**Assessment of compliance of physical-chemical parameters of canned preserves from *Solanurn lycopersicum L.* (Tomato) marketed in the Chókwè city,Mozambique**

**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 storage, ensuring the stability of its properties for a considerable period. This study aimed to evaluate the physicochemical quality of canned tomato paste marketed in the markets of the Chókwè city. The physicochemical parameters analyzed were: pH by the potentiometric method; total titratable acidity by titration with 0.1N sodium hydroxide; total soluble solids content (°Brix) by refraction; lycopene by spectrophotometry; and moisture by 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 to 3.74, all within the range considered safe for consumption (< 4.6), the titratable acidity ranged from 6.25 to 7.92%, the total soluble solids content (°Brix ) was 18.77°Brix for brand A, and varied between 19.03 and 19.09°Brix, meeting the minimum requirement of 6°Brix stipulated by legislation, the lycopene content was between 20.8and 26.8 mg/g, reflecting good levels of this antioxidant, moisture content ranged from 55.82 and 58.34%. It is concluded that the results presented regarding the physical-chemical quality of the canned tomato extract 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, food safety standards, INNOQ, Mozambican

**Introduction**

Tomatoes are one of the most important and popular vegetables in the world. Tomatoes are rich in vitamins and minerals, and in Mozambique are considered an important food crop for the population, both in rural areas and in urban centers (Machalela *et al.,* 2023).

Tomato is rich in lycopene, which is helpful in reducing the prevalence of some chronic diseases. It is rich in vitamins minerals, sodium, iron, phosphorus, beta-carotene, potassium and magnesium, calcium, zinc, vitamins (B1, B2, C, E and K), dietary fiber, carbohydrate, vitamin B6, folate, fatty acid derivatives (including 9-oxo-octadecadienoicacid), vitamin A (beta carotene), and phosphorus. In addition, they are a good source of chromium, pantothenic acid, protein and iron (Ochida *et al.,* 2019).

In Mozambique, the preparation and marketing of canned foods must follow the guidelines of the Technical Secretariat for Food and Nutrition Security (SETSAN). According to the organization, canned products must undergo technological procedures before and after hermetic sealing of the packaging to prevent any changes in their composition. Mozambique has four agro-ecological tomato growing zones: Chókwè, Sussundenga, Nampula and Niassa. According to the PEDSA 2011-2020 report, 93,000 tonnes of tomatoes were produced in 2010, of which 50% deteriorated due to poor harvesting and conservation. According it is essential that processing and preservation techniques reduce food waste in Mozambique without compromising consumer safety. However, canning, while aligned with this strategy, requires rigorous quality maintenance and the minimization of factors that could alter it, thus ensuring consumer safety in the short, medium, and long term.

Despite advances in tomato preservation techniques, as highlighted 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. It is very difficult to store tomato at ambient temperatures for a long time because they ripen very quickly and become unmarketable in a short period. Storage under low temperature has been considered the most efficient method to maintain quality of most fruits and vegetables due to its effects on reducing respiration rate, transpiration, ethylene production, ripening, senescence and rot development (Chandra *et al.,* 2024).

However, it is urgent to implement policies that defend the periodic evaluation of the physical, chemical and biological parameters of these foods, especially in different storage conditions, where variables such as temperature, inadequate handling, relative 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 conducted at the Food Processing Laboratory of the Gaza Polytechnic Institute, located in the Chókwè district, with an area of 2,466 km² and a population density of 88 inhabitants/km². The Chókwè district is located in Gaza Province, Mozambique. Geographically, it is located in the Lionde Administrative Post, approximately 12.4 km from the Chókwè city. It is bordered by Mabalane district to the north, Guijá district to the north and northeast, Chibuto district to the east, Bilene district to the south, and Magude district of Maputo Province to the west (Nhaca *et al.,* 2025).

**Determination of the sample population**

To determine the exact sample (canned food sales units), a survey was carried out among establishments that sell the products under study and, based on the methodology described by also highlighted by Gil (2008), 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

**Where:**

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

e2 – margin of sampling error (5%);

n – Sample size;

N – Study population;

P – Proportion of the real population 0.50;

**Selection of establishments**

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

**Sampling**

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

## 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, 5 g of tomato paste samples were weighed on a HANNA balance with a precision of 0.0001 g. The samples were then diluted in a 100 ml Erlenmeyer flask in a ratio of 5 g of sample to 45 ml of distilled water. The pH meter was then calibrated with buffer solutions of 4.0, 7.0, and 10.0. The electrode was inserted into the already settled samples for 30 seconds, and the pH level was measured on the instrument panel (IAL, 2008).

**Titratable acidity**

For titration, 5 g of tomato paste samples were weighed on a HANNA balance with a precision of 0.0001 g. After titration, the samples were diluted in 100 ml beakers in a ratio of 5 g of sample to 45 ml 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 a pink color. The results were expressed as a %, based on equation 1:

Equation 1: Determination of titratable acidity

AT (%) = × 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 a portable refractometer with a scale of 0 to 32 °Brix was first cleaned, drops of the sample were added to the prism, and then the refractive index expressed in ° Brix was read.

**Lycopene**

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

Equation 2: Determination of Lycopene

(µg/ g)=

Where:

A = is the absorbance measurement; V = volume of solution used in ml; = is the extinction coefficient or molar absorptivity coefficient of a pigment in a specific solvent. For lycopene in petroleum ether, the extinction coefficient is 3450; M = is the mass of the sample.

**Moisture**

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

Equation 3: Determination of Moisture

Moisture %= \*100

## Statistical Analysis

The experimental trial was based on a randomized block design (RBD), with four blocks and four treatments (4x4), totaling a sample size of 16 experimental units. Analysis of variance was performed using the RStudio statistical program, version 4.3.3, and means were compared using Tukey 's test at a 5% significance level. Microsoft Excel 2013 was used to organize the data (tables and graphs).

**Results and discussion**

The analysis of variance of the physicochemical parameters of the canned tomato extract is presented below (Table 1).

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | | | | | |
| Brands | **pH** | **Acidity (%)** | **TSS (°Brix)** | **Lycopene (mg)** | **Moisture (%)** |
| A | 3.57 | 7.00 | 18.77 | 1.34 | 56.62 |
| B | 3.65 | 7.92 | 19.06 | 1.27 | 56.23 |
| W | 3.74 | 7.37 | 19.09 | 1.04 | 58.34 |
| D | 3.68 | 6.25 | 19.03 | 1.22 | 55.82 |

Source: Author. Means ± deviations Pattern followed by the same letters in the same column, do not differ statistically from each other, according to Tukey 's 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 ranged 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 less than or equal to 4.6, in which the probability of microbial multiplication, especially *Clostridium botulinum,* is minimal, presenting results in agreement with this study.

Similar results (3.72 - 3.74) were found in the study by Superior results, although within the recommended parameters (< 4.6), were reported According to Souza *et al.,* (2023) in the preparation of tomato preserves, they obtained pH in the range of 3.96 - 4.08, corroborating the results observed in this study. On the other hand, Santos *et al.,* (2024) in the study on the physicochemical 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;

Hihger results were reported by Modolon *et al*. (2012), who has got a pH of 3.97 to 4.08 quality of tomato fruits, by Oliveira *et al.* (2018), characterizing physicochemical properties of organic tomato varieties, reporting pH between 4.27 and 4.65, by Machalela *et al.* (2023), evaluating the physicochemical characteristics of pulp tomato in natura, obtained pH of 4.79. In contrast, Chirruco *et al.* (2023) found values of pH ranging from 3.0 to 4.0 when analyzing quality of tomatoes produced in the irrigated area of Chókwè, resulting in values higher than the range considered safe. 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 tomato composition,than when these are dissolved in the same water.

**Titratable acidity**

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 The variety as well as the technological process may be the origin of these low levels.

Results according to this obtained in this study was related by Chirruco et al. (2023), acidity value of 6.0%, by Oliveira *et al*. (2020), studying the effect of edible coatings on the quality of cherry tomatoes, reported values of 2.56 to 6.33%, respectively.

Lower results were reported by Nhaca et al. (2025), around 0.59 to 1.66% of acidity, studying the physicochemical properties of tomatoes, and also, 0.38%, were reported by Abreu *et al*. (2011), researching physicochemical characteristics and lycopene retention of tomatoes, and by Rosa *et al.* (2011), 0.27% to 0.41% acidity, studying the control factors at different stages of tomato maturation. This difference may be related to the concentration of acidic compounds and/or the ripeness index of the tomato,

Dantas *et al.* (2021) reported levels below those observed in this study when evaluating the quality of the physicochemical and microbiological parameters of cherry tomatoes marketed in emporiums in Manaus-AM, reporting variations between 2.0 and 4.9%. Tomato varieties and storage conditions can cause a reduction in tomato acidity levels. According to Santos *et al.* (2024), in the study on the selection of tomatoes for agrogeological systems based on physicochemical characteristics, where they reported acidity values in the range of 3.3 to 3.9% and by However, these results observed in the research comply with the regulatory requirements of decree no. 293: 2011 Ed. 1 and 2, which recommends a minimum content of 0.5% citric acid to prevent microbiological deterioration.

**Total soluble solids (TSS)**

The soluble solids content determined by the refractometry method in °Brix is a parameter that involves the degree of sweetness of the fruits, considered the main component responsible for the flavor of the tomato. It can be observed that brand A with 18.77 °Brix presented a statistical difference in relation to brands B (19.06 °Brix), C (19.09 °Brix) and D (19.03 °Brix).

Lower results (4.7°Brix to 5.2°Brix) were reported by Filho *et al.,* (2024) in the study on the productivity and fruit quality of two industrial tomato hybrids in different plant populations, where they reported values between 3.95-4.45°Brix; by Chippy et al. (2020), around 3.50 to 5.83ºBrix, by Santos *et al.,* (2024) in the study on tomato selection targeting agrogeological systems based on physicochemical characteristics, where they reported values between 5-5.6°Brix, Filho et al., (2024) found soluble solids ranging from 8.77 to 13.93ºBrix with tomato extract packaged in cans and glass jars, by Tomás (2014) when studying determining and comparing tomato quality parameters, found soluble solids of 4.1ºBrix.

**Lycopene**

According to the Mozambican Food Quality and Safety Standards, through Decree No. 293:2011, Ed. 1 and 2, it is established 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 100 g 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).

Results according to those obtained in this study were reported by Chippy et al. (2020), around 20.18mg/110g of lycopene.

Lower lycopene contents, 0.00375 to 0.0488 mg/g, were found by Lima et al. (2018) evaluating lycopene content in fruits and tomato-derived products. Zambrano et al. (2015) found 0.00045 to 0.00180 mg/g, evaluating lycopene content and synthesis. Ceballos-Aguirre et al. (2012) recorded 0.00204 and 0.00235 mg/g, studying evolution of antioxidant content in tomatoes. Barcelos et al. (2019) observed 0.0236 to 0.0479 mg/g investigating the effect of processing on the bioactive composition and antioxidant capacity of tomatoes, and Waliszewski and Blasco (2010) reported values of 0.00212 to 0.00270 mg/g when addressing the use of lycopene in the prevention of cancer and cardiovascular diseases.

Still in this sense, concordant results were reported by Santos *et al.,* (2024) in the study on coating with lycopene dye 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

**Moisture​**

The tomato paste brands evaluated in this study showed statistical differences only in the moisture content of brand C, with 58.34%. The moisture content range varied between 55.82 and 58.34%. Similar results to those of the present study were reported

Higher results were reported by Senna *et al.,* (2024) in the study on the impact of industrial processing on tomato composition, where they reported values between 94.2-94.9%, by Sousa *et al*. (2011), 94.08 to 96.15% of moisture, studying on chemical and physical characterization of tomatoes, by Machalela et al. (2023), around 96.13%, 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 marketed 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 allowed the reduction of water levels.

According to Silva *et al.,* (2023) 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.

**Conclusion**

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

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**References**

1. Abreu, W. C.; Barcelos, M. F. P.; Silva, E. P.; A. N. D.; Boas, E. V. B. V.(2011). Physical and chemical characteristics and lycopene retention of dried tomatoes subjected to different pretreatments. Rev Inst Adolfo Lutz. São Paulo 70(2): 168-74.
2. Adolfo Luz Institute. (2008). Analytical standards of the Adolfo Lutz Institute : Physicochemical methods for food analysis. Available at: <https://wp.ufpel.edu.br/nutricaobromatologia/files/2013/07/NormasADOLFOLUTZ.pdf>
3. Barcelos, S. C.; Silva, E. F.; Batista, E. M.; Souza, P.; Farias, V. (2019). Effect of processing on the bioactive composition and antioxidant capacity of tomatoes. Brazilian Journal of Food Research, 10(2): 122-142.
4. Borba, K.., Aykas , D., Saona , L., Urtybia , A. (2020). Miniaturization of optical sensors and their potential for high-throughput screening of foods . Available at : https://www.sciencedirect.com/science/article/abs/pii/S2214799320300382
5. Ceballos-Aguirre, N.; Vallejo-Cabrera, F. A. E,; Arango-Arango, N. (2012). Evaluation of antioxidant content in cherry tomato (Solanum spp.) introductions. Agronomic Act, 61(3): 230-238.
6. Chandra S.; Tiwari S.; Singh A.; Kumar A.; Verma R.; Kumar P. (2024). Effect of storage conditions on quality of tomatoes. Int J Agric Extension Social Dev. 7(9S):25-31. DOI: [10.33545/26180723.2024.v7.i9Sa.1048](https://doi.org/10.33545/26180723.2024.v7.i9Sa.1048).
7. Chippy, A. K.,; Beena, T.; Rahana, S. N.; Amrutha, U. M. (2021). Determination of fruit quality parameters of ten tomato (*Solanum lycopersicum*) genotypes and their Hybrids. Journal of Pharmacognosy and Phytochemistry, 10(1): 1621-1624.
8. Dantas, L., Maia, A., Moreno, M., Melo, N., Souza, R., Souza, R., Martim, S. (2021). Physicochemical and microbiological analysis of cherry tomatoes marketed in emporiums in Manaus-AM. Available at: [https://doi.org/10.33448/rsd-v10i15.23729](https://doi.org/10.33448/rsd-v10i15.23729%20)
9. Filho, A., Almeida, T., Tavares, C. (2024). Productivity and fruit quality of two industrial tomato hybrids in different plant populations. Available at: <https://doi.org/10.56238/arev6n4-125>
10. Gil, AC (2008). Social research methods and techniques. Sao Paulo, publisher Atlas SA Available at : [https://ayanrafael.com/wp-content/uploads/2011/08/gil-ac-mc3a9todos-e-tc3a9cnicas-de-pesquisa-social.pdf](https://ayanrafael.com/wp-content/uploads/2011/08/gil-a-c-mc3a9todos-e-tc3a9cnicas-de-pesquisa-social.pdf) .
11. Lima, J. S.; Santos, E. A. L.; Batista, R. A.; DOS Santos, R. E. M.; Pagani, A. A.C. (2018). Evaluation of lycopene content in tomato fruits and products. 6th Food Safety Symposium. FAURGS, Gramado-RS.
12. Machalela, A. A., Júnior, A. A. M., Vatiro, A., & Nanelo, R. F. (2023). Production and Characterization of Tomato (Lycopersicon esculentum) Jam. *Asian Food Science Journal*, *22*(10), 120–131. <https://doi.org/10.9734/afsj/2023/v22i10679>.
13. Modolon, T. A.; Boff, P.; DA Rosa, J. M.; Souza, P. M. R.; Miquelluti, D. J. Post-harvest quality of tomato fruits subjected to high dilution preparations. Rev. Hort. Bras, 30(1): 58-63, 2012.
14. Monteiro, C., Crepaldi , R., Avelar, A., Peterlini , M., and Pedreira, M. (2012). Hydrogen potential of antibiotic solutions subjected to environmental conditions. Esc Enferm USP, 46 (2), 9-311. Available at: <https://doi.org/10.1590/S0080-62342012000200007>.
15. Nhaca, E. J. M., José, A. E., Mutie, E. C., Bunga, J. S., & Massingue Júnior, A. A. (2025). Nutritional potential of warm season Lycopersicon esculentum (tomato) in Chókwè district. *REVISTA DELOS*, *18*(65), e4555. <https://doi.org/10.55905/rdelosv18.n65-146>.
16. Ochida, C. O.; Itodo, A. U.; & Nwanganga, P. A. (2018). A Review on Postharvest Storage, Processing and Preservation of Tomatoes (Lycopersicon esculentum Mill). *Asian Food Science Journal*, *6*(2), 1–10. <https://doi.org/10.9734/AFSJ/2019/44518>.
17. Oliveira, L. F.; Romano, K. R.; Barros, L. R.; Tolentino, V. R. (2018). Physicochemical and nutritional characterization of organic tomato varieties (Lycopersicon esculentum, Mill). Food Hygiene, 32(278/279): 107-111.
18. Oliveira. T. M. (2020). Effect of edible coatings on the quality of cherry tomatoes grown in organic and conventional systems. Mossoró, ESAM. 121p.
19. Rosa, C. L.; Soares, A. G.; Freitas, D.; Rocha, M.; Ferreira, J. C. (2011). Physicochemical, nutritional and instrumental characterization of four accessions of Italian tomato (Lycopersicum esculentum Mill) of the 'heirloom' type produced under organic management for the elaboration of concentrated pulp. Food and Nutrition, 22(4): 649-656.
20. Santos, M., Cardoso, J., Lopes, V., Schneuider , E., Finatto , T., Varga, T. (2024). Selection of tomato plants for agroecological systems based on physicochemical characteristics. Available at: <file:///C:/Users/25884/Downloads/297707_selecao-de-tomates-voltados-para-sistemas-agroecologicos-com-base-em-caracteristicas-fisico-quimicas.docx+-+Documentos+Google-2.pdf>.
21. Senna, C., Rodrigues, M., Furlong , E. (2021). Impact of industrial processing on tomato composition. Available at: <https://www.editoracientifica.com.br/books/chapter/impacto-do-processamento-industrial-na-composicao-de-tomates-solanum-lycopersicum>.
22. Silva, L., Orvatti , L., Albonico , R. (2023). Physicochemical, microbiological and sensory characterization of tomato jams produced by an association of small producers in western Paraná. Food Hygiene Journal. v.39 (300): e1182.
23. Sousa, A. A.; Grigio, M. L.; Nascimento, C. R.; Silva, A. C. D.; Rego, E. R. E.; Rego, M. M. (2011). Chemical and physical characterization of fruits from different tomato accessions in a greenhouse. Agroambiente Journal, 5(2): 113-118.
24. Souza, T., Lima, G., Macedo, I., Silva, M., Santana, A., Costa, M., Quirino, R., Shinohra, N. (2023). Microbiological and physicochemical evaluation of tomato-based industrialized products *(lycopersicon esculentum)*. Conjecturas, Vol. 21, Nº 3, p.353-361. <https://doi.org/10.53660/CONJ-135-216>.
25. Tomás, L. F. (2014). Determining and comparing the quality parameters of fresh and dried tomatoes. Mozambique, Chimoio.
26. Waliszewski, K. N. E.; Blasco, G. (2010). Nutraceutical properties of lycopene. Public health Mexico, 52(3): 254-265.