



e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



ORIGINAL RESEARCH ARTICLE



## Quality assessment of commercial tomato paste in Kurdistan region of Iraq: Implications for agripreneurship and market standards

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### ARTICLE HISTORY

Received: 16 February 2025

Revised received: 12 April 2025

Accepted: 20 April 2025

### Keywords

Economic benefits

Market standards

Physicochemical analysis

Tomato paste composition

### ABSTRACT

A study was conducted to compare the physicochemical properties of various popular tomato paste brands (TP). The canned tomato paste samples were procured from local markets in Sulaimani, Kurdistan-Iraq, during the year 2023-2024. The physicochemical composition of six tomato paste samples, representing different brands (TP<sub>1</sub>, TP<sub>2</sub>, TP<sub>3</sub>, TP<sub>4</sub>, TP<sub>5</sub>, and TP<sub>6</sub>), was assessed. The analyzed parameters included such as pH level, titratable acidity (TA) %, total solids (T.S) %, °Brix, moisture content %, total sugar, and ash %. The results showed that the pH values spanned from 4.14 (TP<sub>2</sub>) to 4.377 (TP<sub>3</sub>) brands, while the titratable acidity ranged between 1.34% and 2.41%. The TP<sub>3</sub> brand had the highest total solids (34.95%) and the lowest moisture content (65.05%), whereas TP<sub>5</sub> had the lowest total solids (28.64%) and the highest moisture content (71.36%). Moreover, the maximum Brix and total sugar were noted with TP<sub>4</sub> (29.26) but total sugar in TP<sub>6</sub> (1.38%), and the minimum Brix was recorded from TP<sub>5</sub> (26.50) but total sugar in TP<sub>3</sub> (0.92%). Ash content, indicating mineral content the Ash in tomato paste were indicated by using Furnace at 600 °C, the TP<sub>6</sub> brand was the highest level of ash about 5.20%, but the lowest level in TP<sub>5</sub> (3.47%). These results indicated that tomato paste was safe to consumption. This study helps to raise consumer awareness and offers useful insights for improving local tomato paste production to enhance product quality, support the local businesses, and benefit of both the producers and buyers economically.

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**Citation of this article:** Ali, R. A., Sdiq, S. J. M., Salih, A. M., Mahmood, A. A., Omar, Z. O., Yaqub, K. Q., Abdul, N. A., & Sirwan, K. (2025). Quality assessment of commercial tomato paste in Kurdistan region of Iraq: Implications for agripreneurship and market standards. *Archives of Agriculture and Environmental Science*, 10(2), 216-220, <https://dx.doi.org/10.26832/24566632.2025.100204>

### INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most extensively consumed agricultural products in the world, with high economic and nutritional value. Tomato is a significant bioactive and aroma compound source for human dietary in many food applications. They are rich sources of vitamins, particularly vitamins C and E, carotenoids, for example, lycopene, and phenolic compounds like flavonoids, providing phytonutrients that advantage

the human diet. These materials have been linked to the anticipation of chronic degenerative diseases, making the health properties of tomatoes even more redefined. Tomatoes are also an important source of potassium, fiber, calcium, iron, and small amounts of magnesium, thiamine, riboflavin, and niacin (Luna-Guevara *et al.*, 2014). In an agronomic sense, tomatoes play an important role in the agricultural and food-processing industries, creating jobs in farming, distribution, and processing sectors (Flat & Collector, 2015). Tomato growing and tomato-

derived goods such as tomato paste, sauces, and juices serve critical functions in both local and worldwide economies, especially in areas where tomatoes are an essential agricultural product. However, chemical composition might change depending on genetics and environmental factors such as light, temperature, soil quality, and air composition and cultural (harvest timing and irrigation systems) factors (Srivalli et al., 2016; Thaker et al., 2024). Other customer-preferred attributes, for example, red color, firm texture, juiciness, and good flavor, influence the quality and marketability of tomatoes, which are crucial for consumer preference and market demand (Tiwari et al., 2015).

The major portion of the tomato crop is processed into tomato paste, which is an important ingredient in many products like soups, sauces, and ketchup (Sobowale et al., 2012; Landbouwcatalogus, 1995). This processed form of tomatoes offers not only suitability and versatility but also economic value, as it allows for the preservation and transportation of tomatoes over long distances. The industrial production of tomato paste includes several stages, including washing, crushing, sorting, pulping, evaporation, pasteurization, and cooling (World Bank, 2022). These processes enhance the shelf life of tomato paste while preserving its nutritional value (Kelebek et al., 2018; Shekh & Aziz, 2021). Economically, tomato paste production makes considerable value in terms of food security and export potential, particularly for countries with large-scale tomato cultivation (Fatah et al., 2025; Yaqub, 2024).

Two primary methods are used in the production of tomato paste: the first one is hot break, and the second one is cold break (Sobowale et al., 2012). The hot break process, where tomatoes are heated to at least 90°C, inactivates enzymes and is typically preferred for the production of ketchup and sauces because of its texture and consistency (Sobowale et al., 2012). In contrast, the cold break process, which contains heating tomatoes to lower temperatures (40-60°C), produces a paste with a better color, appropriate for other tomato-based products (Fatah et al., 2025; Landbouwcatalogus, 1995). Both methods guarantee that processed tomatoes retain their health benefits, as lycopene, a vital antioxidant, converts more bioavailable in cooked and processed tomatoes than in fresh ones (Shatta, 2017). Additionally, tomato by-products, rich in antioxidants and colorants like lycopene and carotenoids, contribute further economic value, as these compounds have potential uses in other industries, such as cosmetics and pharmaceuticals (Domínguez et al., 2020; Palani et al., 2025; Salih et al., 2019; Yaqub et al., 2024). Thus, by evaluating the quality of these products, this research study not only contributes to consumer awareness but also delivers valuable insights into the domestic tomato paste production process, contributing potential improvements in product quality and economic outcomes for both Agripreneurs and final consumers. Therefore, keeping in view, this research was aimed to evaluate the quality of six tomato paste of different brands available in the markets of Suleimani governorate in the Kurdistan Region of Iraq.

## MATERIALS AND METHODS

### About the study area

The study was conducted in the Sulaimani Governorate, situated in the Kurdistan Region in northern Iraq. In 2023, tomato production in the Kurdistan Region reached 283,633 tons, with Sulaimani province contributing 97,976 tons, accounting for 34.5% of the total production (Salih et al., 2019; Sirwan, 2024).

### Collection of data

A total of six samples were randomly obtained from various supermarkets in Sulaimani. Careful storage protocols were followed to ensure proper handling and transportation of the samples to the laboratory. Table 1 presents demonstrations the samples of different brands (TP<sub>1</sub>, TP<sub>2</sub>, TP<sub>3</sub>, TP<sub>4</sub>, TP<sub>5</sub>, and TP<sub>6</sub>). The table presents critical data, including sample code, weight, and country of origin for each tomato paste sample.

### Analysis of physicochemical parameters

In the analysis of tomato paste for different physicochemical properties such as total acidity, pH, Brix, total solid, and moisture content was performed to evaluate the quality of tomato paste by following the standard methods (Shatta, 2017; Domínguez et al., 2020). The formula used to calculate the moisture content of a substance as a percentage is as follows:

$$\text{Moisture Content (\%)} = \left( \frac{\text{Weight Loss}}{\text{Initial Weight}} \right) \times 100 = \left( \frac{W_1 - W_2}{W_1} \right) \times 100$$

Where: W<sub>1</sub> = Initial weight of the sample (before drying); W<sub>2</sub> = Final weight of the sample (after drying); W<sub>1</sub>-W<sub>2</sub> = Weight loss (moisture lost during drying).

### Determination of total Sugar

The total sugar content of the tomato paste samples was determined using a spectrophotometer, following the method by (Ekşi & Özhamamcı, 2009). The formula calculates the total sugar percentage in a sample as the following:

$$\text{Total sugar \%} = \text{Device reading} \times \text{Dilution} \times \text{Constant factor} (0.0525) \times 100$$

### Determination of ash

Five grams of each tomato paste sample were weighed into crucibles. The samples were charred using a Bunsen flame until they turned black, dried, and showed no trace of foam. Subsequently, they were ashed in a furnace at 600°C, then cooled in a desiccator until a constant weight was achieved as reported by Van & Young (1977).

$$\text{Ash (\%)} = \frac{(\text{Weight of crucible} + \text{ash}) - (\text{Weight of empty crucible})}{\text{Sample weight}} \times 100$$

**Table 1.** Details of different tomato paste brands used for the study.

Samples	Weight	Manufactured Country
TP <sub>1</sub>	800 g	Iran
TP <sub>2</sub>	800 g	Kurdistan Region of Iraq
TP <sub>3</sub>	800 g	Turkey
TP <sub>4</sub>	400 g	Turkey
TP <sub>5</sub>	800 g	Iran
TP <sub>6</sub>	800 g	Iraq

### Statistical analysis

The results are expressed as the mean values of three replications for each parameter. Data analysis was performed using XLSTAT software on Windows (version 7.5.2). Additionally, one-way ANOVA followed by Duncan's multiple range tests ( $p < 0.05$ ) was utilized to conduct multiple comparisons (Dzhivoderova-Zarcheva et al., 2024).

## RESULTS AND DISCUSSION

Table 2 summarizes the physicochemical values of different tomato paste samples. Six tomato paste samples (TP<sub>3</sub>, TP<sub>4</sub>, TP<sub>1</sub>, TP<sub>6</sub>, TP<sub>5</sub>, and TP<sub>2</sub>) exhibited significant differences in pH values. pH values varied from 4.143 (TP<sub>2</sub>) to 4.377 (TP<sub>3</sub>), arranged as follows: TP<sub>3</sub> > TP<sub>4</sub> > TP<sub>1</sub> > TP<sub>6</sub> > TP<sub>5</sub> > TP<sub>2</sub>. This range shows that TP<sub>3</sub> was through TP<sub>2</sub>, the lowest pH value. The pH values of all the samples were found to be 4.6, which is the acceptable cutoff established by the Codex Alimentarius of the tomato- and tomato-based products (Abdulrahman et al., 2025; Bekhet, 2013). Tomatoes are generally classified as acidic foods, with the best pH for tomato paste between 3.8 and 4.3 (Srivalli et al., 2016; Sobowale et al., 2012). Tomato paste's lower pH plays an important role in preventing microorganism growth that leads to spoilage, thus enhancing the stability and shelf life of the paste. These pH values are consistent with those reported for tomato paste in previous studies, which have shown values of 4.87 – 5.30, (3.9 – 4.14) and (4.0 – 4.1), respectively. How pH levels can affect product quality: Natural acidity in tomatoes hovers between 4.0 and 4.5, which helps hold back microbial growth (Jassim & Karim, 2020; Ali & Othman, 2023; Sobowale et al., 2012; Srivalli et al., 2016; Luna-Guevara et al., 2014). Nevertheless, some fluctuations in the pH, for example, during tomato paste processing, storage conditions, and the addition of additives, may take place (Joseph, 2015; Salih et al., 2025). For °Brix (TSS), values of the tomato paste samples varied from 26.500 to 29.167. These results correlate very well with the previous studies, where the values were recorded as 27 and 28 (Talb et al., 2023; Salih et al., 2020; Jassim & Karim, 2020; Rahman et al., 2021). The °Brix content is an important measure of the concentration of soluble solids - mostly sugars - in the tomato paste. It was further observed that the °Brix value was positively correlated with T. S., total sugar content, and TA ( $p < 0.05$ ), suggesting that an increase in °Brix corresponded to total solids and higher acidity. In contrast, moisture content was negatively cor-

related with °Brix, indicating that an increase in moisture content resulted in a decrease in °Brix. This correlation matches findings from other studies (Mustafa & Al-Shaheen, 2021; Ali & Othman, 2023; Salih, 2021). There were significant differences in the moisture and total solids (TS) contents of tomato paste samples of different brands. Moisture content varied from 65.050% - 71.360%, and the T.S. content ranged from 28.640% - 34.950%. It was found that total solids and moisture content were inversely related to each other, in that, with an increase in moisture, there was a reduction in total solids. This relationship is mirrored in the strong negative correlation between moisture and total solids. Additionally, moisture content correlated negatively with total sugar and total acidity, suggesting that with higher moisture, these aspects decline. In contrast, total solids showed a positive correlation with total sugar and total acidity, indicating that increased concentration of total solids is related to an increase of sugar and acidity content in the paste, and this has been confirmed by work done by Olajire et al. (2007) and compared with previous studies in Kurdistan market (Jassim & Karim, 2020; Mustafa & Al-Shaheen, 2021; Ali & Othman, 2023). For the total sugars, the content of the samples ranged from 0.917% to 1.383%, and there were no significant differences ( $p < 0.05$ ). A high positive correlation was also observed between these reported values, °Brix and total solids (TS), meaning that with the increase in the sugar content, there was also a concurrent increase in solutes present in the solution. It also correlated negatively with pH and moisture content, which indicates that samples with a higher sugar content had lower pH values and a higher moisture content. This confirms the results gained in recent study in Kurdistan (Talb et al., 2023; Jassim & Karim, 2020; Mustafa & Al-Shaheen, 2021; Ali & Othman, 2023). Talb et al. (2023), as they reported similar patterns for the total sugar content in different samples of tomato paste. Tomato paste samples had titratable acidity (TA) values between 1.337 and 2.41%, without significant difference ( $p < 0.05$ ). These values were by Talb et al. (2023), who found acidity levels between 1.963% and 2.660%. Generally, as acidity increases, so does preservation because the increased acidity prevents the growth of spoilage microorganisms. The authors reported a positive correlation of titratable acidity with pH, total solids, and °Brix and a negative correlation with moisture content (Talb et al., 2023; Mohammed et al., 2020). That is to say that higher acidity corresponds to higher total solids and °Brix, whereas lower moisture.

**Table 2.** Physical and chemical properties of different tomato paste brands.

Samples	pH	T.A. (%)	T.S. (%)	Brix	Moisture (%)	Total sugar (%)	Ash (%)
TP <sub>1</sub>	4.210 <sup>b</sup>	2.413 <sup>a</sup>	32.050 <sup>b</sup>	29.000 <sup>a</sup>	67.950 <sup>b</sup>	1.350 <sup>a</sup>	5.433 <sup>a</sup>
TP <sub>2</sub>	4.143 <sup>c</sup>	2.312 <sup>a</sup>	30.870 <sup>b,c</sup>	27.333 <sup>b</sup>	69.130 <sup>a,b</sup>	1.030 <sup>a</sup>	4.800 <sup>a,b,c</sup>
TP <sub>3</sub>	4.377 <sup>a</sup>	2.053 <sup>a</sup>	34.950 <sup>a</sup>	29.167 <sup>a</sup>	65.050 <sup>c</sup>	0.917 <sup>a</sup>	3.600 <sup>b,c</sup>
TP <sub>4</sub>	4.363 <sup>a</sup>	1.787 <sup>a</sup>	33.017 <sup>a,b</sup>	29.167 <sup>a</sup>	66.983 <sup>b,c</sup>	1.053 <sup>a</sup>	5.000 <sup>a,b,c</sup>
TP <sub>5</sub>	4.183 <sup>b</sup>	1.601 <sup>a</sup>	28.640 <sup>c</sup>	26.500 <sup>b</sup>	71.360 <sup>a</sup>	0.957 <sup>a</sup>	3.467 <sup>c</sup>
TP <sub>6</sub>	4.203 <sup>b</sup>	1.337 <sup>a</sup>	32.230 <sup>b</sup>	28.833 <sup>a</sup>	67.770 <sup>b</sup>	1.383 <sup>a</sup>	5.200 <sup>a,b</sup>

Value are mean of three replicates; Values with varied letters are significantly different at  $p < 0.05$  level of significance.

The ash contents of the samples ranged from 3.467% to 5.433%, and significant differences ( $p < 0.05$ ) were observed in the ash content of the tomato paste brands. The results are consistent with the data reported by Bekhet (2013), where ash content ranges from 2.48% to 6.06%. The ash content reflects the inorganic residues after the complete burning of organic matter, so it is an important category to indicate the minerals in tomato paste. The ash content, as a general rule, means that the paste has a higher mineral concentration. Overall, the physiochemical characteristics of the tomato paste samples were shown to have various values, while significant variances were also observed among different brands. The following parameters, pH, °Brix, moisture, total solids, total sugar, acidity, and ash content, were all analyzed, and the results showed expected and differing trends, with some consistency depending on the sample. This study may help consumers and producers in the food industry to understand the quality, stability, and nutritional aspects of tomato paste by getting insights from these findings.

## Conclusion

Tomato paste is one of the versatile and popular tomato-based products both domestic and international food supply chain. It serves a major ingredient in diverse cookery applications, including sauces, soups, and stews. Tomato paste not only supports the agricultural sector but also plays a vital role in the food processing industry, particularly in regions that depend significantly on tomato cultivation. Its high demand helps fuel local economies, global trade, and export, providing livelihoods to farmers, manufacturers, and workers who participate in producing and distributing the product. This study concerning some physiochemical properties of tomato paste demonstrated that the values achieved for some of the tomato paste properties were similar to those from other studies and that the quality of the final product is relatively similar in different markets. It was found that some of the samples that were analyzed had different values from those shown on the product labels. There are clear differences between brands and manufacturers that may reflect differences in production process, quality control standards, and raw material sourcing. These findings have serious economic implications. Such inconsistencies in labeling could erode consumer trust, ultimately deterring purchases and changing demand. In addition, inconsistencies can indicate inefficiencies in the supply chain, leading to price distortions, market distortions, or unfair competition between companies. These findings raise several implications for regulators, which include the necessity for stricter enforcement of quality standards and more transparent labeling practices to ensure consistency and protect consumer interests. Improving such issues will pave the path to greater consumer trust and market stability, which is a win-win situation for the tomato paste producers as well as the tomato paste consumer market segments over the long term. In addition, the integration of quality control to the standard world can pave the way for the export of these types of products, hence increasing the economic role of tomato paste packaging in the world economy.

## DECLARATIONS

**Author contribution statement:** Writing original draft preparation: R.A.A.; Data curation: S.J.M.S.; Methodology: Z.O.O.; Writing review and editing: A.A.M.; Visualization: R.A.A.; Project administration: A.M.S.; Formal analysis and investigation: K.Q.Y.; Conceptualization: A.M.S.; Supervision: A.M.S. and K.Q.Y. All authors have read and agreed to the published version of the manuscript.

**Conflicts of interest:** The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

**Ethics approval:** This study did not involve any animal or human participant and thus ethical approval was not applicable.

**Consent for publication:** All co-authors gave their consent to publish this paper in AAES.

**Data availability:** The data that support the findings of this study are available on request from the corresponding author.

**Supplementary data:** No supplementary data is available for the paper.

**Funding statement:** No external funding is available for this study.

**Additional information:** No additional information is available for this paper.

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