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CIÊNCIA E TECNOLOGIA DE ALIMENTOS

## GOAT MILK MANGO YOGHURTS: PHYSICOCHEMICAL STABILITY DURING OR STORAGE

### *IOGURTES DE LEITE DE CABRA COM MANGA: ESTABILIDADE FÍSICO-QUÍMICA DURANTE O ARMAZENAMENTO*

Yvana Maria Gomes dos Santos<sup>1</sup>Emanuel Neto Alves de Oliveira<sup>2</sup>Bruno Fonsêca Feitosa<sup>1\*</sup>Dyego da Costa Santos<sup>1</sup>Regilane Marques Feitosa<sup>1</sup>Francisco Lucas Chaves Almeida<sup>3</sup><sup>1</sup>Universidade Federal de Campina Grande, Campina Grande, PB, Brazil.<sup>2</sup>Instituto Federal do Rio Grande do Norte, Pau dos Ferros, RN, Brazil.<sup>3</sup>Universidade Federal da Paraíba, Bananeiras, PB, Brazil.\*Corresponding author - [brunofonsecafeitosa@live.com](mailto:brunofonsecafeitosa@live.com)

#### Abstract

Goat milk and regional fruits, like the sword mango, are loaded with nutritional potential which warrant investigation as possible sources of generating income, particularly in the deficient semiarid northeastern regions of Brazil. The aim of this study is to assess the stability of the procedure in the production of processed yogurt with goat milk and sleeve pulp. Five different yogurt formulations were processed using varying concentrations of sucrose (5, 10 and 15%) and mango pulp (4, 5 and 6%). Each type of yogurt had a distinctive flavour attributed to the effect of several factors viz., dry extract, ash, lipids, proteins, carbohydrates, calories, pH, acidity and water content, over a 30-day period, with stabilization being performed every 15 days. In this study, the sucrose concentration was identified as the most significant factor among the various physicochemical parameters. In the storage period a decrease in the pH values, calories, lipids, total dry extract and ash was observed, as well as an increase in the acidity values and carbohydrate and water content, in all the yogurts. Yogurts are amenable to market testing, with potential perspectives of significance for income generation and wise utilisation of the available regional premium constituents, like goat milk and sword mango, whose consumption can act as a healthy and nutritious food supplement.

**Key words:** storage, fermented milk, *Mangifera indica* L.

#### Resumo

O leite caprino e as frutas regionais, como a manga espada, são alimentos com potencialidade nutricional que merecem atenção, frente as possibilidades de geração de renda em regiões carentes do semiárido nordestino. Objetivou-se com esta pesquisa avaliar a estabilidade durante o armazenamento de iogurtes elaborados com leite de cabra e polpa de manga. Cinco formulações de iogurte foram elaboradas com diferentes concentrações de sacarose (5, 10 e 15 %) e polpa de manga

(4, 5 e 6 %). Os iogurtes foram caracterizados quanto aos parâmetros de extrato seco, cinzas, lipídeos, proteínas, carboidratos, calorias, pH, acidez e atividade de água, durante um período de 30 dias com avaliação da estabilidade a cada 15 dias. Verificou-se que a concentração de sacarose foi o fator mais significativo perante os parâmetros físico-químicos. Durante o armazenamento houve redução nos valores de pH, calorias, lipídeos, extrato seco total e cinzas e aumento nos valores de acidez, carboidratos e atividade de água de todos os iogurtes. Os iogurtes apresentam potencial para testes mercadológicos, com boas perspectivas de impacto na geração de renda e exploração de matérias-primas regionais, como o leite caprino e a manga espada, uma vez que seu consumo pode ser uma alternativa nutritiva e saudável.

**Palavras-chave:** estocagem, leite fermentado, *Mangifera indica* L.

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## Introduction

In the Brazilian semi-arid region, goat farming is a significant socioeconomic activity. This activity is viable because these animals are highly resilient to the environmental conditions of this region, with its distinctive warm and dry climate, interspersed with long spells of drought. Goat milk is one of the products which is highly digestible and nutrient rich, containing high concentrations of calcium, potassium, phosphorus and magnesium, many times more than those present in cow milk <sup>(1,2)</sup>.

Recently, goat milk has been eagerly sought after, by those individuals experiencing milk intolerance, as a viable alternative and food substitute. The low level of the alpha s-1 casein proteins (15%) reduces the action of  $\beta$ -lactalbumin (allergenic agent) when compared to cow's milk, which contains roughly 39% of structurally different alpha s-1 casein proteins <sup>(3)</sup>. The effects of the intolerance can thus be significantly minimised in lactose-sensitive individuals.

Small farmers of family origin who can access a few of the new technologies are able to commercially produce some globally recognised fermented products like cheeses, dairy drinks and yoghurts. Yoghurt, which is processed through the lactic fermentation of milk has a high market potential because of its commercial diversification and valued sensorial features <sup>(1,4,5)</sup>. Apart from being an outstanding digestive regulator, it contains health-giving and nutritional properties, such as its abundance of calcium, proteins and minerals, such as zinc and magnesium <sup>(4)</sup>.

The fermented product permits complements, like tropical fruits, to be added which provide the characteristic flavour, colour and aroma to the yoghurt. Mango (*Mangifera indica* L.) is a delicious fruit, appearing in a variety of sizes and shapes, and contains 15% sugars, 1% protein, significant quantities of antioxidants, carotenoids, minerals and vitamins A, C and B complex. Brazil is a huge mango producer, generating more than 1.1 million tons, in 2014 alone <sup>(6,7)</sup>.

The states of Bahia and Pernambuco in the Brazilian northeast, produce about 85% of the country's total mango exports, exerting a social impact as it generates employment in an area that continues to require public policies and viable income options <sup>(8)</sup>. In light of this, the goal of the present investigation was to assess the physicochemical stability of the mango goat yoghurts during storage.

## Material and Methods

The yogurts were prepared using the mature sword variety of mangoes, purchased in the retail market of the city of Solânea-PB. After washing them under running water, they were sanitized (chlorinated water solution at 100 ppm / 15 min), peeled, mashed in a domestic blender (1 min), packed in polyethylene plastic bags and stored (-18° C) for use, until the final processing stage, with the added fruit. The caprine sector of the Federal University of Paraíba (UFPB), *Campus* III Bananeiras, supplied the goat milk. The manually drawn milk from the healthy Saanen dairy goats was filtered and the suspended particles removed.

Each of the goat yoghurt formulations was prepared using 5 liters of goat milk with different sucrose levels (5, 10 and 15%) and mango pulp (4, 5 and 6%) as shown in Table 1. These concentrations were established based on the research positivity, which gave good results and acceptance of the added 10% sucrose and 5% fruit pulp. The pre-bench tests performed were done to confirm the final product, concurring with the increases and decreases in the percentages of added sucrose and pulp, from the technological perspective. The quantities of the pulp and sucrose added were also selected according to the norms stipulated by the Technical Regulation on the Identity and Quality of Fermented Milks, established by Resolution No. 46 of October 23, 2007 <sup>(9)</sup>, which specifies a 30% ceiling of non- to be added in fermented yoghurts.

**Table 1.** Formulations used in the preparation of mango goat yoghurts

Formulations	Goat milk	Sucrose *	Milk culture *	Milk culture *
I <sub>1</sub>	5000 mL	250 g (5%)	0,025 g (0,0005%)	200 g (4%)
I <sub>2</sub>	5000 mL	750 g (15%)	0,025 g (0,0005%)	200 g (4%)
I <sub>3</sub>	5000 mL	250 g (5%)	0,025 g (0,0005%)	300 g (6%)
I <sub>4</sub>	5000 mL	750 g (15%)	0,025 g (0,0005%)	300 g (6%)
I <sub>5</sub>	5000 mL	500 g (10%)	0,025 g (0,0005%)	250 g (5%)

\* Values based on the amount of goat's milk used for each formulation; I<sub>1</sub>, I<sub>2</sub>, I<sub>3</sub>, I<sub>4</sub> e I<sub>5</sub> – Yoghurts.

After the goat milk was brought to the Laboratory of Milk Processing (UFPB Campus III), sucrose was added to the milk according to the proportions prescribed for each formulation (Table 1). The mixture was then pasteurized at 85° C for 15 minutes and cooled to 43° C under constant stirring. Next, the lyophilized thermophilic milk culture (Yoflex®®, company Chr. Hansen®®), which was earlier dissolved in 100 ml of the respective milk used in the formulations, at a concentration of 0.005 g / L of milk, containing the microorganisms *Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp. Bulgaricus* was added.

The mixtures were stored in 7-liter capacity stainless steel containers and placed on stoves at 43° C for fermentation until an acidity level of above 0.65% lactic acid was achieved (about 8 hours of fermentation). Once fermentation was completed, the containers containing the yoghurts were stored in a cold room at 4° C / 12 h. for mass maturation. After this stage, the yoghurt mass was broken up and subjected to homogenisation using horizontal and vertical metal lires. Next, the mango pulp was added for each formulation (Table 1), and after manual homogenisation was done it was packaged in 100 ml polypropylene plastic bottles.

The yogurts were subjected to 30-day storage under refrigeration in a cold room (4° C). At this time,

the physicochemical stability of the product was verified at "zero" (0) time (initial after elaboration) and after every 15 days of storage. Based on the Adolfo Lutz Institute<sup>(10)</sup> standards for milk and dairy products, physical and chemical analyses of the total dry extract, ashes, pH, lipids, and titratable total acidity in lactic acid were performed in triplicate; proteins were tested according to the AOAC<sup>(11)</sup>; total carbohydrates per difference (100-% of lipids, proteins, ash and moisture); and water activity at 25° C, by direct reading of the samples using the AquaLab equipment (Decagon Devices®, model 3TE), and energy value<sup>(12)</sup>.

The experimental design adopted for the statistical analysis was a 5 × 3 factorial type (5 yoghurt and 3 storage periods) applied to each parameter, with 5 replicates in the experiment. The Assistat version 7.7 beta<sup>(13)</sup> software was used. Data were submitted to the analysis of variance (ANOVA) and Tukey test at a probability level of 5%.

## Results and Discussion

Table 2 lists the statistical parameters after evaluating the physicochemical stability of the mango goat yoghurts during storage. A significant effect at the 1% probability level was noted for most of the factors, based on the F test for the physicochemical analyses. Factor 3 (yoghurt x storage time) revealed the highest number of non-significant effects in the analyses of the stability of the yoghurts.

The ashes and proteins showed the highest coefficient of variation values, which gave slightly above 10% results, whereas lower values were reported for the water and pH activity parameters, at below 1%. The caloric value justifiably registered the highest Significant Minimum Difference (DMS), as the caloric value corresponds to a parameter achieved by calculating the results of the moisture, ash, lipid and protein. Thus, because it favours a greater difference between its repetitions, it is not considered an analytical analysis.

**Table 2.** Statistical parameters obtained on evaluating the physicochemical stability of the mango goat yoghurts during storage.

Reviews	Statistical Parameters						
	AG	CV (%)	DSM Column	DSM Row	Test F1	Test F2	Test F3
EDT	18.37%	4.16	1.81	1.53	162.61**	1.46 <sup>ns</sup>	1.76 <sup>ns</sup>
Lipids	2.64%	9.11	0.57	0.48	9.07**	78.34**	3.77**
CT	12.54%	6.37	1.90	1.60	191.05**	5.74**	2.10 <sup>ns</sup>
Ashes	0.71%	10.93	0.18	0.16	5.61**	4.28*	0.85 <sup>ns</sup>
Proteins	2.48%	10.88	0.64	0.54	6.73**	3.16 <sup>ns</sup>	0.11**
VC	83.82 Kcal/100g	4.32	8.59	7.27	107.27**	13.95**	1.39 <sup>ns</sup>
A <sub>w</sub>	0.981	0.59	0.01	0.01	3.18*	7.31**	0.57 <sup>ns</sup>
pH	4.43	0.47	0.05	0.05	1.54 <sup>ns</sup>	686.64**	7.36**
ATT	0.88%	2.60	0.05	0.05	17.87**	312.83**	6.35**

EDT - Total dry extract, CT - Total carbohydrates, VC - Caloric value, A<sub>w</sub> - Water activity, ATT - Titratable total acidity, AG - General average, CV - Coefficient of variation, DSM - Minimum significant difference, F1 - Factor 1, F2 - Factor 2 (Storage time), F3 - Factor 3 (yoghurts x storage time), Test F (\*\*Significant at the probability level of 1%; \*Significant at the probability level of 5%; <sup>ns</sup>Not significant).

Table 3 displays the values of the total dry extracts (EDT) of the mango goat yogurts. The sucrose concentration exerted a significant influence on the EDT values because these values were observed to rise when the sucrose concentration increased. No statistical difference was seen among the yoghurts made by using the same sucrose concentrations at the initial time. This was a justifiable increase because commercial sugar basically contains sucrose and has low humidity. This sweetens the product and increases the concentration of the solids.

During storage, all the yogurts showed stable EDT values, with no significant decline when storage was completed (30 days). Queiroga et al.,<sup>(14)</sup> highlight that the variations in the total dry extract of the yoghurt can be affected by the species, race, nutrition and health of the animal which possesses a specific chemical variation for its milk. During the goat milk yogurt characterization using different concentrations of umbu pulp (10, 15 and 20%), Marinho et al.,<sup>(15)</sup> reported higher variations in the total solids than did the present study (between 27.01 and 31.09%); these results are linked to the concentrations of the 20% sucrose added to the formulations by the authors.

Serafeimidou et al.<sup>(16)</sup> found identical behaviour for EDT in their work on the stability of yoghurts stored at 5° C for 14 days, with a drop in the EDT values of yoghurts which used bovine (17.75 to 11.90%) and ovine (20, 63 to 18.94%) milk.

**Table 3.** Mean values of the total dry extract, lipids and carbohydrates of mango goat yoghurts during storage.

Yoghurts	Parameters	Storage (days)		
		0	15	30
I <sub>1</sub>	Total dry extract (%)	15.60 <sup>cA</sup>	15.48 <sup>cA</sup>	14.81 <sup>cA</sup>
I <sub>2</sub>		21.81 <sup>aA</sup>	20.81 <sup>aA</sup>	21.62 <sup>aA</sup>
I <sub>3</sub>		15.02 <sup>cA</sup>	15.12 <sup>cA</sup>	14.81 <sup>cA</sup>
I <sub>4</sub>		21.52 <sup>aA</sup>	22.47 <sup>aA</sup>	21.50 <sup>aA</sup>
I <sub>5</sub>		19.24 <sup>bA</sup>	17.38 <sup>bA</sup>	18.28 <sup>bA</sup>
I <sub>1</sub>	Lipids (%)	3.33 <sup>aA</sup>	3.03 <sup>aA</sup>	2.37 <sup>aB</sup>
I <sub>2</sub>		3.10 <sup>aA</sup>	2.00 <sup>bB</sup>	1.70 <sup>bC</sup>
I <sub>3</sub>		3.10 <sup>aA</sup>	3.00 <sup>aA</sup>	1.73 <sup>bB</sup>
I <sub>4</sub>		3.13 <sup>aA</sup>	2.47 <sup>abB</sup>	2.27 <sup>abC</sup>
I <sub>5</sub>		3.10 <sup>aA</sup>	3.00 <sup>aA</sup>	2.23 <sup>abB</sup>
I <sub>1</sub>	Total Carbohydrates (%)	8.69 <sup>cA</sup>	9.07 <sup>cA</sup>	9.15 <sup>cA</sup>
I <sub>2</sub>		15.73 <sup>aA</sup>	16.03 <sup>aA</sup>	17.13 <sup>aA</sup>
I <sub>3</sub>		8.14 <sup>cB</sup>	8.57 <sup>cAB</sup>	9.79 <sup>cA</sup>
I <sub>4</sub>		15.26 <sup>aB</sup>	17.06 <sup>aA</sup>	16.34 <sup>aAB</sup>
I <sub>5</sub>		12.81 <sup>bAB</sup>	11.33 <sup>bB</sup>	13.04 <sup>bA</sup>

S - Sucrose, PM - Mango pulp, I<sub>1</sub> (5% S and 4% PM), I<sub>2</sub> (15% S and 4% PM), I<sub>3</sub> (5% S and 6% PM), I<sub>4</sub> (15% S and 6% PM) and I<sub>5</sub> (10% S and 5% PM) - Yoghurts. Means in the column followed by the same lowercase letter or in the row followed by the same capital letter for each parameter analysed do not differ statistically among themselves by the Tukey test at 5% significance.

The lipid values of the yoghurts (Table 3) ranged between 3.10 and 3.33%, and showed no statistical effect on the mango pulp and sucrose concentrations when their composition was assessed post processing (0 days). The lipid values concur with the identity and quality standards established by the

Brazilian legislation <sup>(9)</sup>, which recommends a variation from 0.5 to 5.9%. The mango goat yoghurts were classified as whole, based on the same legislation <sup>(9)</sup>, which stipulates lipid values between 3.0 and 5.9% for this category of yoghurt.

However, when the lipid stability of the yoghurt was evaluated during the storage stage, a significant drop in the values was noted during all the evaluation periods, in all the yoghurts. They showed lipid values from 1.70 to 2.37%, at the end of the 30 days; hence, according to the legislation <sup>(9)</sup>, they were categorised as partially skimmed because their values were in the range of 0.6 and 2.9%.

Until the 15th day of storage, yoghurts I<sub>1</sub>, I<sub>3</sub> and I<sub>5</sub> which had been elaborated using the lowest sucrose concentrations showed no statistical differences. Yoghurts elaborated with the higher sucrose concentrations (I<sub>2</sub> and I<sub>4</sub>) demonstrated significant and significant fat content reductions, by 45 and 44%, respectively, for the same period.

Oxidative reactions rank high among the factors that may have induced this significant decline in the lipid values. These reactions may have been triggered by light exposure and / or oxygen permeating through the packaging material, causing the enzymatic or even non-enzymatic hydrolysis. Waraho et al., <sup>(17)</sup> stated that some constituents already present in the food, like free fatty acids and phospholipids, have the potential to raise the lipid oxidation rates. According to Dantas et al., <sup>(18)</sup> and Neves et al., <sup>(19)</sup> carotenoids, the precursor of vitamin A, present in the mango pulp is too low in concentration to have induced a significant antioxidant action on the yoghurt.

Thus, the short shelf-life of the various types of yoghurt resulting from the storage period, in the absence of any added preservative, is also considered among the possible factors that cause the reduction of some constituents because of the ability to trigger some biochemical reactions and even product deterioration through the action of microorganisms.

When Queiroga et al., <sup>(14)</sup> enhanced the natural yoghurt using 5.90% lipids and when Bez et al., <sup>(20)</sup> did the same with goat yogurt using dehydrated Italian grape and 3.54 to 3.70% fat, and placed it in storage for 45 days, a higher lipid concentration was noted. This reaction is probably caused by the lower concentration of the non-milk substances.

The total carbohydrate contents listed in Table 3, as predicted for the initial time (0 days), showed a direct relation to the quantity of sucrose added. This implies that the higher the sucrose concentration, the greater the carbohydrate content in the yogurt. No statistical difference was noted between the products processed using the same sucrose concentration.

A comparison of the initial (0 days) and final (30 days) storage time showed that total carbohydrate values increased with storage. However, only yogurt I<sub>3</sub> elaborated with a lower sucrose content and higher mango pulp concentration showed a significant numerical increase.

The carbohydrate values which reveal a significant or non-significant increase during storage are most often associated with the variations in the lipid values during that period. The total carbohydrates are estimated by the differences and decreases in the lipid values (Table 3), although the protein and ash values (Table 4) remain practically unchanged.

The sucrose concentration was observed to significantly affect the ash values. These values declined correspondingly as the sucrose concentration increased, and no statistical difference was noted for the initial time between the yoghurts processed using the maximum sucrose concentration. This fact is justified by the greater dilution of the milk minerals in the yoghurt, because in these formulations the higher sucrose concentration causes the mineral constituents to get dissolved to a greater degree.

The fruit pulp added to the yogurts also encouraged the milk minerals to get diluted, thus causing the ash values to drop lower. However, as the pulp added was less in proportion than the sucrose, its effect on these values was less.

The fixed mineral residue of yogurt, otherwise termed the ash concentration (shown in Table 4), is principally linked to the mineral-rich milk, particularly calcium. It also bonds with the colour and flavour enhancers, which in the case of the yogurt, are not natural. As the milk quantity in the formulations gets diluted by the added sweetening, flavouring and / or flavouring substances, the quantity of minerals too decreases, provided the substances added are not mineral-rich, like the milk.

**Table 4.** Mean values of the ash, protein and caloric values of the mango goat yoghurts during storage.

Yoghurts	Parameters	Storage (days)		
		0	15	30
I <sub>1</sub>	Ashes (%)	0.80 <sup>aA</sup>	0.76 <sup>aA</sup>	0.74 <sup>aA</sup>
I <sub>2</sub>		0.65 <sup>cA</sup>	0.62 <sup>bA</sup>	0.60 <sup>aA</sup>
I <sub>3</sub>		0.80 <sup>aA</sup>	0.74 <sup>aA</sup>	0.70 <sup>aA</sup>
I <sub>4</sub>		0.73 <sup>bA</sup>	0.65 <sup>abA</sup>	0.64 <sup>aA</sup>
I <sub>5</sub>		0.77 <sup>bA</sup>	0.68 <sup>abA</sup>	0.72 <sup>aA</sup>
I <sub>1</sub>	Proteins (%)	2.97 <sup>aA</sup>	2.61 <sup>aA</sup>	2.56 <sup>aA</sup>
I <sub>2</sub>		2.33 <sup>bA</sup>	2.25 <sup>aA</sup>	2.12 <sup>aA</sup>
I <sub>3</sub>		2.98 <sup>aA</sup>	2.81 <sup>aA</sup>	2.58 <sup>aA</sup>
I <sub>4</sub>		2.39 <sup>bA</sup>	2.30 <sup>aA</sup>	2.26 <sup>aA</sup>
I <sub>5</sub>		2.55 <sup>abA</sup>	2.37 <sup>aA</sup>	2.29 <sup>aA</sup>
I <sub>1</sub>	Calorific value (Kcal/100g)	75.87 <sup>cA</sup>	74.01 <sup>dA</sup>	68.11 <sup>cB</sup>
I <sub>2</sub>		100.13 <sup>aA</sup>	91.13 <sup>bB</sup>	92.27 <sup>aB</sup>
I <sub>3</sub>		72.39 <sup>cA</sup>	72.50 <sup>dA</sup>	65.11 <sup>cB</sup>
I <sub>4</sub>		98.83 <sup>aA</sup>	99.65 <sup>aA</sup>	94.79 <sup>aB</sup>
I <sub>5</sub>		89.36 <sup>bA</sup>	81.81 <sup>cB</sup>	81.40 <sup>bB</sup>

S - Sucrose, PM - Mango pulp, I<sub>1</sub> (5% S and 4% PM), I<sub>2</sub> (15% S and 4% PM), I<sub>3</sub> (5% S and 6% PM), I<sub>4</sub> (15% S and 6% PM) and I<sub>5</sub> (10% S and 5% PM) - Yoghurts. Means in the column followed by the same lowercase letter or in the row followed by the same capital letter for each parameter analysed do not differ statistically among themselves by the Tukey test at 5% significance.

The ash values for all the yoghurts revealed slight variations during the storage period, showing a minimal reduction in the final values (30 days), although it was not significant for all the yoghurts. This suggests that this component did not expressively undergo any change during the experimental conditions of this study. Belmiro et al.,<sup>(21)</sup> reported that the stability of the mineral content was anticipated during the storage time of the food product, because it does not undergo change throughout the storage period. The only time inconsistency is possible in cases of high elevation or water loss in the product, inducing its chemical composition to change.

In their research Queiroga et al.,<sup>(14)</sup> recorded average ash values in the range of 0.63 and 0.72%, when assessing goat yoghurt to which fruit jellies were added. Earlier, Marinho et al.,<sup>(15)</sup> reported a 0.42 to 0.56% variation for goat yogurt when umbu pulp was used; however, they also observed no significant variation in these values during the 45-day storage period. From these findings it is clear that most of these values are less than those of the current research. This is because a higher level of

dilution of the minerals occurs in the yoghurts containing less quantities of the flavour-producing raw materials relative to the food matrix or the fermented milks.

According to Temiz et al.,<sup>(22)</sup> the ash values decreased (0.97 to 0.81%) as the concentration of the flavourings was increased in their study on the physicochemical stability of the yoghurts under storage.

Considering the protein findings (Table 4), the sucrose concentration used exerted a direct and significant effect on the protein content in the yoghurt at the initial time. This suggests that the lower the sugar content added to the formulations, the higher the protein content in the yoghurts, and the occurrence of a significant difference of 5% statistically among the yoghurts processed with a variety of sucrose concentrations. However, yoghurts processed with similar sucrose percentages remained statistically the same.

Similar to the ash content, the protein present in the yogurts is chiefly milk-related and forms the principal protein source, particularly the casein which is predominant. Therefore, when the milk content in the formulations is diluted by the added sucrose and other sweeteners, the protein values in the yoghurts drops. The protein content demonstrated a linear decline with storage; however, this decrease was not significant for all the yoghurts at the times of this study (0, 15 and 30 days).

The initial time (at 0 days) revealed only yogurts I<sub>1</sub> and I<sub>3</sub> which had been elaborated with the lowest sucrose concentration (5%) had protein levels that fell within the prescribed limits of the Brazilian legislation in force<sup>(8)</sup>, which specified 2.9% as the minimum content. This was possible because of the addition of a large quantity of non-dairy substances (sucrose and mango pulp) to the product. These materials added, even without exceeding the 30% limit stipulated by the legislation, induced a marked decrease in the protein values. Further research is recommended in the future to minimise the percentages of the added sucrose and mango pulp or as an alternative to use powdered milk instead in the formulations to ensure that the protein content in all the formulations satisfies the specifications stipulated by the legislation.

The findings of the present study show that the protein concentrations (2.12 and 2.98%) of the mango-flavoured goat milk yoghurts correspond to those reported by Queiroga et al.,<sup>(14)</sup> when goat yogurt was produced using pineapple jelly, cajá manga, passion fruit and umbu (2.61 and 2.95%), as well as concurred with the percentages of Marinho et al.,<sup>(15)</sup> when the goat yoghurts were made with umbu pulp (2.30 to 2.47%). Fagnani et al.,<sup>(23)</sup> recorded the opposite behaviour in the proteins under storage, in which the protein values increased from 3.31 to 3.42%, in their study on the effect of storage on yoghurts made using raw refrigerated milk (4 h / 4° C), after 15 days.

Regarding the caloric value (as evident from Table 4), the highest values were confirmed for the yogurts elaborated with the greatest sucrose concentrations. As the concentration of the added sugar was decreased, the caloric values also correspondingly declined, and as noted for the total carbohydrate content, the sucrose concentration acted as an independent and important variable for these observations. The absence of statistical differences in the number of calories was confirmed among the yoghurts elaborated with the identical sucrose concentration, although a difference was seen among the yoghurts with the addition of different sucrose concentrations (5, 10 and 15%). Samples I<sub>2</sub> and I<sub>4</sub> were predicted to have the highest caloric values, as the highest sugar concentration (15%) had been added to them, and which had caused the carbohydrate concentration to rise in these yogurts and consequently their caloric value.

A significant drop in the caloric values of the yogurts was observed for all the formulations from the



initial (0 days) to final (30 days) time of storage. This decline is directly associated with the lipid content of the yoghurts, which significantly decreased, and which was responsible for the lowered calorie content of the yoghurts during the same time period.

The RDC n°. 359<sup>(24)</sup> has stipulated 200 g as a yoghurt-serving for all the varieties. Thus, at the initial time, the yoghurts in this study provided between 144.78 Kcal and 200.26 Kcal per serving, which is on average (172.52 Kcal) equivalent to 8.6% of the daily value of a 2000-Kcal diet. According to RDC n°. 54 of the National Health Surveillance Agency<sup>(25)</sup>, this indicates that these yogurts are not suitable as low-calorie foods, but are a more nutritious alternative for diets and goat milk consumption, which most often are not desired by the population due to their distinctive flavour and aroma.

To study the effect of water activity (Table 5), the yogurt containing the lowest concentrations of sucrose and mango pulp (I<sub>1</sub>) revealed the highest value (0.981). The yoghurt possessing the highest sucrose concentration and the lowest mango pulp concentration of (I<sub>2</sub>) registered the lowest value (0.973). These results are justified because, as more sucrose which is low in humidity was added, a higher level of dilution was observed in the milk in the formulation, which contained high moisture levels and water activity.

**Table 5.** Mean values of water activity, pH and acidity of the mango goat yogurts during storage.

Yoghurts	Parameters	Storage (days)		
		0	15	30
I <sub>1</sub>	Activity of water A <sub>w</sub>	0.981 <sup>aA</sup>	0.984 <sup>aA</sup>	0.984 <sup>aA</sup>
I <sub>2</sub>		0.973 <sup>aB</sup>	0.978 <sup>aB</sup>	0.986 <sup>aA</sup>
I <sub>3</sub>		0.975 <sup>aB</sup>	0.979 <sup>aB</sup>	0.985 <sup>aA</sup>
I <sub>4</sub>		0.975 <sup>aA</sup>	0.977 <sup>aA</sup>	0.978 <sup>aA</sup>
I <sub>5</sub>		0.979 <sup>aB</sup>	0.987 <sup>aAB</sup>	0.991 <sup>aA</sup>
I <sub>1</sub>	pH	4.54 <sup>abA</sup>	4.49 <sup>aB</sup>	4.27 <sup>abC</sup>
I <sub>2</sub>		4.54 <sup>abA</sup>	4.48 <sup>aB</sup>	4.24 <sup>bcC</sup>
I <sub>3</sub>		4.53 <sup>bA</sup>	4.47 <sup>aB</sup>	4.29 <sup>abC</sup>
I <sub>4</sub>		4.57 <sup>abA</sup>	4.39 <sup>bB</sup>	4.29 <sup>aC</sup>
I <sub>5</sub>		4.58 <sup>aA</sup>	4.48 <sup>aB</sup>	4.27 <sup>abC</sup>
I <sub>1</sub>	Titratable total acidity (%)	0.92 <sup>aB</sup>	0.80 <sup>aC</sup>	1.03 <sup>aA</sup>
I <sub>2</sub>		0.85 <sup>bcB</sup>	0.74 <sup>bcC</sup>	0.92 <sup>baA</sup>
I <sub>3</sub>		0.89 <sup>abB</sup>	0.80 <sup>aC</sup>	1.01 <sup>aA</sup>
I <sub>4</sub>		0.81 <sup>cB</sup>	0.77 <sup>abC</sup>	1.03 <sup>aA</sup>
I <sub>5</sub>		0.86 <sup>bcB</sup>	0.79 <sup>abC</sup>	0.95 <sup>baA</sup>

S - Sucrose, PM - Mango pulp, I<sub>1</sub> (5% S and 4% PM), I<sub>2</sub> (15% S and 4% PM), I<sub>3</sub> (5% S and 6% PM), I<sub>4</sub> (15% S and 6% PM) and I<sub>5</sub> (10% S and 5% PM) - Yoghurts. Means in the column followed by the same lowercase letter or in the row followed by the same capital letter for each parameter analysed do not differ statistically among themselves by the Tukey test at 5% significance.

Interestingly, the water activity value among the yoghurts showed hardly any difference and was not significant during any of the periods (0, 15 and 30 days). All the samples during storage revealed an increase in the water activity values, but significance was noted only for I<sub>2</sub> and I<sub>5</sub>. The rise in the

water activity values during storage may be attributed to the increased moisture levels in the yogurts because of the decrease in the dry extract values (Table 3).

However, the significant influence exerted by the variables of sucrose and mango pulp in the parameter mentioned above could not be confirmed. Other works also reported water activity values similar to those achieved in the present study, as in the umbu pulp goat yoghurts (0.96 to 0.97), recorded by Marinho et al. <sup>(15)</sup>.

From Table 5 it is confirmed that the highest acidity value (initial time) was evident in the yoghurt processed with the lowest concentrations of sucrose and mango pulp; this caused the milk to become less diluted, consequently inducing a rise in the lactic acid values from lactose fermentation. Therefore, higher lactic acid quantities were present in the formulation (I<sub>1</sub>). No statistical difference was identified between yogurts I<sub>1</sub> and I<sub>3</sub>; I<sub>2</sub>, I<sub>4</sub> and I<sub>5</sub> for acidity and between I<sub>1</sub>, I<sub>2</sub>, I<sub>4</sub> and I<sub>5</sub> for pH at the initial point in time (0 days).

During the storage phase, all the yoghurts demonstrated an inversely proportional behaviour for the pH and acidity parameters, in which the pH values declined and the acid values significantly escalated. The only difference was observed in the pH values, where the decrease in value was constant and linear. The acidity values on the contrary, significantly declined for all the yoghurts during the first 15 days of the storage period, registering a substantial rise in these values at the completion of 30 days. These values were higher than those noted at the initial time (0 days), for all the yoghurts.

Na fermentação do leite, a lactose é convertida em ácido láctico e outros compostos, caracterizando o pH mais ácido do iogurte. Além disso, a própria redução do pH desestabiliza as micelas de caseína (proteínas presente no leite) e contribui para a formação de agregados que imobilizam sua parte líquida e atribuem a consistência do produto.

During milk fermentation, the lactose is changed to lactic acid and other compounds, to produce the distinctive more acidic pH of the yoghurt. Besides, the lowered pH itself destabilizes the casein micelles (milk proteins) and enables aggregate formation. This immobilizes the liquid component, thus ensuring the consistency of the yoghurt.

According to Normative Instruction No. 46, of October 23, 2007, the yoghurt acidity values should ideally fall between 0.6 and 1.5% <sup>(9)</sup>; therefore, the yoghurts of the present research comply with this legislation.

Pimentel et al., <sup>(26)</sup> also reported similar behaviours in the pH and acidity values demonstrating a drop in the pH (from 4.45 to 4.24) and a spike in the acidity (from 1.11 to 1.17%) in their study on the effect of storage on probiotic skimmed-milk yoghurt for 28 days. Silva et al., <sup>(27)</sup> also recorded a decrease in the pH values (from 4.01 to 3.89) and a rise in the acidity (from 0.98-1.18%), although neither exerted a significant effect during 45-day storage period of the yogurt. Earlier, Araújo et al., <sup>(28)</sup> had identified pH values of 4.85 in the goat milk yoghurts.

## Conclusions

The sucrose level in yoghurts was identified as the most significant factor among the physicochemical parameters that satisfy the legislative requirements, excluding the protein content for yoghurts

processed with 10 and 15% of sucrose

Storage was noted to cause a drop in the values of pH, calories, lipids, total dry extract and ash, and at the same time induce an increase in the values of acidity, as well as carbohydrate and water content of all the types of yoghurts. The alterations observed in the dry extract, protein, ash and water activity were inconsequential.

As yoghurts possess the potential for market testing and have good prospects of impacting income generation, as well as the wise usage of the available regional raw materials, like goat milk and sword mango, their consumption can become a healthy and nutritious alternative in human diets.

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