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Quality of artisan production yoghurt in the communities of the district of Xai-Xai

Abel Alberto Massingue Júnior [1,*] and António Elísio José [2]

[1] *Food Processing Engineering, Higher Polytechnic Institute of Gaza, Department of Food Processing Engineering, Faculty of Agriculture, Mozambique.*

[2] *Food Science and Technology, Higher Polytechnic Institute of Gaza, Department of Food Processing Engineering, Faculty of Agriculture, Mozambique.*

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Abstract

Yogurt is a product derived from milk fermented by the action of lactic bacteria (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) that use part of the lactose, transforming into lactic acid and aromatic compounds that characterize yogurt. The present research had the perspective of evaluating the yogurt traditionally produced by the communities of Xai-Xai, seeking to know (i) the physicochemical constitution by determining pH by electrometry, titratable acidity by titration, moisture by desiccation at 105ºC, of the ashes by incineration at 550ºC and fat by the Soxhlet method and (ii) microbiological quality by the most likely number method. Data were evaluated in Completely Randomized Design with 16 yogurt samples, of which 15 were artisanal and 1 industrial, at a significance level of 5%. The results showed pH from 3.84±0.01 to 4.49±0.00, titratable acidity from 0.21±0.03 to 0.39±0.05%, moisture from 80.95±0.26 to 91.84±1.78%, ash from 0.22±0.26 to 1.88±0.25% and fat in the amount of 0.34±0.31 to 5.27±1.46%; the microbiological count was <3.0 to 9.2 NMP/mL for total and thermotolerant coliforms. There were no significant differences between artisanal yogurt and Cactinoza in terms of pH, moisture, ash and fat. Characteristics differed in terms of titratable acidity for both technics of yogurt production artisanal and industrial. Regarding microbiological quality, thermotolerant coliforms were free of turbidity differently from total coliforms, which presented one sample with 2 cloudy tubes. All samples analyzed were in accordance with legislation established by National Health Surveillance Agency and Technical Regulation on Identity and Quality of Fermented Milk.

Keywords: Dairy products; Yogurt; Artisanal production; Food quality; Food processing and hygiene.

1 Introduction

The quality of food products and their influence on nutrition and human health have been highlighted in scientific circles [8]. Yogurt is a product derived from milk fermented by the action of lactic acid bacteria *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. These bacteria use part of the lactose, which is the sugar found in milk, transforming it into lactic acid and aromatic compounds that characterize yogurt [7].

In yogurt fermentation, thermophiles microorganisms initially develop with great intensity to generate a favorable environment for bulgaricus microorganisms, which gradually intensify their development. Thu, the two cultures are symbiotic [42]. According to Fernandes [13], fermented milks are important for the treatment and prevention of various organic disorders, such as disorders of the stomach, liver and intestines.

* Corresponding author: Abel Alberto Massingue Júnior

Food Processing Engineering, Higher Polytechnic Institute of Gaza, Department of Food Processing Engineering, Faculty of Agriculture, Mozambique.

In the communities of Xai-Xai, artisanal yoghurt is produced from milk from Nguluzane farm or from local breeders and is available and/or marketed in polyethylene terephthalate (PET) bottles. These communities, as they are the most prominent in the production and commercialization of this product in the Baixo-Limpopo area, considered an inter-district and/or provincial access corridor, infer rapid access, but the production and/or commercialization conditions can cause the adhesion of colonies and/or microbial strains, allowing food-borne hazards to consumers. As a way of contributing to the perception and minimization of these concerns, the present work was carried out with the objective of evaluating the physical-chemical and hygienic-sanitary qualities of yogurt traditionally produced by the communities of Xai-Xai.

2 Material and methods

2.1 Study area

The work was carried out in the communities of Xai-Xai, southern Gaza province and the capital of the same province, covering an area of 1,870 km^2. According to MAE [22], this geographic area borders the district of Chongoene (to the north and west), to the south with the district of Limpopo, and to the east it is bordered by the Indian Ocean. It has sandy textured soils with brown and/or reddish coloration. According to INE [20], Xai-Xai has 4 Municipal Administrative Posts, namely: Xai-Xai Beach, Inhamissa, Patrice Lumumba-Sede, structured in 17 communities, the age group varies from 0 to 85 according to INE [19], the main activity being rainfed agriculture.

2.2 Collection of samples

15 samples of artisanal yoghurt were collected from family producers in the communities of Xai-Xai, using the probabilistic model based on simple random sampling. For this purpose, 500mL of each sample were placed in previously sterilized polyethylene terephthalate (PET) bottles, placed in polypropylene bags containing ice cubes, and taken to the Laboratory of Hygiene and Food Quality of the Higher Polytechnic Institute of Gaza to the effect of physical-chemical and microbiological analyses. Likewise, 1 other sample of industrially produced yogurt, brand Cactinoza, was purchased at the local supermarket for the same purpose.

2.3 Physicochemical analysis

The pH, titratable acidity, moisture content, ash content and fat content were evaluated, following the methods proposed by IAL [18] and AOAC [4].

2.3.1 *Sample preparation*

In the preparation of the samples, 25mL of yogurt were distributed in transparent cups coded according to the origin, followed by the addition, in compliance with Zenebon *et al*. [47], of 25mL of distilled water with subsequent homogenization.

2.3.2 *Hydrogen Potential (pH)*

The determination of pH values was carried out in triplicate using electrometric procedures involving potentiometric devices, allowing a direct determination of pH through the pHmeter model HANNA (HI 2212 pH/ ORP Meter), where 10mL of the sample was transferred to a 25mL beaker where the pH meter electrode was immersed, determining the value by direct reading.

2.3.3 *Titratable acidity*

In triplicate, 10mL of the sample was transferred to a 50mL Erlenmeyer flask, 25mL of distilled water was added, followed by homogenization and the addition of 3 drops of the phenolphthalein solution. This solution was then titrated with 0.1N NaOH solution until reaching the indicator turning point. The value of 0.1N sodium hydroxide spent in the titration was then read. Express 1 was used to determine the percentage of acidity in lactic acid.

$$\frac{V*f*0.9}{P} = \%\ \text{lactic acid} \qquad \text{............(1)}$$

Where:

V- Number of mL of 0.1N sodium hydroxide solution spent in the titration;
P- Number of grams of the sample used in the test;
f- 0.1N sodium hydroxide solution factor;

0.9- Conversion factor for lactic acid.

2.3.4 Moisture content

The moisture content was determined in triplicate by the gravimetric method using heat. For this purpose, 5grams of the sample were weighed in petri dishes and placed in an oven with circulating air at 105ºC for 2 hours, after which they were removed with the aid of tweezers, allowed to cool to room temperature and weighed again. Equation 2 indicates the determination of the percentage of moisture.

$$\frac{(\text{Weight of plate} + \text{sample}) - \text{Final weight}}{\text{Weight of sample}} * 100 = \%\ \text{moisture} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

2.3.5 Ash determination

On an analytical balance, 5 grams of the sample were weighed in porcelain crucibles and placed in a muffle furnace at a temperature of 550°C until the verification of complete incineration of organic to inorganic matter, translated into white powder. The crucibles were then transferred to an oven at 105ºC for 30 minutes with emphasis on lowering the temperature, followed by weighing them with the incinerated sample in inorganic matter. Expression 3 was used to determine the percentage of the incinerated sample.

$$\frac{(\text{WeCrucible weight} + \text{incinerated sample}) - \text{Crucible weight}}{\text{sample Weight} * 100} = \%\ \text{of incinerated residue} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

2.3.6 Fat content

5 grams of the yogurt sample were weighed on an analytical balance, placed on a cone-shaped filter paper and introduced into the fat extractor tube. 250mL of diethyl ether were added to 500mL volumetric flasks, previously dried in an oven at 105ºC for 30 minutes, cooled to room temperature and their weight measured, and then placed in the heating hood (60ºC) to facilitate the extraction of the fat contained in the sample. The extracted fat was deposited in the flask, which, after the extraction process, was again dried and weighed. Equation 4 was used to determine the percentage of fat.

$$\frac{(\text{weight} + \text{fat}) - \text{balloon weight}}{\text{sample Weight} * 100} = \%\ \text{fat} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

2.4 Microbiological analyzes

In carrying out the microbiological analysis, the hygienic-sanitary quality was determined. For this purpose, serial dilutions of the sample were made in 10^{-1}, 10^{-2} and 10^{-3} for counting total coliforms and thermotolerant coliforms (Escherichia coli), using the technique of the most probable number NMP/mL as recommended by Pereira [33].

2.4.1 Preparation of samples, culture media and dilutions

Aseptically, yogurt samples were homogenized in a beaker and left ready for microbiological analysis. For this experiment we used (i) peptone water, obtained by diluting 1 gram of peptone in 1000mL of distilled water, (ii) Lauryl Sulfate Tryptose Broth, obtained by diluting 28.83 grams of this medium in 810mL of distilled water, (iii) Bright Green Lactose Broth (BGLB) obtained by diluting 3.96 grams in 100mL of distilled water and (iv) Broth Escherichia Coli (BEC) prepared by diluting 3.0 grams of the medium in 81mL of distilled water. All media were sterilized at 100°C for 25 minutes.

To obtain the different dilutions, a stock solution was prepared by adding 5mL of the sample to 5mL of peptone water. From this solution, serial dilutions were made up to 10^{-3} by adding 1mL to each test tube containing 9mL of Lauryl Sulfate Tryptose broth.

2.4.2 Determination of total coliforms and thermotolerant coliforms

Presumptive test

In triplicate, the dilutions indicated in point 2.4.1 were incubated in an oven at 40ºC for 24 hours for total coliforms and 48 hours for thermotolerant coliforms, thus constituting the presumptive test.

Confirmatory test

The confirmatory test was performed by verifying the turbidity of the presumptive test tubes that reflected microbial or not (-). Tubes with turbidity were designated as positive (+) and were isolated from growth the others for the purpose of confirming the presence of microbial load. For this purpose, 1mL aliquots of the contents of each positive tube were transferred to test tubes containing 9.0mL of Bright Green Lactose Broth (BGLB) for total coliforms (CT) and Broth Escherichia coli (BEC) for thermotolerant coliforms (CTT). After being homogenized and flamed, the tubes were incubated in an oven at 40°C for 24 and 48 hours for the CT and CTT, respectively. The determination of the most likely number of coliforms per milliliter (MPN/mL) was based on combining the number of positive tubes from the dilutions (10^{-1}, 10^{-2} and 10^{-3}) using the Most Likely Number (MPN) table.

2.5 Statistical analysis

The experiment was based on a Completely Randomized Design (CRD) for the 16 yogurt samples. The data were organized in an Excel spreadsheet and then submitted to analysis of variance (ANOVA) using the general linear model (GLM), in the case of significant effects, the means were evaluated using the Tukey test at a significance level of 5 %, using the Minitab statistical package version 18.1.

3 Results and discussion

3.1 Physicochemical analysis

The physical-chemical components studied in the present work are presented in table 1.

Table 1 Evaluation of physicochemical characteristics in artisanal production yoghurts collected from producers and industrial production yoghurt

	Parameters				
Samples	**pH**	**Titratable acidity**	**Humidity**	**Ashes**	**Fat**
A	3,99±0,01^{g}	0,33±0,05^{abc}	88,58±0,11^{cd}	0,74±0,10^{bcdef}	3,04±0,91^{abc}
B	4,03±0,00^{f}	0,39±0,02^{a}	85,78±0,17^{f}	0,92±0,04^{bcd}	3,09±0,47^{abc}
C	4,13±0,02^{d}	0,35±0,02^{abc}	86,11±0,11^{ef}	0,86±0,10^{bcde}	4,17±0,16^{ab}
D	4,14±0,00^{d}	0,32±0,05 ^{abc}	90,84±0,20^{ab}	0,22±0,26^{f}	2,42±0,05^{abc}
E	4,09±0,01^{e}	0,28±0,06 ^{abc}	89,92±1,50^{bc}	0,52±0,07^{cdef}	4,68±1,35^{ab}
F	3,96±0,00^{g}	0,32±0,02 ^{abc}	87,58±0,29^{de}	0,76±0,10^{bcdef}	4,03±0,74^{ab}
G	4,03±0,02^{f}	0,35±0,06 ^{abc}	91,84±0,37^{a}	0,28±0,06^{ef}	3,97±0,60^{ab}
H	3,98±0,00^{g}	0,38±0,05^{ab}	85,66±0,3^{f}	0,84±0,14^{bcde}	4,22±0,67^{ab}
I	3,84±0,01^{h}	0,37±0,09^{ab}	80,95±0,26^{g}	1,00±0,25^{bc}	3,54±0,17^{ab}
J	4,44±0,01^{b}	0,37±0,01^{ab}	89,04±0,99^{cd}	0,30±0,23^{ef}	2,10±0,97^{bc}
K	4,49±0,00^{a}	0,32±0,02^{abc}	88,77±0,62^{cd}	1,88±0,25^{a}	2,28±1,77^{abc}
L	4,41±0,00^{b}	0,28±0,08^{abc}	86,59±0,24^{ef}	1,18±0,32^{b}	0,34±0,31^{c}
M	4,12±0,01^{de}	0,36±0,01^{ab}	88,66±0,13^{cd}	0,32±0,32^{ef}	4,76±1,41^{ab}
N	4,20±0,00^{c}	0,23±0,02^{bc}	89,80±0,27^{bc}	0,68±0,15^{bcdef}	5,27±1,46^{a}
O	4,11±0,00^{de}	0,38±0,02^{ab}	86,06±0,61^{ef}	0,36±0,23^{def}	4,69±1,24^{ab}
P	4,21±0,00^{c}	0,21±0,03^{c}	87,56±0,55^{de}	0,56±0,10^{cdef}	3,50±1,27^{ab}

Means ± standard deviation followed by the same letter in the same column do not have significant differences between them at the 5% significance level. **A** (25º:3':22.9"S ; 33º:39':25.2"E), **B** (25º:3':15.9"S ; 33º:39':44.0"E), **C** (25º:39':13.4"S ; 33º:39':22.2"E), **D** (25º:1'2:17"S ; 33º:37':53.8"E), **E** (25º:1':11.6"S ; 33º:37':45.3"E), **F** (25º:1':15.1"S ; 33º:37':48.2"E), **G** (25º:1':8.1"S ; 33º:37':59.5"E), H (25º:1':57.1"S ; 33º:38':11.1"E), **I** (25º3'41.929"S ; 33º38'59.832"E), **J** (25º4'26.809"S ; 33º38'27.949"E), K (25º4'20.626"S ; 33º39'4.76"E), **L** (25º:4':25.0"S ; 33º:38':28.8"E), **M** (25º:2':45.4"S ; 33º:40':55.7"E), **N** (25º:2':58.1"S ; 33º:41':45.8"E) e amostra **O** (25º:5':1.8"S ; 33º:42':28.1"E). **P** = industrially produced yogurt (Cactinoza).

3.1.1 *Potential of hydrogen (pH)*

The results showed that the pH ranged from 3.84 to 4.49 in the artisanal production samples and the statistical difference in this aspect was evident. This range of values can be considered acceptable assuming that in the yogurt production process, the pH value directly implies the metabolic activity of the bacteria, which may favor a certain group over another. In the case of yogurt fermentation, bacteria of the lactobacillus genus tend to resist better at lower pH values and outperform the streptococcus genera. Also, this fact may be associated with the cooling step during processing. Meanwhile, the pH value of the industrial production sample showed a significant difference with most artisanal samples (93.3%). This is possibly related exclusively to the industrial production process itself, which includes the acidity control step during the production chain, making it possible to interrupt the metabolic activity of lactic acid bacteria when the desired acidity point is reached. The artisanal samples differed mostly from the industrial production sample, which may be related to the non-technified production, characterized by non-standardization of fermentation, thus influencing the pH. On the other hand, considering that each producer has their knowledge of the yogurt production techniques, the incorporated ingredients may also have favored the verified differentiation.

In the study carried out by Silva *et al.* [38] on microbiological aspects, pH and acidity of artisanal production yogurts compared to industrialized yogurts in the region of Santa Maria-RS, obtained pH values in the range of 4.2 to 4.4, results in agreement with part of the values found in the present study. Fernandes [13], in their study aimed at monitoring the microbiota of yogurts, and Silva *et al.* [40], in their work on the physicochemical characterization of yogurt added with the pulp of the xique-xique fruit (p*ilosocereus gounellei*), had a pH around 4.0 and 4.9, respectively, being higher in 25% of the samples. Samples evaluated in the present study. This differentiation is possibly correlated with the continuous metabolic activity of lactic acid bacteria, which act by consuming lactose, inferring a decrease in pH, raising the acidity of the sample medium. In the study developed by Andrade [2] in his research with the objective of evaluating the physicochemical and microbiological quality of fermented milks, he obtained pH values in the range of 3.5 to 3.8, a similar result was obtained in sample I of the present study.

Tamime *et al.* [43], in their study on yogurt, obtained pH values in the range of 3.7 and 4.6 and were supported by the statement that this parameter has a large amplitude, being found in a pH range between 3, 7 and 4.06. These values are in agreement with the results obtained in the present study. The pH results found in the present study are also in agreement with the research carried out by Fernandes *et al.,* [12] with the objective of carrying out an evaluation of the physicochemical quality of yogurts sold in Viçosa, which obtained a pH ranging from 3.7 to 4 ,6, similar to the study carried out by Morais *et al.* [27] who found a pH between 4.3 and 4.5 in their study on yogurts made with different concentrations of araticum pulp. These values are similar to those found in this study. Rodas [37], analyzing the pH of 8 samples of yogurts added with fruit, obtained values between 3.6 and 4.3, similarly, Gutierrez *et al.* [16] found pH values around 3.90 to 4.33 for yogurt samples, all in line with the results found in the present research.

3.1.2 *Titratable acidity*

The results showed that the acidity ranged from 0.23 to 0.39% in the artisanal production samples and there was a noticeable statistical difference in this parameter. This range of values can be considered acceptable assuming that the percentage of lactic acid resulting from the fermentation process is correlated with the amount of lactose hydrolyzed by lactic acid bacteria (*streptococcus* and *lactobacillus*) according to Fernandes *et al*., [12]. In the same way that the variations observed in the acidity levels may be associated with the initial pH value, which was fixed at 3.84 to 4.49. However, the acidity value of the industrial sample showed a statistical difference with all artisanal samples. This differentiation is possibly allied to the reduction of the pH of the yogurt samples related to the storage time that according to Capitani *et al.* [6] may favor the continuous production of lactic acid by lactic acid bacteria with a tendency to increase acidity levels and those lactobacilli produce acids and continue to grow at pH between 4.0 and 4.4.

In the evaluation made by Fernandes [13] in his research on monitoring the microbiota of commercial yogurts, acidity values of around 0.7 and 1.25% were obtained, a range of values that were found in the present study, in line with the reported results by Silva *et al.* [38] who obtained acidity around 0.7 and 1.17% of lactic acid in their work on evaluating the quality of yogurts, similarly similar to the results obtained by Martin [23], highlighting that he found acidity percentage around 0.7 and 1.25% lactic acid.

Acidity results above those found in the present study were also reported by Pimentel *et al.* [35] in their research on the physicochemical, microbiological and storage stability of inulin-type probiotic yogurt of different degrees of polymerization, having found acidity ranging from 1.11 to 1.17%. This variation can be justified by failures during processing and, or the addition of ingredients as that would influence the acidity of the final product. Higher results (0.70-0.72% lactic acid) than those found in this study were also reported by Giese *et al.* [15] analyzing the physical-chemical and sensorial characterization of yogurts sold in the western region of Paraná, and by Silva *et al.* [40] (around

0.79% lactic acid) in their research on the physicochemical characterization of yogurt added with the pulp of the xique-xique fruit (*pilosocereus gounellei*). This differentiation may be correlated with inadequate temperature control during storage, as well as the rapid kinetic effect of substrate degradation in lactic cultures. In turn, Moreira *et al.* [28] found 0.68% acidity for apple yogurts sweetened with honey, Mundim [29] when making yogurts supplemented with inulin, and obtained acidity ranging from 0.48% to 0.72%, both being above those reported in the present study.

3.1.3 Moisture content

The results showed that the moisture content ranged from 80.95% to 91.84% in the artisanal yogurt samples. This range of moisture values can be considered acceptable, considering that Noro [31] states that the moisture content of milk used in yogurt production varies from 86.0 to 88.0%. The significant differences between the samples of this yogurt may be correlated with the total soluble solids (TSS) content of the milk used in the production, which also varied significantly from 6 to 12ºBrix. In turn, the moisture of the industrial production sample showed a significant difference in relation to the majority (93.3%) of the artisanal production samples. These differences may be related to the technological process of the dairy industries, characterized by the prior chemical analysis of the raw material, which allows for the use or not of quality milk, as well as the severity of the other production processes.

According to Silva *et al.* [40], in their work on the elaboration and physical-chemical characterization of yogurt added with the pulp of the xique-xique fruit (*Pilosocereus gounellei*), the moisture content is 86.5%, in agreement with the results obtained in the present work. Tamime *et al.* [43], in their research on yogurt: science and technology, Medeiros *et al.* [25], in their development on yogurt and Oliveira *et al.* [32], when making skimmed yogurt (light) based on buffalo milk and sweetened with honey, reported moisture of 78.57, 78.8, 77.9 and 77.07%, respectively, lower results than those obtained in the present study. On the other hand, Rensis and Souza [36], when developing their work on light yogurts made with the addition of inulin fiber and oligofructose, had a moisture content of around 83.96%. This difference can be justified taking into account the ability of the probiotics added to the formulation to bind to water, retaining it and, as a consequence, reducing the moisture of the product. Martins *et al.* [24], in their evaluation of the physical-chemical, sensory and rheological profile of yogurt made with water-soluble soy extract and supplemented with inulin, found moisture values around 85.2%, results in agreement with the present study.

3.1.4 Ash content

The results showed that the ash content ranging from 0.22 to 1.88% in artisanal samples with statistical differences between them. This range of values can be considered acceptable based on the mineral content of milk (0.80%) used in the processing of these products, as mentioned by Noro [31]. However, the ash value of the industrial sample showed a significant difference with the majority (93.3%) of the artisanal samples. This fact is possibly associated with the composition of the milk and the amount of ingredients incorporated.

Soares *et al.* [41] reported in their work entitled the use of cheese mass as an alternative for the production of probiotic yogurt, that the inorganic matter obtained is 0.99%, which is in agreement with the results obtained in the present work. Silva *et al.* [40] describes, in their research on the elaboration and physical-chemical characterization of yogurt added with xique-xique fruit pulp, that the ash value is 0.76%, similar to that obtained in some samples from the present study. In the study developed by Silva [39] on the development and chemical and sensory characterization of semi-skimmed yogurt added to whey protein concentrate, ash in the range of 0.73 to 0.82% was observed. Likewise, Antunes *et al.* [3], when working with yogurt made from bovine milk, found ash contents around 0.82%, similar to most samples in this work. Martins *et al.* [24] about the physical-chemical, sensory and rheological profile of yogurt made with water-soluble soy extract and supplemented with inulin, obtaining 0.5% ash, therefore, in line with this research.

3.1.5 Fat content

The fat content varied from 0.34 to 5.27% in the artisanal samples and a statistical difference was verified in this aspect. This range of values can be considered acceptable assuming that yogurt can be classified according to cream fat content (minimum 6% fat); whole (minimum 3% fat), partially skimmed (maximum 2.9% fat content) and skimmed (maximum 0.5% fat), this according to Souza [42]. Another factor that is possibly related to these differences is the skimming of the milk during processing, which, according to Vidal and Netto [46], consists of the partial removal of cream from the milk. The fat content of the industrial sample showed a significant difference with some (46.6%) artisanal samples. These differences can also be correlated with the industrial technological process, which produces yogurt according to the needs and/or preferences of consumers regarding the desired fat content, which can be whole, semi-skimmed or skimmed.

According to Medeiros *et al.* [25] in the yogurts they developed obtained 2% fat in their research on physicochemical, microbiological and sensorial evaluation of yogurt, in agreement with the results found in the present work. Nascimento *et al.* [30] reported in their study about the elaboration of yogurt with added sugar and without incorporation of added sugar, that the fat content is around 4% to 4.50%, similar results were found in the present study. Results in agreement with those obtained in 18.75% of the samples evaluated in the present study were reported by Rodas [37] in their study on physicochemical characterization and viability of lactic acid bacteria in yogurts with fruit, having found a fat content of 2.73%. In the evaluation carried out by Pereira [34] in his work that evaluated the effect of the lactose content and the type of culture on the acidification and post-acidification of yogurts, he reported the fat content in the range of 3.92 to 4.07%, in agreement with the results obtained in this study. Results consistent with those obtained in 31.3% of the samples evaluated in this study were also referenced by Cunha *et al.* [10], when carrying out the physicochemical, microbiological and rheological evaluation of fermented milk added with probiotics and by Silva [39], when developing probiotic yogurt using cultures of *Streptococci thermophilus* and *Lactobacillus bulgaricus*, when they found a fat content around 3, 03 and 3.15%, respectively.

3.2 Microbiological Analysis

Table 2 shows the results of microbiological analyzes carried out for total and thermotolerant coliforms in yogurt samples.

Table 2 Microbiological counts in samples of yogurt produced in Xai-Xai and industrial production communities

Samples	(MPN/mL) Total Coliforms	(NMP/mL) Thermotolerant Coliforms
A	< 3,0	< 3,0
B	< 3,0	< 3,0
C	< 3,0	< 3,0
D	< 3,0	< 3,0
E	< 3,0	< 3,0
F	< 3,0	< 3,0
G	9,2	< 3,0
H	< 3,0	< 3,0
I	< 3,0	< 3,0
J	< 3,0	< 3,0
K	< 3,0	< 3,0
L	< 3,0	< 3,0
M	< 3,0	< 3,0
N	< 3,0	< 3,0
O	< 3,0	< 3,0
P	< 3,0	< 3,0

NMP/mL - Most likely number per milliliter for total and/or thermotolerant coliforms; m - minimum population amount per milliliter that can be present; and M - maximum population amount per milliliter that can be present. **A** (25º:3':22.9"S ; 33º:39':25.2"E), **B** (25º:3':15.9"S ; 33º:39':44.0"E), **C** (25º:39':13.4"S ; 33º:39':22.2"E), **D** (25º:1'2:17"S ; 33º:37':53.8"E), **E** (25º:1':11.6"S ; 33º:37':45.3"E), **F** (25º:1':15.1"S ; 33º:37':48.2"E), **G** (25º:1':8.1"S ; 33º:37':59.5"E), H (25º:1':57.1"S ; 33º:38':11.1"E), **I** (25º3'41.929"S ; 33º38'59.832"E), **J** (25º4'26.809"S ; 33º38'27.949"E), K (25º4'20.626"S ; 33º39'4.76"E), **L** (25º:4':25.0"S ; 33º:38':28.8"E), **M** (25º:2':45.4"S ; 33º:40':55.7"E), **N** (25º:2':58.1"S ; 33º:41':45.8"E) e amostra **O** (25º:5':1.8"S ; 33º:42':28.1"E). **P** = industrially produced yogurt (Cactinoza).

The microbiological count of total coliforms (TC) and thermotolerant coliforms (CTT) ranged from <3.0 to 9.2NMP/mL, this range is acceptable according to the microbiological criteria for counting this group of microorganisms. The results showed that the MPN/mL of CT from the industrial sample did not translate to microbial growth (-) and resembled most artisanal samples. Only one (6.7%) artisanal sample showed microbial growth (+). This microbial load may be related to non-observance of good hygienic-sanitary practices at the time of production. Another aspect that can be correlated to this result is the lack of use of sanitizers and/or detergents during the process of washing utensils, considering that total coliforms are, Nascimento *et al.* [30], hardly eliminated without the use of these products.

As for thermotolerant coliforms, it was found that all samples analyzed did not characterize bacterial development. The safety of these samples is indicative of the severity of the hygienic-sanitary conditions. Another factor that possibly explains the insignificant presence of this group of microorganisms is the acidity promoted by lactic acid bacteria during fermentation, a phenomenon that favors, according to Ferreira [14], the disturbance of microbial cells (strains), thus inhibiting their proliferation. Lima *et al.* [21] when stating that the presence of coliforms in yogurts is limited by acidity. In the assessment made by Moraes *et al.* [26] in their research on the microbiological quality of yogurt sold in the city of Pelotas, a microbial load of <3.0 NMP/mL was verified in all samples analyzed for total and thermotolerant coliforms, which is in agreement with the results of this research.

In line with the findings of the present trial, Emiliano *et al.* [11] in their work on microbiological aspects of homemade and industrialized yogurts in the region of Santa Maria-RS, also found NMP/mL <3.0, all in accordance with the standard established by the legislation of Resolution RDC No. National Health Surveillance Agency, January 2, 2001 (<10 NMP/mL), according to Brazil [5]. The MPN of total and fecal coliforms found in the analyzed samples is still similar to the results found by Tebaldi *et al.* [44], in their work on the microbiological evaluation of fermented dairy beverages in the retail trade of southern Minas Gerais. According to Costa *et al.,* [9] and Almeida *et al.* [1], the MPN of coliforms allowed for fermented milk is up to 100 MPN/mL for total coliforms and 10 MPN/mL for thermotolerant coliform.

4 Conclusion

Regarding the physical-chemical issue, no significant differences were observed between artisanal and industrialized yogurt (Cactinoza) in terms of pH, moisture, ash and fat, but rather in terms of titratable acidity levels. 93.3% of the yogurt samples produced by hand in the communities of Xai-Xai meet the microbiological standards required by the legislation, showing acceptable levels of thermotolerant coliforms and total coliforms. In view of the results obtained in the present study, there was sufficient evidence of compliance with good manufacturing and hygienic-sanitary practices of artisanal handlers.

Compliance with ethical standards

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Disclosure of conflict of interest

This work was carried out with the consent, contribution and approval of its authors. There are no conflicts of interest.

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