

Research Article

Physicochemical Characterization of Fresh and Powdered Tomato in Arba Minch, Ethiopia

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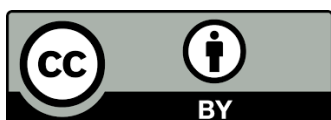
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Abstract

Tomato (*Solanum lycopersicum* L.) is the largest vegetable crop produced and consumed in the world. Tomatoes are a top source of Vitamin A and C, contain more dietary fibre, beta-carotene, iron, lycopene, magnesium, niacin, potassium, phosphorus, riboflavin, and thiamine. Tomatoes have a limited shelf life in ambient conditions and are highly perishable. It creates glut during the production season and becomes scanty during the off-season. Short shelf life, coupled with inadequate processing facilities results in heavy revenue loss to the country. The aim of conducted research was analyzed the Physico-chemical properties, evaluated the effects of different pretreatments (NaCl and CaCl₂) and optimized the drying and processing techniques to achieve the desired quality of tomato powder. This involves the production of tomato powder using the grinder. The demand for tomato powder is increasing rapidly in the domestic and international markets, with a significant portion used to prepare convenience food. Physicochemical analysis of fresh tomatoes and powder was carried out at ambient temperature. Physiochemical parameters recorded revealed that fresh tomatoes have an average length of 6.33 cm and an average breadth of 5.33 cm. The average length-breadth



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ratio was 1.18, and the average weight of fresh tomatoes was 143.76 gms. The average moisture content of fresh tomatoes was 95.31%, acidity 0.17%, and lycopene 15 mg/100 g. The moisture content of tomato powder T₀ and T₁ was 7.7% and 5.60% respectively, acidity was 0.45 and 0.60, lycopene content was 1.41 mg/100 g and 2.37 mg/100 g, non-enzymatic browning was 0.92 and 0.65, dehydration ratio was 26.61 and 25.11, and the rehydration ratio was 1.75 and 2.85 respectively. The application of this research provides a viable solution to reduce post-harvest losses and enhance the economic value of tomatoes. By converting fresh tomatoes into powder, the shelf life is significantly extended, ensuring a stable supply throughout the year.

Keywords

Fresh tomato; lycopene; tomato powder; shelf life

1. Introduction

Food supply is achieved either by an increase in production or a reduction in losses. Hence, the eradication of waste leads to a rise in food production. Tomato is the most popular vegetable in today's home gardens and the most commonly consumed in meals. The interests of the consumer in functional foods for health and the prevention of various diseases have been growing recently. Tomatoes and tomato products are rich in health-related food components as they are good sources of carotenoids (in particular, lycopene), ascorbic acid (vitamin C), vitamin E, folate and flavonoids [1]. Their regular consumption may lower the risk of the development of several types of diseases, among them cancer and heart diseases. As a functional food, tomatoes have been confirmed to reduce and prevent the risk of prostate cancer. In many countries, raw tomatoes and tomato products are promoted as part of a healthy lifestyle and a good dietary habit. Tomatoes and their preserves are good sources of nutritious ingredients. Lycopene, a powerful antioxidant, scavenges free radicals 1,000 times better than the vitamins. It has been reported to have excellent effects on various cancers and diseases [2].

Tomatoes are either fresh or processed into paste, puree, ketchup and powder. Unfortunately, they are not only seasonal but highly perishable and deteriorate a few days after harvest, losing almost all their required quality attributes. Some could likely result in total waste. The seasonal glut experienced at each harvest, apart from marking the extremes of wastage of produce, dampens the farmer's spirit to farming as it is forced to sell off produce at a loss to avert imminent total wastage. The prevention of these losses and wastage is essential mainly due to subsequent imbalance in supply and demand at the harvesting off-season and economic considerations [3]. The control sample, which did not undergo pretreatment, served as a baseline for comparison. The measured physico-chemical properties of the control sample provided a reference point to evaluate the effects of the pretreatment on the tomato samples. The pretreatment of tomatoes improves structural integrity and preserves color, vitamins, and antioxidant activity in dried tomato samples [4].

There is sufficient market demand for dehydrated fruits and vegetables worldwide [5]. Dehydration removes most water from fruits and vegetables and highly improves the shelf life of the final dried products, resulting from reduced water activity. The fundamental essence of drying

is to reduce the moisture content of the product to a level that prevents deterioration within a specific period, generally regarded as the “safe storage period,” as reported by [6]. Drying fruit and vegetables using high temperature and for a long drying time by conventional heating damages the quality of the final dried products [7]. The acids are mostly malic and citric; organic acids comprise about 15% of the dry content of fresh tomato [8]. Dried tomato powder has gained commercial importance, and its growth on a commercial scale has become an essential sector of the agricultural industry [3]. This research aims to create an efficient and scalable method for producing high-quality tomato powder that preserves necessary nutrients and extends shelf life. By optimizing drying and processing techniques, the study enhances the economic value of tomatoes, minimizes post-harvest losses, and satisfies the increasing demand for convenience foods in both domestic and international markets. The control sample, which did not undergo pretreatment, served as a baseline for comparison. The measured physico-chemical properties of the control sample provided a reference point to evaluate the effects of the pretreatment on the tomato samples. The pretreatment of tomatoes improves structural integrity and preserves color, vitamins, and antioxidant activity in dried tomato samples [4].

2. Materials and Methods

2.1 Sample Collection

A freshly harvested tomato variety was procured from the local market of Arba Minch. The harvested tomatoes were brought to the Chemistry Laboratory, Division of Chemistry, College of Natural Sciences, Abaya Campus, Arba Minch University. They were kept in shade for 1 hour to remove field heat. The bruised, diseased, and damaged tomatoes were removed. Fresh, healthy tomatoes were selected and thoroughly washed with tap water to remove dirt or contaminants shown in Figure 1. The selected tomatoes were cut and sliced into uniform pieces to ensure drying. Calcium chloride is used as a pre-treatment tabulated in Table 1 with drying as depicted in Figure 2. Agents to improve the firmness and texture of the dried tomatoes, and sodium chloride is used to enhance the flavor and act as a preservative.



Figure 1 Fresh tomato.



Figure 2 Oven drying.

Table 1 Pre-treatment details.

S. No.	Treatment details
(T ₀)	Control
(T ₁)	1% calcium chloride + 0.25% sodium chloride

2.2 Chemicals

Calcium chloride, Sodium chloride, Sodium Hydroxide, Acetone, Petroleum ether, Sodium sulphate, Alcohol, and Phenolphthalein.

2.3 Equipment's

Spectrophotometer, Glass stoppered flask, Filter paper, Beaker, Watch glass, Glass funnel, Oven, and Vernier calliper.

3. Methods

3.1 Oven Drying Methods

The rack was placed in the center of the oven and heated to 200 F (93°C). The tomatoes were rinsed with cool water and dried thoroughly with a clean kitchen towel or layers of paper towels. The tomatoes were cut into small quarters. The cut tomatoes were placed on a wire rack set on a large rimmed baking sheet, leaving about 1-inch of space between pieces. And it was transferred to the oven. After the first hour, the tomatoes were checked every half hour, removing them when the edges curl up, and they reduce in size by about a third, about 3 hours depending on the ambient humidity and the juiciness of the tomatoes.

Characterization of both fresh tomato and powder tomato took place as tabulated in Table 2. This characterization of fresh and powdered tomato extracts was conducted in triplicate. The data were represented by the mean of three independent experiments for each parameter.

Table 2 Observations to be recorded in Fresh (before dried) and Powdered Tomato.

S. No	Parameters		
		Fresh Tomato	Powder Tomato
1	Length (cm)	✓	
2	Breadth (cm)	✓	
3	Length/Breadth ratio	✓	
4	Weight (g)	✓	
5	Moisture (%)	✓	✓
6	Acidity (%)	✓	✓
7	Lycopene (mg/100 g)	✓	✓
8	Non enzymatic browning		✓
9	Dehydration ratio		✓
10	Rehydration ratio		✓

3.2 Length (cm)

The length of the fruits from ten randomly selected samples in triplicate of each treatment was measured by a vernier calliper. Average values were calculated and expressed in cm.

3.3 Breadth (cm)

The breadth of the fruits from ten randomly selected samples in triplicate of each treatment was measured by vernier calliper at the middle portion, base, and apex of the fruit. Average values were calculated and expressed in cm.

3.4 Length/Breadth Ratio

The length/breadth ratio of the fruits from ten randomly selected samples in triplicate of each treatment was measured. Average values were calculated.

3.5 Weight (g)

The fresh weight of tomato fruits from each treatment for 10 randomly selected samples in triplicate was recorded, and average values were calculated and expressed in grams.

3.6 Moisture (%)

Moisture content of the fresh and dried tomatoes was determined using a laboratory oven method [9]. 100 gms of sample in Triplicate was weighed accurately & dried to constant weight at 45°C for 4 hours. The loss of weight was determined to calculate the moisture content as:

$$\text{Moisture Content(\%)} = \frac{(\text{Initial weight(g)} - \text{final weight(g)}) \times 100}{\text{initial weight(g)}}$$

3.7 Acidity (%)

The fresh tomato and powder tomato samples (T_0 and T_1) were weighed accurately and mixed with a known volume of distilled water. The titrable acidity was estimated by titrating 5 mL of a sample against 0.1 N NaOH solution using phenolphthalein as an indicator. The acidity was calculated and expressed as per cent anhydrous citric acid [9].

3.8 Lycopene (mg/100 g)

Lycopene is an important food component in terms of its impact on color but also because of its recognized health benefits. There is no recommended dietary allowance (RDA) established for lycopene, and intake of 5 to 10 mg lycopene per day is suggested. Lycopene estimation was done by using [9]. A 10 g sample was repeatedly extracted with acetone until the residue became colourless. The acetone extract was transferred to a separating funnel containing 15 ml of petroleum ether, and then, 5% sodium sulphate solution was added. The lower acetone phase was repeatedly extracted with petroleum ether similarly, until it became colourless. The upper petroleum ether extract was pooled and its volume was up to 50 ml with petroleum ether. Dilute an aliquot to 50 ml with petroleum ether, and the colour was measured in a 1 cm cell at 503 nm in a spectrophotometer (UV-VIS double beam spectrophotometer) using petroleum ether as blank.

The results are reported as:

$$\text{Lycopene content (mg/100g)} = \frac{3.12 * A * D * 100}{1 * W * 1000}$$

Where, A = absorbance at 503 nm; D = dilution of extract to 100 ml; W = sample weight taken.

3.9 Non Enzymatic Browning

To estimate non-enzymatic browning, 5 g of the sample was mixed with 100 ml of 60 ml/100 ml absolute alcohol in a glass stoppered flask. The mixture was shaken thoroughly, kept for 12 h, and filtered through Whatman No.4 filter paper [10].

3.10 Dehydration Ratio

The known weight of the samples was dried, and the weight of the dried sample was recorded [11]. The dehydration ratio was calculated using the equation:

$$\text{Dehydration ratio} = \frac{\text{Weight of prepared material}}{\text{Weight of dried material}}$$

3.11 Rehydration Ratio

A dried sample weighing 5 g was placed in a 500 ml beaker containing 150 ml of boiled distilled water. The beaker was covered with a watch glass and continued to cook for 20 minutes. The sample was transferred into a glass funnel covered with coarsely porous Whatman No.4 filter paper. After filtration, the sample was removed from the funnel and weighed immediately. The rehydration ratio was calculated using the equation:

$$\text{Rehydration ratio} = \frac{\text{Weight of rehydrated sample}}{\text{Weight of sample taken for rehydration}}$$

4. Results and Discussion

The present project “Physicochemical Characterization of Fresh and Powdered Tomato,” was carried out under two experiments:

Experiment No.1: To study the physicochemical properties of fresh tomatoes.

Experiment No.2: To study the chemical properties of tomato powder after pretreatment application and drying.

In the above experiments, the physico-chemical properties were assessed at the initial stage, i.e.; when the tomatoes were fresh and after the tomato powder was formed. The salient findings of the experiments are mentioned as follows:

4.1 Physico-Chemical Characteristics of Fresh Tomato

Table 3 reveals the physico-chemical characteristics of fresh tomato. Physical parameters revealed that freshly harvested tomato had an average length 6.33 cm, breadth 4.33 cm, length/breadth ratio 1.4, average fruit weight 143.76 g. Chemical composition of tomato revealed that it contained 95.31 per cent moisture, acidity 0.17% and 15 mg/100 g lycopene.

Table 3 Physico-chemical characteristics of fresh tomato.

S. No.	Parameters	Tomato	References
1	Length (cm)	6.33	7-9 [12]
2	Breadth (cm)	4.53	4-5 [13]
3	Length/breadth ratio	1.4	1.4 to 2.25 [12]
4	Weight (g)	143.76	75-150 [13]
5	Moisture (%)	95.31	93% [12]
6	Acidity (%)	0.17	0.13% to 0.65% [14]
7	Lycopene (mg/100 g)	15.64	4-76 [13]

In summary, Table 3 provides detailed measurements of the physical dimensions and weight of freshly harvested tomatoes, as well as their chemical composition, highlighting their high moisture content, relatively low acidity, and significant lycopene content. These characteristics are essential for understanding the quality and nutritional value of fresh tomatoes.

4.2 Physico-Chemical Characteristics of Tomato Powder

4.2.1 Moisture Content

The effect of pre-treatments and drying method on the moisture content (%) of tomato powder is depicted in Table 4. The initial moisture content of fresh tomato was 95.31%. During the drying operation, there was a reduction in the moisture content of the tomato powder, which was influenced significantly by pre-treatments and drying. The pre-treatment helps in reducing the moisture content more effectively, leading to a lower final moisture content in the treated tomatoes

shown in Figure 3. After the drying process and forming of powder, the moisture content significantly decreased to 7.7 and 5.60% respectively in the control (T_0) and T_1 treated sample, which states that the higher the drying temperature, the greater the moisture loss [15].

Table 4 Physico-chemical characteristics of tomato powder.

S. No	Parameters	T_0	References	T_1	References
1	Moisture (%)	7.70	4-6% [16]	5.60	3-5% [17]
2	Acidity (%)	0.45	0.3-5.1 [14]	0.60	0.5-4.9% [18]
3	Lycopene (mg/100 g)	1.41	12-15% [18]	2.37	15-18% [19]
4	Non-Enzymatic browning	0.92	0.5-1.2 [20]	0.65	0.3-0.8 [20]
5	Dehydration ratio	26.61	8-30 [21]	25.11	7-23 [21]
6	Rehydration ratio	1.75	1.8-3.5 [22]	2.80	3.4-4.3 [22]



Figure 3 Controlled and treated sample.

During the drying operation and formation of powder, there was a reduction in the moisture content of tomato samples, which was influenced significantly by pre-treatments and drying. Results showed that Calcium Chloride and Sodium Chloride treated samples have lower moisture than the control due to increased water removal and moisture mobility in tomato slices during drying, and these pre-treatments influenced the drying kinetics of tomato by evident changes in texture of dip-treated tomatoes [10, 23]. And the combination of calcium chloride and sodium chloride likely enhances the drying process by altering the cell structure and reducing water retention in the tomato slices [24]. Generally, Oven drying combined with pre-treatment offers several advantages: high efficiency, uniform drying, quality preservation (by retaining the color, flavor, and nutritional content of the tomatoes), and enhanced shelf life.

4.2.2 Acidity (%)

The effect of pre-treatments and drying method on acidity (%) of tomato powder is depicted in Table 4. The initial acidity of fresh tomato was 0.17%. During the drying operation, there was an increase in acidity of tomato powder, which was influenced significantly by pre-treatments and drying as below Figure 4. After the drying process and forming of powder as shown in Figure 5, the

acidity increased dramatically to 0.45 and 0.60% respectively in the control (T_0) and T_1 treated sample.



Figure 4 Grinder for tomato powder production.



Figure 5 Controlled and treated tomato powder formed.

During drying operation and powder formation, there was an increase in acidity of tomato powder, which was influenced significantly by pre-treatments and drying. The drying methods carried out by oven drier indicate higher acidity in samples, which are supposed to be related to partial fermentation, due to longer consumption and pectic enzyme activity in the first hours of drying. Similar results have been reported by [25].

The increase in acidity (%) during oven drying and the higher acidity in pre-treated samples compared to the control can be attributed to several factors: Concentration Effect: As moisture is removed during oven drying, the concentration of organic acids in the tomato increases, leading to higher acidity. This is a common phenomenon in drying processes where water removal concentrates the remaining components. Chemical Reactions: Pre-treatments with calcium chloride and sodium chloride can cause chemical changes in the tomato's cellular structure, leading to the release of more organic acids. These acids contribute to the overall increase in acidity. Enzyme Activity: The pre-treatment and drying process can influence enzyme activity within the tomatoes. Certain enzymes may become more active during drying, leading to the production of additional

organic acids. Increased acidity (%) gave flavor enhancement, high nutritional value, and preservation for tomato powder [26, 27].

4.2.3 Lycopene

The effect of pre-treatments and drying method on the lycopene (mg/100 g) of tomato powder is depicted in Table 4. The initial lycopene content of fresh tomato was 15.64 mg/100 g. During the drying operation, there was a decrease in the lycopene content of tomato powder, which was influenced significantly by pre-treatments and drying. After drying process and forming of powder, the lycopene content significantly decreased to 1.41 and 2.37 mg/100 g respectively in control (T_0) and T_1 treated sample. Lycopene, the pigment responsible for the red color in tomatoes, decreases during oven drying due to Heat Sensitivity: Lycopene is sensitive to high temperatures (Lycopene degradation typically occurs at temperatures above 70°C) [28, 29]. Prolonged exposure to heat during oven drying can cause the degradation of lycopene molecules, leading to a reduction in their content [30]. Oxidation: The drying process can expose lycopene to oxygen, leading to oxidation. Oxidation breaks down lycopene, reducing its concentration in the dried tomato powder [31].

Pre-treatments and powder formation significantly influenced the lycopene content in tomato samples. Results showed that Calcium Chloride and Sodium Chloride treated samples have higher lycopene content than the control sample. This is due to Cell Structure Stabilization (Calcium chloride helps in stabilizing the cell walls of tomatoes, reducing the breakdown of cell structures during the drying process), Osmotic Effect (Sodium chloride creates an osmotic effect that draws out moisture from the tomatoes more efficiently), Reduced Oxidation (The combination of calcium chloride and sodium chloride can reduce the oxidation of lycopene) and Enhanced Drying Efficiency (The pre-treatment improves the overall drying efficiency, leading to a quicker drying process) more Lycopene degradation was observed in control samples, however, pre-treated sample had significant protective effect on lycopene degradation. Results regarding the impact of CaCl_2 and NaCl were qualitatively similar to those reported by [32].

4.2.4 Non-Enzymatic Browning

The effect of drying method and pre-treatments on the non-enzymatic browning of tomato powder is depicted in Table 4. During drying operation and powder formation, there was an increase in non-enzymatic browning values, which was influenced significantly by pre-treatments. The non-enzymatic browning recorded in T_0 was 0.92, and in T_1 was 0.65.

Oven drying is widely used to control browning as it inhibits enzymatic browning by acting with intermediates in the Maillard reaction leading to the prevention of pigmentation [25]. Oven drying typically involves higher temperatures, which can accelerate the Maillard reaction, leading to increased non-enzymatic browning. The higher the temperature, the more pronounced the browning effect [30]. During the drying operation and powder formation, there was an increase in non-enzymatic browning values of tomato powder, which was influenced significantly by the drying time. Prolonged drying times in the oven can also contribute to more browning. The longer the tomatoes are exposed to heat, the more likely browning reactions occur [33].

Oven drying reduced the moisture content of tomatoes, which was concentrated sugars and amino acids, further promoting non-enzymatic browning [34]. Pre-treatments such as blanching or adding antioxidants helped mitigate the extent of browning during oven drying. These treatments

inhibited the Maillard reaction and other browning processes [30].

These factors combined make the pre-treated samples with NaCl and CaCl₂ exhibit lower non-enzymatic browning compared to the control sample. Results showed that Calcium Chloride and Sodium Chloride treated samples have lower nonenzymatic browning value than the control. Calcium Chloride influenced the Maillard reaction, a chemical reaction between amino acids and reducing sugars that gives browned foods a distinctive flavor [35]. Calcium Chloride was used to protect the carotenoid pigments and colour retention in dehydration and its effect was more known during processing but a definite explanation of the mechanism whereby calcium serves to retard non-enzymatic browning in dehydration of tomato cannot be offered clearly. It had been reported that calcium was acting in some manner to block the amino group, whereby the latter was restrained from entering into the browning reaction. CaCl₂ influenced the kinetics of response and the formation of Maillard reaction products. The presence of CaCl₂ had led to variations in the browning intensity and flavor profile of the tomatoes [36]. It was also believed that calcium could form chelating compounds with organic substances having an alpha amino carboxylic acid structure [37].

Non-enzymatic browning in tomato powder is influenced by several factors, including specific salts like sodium chloride and Calcium chloride. Here's why the browning is higher in the controlled sample compared to the pre-treated samples:

Reduction of Water Activity: NaCl and CaCl₂ can reduce the water activity in the tomato powder. Lower water activity slows down the Maillard reaction, which is a primary cause of non-enzymatic browning. This means pre-treated samples with these salts have less browning than the control sample.

pH Influence: Sodium chloride and Calcium chloride affected the pH of the tomato powder. A lower pH inhibited the Maillard reaction, leading to reduced browning. The control sample, without these salts, had a pH that favors more browning.

Ionic Strength: The ionic strength of NaCl and CaCl₂ interfered with the browning reactions. These salts interacted with the reactants in the Maillard reaction, thereby reducing the extent of browning.

Antioxidant Properties: Calcium chloride, in particular, has been noted to have some antioxidant properties, which further reduce the browning by inhibiting oxidative reactions [38].

4.2.5 Dehydration Ratio

The effect of pre-treatments and drying method on the dehydration ratio of tomato powder is depicted in Table 4. After the drying process and powder formation, the dehydration ratio of T₀ was 26.61 and T₁ was 25.11.

Oven drying provides a controlled environment, ensuring uniform drying of tomato slices. This uniformity contributes to a consistent dehydration ratio across the entire batch [34]. At the same time, oven drying is effective in reducing moisture content and increasing the quality of the final product [39]. It can also lead to some loss of nutrients due to the high temperatures involved. However, the dehydration ratio remains high as the primary goal is to remove as much moisture as possible [34].

Pre-treatments and powder formation significantly influenced the dehydration ratio in tomato powder. Results showed that Calcium Chloride and Sodium Chloride treated samples had higher dehydration ratios than the control sample. The dehydration ratio was lowest in NaCl-treated

samples, as NaCl, an osmotic agent, leached the juice into the medium. Pre-treated tomatoes with NaCl and CaCl₂ had caused osmotic dehydration, where water was drawn out of the tomato cells. This process helps reduce the moisture content more effectively than in the controlled sample. Further calcium appears to maintain the structural integrity of the cell walls. Similar observations were recorded [40].

The salts altered the cell structure of the tomatoes, making it easier for moisture to escape during the drying process. This results in a higher dehydration ratio for the pre-treated samples. Both NaCl and CaCl₂ reduced the water activity in tomatoes. Lower water activity means the tomatoes lose moisture more efficiently during drying, leading to a higher dehydration ratio [34].

4.2.6 Rehydration Ratio

The effect of pre-treatments and drying method on the rehydration ratio of tomato powder is depicted in Table 4. After the drying process and powder formation, the rehydration ratio of T₀ was 1.75 and T₁ was 2.80.

Pre-treatments and methods of drying significantly influenced the rehydration ratio in tomato samples. Results showed that Sodium Chloride and Calcium Chloride treated samples have higher rehydration ratios than the control sample. This was due to the salts altering the cell structure of the tomatoes, making it easier for water to penetrate and rehydrate the dried tissue. This structural change enhances the rehydration capacity. Salts increased the water-binding capacity of the dried tomatoes. This means that when the dried tomatoes were rehydrated, they absorbed and retained more water, leading to a higher rehydration ratio. And reduced non-enzymatic browning, which otherwise affected the texture and rehydration properties of the dried tomatoes. By minimizing browning, the structural integrity of the dried tomatoes was better preserved, allowing for improved rehydration. Results revealed that the effectiveness of Sodium Chloride and Calcium Chloride on the textural qualities of tomato resulted in the best rehydration properties and showed a higher value. Similar results were observed by [41]. A higher rehydration ratio indicates better water absorption and a closer resemblance to the product. Texture is a key quality attribute that affects the sensory perception and acceptability of food products. It includes properties like hardness, cohesiveness, chewiness, and springiness. The rehydration process can impact the texture of the rehydrated product, as reported by [15].

4.3 Interpretation of Results

The mean values obtained from the laboratory experiments, which were conducted in triplicate, were carefully analyzed to reduce the impact of random experimental errors and to increase the accuracy and reliability of the results. Performing the procedure three times allowed for a more precise estimation of the measured parameters, as it helped to account for minor variations that may occur during each run. This replicative approach is a standard practice in scientific research to ensure data consistency and enhance the findings' statistical reliability.

After calculating the mean values, a comparison was made with previously published data and ranges reported in relevant literature. The results obtained in this study were found to fall within the expected range documented in earlier research, indicating strong agreement with established findings. This alignment not only validates the current experimental procedures but also suggests that the techniques and conditions used were appropriate and effective. Therefore, the consistency

between the obtained results and the literature enhances the credibility of the study and supports the reliability of the methodology applied.

5. Conclusion

From the present study, it can be concluded that tomato powder was produced by using an oven dryer and a grinder. The physico-chemical properties of both fresh tomato and powder tomato were determined. It was concluded that the powder made from pretreated tomatoes had better chemical characteristics than the one kept as a control. The controlled sample's powder had higher moisture content, non-enzymatic browning, and dehydration ratio than the treated samples. On the other hand, the controlled sample's powder had lower acidity, lycopene and rehydration ratio than the treated sample's powder. Finally, the powder produced from the treated sample had the best quality, and it is suitable for tomato powder production using oven dry method and a grinder.

Author Contributions

Hawi Jihad Kedir and Birhanu Zeleke Tilinti: Conceptualized and designed the study, conducted the primary literature review, drafted the initial manuscript, collect data, analyzed properties, and interpreted of the results. Kasahun Tsegaye Mekonnen: Refine the methodology, reviewed and edited the manuscript critically for important intellectual content, and supervised the overall project. All authors read and approved the final version of the manuscript.

Competing Interests

The authors have no conflict of interest in this study.

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