1): Survey on interest in the consumption of buffalo milk and its derivatives

1. Do you drink milk?
2. If the previous answer was YES, which of these types of milk do you consume? (Multiple choice)
3. Are you familiar with buffalo milk?
4. Did you know that pasteurized buffalo milk is available for purchase in supermarkets?
5. Do you consume dairy products?
6. If the previous answer was YES, what derivatives do you consume? (Multiple choice)
7. Are you interested in buffalo milk derivatives?
8. If the previous answer was YES, which derivatives are you interested in consuming? (Multiple choice)

Table 2
Questions asked in Questionnaire 2 (Q2): Survey on interest in the consumption of buffalo milk yogurt

1. Do you consume yogurt?
2. If the previous answer was YES, how often do you consume yogurt? (Multiple choice)
3. If the previous answer was YES, what flavors of yogurt do you usually consume? (Multiple choice)
4. What are the most important characteristics for you when choosing a yogurt? (Multiple choice)
5. Did you know that buffalo milk yogurt is available for purchase in supermarkets?
6. Would you consume yogurt made from buffalo milk?
7. Which yogurt flavors below would you like to try? (Multiple choice)
8. If you were to help produce a buffalo milk yogurt, what flavor would you suggest?
9. How much would you be willing to pay for a 150 mL pot of buffalo milk yogurt?

sampling method used was non-probability sampling, specifically convenience sampling, as participants were able to voluntarily respond to the survey. After this period, the spreadsheets generated from the responses to the questionnaires were analyzed.

2.2. OBTAINING BUFFALO MILK AND QUALITY OF RAW MATERIAL

The milk used in this research was collected at the Agronomic Experimental Station of the Federal University of Rio Grande do Sul (UFRGS), in the municipality of Eldorado do Sul/RS, through mechanical milking of Murrah dairy buffaloes, under appropriate hygienic conditions, in accordance with the Manual of Good Agricultural Practices (GAP) for Milking in Bubalinoculture (Di Domenico & Motta, 2022). The samples were stored in isothermal boxes and sent to the Microbiology and One Health Laboratory at the Institute of Basic Health Sciences (ICBS – UFRGS). The Standard Plate Count (SPC) was performed on Plate Count Agar (PCA), incubated at 37 °C for 48 h, to assess the hygienic-sanitary quality of the milk (ISO 4833-1, 2013). The results were expressed in colony-forming units per milliliter (CFU/mL). The determination of the centesimal composition of the milk samples was obtained using a milk analyzer (Akso Master Pro Touch).

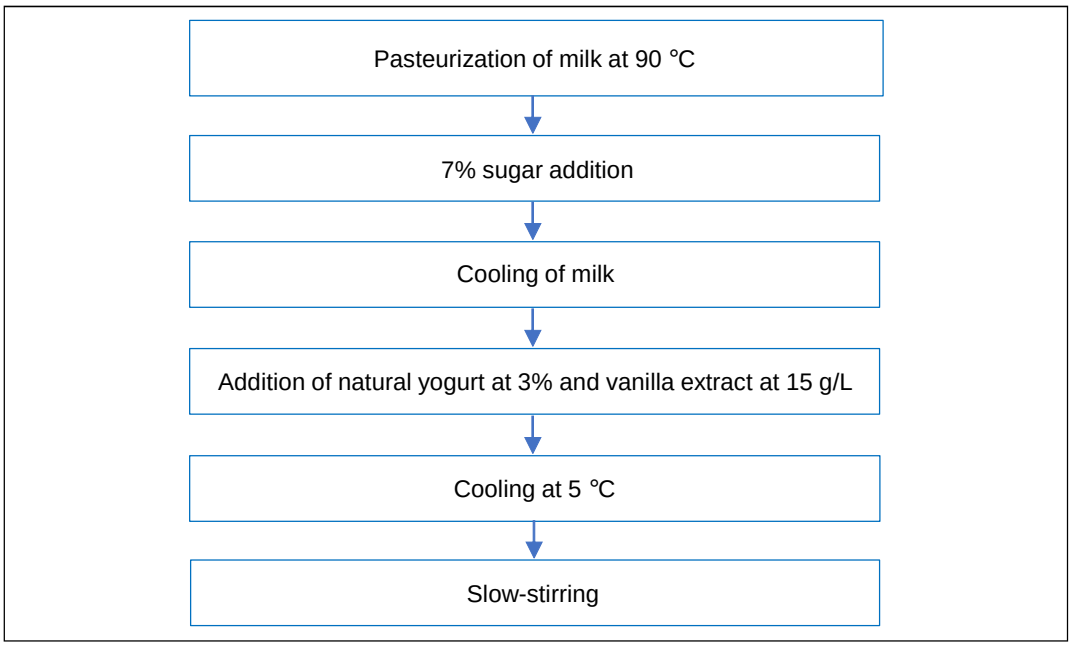
2.3. PRODUCTION OF BUFFALO MILK YOGURT

To produce the yogurt, 500 mL of raw buffalo milk were filtered and subsequently pasteurized in a previously sterilized container. The buffalo milk was heated to 90 °C for 15 minutes, and then 7% sugar was added. The milk was cooled to a temperature of 45 °C for the inoculation of the microbial culture (natural yogurt) at a concentration of 3%, with the addition of vanilla extract at 15 g/L. Afterwards, the milk was incubated in a water bath for 6 h at 45 °C. At the end of the fermentation process, the container with yogurt was cooled in the refrigerator to 5 °C. The yogurt was then slowly stirred for homogenization. The manufacturing sequence described was repeated twice, resulting in 2 batches of buffalo milk yogurt (I1 and I2). The processed yogurts were stored at 5 °C for 3 days. The production of buffalo milk yogurt was carried out according to Figure 1.

2.4. MICROBIOLOGICAL ANALYSIS OF VANILLA FLAVORED BUFFALO MILK YOGURT

Vanilla-flavored buffalo milk yogurts were analyzed in accordance with the Technical Regulation on the Identity and Quality of Fermented Milks described in Normative

Figure 1
Production of vanilla-flavored buffalo milk yogurt flowchart



Instruction (IN) No. 46 of the Ministry of Agriculture, Livestock, and Supply (Brasil, 2007).

For microbiological analyses, a total of 25 g of the sample was diluted in 225 mL of 0.85% saline solution (NaCl), and then 1 mL of this solution was diluted in 9 mL of 0.85% NaCl. Six serial dilutions were performed, in triplicate. The following microbiological analyses were performed: Lactic acid bacteria (LAB) count on Man Rogosa Sharpe (MRS) agar, total coliform count on Violet Red Bile Agar (VRBA) medium, and mold and yeast count on Potato Dextrose Agar (PDA) medium. Inoculation was performed for 48 h at 37 °C, except for the analysis of molds and yeasts, which was performed for 7 days at 20 °C. All analyses were performed in triplicate.

2.5. PHYSICOCHEMICAL ANALYSIS OF BUFFALO MILK YOGURT

The physicochemical analyses of the yogurt samples were performed at the Institute of Food Science and Technology (ICTA – UFRGS). The pH was measured using a pH meter (model Q400AS, Quimis, Diadema, SP, Brazil) on the day of production after cooling the product. Moisture was measured using a moisture determination balance (i-Thermo, Bel Engineering, Monza, Italy) at 105 ºC for 90 minutes. Protein was measured using the micro-Kjeldahl method with 6.38 as the conversion factor (AOAC, 1997), and lipids were measured by chloroform extraction (Bligh & Dyer, 1959). Viscosity was evaluated at 8 and 20 °C using a Haake Mars III rheometer (Thermo Scientific, Germany), equipped with a Peltier system for temperature control and a cone-plate geometry with a 35 mm diameter and a 2° angle. The samples were acclimated at each of the above-mentioned target temperatures for 2 minutes, after which dynamic analysis was performed in the strain rate range of 1 to 100 s^{-1}. The apparent viscosity was determined at 40 s^{-1}, a rate at which all samples exhibited linear behavior. Color analysis was performed on the parameters L, a*, and b* using a colorimeter (Konica Minolta, model CR-400) according

to the international standard for food color measurements set by the Commission Internationale de L'Eclairage (CIE). All analyses were performed in duplicate

2.6. SENSORY ANALYSIS OF VANILLA FLAVORED BUFFALO MILK YOGURT

For the sensory analysis of buffalo milk yogurt, 91 untrained panelists of both sexes, aged between 18 and 70 years, all of whom were students and staff members of the Federal University of Rio Grande do Sul (UFRGS), participated. The test was conducted from 9 am to 2 pm at the Sensory Analysis Laboratory of the Institute of Food Science and Technology (ICTA). The panelists were recruited based on their availability and interest. The sensory analysis was performed using the 9-point Hedonic Scale: 1 (I disliked it very much) and 9 (I liked it very much). The following attributes were evaluated: appearance, color, aroma, flavor, aftertaste, texture, and overall acceptance.

The samples were coded with three random digits. For evaluation, 20 mL of each sample were served in disposable plastic cups, with the yogurt temperature around 5 °C, accompanied by water to cleanse the taste buds between evaluations. Additionally, the panelists were asked about their purchase intention regarding the yogurt.

3. RESULTS AND DISCUSSION

3.1. QUESTIONNAIRE 1: INTEREST SURVEY ON THE CONSUMPTION OF BUFFALO MILK AND ITS DERIVATIVES

In Questionnaire 1, a total of 138 respondents participated, of whom 85.5% were women, 13.8% were men, and 0.7% identified as non-binary. The age distribution of the participants was as follows: 18–25 years (25.4%), 26–40 years (24.6%), 41–

Regarding milk consumption, 111 respondents (80.4%) indicated that they consume milk, while 27 respondents (19.6%) stated that they do not. This data underscores not only the nutritional significance of milk as a source of calcium and other essential nutrients but also its social importance. The cultural consumption of milk is deeply embedded in our society, as evidenced by the research findings. In many cultures, milk serves as a staple food, contributing to individuals' health and growth while also holding a significant place in family traditions.

When asked about the types of milk they consume, with the option to select multiple responses, 108 respondents (78.2%) indicated cow's milk, 17 (12.3%) chose buffalo milk, 4 (2.9%) selected goat's milk, 2 (1.4%) opted for sheep's milk, 3 (2.1%) reported consuming plant-based milk, and 27 (19.6%) stated that they do not consume milk. This result can be attributed to the greater prevalence of dairy cattle compared to buffalo farming in the country. According to Almeida *et al.* (2021), there are approximately 16.2 million milked cows, whereas the buffalo population totals around 3 million animals (ABCB, 2024).

Regarding knowledge of buffalo milk, 74 respondents (53.6%) indicated that they were not familiar with this type of milk, while 64 respondents (46.4%) stated that they were familiar with it. Regarding knowledge of the availability of pasteurized buffalo milk in supermarkets, 47 respondents (34.1%) indicated that they were aware of its availability, while 91 respondents (65.9%) stated that they were not aware. These percentages can be associated with the growth, albeit slow, of buffalo milk production in the country. According to Ricci & Domingues (2012), buffalo milk production has increased by 301% over the last 50 years, compared to a 59.3% increase in cow milk production.

Regarding the consumption of dairy products, 133 respondents (96.4%) indicated that they consume dairy products, while 5 respondents (3.6%) stated that they do not. When asked which dairy products they consume, with the option to select multiple responses, 132 respondents (95.7%) answered cheese, 113 (81.9%) answered butter, 106 (76.8%) answered yogurt, 103 (74.6%) answered ice cream, 93 (67.4%) answered *dulce de leche* (caramel milk), 53 (38.4%) answered dairy drinks, 37 (26.8%) answered fermented milk, 5 (3.6%) answered that they do not consume dairy products, and 11 (7.7%) answered others. This result is consistent with the studies of Ribeiro Júnior *et al.* (2020) and

Nascimento *et al*. (2023), who observed higher cheese consumption in their research. The consumption of this dairy product is linked to cultural factors, influenced by German and Italian immigrants, as well as the need to preserve and utilize the milk produced.

Regarding interest in buffalo milk derivatives, 121 respondents (87.7%) expressed interest, while 17 respondents (12.3%) stated that they were not interested. Regarding which buffalo milk derivatives they would be interested in, with the option to select multiple responses, 118 respondents (85.5%) expressed interest in cheese, 69 (50%) in yogurt, 64 (46.4%) in butter, 51 (37%) in *dulce de leche*, 47 (34.1%) in ice cream, 22 (15.9%) in dairy drink, 19 (13.8%) in fermented milk, and 1 (0.7%) in «lactose-free». The results indicate that, despite the population's limited familiarity with buffalo milk and its derivatives, there is interest in these products. This may be attributed to the low level of publicity and the limited availability of buffalo milk derivatives in the market.

3.2. QUESTIONNAIRE 2: INTEREST SURVEY ON THE CONSUMPTION OF BUFFALO MILK YOGURT

In Questionnaire 2, there were 155 respondents, of whom 71% were women, 27.7% were men, and 1.3% identified as non-binary. The distribution of participants by age group was as follows: 18-25 years (30.3%), 26-40 years (31%), 41-60 years (30.3%), and over 60 years (8.4%).

Regarding yogurt consumption, 143 (92.3%) participants indicated that they consume yogurt, while the remaining 12 (7.7%) reported that they do not. This result is consistent with the findings of Dantas *et al*. (2019), in which 86.5% of participants reported consuming yogurt. Furthermore, in this study, when asked about the frequency of consumption, 43 (27.7%) individuals reported consuming yogurt less than once a week, 25 (16.1%) three times a week, 23 (14.8%) twice a week, 23 (14.8%) once a week, 15 (9.7%) once a day, 7 (4.5%) four times a week, 4 (2.6%) five times a week, and 4 (2.6%) more than once a day. Similar results were found by Dantas *et al*. (2019), where 10.2% of respondents reported consuming yogurt once a day and 15.6% reported consuming it three times a week.

Regarding the flavors of yogurt that participants usually consume, with the possibility of multiple choices, 108 (69.7%) respondents selected strawberry, 62 (40%) selected red fruits, 49 (31.6%) selected coconut, 41 (26.5%) selected plum, 30 (19.4%) selected honey, 25 (16.1%) selected oatmeal, 23 (14.8%) selected papaya, 22 (14.2%) selected plain, 5 (3.2%) selected fruit salad, and 15 (9.6%) selected other flavors. These results are similar to the study by Ribeiro *et al*. (2010), in which 58.1% of respondents selected strawberry as their preferred flavor, making it the most popular choice.

As for the most important characteristics when choosing yogurt, with the possibility of multiple choices, 116 (74.8%) respondents selected flavor, 92 (59.4%) selected consistency, 79 (51%) selected nutritional value, 36 (23.2%) selected appearance, 29 (18.7%) selected odor, and 17 (11%) selected color.

Regarding knowledge about the availability of buffalo milk yogurt in supermarkets, 118 (76.1%) respondents reported being unaware, while 37 (23.9%) reported being aware. This highlights the need to intensify the promotion of buffalo milk-based products in the market. When asked if they would consume yogurt made from buffalo milk, 148 (95.5%) respondents answered yes, and 7 (4.5%) answered no. This indicates that there is an interest in and/or curiosity about consuming dairy products made from buffalo milk

When asked which yogurt flavors they would be interested in consuming, with the possibility of multiple choices, 91 (58.7%) respondents selected vanilla, 55 (35.5%) selected grape, 53 (34.2%) selected coffee, 50 (32.3%) selected granola, 39 (25.2%) selected lavender with orange, 39 (25.2%) selected cinnamon, and 22 (14.2%) selected yerba mate.

When asked which flavor they would suggest for the production of buffalo milk yogurt, 35 (22.6%) respondents suggested strawberry, 16 (10.3%) suggested red fruits, 11 (7.1%) suggested coconut, 11 (7.1%) suggested plum, 9 (5.8%) suggested honey, 8 (5.2%) suggested natural, 6 (3.9%) suggested fruit salad, 5 (3.2%) suggested peach, 5 (3.2%)

suggested passion fruit, 5 (3.2%) suggested pineapple, 4 (2.7%) suggested blueberry, 4 (2.7%) suggested orange, 3 (1.9%) suggested chocolate, 3 (1.9%) suggested banana, 3 (1.9%) suggested açaí, 3 (1.9%) suggested bergamot, 3 (1.9%) suggested apple, and 21 (13.5%) suggested other flavors–such as *jaboticaba* (similar to Muscadine grapes), *dulce de leche*, carrot and honey, guava, star fruit, pitaya, whey, butiá, coffee, chocolate, hazelnut, kiwi, cashew, watermelon, lemon, raisins, apricot, soursop, cupuaçu, flakes, and mango.

Regarding the amount they would be willing to pay for a 150 mL pot of buffalo milk yogurt, 91 (58.7%) respondents indicated a price range between R$ 7.00 and R$ 9.00; 42 (27.1%) indicated a range between R$ 9.00 and R$ 11.00; 17 (11%) indicated a range between R$ 11.00 and R$ 13.00; 4 (2.6%) indicated a range between R$ 13.00 and R$ 15.00; and 1 (0.6%) respondent indicated a price greater than R$ 15.00[6].

3.3. ANALYSIS OF THE CENTESIMAL COMPOSITION AND STANDARD PLATE COUNT (SPC) OF BUFFALO MILK

In Brazil there is no specific federal legislation for buffalo milk. Therefore, the parameters established by IN No. 76/2018 (Brasil, 2018a) must be met when assessing the quality of this milk. Additionally, the Resolution of the Secretariat of Agriculture and Supply (SAS) - 03/2008 from the State of São Paulo, which sets specific limits for buffalo milk (São Paulo, 2008), can be used.

Buffalo milk was analyzed for its centesimal composition (Table 3), where 3.74 g/100 g of fat was found. Higher values were reported by other authors (Di Domenico *et al*., 2023; Godinho *et al*., 2020), and it was also found to be below the value established in Resolution SAS - 03 (São Paulo, 2008). The overall average for protein was 3.96 g/100 g, a higher value (4.12 g/100 g) was found in the study by Bailone *et al*. (2017). In buffalo milk, 5.95 g/100 g of lactose was also found, lower values were observed in the studies by Bailone *et al*. (2017) and Costa Filho *et al*. (2014). The density found in this study (1035.25 g/mL) was higher than the limits established by current legislation (Brasil, 2018a, 2018b) for bovine milk, as well as exceeding the specific state legislation for buffalo milk (São Paulo, 2008). However, the density value of buffalo milk is similar to that found by other authors in the literature (Godinho *et al*., 2020; Di Domenico *et al*., 2023), which exhibits this high density due to the conformation of its fat globules, which are larger than those in cow's milk (Di Domenico, 2023). In addition, SPC was performed, yielding 2.09 x 10^5 CFU/mL. This value is below the maximum limit allowed by law (3.00 x 10^5 CFU/mL) (Brasil, 2018a, 2018b). Lower values (3.35 x 10^4 CFU/mL) were found by Di Domenico *et al*. (2023) when evaluating the same herd from April to December 2021. The SPC value suggests that GAP were followed at the time of milking, as the result is within what is recommended by law.

3.4. MICROBIOLOGICAL ANALYSIS OF VANILLA FLAVORED BUFFALO MILK YOGURT

Microbiological analyses were conducted on buffalo milk yogurt, and it was found to meet the microbiological parameters established by Normative Instruction No. 46, dated October 23, 2007 (Brasil, 2007). In the analyzed yogurts, 4.73 x 10^7 CFU/g of LAB were found in samples from batch 1 (I1), and 5.3 x 10^7 CFU/g in samples from batch 2 (I2) after 3 days of production. These values are in accordance with the legislative requirement (Brasil, 2007), which stipulates a minimum of 1 x 10^7 CFU/g of LAB for yogurt. In the study by Al-Manhel & Niamah (2017), the *Lactobacillus acidophilus* count in buffalo milk yogurt was lower than that of the present study, at 6.31 x 10^6 CFU/g on the first day, and after 28 days of storage, a reduction to 7.94 x 10^4 CFU/g was observed. In the study by Hamed *et al*. (2021), the initial counts of *Streptococcus thermophilus* (3.31 x 10^8 CFU/g) and *Lactobacillus bulgaricus* (1.66 x 10^8 CFU/g) were higher than

[6] [Editor's Note]: On 2 September 2025, the nominal exchange rate between the Brazilian Real and the US dollar was approximately 5.46. At such prices, the price that the consulted consumer was willing to pay for 150 mL of buffalo milk yoghurt ranged from US$ 1.28 to just over US$ 2.75

Table 3
Average centesimal composition results of buffalo milk compared to the official parameters of IN No. 76/2018 and SAS – 03/2008

Parameters	Buffalo milk	IN No. 76/2018 (minimum value)	SAS - 03/2008 (minimum value)
pH	6.69 ± 0.18	-	6.40 to 6.90
Protein (g/100 g)	3.96 ± 0.17	2.9	-
Fat (g/100 g)	3.74 ± 0.10	3	4.5
Lactose (g/100 g)	5.95 ± 0.27	4.3	-
SNF (g/100 g)	10.81 ± 0.49	8.4	8.57
Salts (g/100 g)	0.89 ± 0.04	-	-
Water (g/100 g)	0 ± 0.00	-	-
Density (g/mL)	1,036.25 ± 0.80	1,028 to 1,034	1,028 to 1,034
CI (ºC)	-0.74 ± 0.03	-0.512 to -0.536	-0.520 to -0.570
Temperature (ºC)	23.3 ± 1.67	-	-
Conductivity (mS/cm)	3.93 ± 0.16	-	-

Notes: IN: Normative Instruction; SAS: Secretariat of Agriculture and Supply; SNF: Solid Non-Fat; CI: Cryoscopic In. Source: Prepared by the authors (2024), Brazil (2018a) and São Paulo (2008)

those of the present study and remained viable for 14 days.

After 3 days of yogurt production, no counts were observed for total coliforms, molds, and yeasts. Within the limitations of the technique, the result was expressed as <10 CFU/mL. These results corroborate findings from other studies in the literature (Akgun *et al*., 2016; Mohsin *et al*., 2022). The results indicate that Good Manufacturing Practices (GMPs) were followed, as the buffalo milk yogurt produced did not contain total coliforms, molds, and yeasts.

3.5. PHYSICOCHEMICAL ANALYSIS OF VANILLA FLAVORED BUFFALO MILK YOGURT

The results for the physicochemical analysis of buffalo milk yogurt are shown in Table 4. The pH values in this study (4.71 and 4.77) are close to the results found in the literature for buffalo milk yogurts (Pinto *et al*., 2018; Al-Manhel & Niamah, 2017; Akgun *et al*., 2016; 2018), although there is no Standard of Identity and Quality for buffalo milk yogurt. The protein contents of the buffalo milk yogurt in the present study (4.15 g/100 g and 4.39 g/100 g) are similar to the unsweetened full-fat yogurt (4.2 g/100 g) prepared by Akgun *et al*. (2018). Terzioglu *et al*. (2023) reported slightly higher protein levels (5.31 g/100 g), whereas Guimarães *et al.* (2015) reported lower values (3.71 g/100 g) for yogurt made from buffalo milk. Regarding fat content, the results of the present study (3.4–3.9 g/100 g) are similar to those reported by Akgun *et al.* (2018), who found 3.1% fat in samples of unsweetened whole buffalo milk yogurt. However, Guimarães *et al*. (2015) and Terzioglu *et al*. (2023) reported higher values for buffalo milk yogurt, at 5.88 g/100 g and 8.25 g/100 g, respectively. The variations in the parameters of buffalo milk yogurt reported in the literature can be attributed to differences in milk composition, which are influenced by genetic factors, lactation periods, milking practices, climate, and animal feeding (Guimarães *et al*., 2015).

Furthermore, the apparent viscosity values observed in this study were within the range reported in the literature (3.52–3.81 Pa·s at 8 °C and 3.13–3.69 Pa·s at 20 °C). Viscosity values are influenced by factors such as temperature, composition, type of starter culture, heat treatment, and the use of stabilizers. Yogurts with higher solid contents exhibit greater viscosity. Certain strains of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* produce exopolysaccharides, which impart a filamentous texture to yogurt and

Table 4
Physicochemical parameters of vanilla-flavored buffalo milk yogurt

Physicochemical analysis	Sample 1 (I1)	Sample 2 (I2)
pH	4.71	4.77
Protein (g/100 g)	4.15 ± 0.02	4.39 ± 0.00
Fat (g/100 g)	3.4	3.9
Apparent Viscosity at 8 °C (Pa·s)	3.52	3.81
Apparent Viscosity at 20 °C (Pa·s)	3.13	3.69
Color		
L[1]	89.77	91.55
a*[2]	-2.92	-2.85
b*[3]	11.27	11.23

Notes. [1]L = Luminosity; [2]a = red/green coordinate; [3]b = yellow/blue coordinate

Table 5
Sensory analysis scores of vanilla-flavored buffalo milk yogurt

Sensory analysis	Vanilla-flavored buffalo milk yogurt
Global Acceptance	7.8 ± 1.23
Appearance	7.9 ± 1.44
Color	8.0 ± 1.40
Aroma	7.5 ± 1.52
Taste	8.1 ± 1.10
Aftertaste	7.4 ± 1.66
Texture	7.9 ± 1.52

contribute to its increased viscosity (Trachoo, 2002). Han *et al*. (2012) analyzed the viscosity at 22 ± 2 °C and found 1.78 Pa·s for buffalo yogurt samples with reduced fat content, compared to 2.15 Pa·s for samples with reduced fat content and the addition of blueberry, attributing the difference in these values to the solids content. Akgun *et al.* (2018) analyzed the viscosity at 10 °C of whole buffalo milk yogurts and found values ranging from 3.8 to 5.2 Pa·s for samples with pH = 4.80, and approximately 5.4 Pa·s for samples with pH = 4.55.

Regarding color parameters, the samples in the present study were lighter than those reported in the literature, with L values ranging from 89.77 to 91.55. Pinto *et al*. (2018) found L values of 70.20 for buffalo milk yogurt, while Akgun *et al*. (2018) found values ranging from 84.50 to 85.45 for buffalo yogurt prepared with the starter culture *S. thermophilus* and *L. delbrueckii* subsp. *Bulgaricus*. In the a* parameter, which ranges from green (-60) to red (+60), the samples in the present study were within the negative spectrum, with values between -2.85 and -2.92. These values were similar to those reported by Akgun *et al*. (2018),

who obtained values between «2.34 and «2.57, while Pinto *et al*. (2018) obtained a value of 0.43. For the b* parameter, the present study found values ranging from 11.23 to 11.27. Lower results were observed by Akgun *et al*. (2016) when analyzing yogurt with different fat contents (1.5%, 3%, 4.5%, and 6%), with b* values of 8.14, 7.90, 8.25, and 8.05, respectively. The differences in color may be attributed to microorganisms, as the present study used natural yogurt, whereas the referenced studies used commercial starter cultures, or to the presence of refined sugar in the composition.

3.6. SENSORY ANALYSIS OF VANILLA FLAVORED BUFFALO MILK YOGURT

For the sensory analysis of buffalo milk yogurt, 91 evaluators participated, of whom 64% were women and 36% were men. The distribution of participants by age range was as follows: 18–25 years (45%), 26–40 years (39.6%), 41–60 years (14.3%), and over 60 years (1.1%). The results of the sensory analysis are presented in Table 5. The attribute with the highest acceptance was flavor, with a score of 8 (89%), while the lowest score was for aftertaste, with a score of 7.4 (82%). Different results were reported by Lima *et al.* (2020), where the score for flavor was 5.13 (59%) on a 9-point scale, which is lower than the score found in this study. The overall acceptance of the yogurt in this study was 7.8 (87%). This result corroborates the findings of Juanid *et al.* (2023), in which the average overall acceptance score was the same as that of this study (7.8) (87%). Regarding the intention to purchase the product, 87.9% of participants indicated they would buy the yogurt, 8.8% stated they would not purchase it, and 3.3% did not respond, suggesting the potential for a product with a flavor that is not widely explored in southern Brazil, warranting further market exploration. The sensory evaluation revealed that the vanilla-flavored buffalo milk yogurt exhibited excellent acceptance (AI > 80%) across all attributes analyzed, with a high average overall acceptance index.

4. CONCLUSION

This study demonstrated a clear interest from the population of Rio Grande do Sul, Brazil, in consuming buffalo milk. Although milk consumption in general is common (80.4%), only 12.3% reported specifically consuming buffalo milk. However, 87.7% expressed interest in purchasing buffalo milk, and 95.5% showed willingness to consume buffalo milk yogurt, highlighting both significant consumer demand and an untapped opportunity for market expansion.

In addition to the identified market potential, this study developed a vanilla-flavored buffalo milk yogurt. Microbiological and physicochemical analyses demonstrated that the product meets the microbiological standards required by legislation for fermented dairy products. Furthermore, it presents high nutritional quality, characterized by its elevated protein content and desirable viscosity, suggesting that buffalo milk yogurt may offer a unique and healthy alternative to traditional dairy products.

Despite the strong interest in buffalo milk products, the population demonstrates limited knowledge of their availability. This finding represents a significant challenge for their successful introduction and market expansion. While consumers are mostly familiar with traditional dairy products, the gap in awareness regarding buffalo milk highlights the need for targeted marketing strategies, consumer education, and improved distribution, especially through conventional retail channels. Nonetheless, the development of buffalo milk yogurt, particularly in flavors such as vanilla, offers a promising opportunity to reach this untapped market and meet the growing demand for differentiated, high-quality dairy products.

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