**Evaluation of the conformity of the physical-chemical parameters of canned preserves of *Solanurn lycopersicum L.* (Tomato), marketed in the city of Chókwè.**

**Abstract**

Canned tomato paste is a widely used culinary product due to its practicality, long shelf life and characteristic tomato flavor, which is preserved during conservation, ensuring the stability of its properties for a considerable period. This study aimed to evaluate the physicochemical quality of canned tomato paste sold in the markets of the city of Chókwè. The physicochemical parameters analyzed were: pH by the potentiometric method; Total titratable acidity by titration with sodium hydroxide at 0.1N; Total soluble solids content (°Brix) by refraction; Lycopene by spectrophotometry and Moisture by the dissection method at 105°C. The study was based on a randomized block experimental design (RBD), containing 4 blocks (Limpopo supermarket, Azza supermarket, Al Madheena supermarket and Al-Taj supermarket); 4 treatments (A – Recheio, B – Primavera, C – Mama tia and D – Promex) and 3 replicates. The data obtained were subjected to analysis of variance (ANOVA) and the means compared by Tukey's test (p <0.05), using the statistical program RStudio 4.3.3. Under the experimental conditions, the results indicated average pH values between 3.57 and 3.74, all within the range considered safe for consumption (< 4.6), titratable acidity ranged from 6.25 to 7.92, total soluble solids (°Brix) was 18.77 for brand A, and varied between 19.03 and 19.09, meeting the minimum requirement of 6°Brix stipulated by legislation, lycopene content showed between 20.8 mg and 26.8 mg, reflecting good levels of this antioxidant, moisture content between 55.82% and 58.34%. It is concluded that the results presented regarding the physical-chemical quality of the canned tomato paste were within the quality and food safety standards and those required by Mozambican standards based on decree no. 293: 2011 Ed. 1 and 2 of INNOQ.

**Keywords** : Tomato paste; Quality standards and food safety

**Introduction**

The use of techniques to preserve tomatoes and delay their deterioration and senescence is an ancient practice, but currently, with the advancement of processing technologies, such as refrigeration, freezing and pasteurization, in addition to the application of chemical substances, it is possible to extend the shelf life of foods and improve their sensory characteristics (Santos & Santos, 2008; Torrezan , 2021).

Despite advances in tomato preservation techniques, as highlighted by Souza (2019), there is a scientific gap regarding the preservation of food quality and its aging process (senescence) when stored in marketing areas, highlighting that storage conditions play a crucial role in this context.

In Mozambique, the preparation and marketing of canned foods must follow the guidelines of the Technical Secretariat for Food and Nutritional Security (SETSAN). According to the organization, canned products must undergo technological procedures before and after the hermetic sealing of the packaging, in order to avoid any change in their composition ( Koning *et al.,* 2014).

According to Mosca & Abbas (2016), it is essential that processing and preservation techniques reduce food waste in Mozambique, without compromising consumer safety. However, canning, although aligned with this strategy, requires rigor in maintaining quality and minimizing factors that may alter it, thus ensuring consumer safety in the short, medium and long term.

However, it is urgent to implement policies that defend the periodic evaluation of the physical, chemical and biological parameters of these foods, especially under diverse storage conditions, where variables such as temperature, inadequate handling, relative air humidity and packaging defects can affect their quality (Borba, 2020).

Therefore, this study aims to evaluate the compliance of physical-chemical parameters with the standards established by Mozambican regulatory bodies, such as INNOQ (National Institute of Standardization and Quality) and INAE (National Institute of Consumer Protection).

**Materials and methods**

**Study area**

The experiment was developed at the Food Processing Laboratory of the Instituto Superior Politécnico de Gaza, located in the district of Chókwè with an area of 2,466 km² and a population density of 88 inhabitants/km². The district of Chókwè is located in the province of Gaza, Mozambique. Geographically, it is located in the Administrative Post of Lionde, approximately 12.4 km from the city of Chókwè. It has geographical limits, to the north with the district of Mabalane, to the north and northeast with the district of Guijá, to the east with the district of Chibuto, to the south with the districts of Bilene and to the west it is limited by the district of Magude of Maputo Province (MAE, 2019).

**Sample determination**

To determine the exact sample (canned food sales units), a survey of the establishments that sell the products under study was carried out and, based on the methodology described by Pocinho (2009) (this author is not cited in the bibliography!) and also highlighted by Gil (2008) (this author is not cited in the bibliography!), the sample size was determined and the random number table was applied to determine the selected units through the following equation 4:

Equation 4 : Sample determination

$$n=\frac{Z^{2}×P(1-P)×N}{e^{2}×\left(N-1\right)+z^{2}×p(1-p)}$$

**Where:**

Z2 – is the confidence coefficient (95%) = 1.96;

e2 – margin of sampling error (5%);

n – Sample size;

N – Study population;

P – Proportion of real population 0.50;

**Selection of establishments**

The selection of commercial establishments was based on accessibility criteria and brand diversity. Four points were selected (Limpopo Low Supermarket, Azza Supermarket, Al Madheena Supermarket and Al-Taj Supermarket) from the Chókwè district, considering the geographical distribution (covering central areas and consumer affluence); Brand diversity (ensuring that different manufacturers were represented).

**Sampling**

For the study, a stratified random sampling was adopted (the strata being the brands: A – Recheio, B – Primavera, C – Mama tia and D – Promex ) ensuring representativeness of the different brands available in the public market of Chókwè. The selection of commercial establishments was based on accessibility criteria and brand diversity.

## Analysis of physical-chemical parameters

Following the methodology described by IAL (Adolfo Lutz Institute), (2008), the following variables were determined: pH, total titratable acidity, total soluble solids, lycopene and moisture.

**Potential of hydrogen (pH)**

Following the electrometric method, 5g of tomato paste samples were weighed using a HANNA scale with an accuracy of 0.0001g. After this, the samples were diluted in a 100ml Erlenmeyer flask in a proportion of 5g of sample and 45ml of distilled water. The pH meter was then calibrated with buffer solutions of 4.0, 7.0 and 10.0, and the electrode was introduced for 30 seconds into the already rested samples and the pH level was taken from the instrument panel (IAL, 2008).

**Titratable acidity**

By titration, 5g of tomato paste samples were weighed using a HANNA scale with an accuracy of 0.0001g. Once this was done, the samples were diluted in 100ml beakers in a proportion of 5g of sample and 45ml of distilled water. After homogenization of the sample, 3 drops of Phenolphthalein indicator were added, followed by titration with 0.1 Molar Sodium Hydroxide solution under constant stirring. The volume used was removed after the appearance of the pink coloration. The results were expressed in %, based on equation 1:

Equation 1: Determination of titratable acidity

AT (%) = $\frac{V ×F ×M}{P}$× 100

Where:

AT (% ) = is the titratable acidity in percentage; V = is the volume of NaOH solution in mL required to neutralize the vegetable preserve sample; F = correction factor of the sodium hydroxide solution; M = molarity of the sodium hydroxide solution; P = mass of the vegetable preserve sample g (in grams) .

**Soluble solids content (°Brix)**

°Brix was determined by refractometry. The prism of the portable refractometer with a scale of 0-32°Brix was first cleaned, and drops of the samples were added to the prism, and then the refractive index expressed in ° Brix was read.

**Lycopene**

To determine lycopene, 5g of the sample was weighed in a 250ml Erlenmeyer flask, diluted with 10ml of petroleum ether, then homogenized and filtered. The filtered sample was then placed in cuvettes and introduced into the spectrophotometer for reading. The results were expressed using equation 2:

Equation 2: Determination of Lycopene

(µg/ g)=$\frac{(A\*V\*1000000)}{(CE\*M\*100)}$

Where:

A = is the absorbency measurement; V = volume spent of the solution and ml; $ A1cm$= is the extinction coefficient or molar absorptivity coefficient of a pigment in a specific solvent. For lycopene in petroleum ether the extinction coefficient value is 3450; M = is the mass of the sample.

**Humidity**

First, the Petri dishes were weighed, then 5g of the sample was weighed into the Petri dishes using a HANNA scale with an accuracy of 0.0001g. This sample was heated in an oven at 105°C for two hours. After cooling, the sample was weighed, and the result was expressed in %, based on equation 3:

Equation 3: Determination of Moisture

Humidity%= $\frac{Peso inicial-Peso final}{Peso inicial}$\*100

## Statistical Analysis

The experimental trial was based on a Randomized Block Design (RBD), with 4 blocks and 4 treatments (4×4) totaling a sample size of 16 experimental units. The analysis of variance was performed according to the procedure of the statistical program RStudio version 4.3.3, and its means compared by the Tukey test at 5% significance. For data organization (tables and graphs) the Microsoft Excel 2013 package was used.

**Results and discussion**

The analysis of variance of the physical-chemical parameters of canned tomato paste is presented below (Table 1).

Table 1: Analysis of variance of the Physicochemical parameters of canned tomato paste preserves

|  |
| --- |
| Parameters |
| Brands | **pH** | **Acidity (%)** | **TSS (°Brix)** | **Lycopene (mg)** | **Moisture (%)** |
| THE | 3.57$\pm 0,13^{d}$ | 7.00$\pm 1,15^{c}$ | 18.77$\pm 0,42^{b}$ | 1.34$\pm 0,32^{a}$ | 56.62$\pm 3,32^{b}$ |
| B | 3.65$\pm 0,09^{ c}$ | 7.92$\pm 1,24^{a}$ | 19.06$\pm 0,29^{a}$ | 1.27$\pm 0,22^{b}$ | 56.23$\pm 5,78^{b}$ |
| W | 3.74$\pm 0,14^{a}$ | 7.37$\pm 0,98^{b}$ | 19.09$\pm 0,50^{a}$ | 1.04$\pm 0,11^{d}$ | 58.34$\pm 5,70^{a}$ |
| D | 3.68$\pm 0,16^{b}$ | 6.25$\pm 0,84^{d}$ | 19.03$\pm 0,59^{a}$ | 1.22$\pm 0,21^{c}$ | 55.82$\pm 6,44^{b}$ |

Source: Author. Means ± deviations pattern followed by the same letters in the same column, do not differ statistically from each other, by the Tukey test at 5% significance. Caption: A – Filling; B – Spring; C – Mama Tia and D – Promex. TSS – Total Soluble Solids.

pH (Power of Hydrogen)

The pH values found in this study range from 3.57 to 3.74, and were statistically different from each other. Higher values were observed in brands C (3.74) and D (3.68) and lower values in brands A (3.57) and B (3.65). According to Monteiro *et al* . (2012) , the safe pH range is considered to be less than or equal to 4.6, in which the probability of microbial multiplication, especially *Clostridium botulinum,* is minimal, showing results in agreement with this study.

Similar results (3.72 - 3.74) were found in the study by Borguini (2006), who evaluated the different types of tomato preserves and products obtained by conventional and organic cultivation. Superior results, but within the recommended parameters (<4.6 ), were reported by Oliveira *et al* ., (2015) and Santos (2014), when analyzing tomato preserves of the *Lycopersicon esculentum MILL variety )* obtained in local commerce in Brasília, observing levels between 3.0-4.0. According to Souza *et al.,* (2023) in the preparation of tomato preserves, they obtained a pH in the range of 3.96 - 4.08, in line with the results observed in this study. On the other hand, Santos *et al.,* (2024) in the study on the physical-chemical and microbiological quality of edible calcium chloride coatings in the preparation of post-harvest tomato preserves, reported pH in the range of 3.9 - 4.15, being above the levels observed in this study where, possibly, the addition of calcium chloride coating will have influenced the observation of these high levels;

According to Santos (2023), in the study on physical-chemical attributes of preserves based on cherry tomato fruits produced in the upper Sertão Sergipano, he reported a pH in the range of 3.53 - 4.17, in line with the levels observed in this study. In contrast, Abreu *et al.,* (2013) found an average value of 4.60, when analyzing the physical and chemical characteristics of preserved dried tomatoes, resulting in values higher than the range considered safe, and these levels can be explained by the evaporation of the water content in the tomato structure, favoring the concentration of OH - ions , due to the presence of mineral salts in the composition of the tomato than when they are dissolved in the same water.

**Titratable acidity**

pH and acidity values are correlated, meaning that low acidity values indicate a higher pH, which allows microbial multiplication that causes food deterioration and harms the health of the end consumer ( Fabbri , 2009).

In the present study, acidity was observed between 6.25% and 7.92% for B and C, while brands A and C represented 7% and 7.37% respectively. Lower results were reported by Guedes *et al.,* (2020), when studying the physical-chemical and microbiological quality of tomato derivatives marketed in Ituiutaba-MG, where they obtained acidity values in the range of 1.2 to 2.2% and the variety as well as the technological process may be the origin of these reduced levels. On the other hand, Santos (2023) observed levels in agreement with the present study, when evaluating the physical-chemical parameters of cherry tomato fruits produced in the upper Sertão Sergipano, reporting acidity values in the range of 6.2 - 12.1%.

Dantas *et al.,* (2021) reported levels below those observed in this study, when evaluating the quality of the physical-chemical and microbiological parameters of cherry tomatoes sold in emporiums in Manaus-AM, having reported ranges between 2.0 - 4.9%, with the tomato varieties and storage conditions possibly causing a reduction in the acid indexes of the tomatoes. According to Santos *et al.,* (2024) in the study on the selection of tomatoes aimed at agrogeological systems based on physical-chemical characteristics, where they reported acidity values in the range of 3.3 - 3.9% and by Júnior *et al.,* (2014) with levels between 6.1 and 9.1% being below the levels observed in the present research, which supports the alteration in the quality of tomato-derived products by the technological process involved. However, these results observed in the research are in line with the normative requirements according to decree no. 293: 2011 Ed.1 and 2, which advocates a minimum of 0.5% citric acid to prevent microbiological deterioration.

**Total soluble solids (TSS)**

The soluble solids content determined in °Brix is a parameter involving the degree of sweetness of the fruits, considered the main component responsible for the flavor of tomatoes (Chitarra & Chitarra, 2005). It can be observed that brand A with 18.77 °Brix showed a statistical difference in relation to brands B (19.06 °Brix), C (19.09 °Brix) and D (19.03 °Brix).

Resolution RDC No. 272, of September 22, 2005 (~~BRAZIL~~, Brazil 2005), establishes the minimum content of 6°Brix of soluble solids for tomato paste, therefore, all brands of tomato paste studied in this study are in accordance with current legislation.

Lower results (4.7°Brix to 5.2°Brix) were reported by Rosa *et al.* (2011), when studying the physical-chemical, nutritional and instrumental characterization of four Italian tomato accessions, and the *in natura state possibly* interfered in the observance of these levels, since it would not have undergone any technological process, especially cooking, which reduces the concentration of soluble solids by releasing water molecules (water vapor); by Filho *et al.,* (2024) in the study on the yield and quality of fruit of two industrial tomato hybrids in different plant populations, where they reported values between 3.95-4.45°Brix; by Dias *et al.,* (2024) in the study on the performance of industrial tomato plants inoculated with phosphate-solubilizing rhizobacteria, where they reported values between 4.4-5.9°Brix; by Santos *et al.,* (2024) in the study on the selection of tomatoes aimed at agrogeological systems based on physical-chemical characteristics, where they reported values between 5-5.6°Brix; by Santos *et al.,* (2020) in the study on the transformation of data by aligned stations in an experiment to evaluate the quality of tomato extract, where they reported 3.2-5°Brix and by Silva (2015) (this author is not cited in the bibliography!), in the study on the dehydration of homemade tomato sauce using the foam-mat method, where they observed values between 5.22-5.42°Brix and possibly the dehydration method and implementation conditions may have facilitated the removal and reduction of soluble solids in the tomato structure.

**Lycopene**

According to the Mozambican Standards for quality and food safety through Decree No. 293: 2011 Ed.1 and 2, it is stated that for canned tomatoes, the concentration is generally measured in milligrams of lycopene per 100 grams of tomato paste, considering 5 mg of lycopene per 100g of product. Based on this proportion, we obtained the following lycopene values: 26.8 mg (A), 25.4 mg (B), 20.8 mg (C) and 24.4 mg (D).

Similar results were reported by Fabbri (2009) in his experiment on the study of ionizing radiation in canned tomatoes and tomato sauces.( *lycopersicum esculentum mil)* , having obtained values between 18.13 and 42.84 mg; Concordant results were reported by Chada (2021), in the study on obtaining lycopene from tomato pomace subjected to industrial processes and by unconventional extraction and drying techniques, reporting values between 18.6-24.8 mg; Similar results were also reported by Vargas (2021), in the study on conventional and unconventional extractions of lycopene in canned tomatoes, where he reported values between 20.2-26.4 mg.

Still in this regard, concordant results were reported by Santos *et al.,* (2024) in the study on coating with lycopene coloring present in tomatoes as an alternative food supplement, reporting values between 18.9-32.2 mg, the same scenario of similar results was evidenced by Sacama (2022), in the study on the importance of tomato preservation by heat treatment and antioxidants in the diet, where he reported values between 20.5-28.3 mg.

According to Barbosa *et al.,* (2014) studying the comparison of lycopene extraction methodologies in tomato extracts quantified by double-beam spectrophotometer in the visible region, they observed values between 22-25.4 mg and by Rodrigues (2014), in the study on the evaluation of irradiation as a method of post-harvest conservation of tomatoes, being in agreement with the levels obtained in this study.

**Humidity**

The brands of tomato paste evaluated in this study only showed statistical difference in the moisture content of brand C, with 58.34%. The moisture range was between 55.82 - 58.34%. Similar results to those of the present study were reported by Abreu *et al.,* (2013), when they studied the physical and chemical characteristics of preserved dried tomatoes, where they reached an overall average of 56.32%.

Superior results were reported by Senna *et al.,* (2024) in the study on the impact of industrial processing on the composition of tomatoes, where they reported values between 94.2-94.9%, and these high levels may be associated with the technological process and the high level of water activity of the product.

According to Dantas *et al.,* (2021) analyzing the physical-chemical and microbiological quality of cherry tomatoes sold in stores in Manaus-AM, they reported levels between 90.70-98.72%, revealing that these products were not subjected to a technological process that would allow the reduction of water levels.

According to Matos *et al* ., (2020), comparing tomato extracts produced at different stages for the preparation of preserves, values between 84.62-92.43% were observed, being above the levels observed in this study and possibly the cooking process and concentration of tomato mass may have influenced the observation of low levels in this research.

According to Silva *et al.,* (2025) in the study on the physical-chemical, microbiological and sensory characterization of tomato jams, where they reported values between 85.52-91.4% and by Muller et al., (2018) studying the same material, they observed levels between 83.54-90.26%, and these high levels can possibly be explained by the varieties used, technological process involved and purpose of the extract.

According to **Almeida *et al.,* (2021),** moisture content also has implications for food safety; products with higher moisture content may be more susceptible to microbial growth, which may compromise product safety and endanger the health of the end consumer.

**Conclusion**

In conclusion, the canned tomato paste sold in Chókwè complies with the quality and food safety requirements, presenting good physical and chemical parameters for consumption. However, it is essential that the industry and regulatory bodies continue to monitor these aspects to ensure the continued quality and safety of these products.

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