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Addition of prebiotic jabuticaba pulp (Myrciaria cauliflora) as sweetener in kefir

Adição de polpa prebiótica de jabuticaba (Myrciaria cauliflora) como adoçante em kefir

Adición de pulpa prebiótica de jabuticaba (Myrciaria cauliflora) como edulcorante en kéfir

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Abstract
Kefir is a fermented dairy product rich in micronutrients that contribute to human health and well-being. Sucrose is the most used sweetener added, however, if consumed in excess can cause harm to health beyond. An alternative to sucrose is fruit pulp, such as jabuticaba, which contains natural sugars, great nutritional value and can improve flavor to the final product. This present study aimed to evaluate the effect of different concentrations of sucrose and prebiotic jabuticaba pulp in milk kefir, evaluating the physicochemical, microbiological and sensory properties for 30 days of storage. The kefir fermentation process was characterized analyzing pH, acidity, total soluble solids (TSS) content, and count of yeasts and lactic acid bacteria (LAB). Afterwards, 5 kefir formulations were prepared, with 5% and 7.5% of sucrose, 5% and 7.5% of jabuticaba pulp spray dried with polydextrose and the control without addition of sucrose. Water holding capacity (WHC), pH, TSS, and aerobic and anaerobic yeast count and LAB of formulations were performed on days 0, 15 and 30 of storage at 4 °C. Samples with sucrose showed higher sensory acceptance, and samples with jabuticaba pulp were characterized as very acid, acid aroma, liquid texture, slightly bitter and slightly sweet. The results of this study showed that the addition of prebiotic jabuticaba pulp is a good strategy to make kefir healthier.
Keywords: Fermented milk; Kefir; Sugar reduction; Prebiotic.

Resumo
O kefir é um produto lácteo fermentado rico em micronutrientes que contribuem para a saúde e o bem-estar humano. A sacarose é o adoçante mais utilizado, contudo, seu consumo excessivo pode causar danos à saúde. Uma alternativa à sacarose é a polpa de frutas, como a jabuticaba, que contém açúcares naturais, elevado valor nutricional e pode aprimorar o sabor do produto final. O presente estudo teve como objetivo avaliar o efeito de diferentes concentrações de sacarose e polpa prebiótica de jabuticaba no kefir de leite, analisando suas propriedades físico-químicas, microbiológicas e sensoriais ao longo de 30 dias de armazenamento. O processo de fermentação do kefir foi caracterizado por meio da análise de pH, acidez, teor de sólidos solúveis totais (TSS) e contagem de leveduras e bactérias ácido-láticas (BAL). Posteriormente, foram preparadas cinco formulações de kefir, contendo 5% e 7,5% de sacarose, 5% e 7,5% de polpa de jabuticaba liofilizada com polidextrose, além da formulação controle sem adição de sacarose. A capacidade de retenção de água (CRA), o pH, o teor de TSS e a contagem aeróbica e anaeróbica de leveduras e BAL foram avaliados nos dias 0, 15 e 30 de armazenamento a 4 °C. As amostras com sacarose apresentaram maior aceitação sensorial, enquanto as amostras contendo polpa de jabuticaba foram caracterizadas como muito ácidas, com aroma ácido, textura líquida, sabor levemente amargo e levemente doce. Os resultados deste estudo demonstraram que a adição de polpa prebiótica de jabuticaba representa uma estratégia promissora para tornar o kefir mais saudável.
Palavras-chave: Leite fermentado; Kefir; Redução de açúcar; Prebiótico.

Resumen
El kéfir es un producto lácteo fermentado rico en micronutrientes que contribuyen a la salud y el bienestar humano. La sacarosa es el edulcorante más utilizado; sin embargo, su consumo excesivo puede ser perjudicial para la salud. Una alternativa a la sacarosa es la pulpa de frutas, como la jabuticaba, que contiene azúcares naturales, un alto valor nutricional y puede mejorar el sabor del producto final. Este estudio tuvo como objetivo evaluar el efecto de diferentes concentraciones de sacarosa y pulpa prebiótica de jabuticaba en el kéfir de leche, analizando sus propiedades fisicoquímicas, microbiológicas y sensoriales durante 30 días de almacenamiento. El proceso de fermentación del kéfir se caracterizó mediante el análisis de pH, acidez, contenido de sólidos solubles totales (TSS) y recuento de levaduras y bacterias ácido-lácticas (BAL). Posteriormente, se prepararon cinco formulaciones de kéfir: con 5% y 7,5% de sacarosa, con 5% y 7,5% de pulpa de jabuticaba liofilizada con polidextrosa, y una formulación control sin adición de sacarosa. La capacidad de retención de agua (WHC), el pH, el contenido de TSS y el recuento aeróbico y anaeróbico de levaduras y BAL en las formulaciones fueron evaluados en los días 0, 15 y 30 de almacenamiento a 4 °C. Las muestras con sacarosa presentaron una mayor aceptación sensorial, mientras que las muestras con pulpa de jabuticaba se caracterizaron por ser muy ácidas, con aroma ácido, textura líquida, sabor ligeramente amargo y ligeramente dulce. Los resultados de este estudio indican que la adición de pulpa prebiótica de jabuticaba es una estrategia prometedora para hacer que el kéfir sea más saludable.
Palabras clave: Leche fermentada; Kéfir; Reducción de azúcar; Prebiótico.

1. Introduction

Kefir is characterized by small, irregularly shaped, white or yellowish granules, containing 3 to 35 mm in diameter, and can be cultured in milk or water. Cultivation with milk results in a viscous, refreshing, fizzy fermented milk with a slightly acidic flavor (Farnworth, 2005) generally flavored and sweetened by sucrose or sweeteners. This fermented milk results from the action of a complex mixture of microorganisms in a matrix of polysaccharides containing carbon dioxide and ethanol. (Garrote et al., 1997; Lopitz-Otsoa et al., 2006).

Kefir has a rich composition, which includes minerals, sugars, carbohydrates, proteins, peptides, vitamins and fats (Rosa et al., 2017). Furthermore, its fermentation process further increases nutritional value, due to secondary bioactive ingredients such as catechin, vanillin, ferulic acid and salicylic acid (Farag et al., 2020). Among the minerals present are potassium, calcium, phosphorus, magnesium, sodium, zinc, iron and copper in addition to group B vitamins such as B5, B2 and B1 (Gökırmaklı & Güzel-Seydim, 2022; Liutkevicius & Sarkinas, 2004; Satir & Guzel-Seydim, 2016; Turker et al., 2013). However, the nutritional profile of kefir is influenced by the amount of grains, the type of milk and technology used in its production, feeding conditions and breeds (Satir & Guzel-Seydim, 2016).

Milk kefir is composed by microorganisms lactobacilli, lactococci, leuconostoc, bifidobacteria and yeast (Arslan, 2015). The microbial composition of kefir grains is extremely variable, as it is strongly influenced by the geographic origin, climatic conditions, the processing method (incubation temperature and time, agitation, grain/milk ratio, etc.) and the type of milk used to carry out periodic subculture (Garofalo et al., 2015).

Sucrose is the sweetener most used in the production of fermented milk due to its physicochemical and sensorial characteristics, and low cost. In addition to providing a sweet flavor, it influences the properties of texture, shape, color, appearance, yield/volume, water activity, among others (Wan et al., 2021). However, if consumed in excess, sugar can improve the risk of several health problems, such as diseases of the oral cavity, obesity, diabetes and cardiovascular problems (Mooradian et al., 2017). Previous studies highlighted that the sensorial properties, physicochemical properties, and microbiological properties of yogurt are influenced by sucrose content reduction (Pereira et al., 2024; Torrico et al., 2020). Furthermore, the use of non-caloric sweeteners may also reduce the acceptability of the product (Du & Myracle, 2018). Kefir may contain a high sucrose content, and therefore strategies to reduce or replace this sweetener deserve to be studied.

Jabuticaba (*Myrciaria cauliflora*) is a native Brazilian Atlantic Forest berry, and its spherical fruits (ϕ 2-4 cm) have a dark-purple peel, a sweet (12 °Brix), astringent and acid (pH 3.3- 4.5) white soft juicy pulp, and between one and four small seeds (Fernandes et al., 2020; Inada et al., 2018; Inada et al., 2015; Morales et al., 2016). The nutritional value of jabuticaba is

due to its content of carbohydrates (~ 90%), dietary fiber of the peel (38%), ascorbic acid, β-Carotene, mineral such as iron, copper and manganese, and phenolic compounds (Fernandez-Barbero et al., 2019; Inada et al., 2015; Morales et al., 2016). The fruits are consumed fresh and processed as jams, juices, liqueurs, ice-creams, and peel flour (Clerici and Carvalho-Silva, 2011; Geraldi et al., 2021). Furthermore, its consumption can bring health benefits such as na increased serum antioxidant capacity and plasma glucagon-like peptide-1 response after a carbohydrate meal (Geraldi et al., 2022).

Drinks sweetened with sucrose and flavored with aronia or elderberry pulp were well accepted sensorially (Du and Myracle, 2018). Furthermore, the addition of freeze-dried *Arbutus unedo L*. and *Tamarindus indica L*. fruits increased the quantity and variety of phenolic compounds and reduced the pH of the kefir (Kulaksız Günaydı & Ayar, 2022).

Taking all this into account and growing consumer demand for healthier products, this present study aimed to evaluate the effect of different concentrations of sucrose and prebiotic jabuticaba pulp in milk kefir, evaluating the physicochemical, microbiological and sensory properties for 30 day. of storage.

2. Methodology

An experimental, laboratory research of a quantitative nature was carried out (Tossi & Petry, 2021; Pereira et al., 2018) using descriptive statistics using mean values, absolute frequency, and relative percentage frequency (Shitsuka et al., 2014) and statistical analysis (Vieira, 2021).

2.1 Materials

To prepare the kefir, a commercial kefir culture MT036LX (Sacco Brasil Comércio de Alimentos, Brazil), UHT whole milk (Piracanjuba, Brazil) and sucrose obtained from the local market (Brazil) were used. For flavoring, dehydrated pulp of jabuticaba (*Myrciaria jabuticaba (Vell.) Berg.*) obtained by spray dryer processing with polydextrose fiber donated by the company Sylvestre® (Tatuí, Brazil).

2.2 Experimental design and kefir preparation

Four kefir formulations were prepared: 0%-S without added sucrose and jabuticaba pulp; 5%-S with 5% sucrose; 7.5%-S with 7.5% sucrose; 5%-JP with 5% jabuticaba Pulp; and 7.5%-JP with 7.5% jabuticaba pulp.

The commercial microorganism MT036LX (Sacco, Brazil) was used as the kefir starter culture, consisting of microorganisms *Lc. lactis* ssp. *lactis, Lc. Lactis* ssp. *cremoris, Lc. lactis* ssp. *lactis* biovar.*diacetylatis, Leuconostoc* ssp., *L. brevis, Saccharomyces cerevisiae* e *Kluiveromyces lactis*.. The culture was previously fractionated in sterilized milk and frozen (-20 °C) until use.

For the fermentation process, the culture was thawed in the refrigerator (4°C) for 8 hours and aseptically inoculated in UHT milk at 25°C in previously sanitized fermenters and incubated in BOD at a temperature of 25 °C for 17 hours until the pH reaches 4.5. Afterwards, rapid cooling was carried out by immersing the containers in ice water. Then, 5 formulations were produced, with 0%, 5% and 7.5% sucrose, and 5% and 7.5% prebiotic jabuticaba pulp. Each formulation was mixed for 30 seconds until a homogeneous liquid was obtained and then packaging was carried out aseptically. The formulations were packaged in previously sanitized 200 ml transparent polyethylene bottles (sodium hypolocorite solution at 300 ppm active chlorine), leaving 10% empty space in each bottle. The bottles were closed with plastic screw caps, with seal and safety seal, also previously sanitized and dried. Immediately after filling, the bottles were stored in BOD at 4 °C for 30 days.

Physicochemical and microbiological analyzes were carried out at times 0, 8, 11, 15, 17 hours of fermentation, and at 0, 15 and 30 days of storage.

2.3 Evaluation of physicochemical properties of kefir

To evaluate the fermentation process, analyzes of pH, acidity and total soluble solids (TSS) were carried out. TSS, pH, and water holding capacity were analyzed to evaluate the kefir formulations.

2.3.1 pH

The pH was evaluated using the potentiometric method, using a bench pH meter (PA200, Marconi, Brazil).

2.3.2 Total soluble solids content (° Brix)

Total soluble solids contents were quantified by refractometry, using the ATC portable refractometer (model GT427, Mettler Toledo, Switzerland), with a smaller scale division of 0.01 º Brix.

2.3.3 Acidity analysis

Acidity was measured using the titration method. 10 mL of the sample was added to a 125 mL Erlenmeyer flask and titrated with 0.1N Dornic solution (AOAC, 2010). The results were expressed as % lactic acid.

2.3.4 Water holding capacity

The water holding capacity (WHC) was determined using the modified method used by (Davanço et al., 2013). 10 g of kefir sample was weighed into a falcon tube with a capacity of 50 mL, and then centrifuged (DT-4500; Daiki, China) at 5 °C for 10 min at 1250× g. Afterwards, the precipitated serum was weighed. The WHC was calculated based on the formula:

$$WHC\ (\%) = (10 - W)/10 \times 100\%$$

where: A—mass of separated serum (g)

2.4 Evaluation of microbiological properties of kefir

The count of yeasts and lactic acid bacteria (aerobic and anaerobic) was carried out according to the methodology described by the Compendium of Methods for the Microbiological Examination of Food (Downes & Ito, 2001) for the evaluation of the fermentation process and the shelf life of fermented milk. The results were expressed in CFU/mL.

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2.4.1 Yeast count

Dilutions were made in test tubes with 9 mL of 0.9% saline solution. 1 mL of the sample was pipetted, at dilution 10-1, and diluted until dilution 10-6. After dilutions, 100µL of dilution 10-6 was inoculated into a Petri dish containing the potato dextrose agar culture medium. The plates were incubated at 25°C during 48 h.

2.4.2 Lactic acid bacteria

Sample preparation was as previously described (2.1.4.1 Yeast count). To determine lactic acid bacteria, samples were plated on MRS agar culture medium (Man Rogosa Sharpe) and incubated aerobically and anaerobically at 37 °C during 48 h.

2.5 Sensory evaluation

The sensory analysis of kefir was carried out at the Sensory Analysis Laboratory of the State University of Mato Grosso. Approval for the study was obtained by the Ethics Committee (CAAE: 53799521.6.0000.5166).

The study was carried out with 80 consumers aged between 18 and 60 years, who could not be pregnant, breastfeeding or people with vulnerable health conditions, and the selection criterion was the consumption of fermented milk at least once a week. Only tasters who did not have restrictions of any kind (such as allergies or food intolerance, religious, etc.) were recruited for the consumption of kefir. Before the sensory evaluation, consumers read and signed the informed consent form in which they agree to voluntarily participate in the sensory analysis.

The samples (30 mL) were presented at the kefir consumption temperature (4 ºC), in plastic containers identified with 3 randomized digits and presented in a monadic manner, the order of presentation followed a Balanced design (Macfie et al., 1989). Water and biscuits were used to clean the palate between samples.

Acceptance test and check-all-that-apply (CATA) tests were carried out at time 0 of storage. The acceptance test was carried out using a structured hedonic scale of nine points, with extremes ranging from very much dislike to very much like, for the attributes of color, aroma, flavor, texture and overall impression (Meilgaard et al., 1999). The CATA attributes were bread aroma, slightly acidic flavor, milky aroma, attractive color, very viscous texture, not very sweet flavor, acidic flavor, fermented aroma, very sweet flavor, acidic aroma, milky flavor, curd texture, very sweet texture. liquid, jabuticaba flavor, airy texture, ideal viscosity, ideal color, yogurt flavor, bread flavor, ideal sweetness.

2.6 Statistical analysis

The experiment was done in triplicate. Data from physicochemical, microbiological and consumer test analyzes were evaluated using analysis of variance (ANOVA) at a significance level of 5%, and the difference between the mean results was evaluated using the Tukey test ($p < 0.05$), using the statistical program Statistica (v16 version, Oklahoma, USA).

Correspondence analysis considering chi-square distance (Vidal et al., 2015) was calculated in the matrix containing the frequency of use of each term for each sample using, and principal coordinate analysis was carried out to correlate sensory attributes and overall liking using XLSTAT 2018 (Addinsoft, New York, USA).

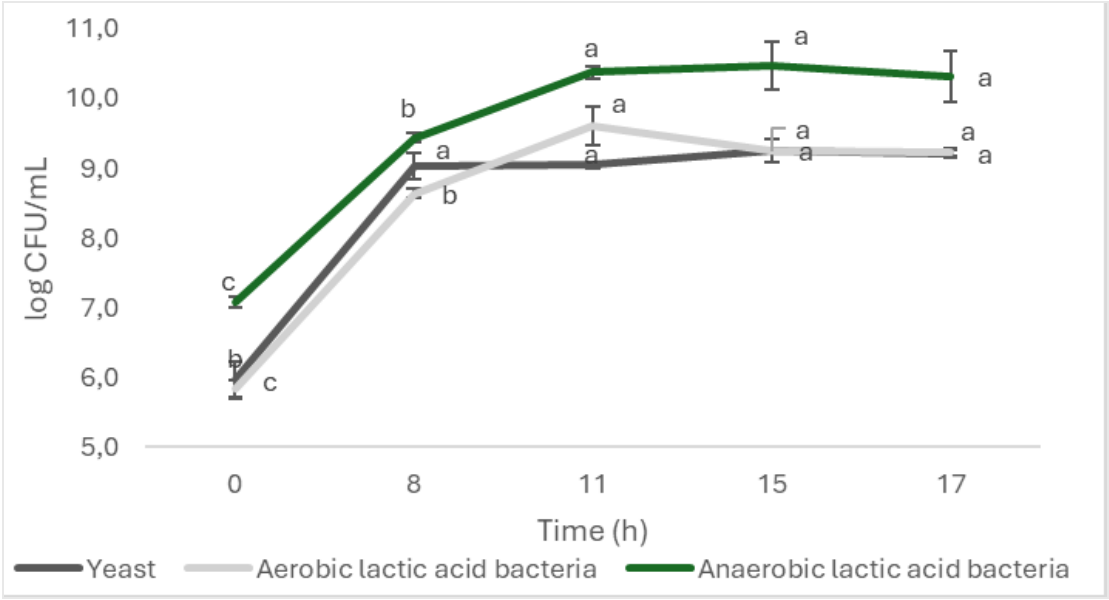
3. Results and Discussion

3.1 Kefir fermentation process

3.1.1 Count yeast and lactic acid bacteria

The results obtained from counting yeasts, and aerobic and anaerobic lactic acid bacteria during the fermentation process are shown in Figure 1.

Figure 1 - Growth of yeast and lactic acid bacteria during the fermentation process.



Equal letters for the same analysis are not statistically different (p > 0.05). Source: Authors.

As can be seen, there was a significant increase in the growth of yeasts, aerobic and anaerobic acid lactic bacteria between the times 0 h and 17 h, indicating the occurrence of fermentation. The same behavior was observed previously (Garofalo et al., 2015; Gul et al., 2015; Suriasih et al., 2012).

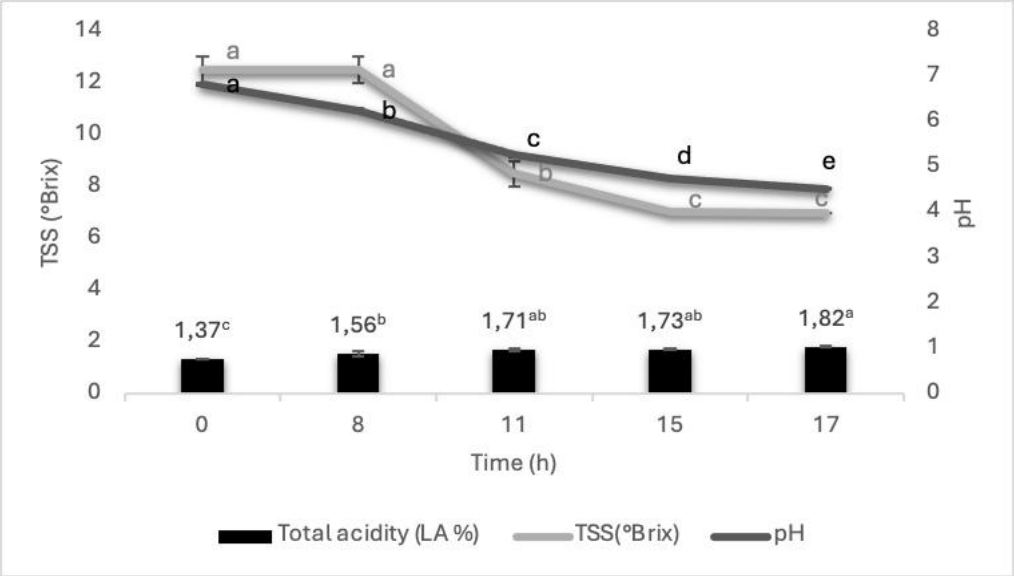
Kefir quality criteria establish that the total lactic acid bacteria count (CFU/g) must be at least 107, and the specific yeast count (CFU/g) must be at least 104 in fermented milk (Brazil, 2007; WHO/FAO, 2011), therefore, the kefir produced in this study meets the requirements of the legislation, and the product developed in the study can be considered probiotic.

After 17 hours of fermentation, the kefir reached the CFU/mL counts found in the literature (Hong et al., 2019). Strains of the genera *Lactobacillus spp*. e *Bifidobacterium spp.* have been shown to produce prophylactic and therapeutic effects in humans. These live microorganisms when administered in correct quantities are known as probiotics. (Saleem et al., 2023; Yilmaz et al., 2022).

3.1.2 Physicochemical parameters during the fermentation process

The results obtained for pH, acidity and TSS (°Brix) are shown in Figure 2.

Figure 2 - Physicochemical changes during the kefir fermentation process at 25°C.



Equal letters for the same analysis are not statistically different (p > 0.05). TSS- Total soluble solids. Source: Authors.

After 17 hours of fermentation, the pH of the kefir reached 4.5. It is important to maintain this value, as yogurt with a pH > 4.6 favors the separation of the whey, because the gel has not been sufficiently formed. On the other hand, at a pH < 4.0, the grain contracts due to reduced hydration. of proteins, which causes the product to drain (Brandão, 1995). Previous studies to obtain kefir from bovine milk also obtained similar pH results (Gul et al., 2015; Hong et al., 2019; Irigoyen, 2005).

The final acidity value is within the parameters required by legislation, between 0.6 and 2.0 (Brazil, 2007; WHO/FAO, 2011). Acidity makes yogurt relatively stable foods by inhibiting the growth of Gram-negative bacteria (Vedamuthu, 1991).

During 17 hours of fermentation, total soluble solids decreased ($p < 0.05$), this is due to the microorganisms present in kefir use the solids of the milk as a carbon source, mainly lactose (Alves et al., 2021; Suriasih et al., 2012).

3.2 Evaluation of the shelf life of kefir flavored with jabuticaba pulp

Table 1 presents results of the microbiological and physicochemical stability of kefir samples with different concentrations of sucrose and jabuticaba pulp during 30 days of refrigerated (4 °C) storage.

Table 1 - Microbiological and physicochemical stability of kefir formulations with and without addition of sucrose or jabuticaba pulp stored at 4 °C.

		Days		
	Sample	0	15	30
Yeasts (log CFU/mL)	0%-S	9.03 ± 0.19^{aA}	7.54 ± 0.06^{dC}	8.65 ± 0.10^{bB}
	5%-S	9.04 ± 0.14^{aA}	7.81 ± 0.14^{cB}	9.19 ± 0.04^{aA}
	7.5%-S	9.11 ± 0.10^{aB}	7.71 ± 0.07^{cdC}	9.29 ± 0.03^{aA}
	5%-JP	9.13 ± 0.14^{aA}	8.85 ± 0.08^{aB}	8.70 ± 0.08^{bB}
	7.5%-JP	9.18 ± 0.10^{aA}	8.54 ± 0.03^{bB}	8.63 ± 0.10^{bB}
LAB aerobic (log CFU/mL)	0%-S	8.81 ± 0.03^{abA}	8.73 ± 0.11^{cA}	8.18 ± 0.17^{dB}
	5%-S	8.92 ± 0.06^{abB}	8.96 ± 0.09^{bAB}	9.11 ± 0.07^{abA}
	7.5%-S	9.23 ± 0.08^{aA}	8.94 ± 0.06^{bB}	9.28 ± 0.04^{aA}
	5%-JP	8.62 ± 0.35^{bB}	9.29 ± 0.05^{aA}	8.83 ± 0.08^{bcAB}

	7.5%-JP	8.88±0.21^{abAB}	9.19±0.05^{aA}	8.72±0.25^{cB}
LAB anaerobic (log CFU/mL)	0%-S	9.65±0.22^{aA}	9.47±0.12^{aAB}	9.15±0.12^{cB}
	5%-S	9.71±0.22^{aA}	9.14±0.43^{aA}	9.81±0.18^{aA}
	7.5%-S	9.72±0.11^{aA}	8.97±0.29^{aB}	9.72±0.09^{abA}
	5%-JP	9.42±0.06^{aA}	9.09±0.13^{aB}	9.57±0.05^{abA}
	7.5%-JP	9.38±0.23^{aA}	9.17±0.18^{aA}	9.48±0.13^{bA}
pH	0%-S	4.52±0.00^{aB}	4.61±0.03^{aA}	4.62±0.01^{aA}
	5%-S	4.50±0.01^{aAB}	4.48±0.02^{cB}	4.51±0.01^{cA}
	7.5%-S	4.49±0.01^{aB}	4.50±0.02^{cB}	4.54±0.01^{bA}
	5%-JP	4.40±0.02^{bB}	4.56±0.01^{bA}	4.55±0.01^{bA}
	7.5%-JP	4.36±0.02^{cB}	4.55±0.02^{bA}	4.54±0.01^{bA}
TSS (°Brix)	0%-S	8.00±0.15^{cB}	9.00±0.47^{cA}	8.00±0.40^{cB}
	5%-S	12.95±0.18^{bAB}	13.35±0.35^{bA}	12.75±0.55^{bB}
	7.5%-S	15.00±0.38^{aAB}	15.55±0.45^{aA}	14.80±0.46^{aB}
	5%-JP	12.50±0.41^{bB}	12.70±0.52^{bAB}	13.00±0.32^{bA}
	7.5%-JP	14.90±0.22^{aA}	15.00±0.12^{aA}	15.00±0.38^{aA}
WHC (%)	0%-S	66.73±2.10^{cA}	56.55±0.74^{cB}	58.13±1.78^{cB}
	5%-S	72.66±1.75^{bA}	65.38±1.35^{bC}	70.74±2.68^{aB}
	7.5%-S	76.74±1.41^{aA}	73.67±1.52^{aB}	72.28±2.66^{aB}
	5%-JP	72.82±1.58^{bA}	65.55±1.95^{bB}	62.58±1.85^{bC}
	7.5%-JP	71.51±1.05^{bA}	68.98±5.32^{abAB}	65.18±1.04^{bB}

Equal lowercase letters in the same column for the same parameter are not statistically different ($p > 0.05$). Equal capital letters on the same line are not statistically different ($p > 0.05$). LAB- Lactic acid bacteria, TSS - Total soluble solids, WHC- water holding capacity. 0%-S: natural kefir; 5%-S: kefir sweetened with 5% sucrose; 7.5%-S: kefir sweetened with 7.5% sucrose; 5%-JP: kefir added with 5% jabuticaba pulp; 7.5%-JP: kefir added with 7.5% jabuticaba pulp. Source: Authors.

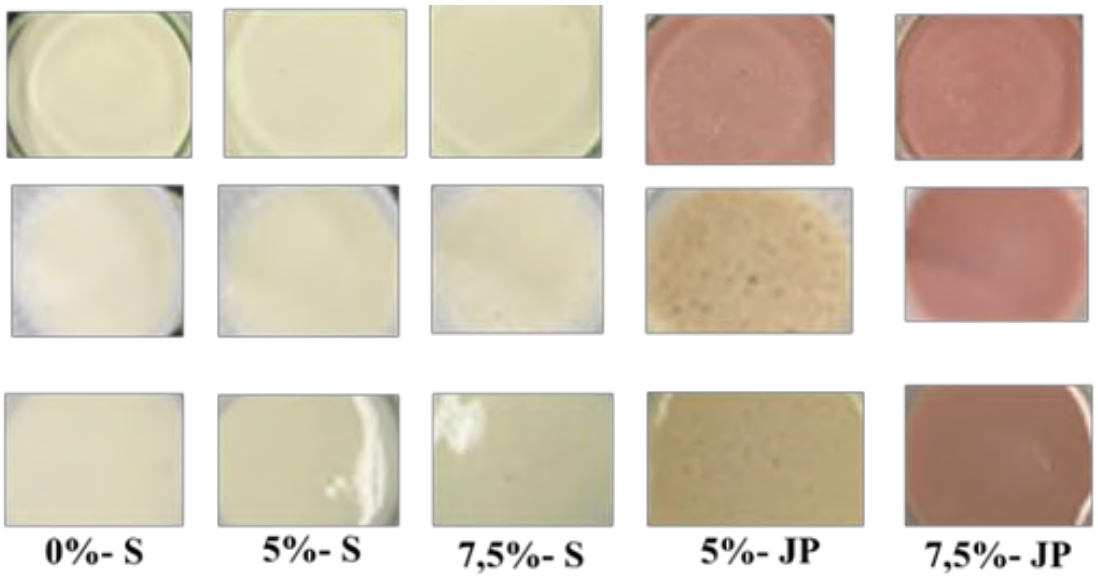
The addition of 5% and 7.5% sucrose increased the growth of yeast and LAB during 30 days of storage (Table 1), possibly because sucrose is the main fermentation substrate for microorganisms. Yeast produces CO_2 during fermentation, and this plays a fundamental role in developing the characteristics of kefir (Carvalho, 2011).

The addition of jabuticaba pulp reduced the pH values of the samples ($p < 0.05$), possibly due to the fruit's natural organic acids (Inada et al., 2015). TSS levels were higher at concentrations of 7.5% sucrose and 7.5% jabuticaba pulp during 30 days of storage, followed by a concentration of 5% of both solutes ($p < 0.05$). The TSS content in kefir represents the amount of solids in the drink, and therefore the more solids (sucrose and jabuticaba pulp) are added, the higher the value obtained.

The addition of pulverized and freeze-dried jabuticaba pulp improved the WHC of kefir compared to the control sample. WHC ranged from 56% to 76% in samples during storage and was lowest in the without sucrose addition (0%-S) and highest in the formulation with 7.5% sucrose content during 30 days of storage ($p < 0.05$). Similar results were found in the literature (Ban et al., 2020).

The visual color change during storage is shown in Figure 3.

Figure 3 - Evaluation of the sample color during 30 days of storage utilizing different concentrations of sugar and jabuticaba pulp.



0%-S: kefir natural; 5%-S: kefir adoçado com 5% sacarose; 7.5%-S: kefir adoçado com 7,5% de sacarose; 5%-JP: kefir adicionado de 5% polpa de jabuticaba; 7.5%-JP: kefir adicionado de 7,5% de polpa de jabuticaba. Source: Suzin et al. (2025).

It can be observed that the samples with jabuticaba pulp had a considerable color change during storage, mainly the sample with 5% jabuticaba pulp. The main factors responsible for the degradation of anthocyanins, the pigment responsible for the characteristic color of jabuticaba, are pH, temperature and oxygen concentration. (Damodaran and Parkin, 2019). The pigment concentration also influenced color stability (Barretto et al., 2020), with samples with 7.5% jabuticaba pulp showing a more stable color for longer.

3.3 Sensory evaluation

3.3.1 Acceptance test

Table 2 presents the sensory acceptance and purchase intention results of kefir samples with and without the addition of sucrose or jabuticaba pulp.

Table 2 - Sensory acceptance and purchase intention of kefir with and without added sucrose or jabuticaba pulp.

Sample	Aroma	Flavor	Texture	Overall impression	Purchase intention
0%-S	6.44^{b}	4.87^{b}	5.81^{b}	5.54^{b}	2.56^{b}
5%-S	7.42^{a}	7.50^{a}	7.45^{a}	7.65^{a}	4.07^{a}
7.5%-S	7.47^{a}	8.17^{a}	7.62^{a}	8.05^{a}	4.41^{a}
5%-JP	6.35^{b}	4.90^{b}	5.94^{b}	5.57^{b}	2.57^{b}
7.5%-JP	6.20^{b}	5.26^{b}	6.05^{b}	5.69^{b}	2.65^{b}

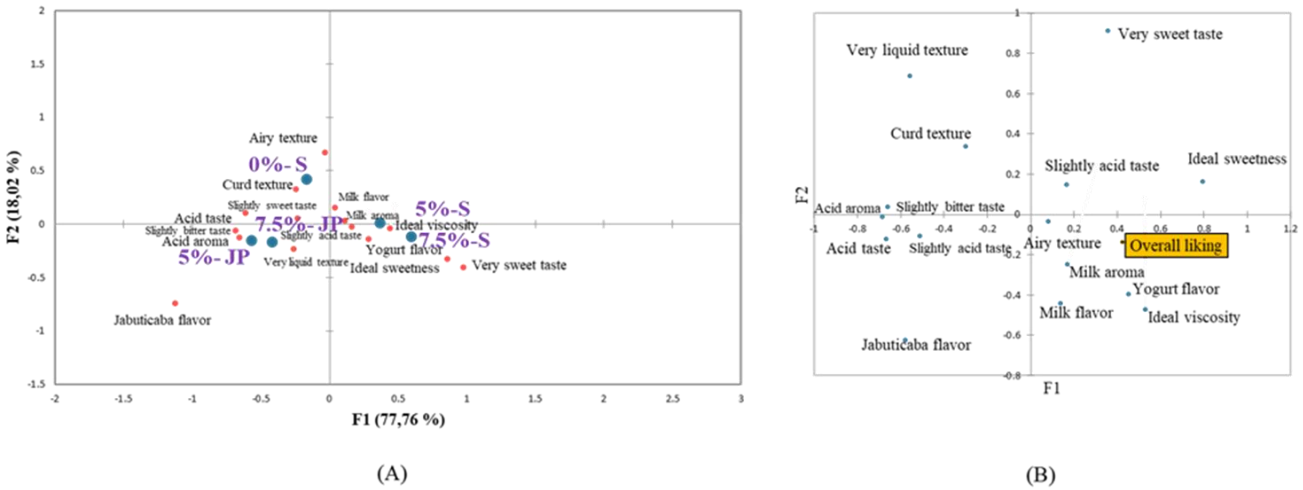
Equal letters in the same column for the same parameter are not statistically different ($p > 0.05$). 0%-S: natural kefir; 5%-S: kefir sweetened with 5% sucrose; 7.5%-S: kefir sweetened with 7.5% sucrose; 5%-JP: kefir added with 5% jabuticaba pulp; 7.5%-JP: kefir added with 7.5% jabuticaba pulp. Source: Authors.

Samples sweetened by sucrose had greater consumer acceptance ($p < 0.05$). Sucrose reduces acidity due to acids produced during yogurt fermentation (Wan et al., 2021). The attribute that presented the lowest score in samples with jabuticaba pulp was flavor, probably due to the acidity of the pulp (pH 2.5) and no addition of sucrose.

There was no statistical difference for all attributes evaluated between the samples with 5% and 7.5% sucrose. Another study showed that consumers gave higher ratings for flavor, aroma and overall acceptance to kefir samples with 5% sucrose (Kulaksız Günaydı & Ayar, 2022). Therefore, it is possible to reduce the sucrose addition in kefir formulations to 5% to have a healthier product with similar sensory properties.

The results from the CATA questionnaire are presented in Figure 4. It is observed that the tasters noticed that the samples that contained jabuticaba pulp were more acidic when compared to the samples that contained added sucrose.

Figure 4 - (A) Representation of samples and attributes in the first two dimensions of the correspondence analysis (CA) of kefir samples using CATA questions. (B) Correlation between sensory attributes and global acceptance in the first two dimensions of the principal coordinates analysis.



0%-S: kefir natural; 5%-S: kefir adoçado com 5% sacarose; 7.5%-S: kefir adoçado com 7,5% de sacarose; 5%-JP: kefir adicionado de 5% polpa de jabuticaba; 7.5%-JP: kefir adicionado de 7,5% de polpa de jabuticaba. Source: Authors.

The 0% sucrose content sample was related to the attributes curd texture, acid taste, airy texture and not very sweet taste. The samples with 5% and 7.5% sucrose content were related to the attributes ideal sweetness, yogurt taste, low acid taste, ideal viscosity, milk flavor, milk aroma. The 5% and 7.5% JB samples were related to a slightly bitter taste, a very liquid texture, an acidic taste, a jabuticaba flavor, a slightly sweet taste, and an acidic aroma.

From Figure 4 it is possible to observe that the global acceptance of kefir is related to the parameters of aerated texture, milk aroma, milk flavor, yogurt flavor, ideal viscosity, ideal sweetness and low acid taste and that the samples with 5% and 7.5% sugar are closer to these attributes.

4. Conclusion

Evaluation of microbiological stability demonstrated that all kefir formulations can be labeled as probiotics. The physicochemical and microbiological characteristics of kefir flavored with powdered jabuticaba pulp were not affected during 30 days of shelf life. However, kefir with jabuticaba pulp had lower acceptance when compared to samples with added

sucrose, possibly due to the lack of sweet flavor and greater acidic flavor. Future studies combining jabuticaba pulp with sugar may improve the sensory acceptance of fermented milks.

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