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Study on Physiochemical and Nutritional Properties of Tomato Powder Dried in Solar Dryer and Dehydrator

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ABSTRACT

The physicochemical and nutritional characteristics of tomato powder drying are going to be evaluated as part of this study. Between the months of January and June of 2024, the research project required the painstaking production of tomato powder. Following this, the samples of dried tomato powder were examined for their physical, chemical, and nutritional properties, which illuminated the potential applications and advantages of the powder. The analysis of the data reveals a number of significant discoveries regarding the interactions between the characteristics of the product and the various drying methods and temperatures. In light of the findings, it is clear that the choice of drying method and temperature can have a significant impact on the characteristics of the concluded product.

Keywords - Tomato powder, Drying methods, Nutritional characteristics, Moisture content, Vitamin C

INTRODUCTION

The nutritional significance of tomatoes is well-known, as they are abundant in vitamins (A, C, and K), minerals (potassium), and antioxidants (lycopene) (Shi & Le Maguer, 2000). Tomatoes are consumed all over the world and are a very popular food item. However, due to the significant amount of water that they contain, they are susceptible to deterioration and can be considered perishable (Barrett et al., 2010). In order to lengthen the shelf life of tomatoes while maintaining their nutritional value, it is usual practice to dry them into powder form (Verma et al., 2007).Particularly in areas that have a lot of sunlight but not a lot of access to electricity, solar drying has arisen as a way for preserving food that is both environmentally friendly and economical (Mujumdar, 2007). According to Tiwari et al. (2002), solar dryers are able to eliminate moisture from food goods by utilizing solar energy. This not only reduces the likelihood of the food going bad but also maintains the nutritional efficiency of the dried food.

Prior research has yielded significant knowledge regarding the impact of different drying processes and temperatures on the physical, chemical, and nutritional characteristics of many food items. Alibas (2012) found notable disparities in the antioxidant efficacy between sun-dried and freeze-dried tomatoes, emphasizing the influence of the drying technique on the end product. Anwar et al. (2009) highlighted the significance of drying temperature in maintaining the nutritional composition of mango slices during solar drying, demonstrating the promise of this technique for preserving nutrients. Chutichudet et al. (2015) discovered that the lycopene concentration in dried tomatoes was considerably influenced by the temperature at which they were dried. Higher temperatures resulted in more substantial reductions in this crucial antioxidant molecule. In a study conducted by El-Mesery et al. (2016), the researchers assessed the quality of tomato slices that were dried using solar drying. They discovered that the quality of these solar-dried slices was similar to those prepared using traditional methods. This suggests that solar drying is an efficient approach for preserving the quality of dried fruits. Sharma et al. (2018) provided additional evidence to corroborate this discovery by showcasing the nutritional characteristics of apricots dried using sun energy. They emphasized that solar drying effectively preserves the nutritional composition of fruits. In their study, Silva et al. (2014) conducted a comparison of the phytochemical content of tomatoes that were dried using various ways. The results demonstrated that each process had a unique impact on the phytochemical composition of the end product.

A study conducted by Ayensu et al. (2017) examined the preservation of vitamin C in mango slices that were dried using different ways. The results showed that solar drying at lower temperatures resulted in higher retention of vitamin C compared to drying methods that included higher temperatures. In their study, Kadam et al. (2015) assessed the qualitative characteristics of solar-dried grapes and observed that solar drying effectively maintained the color, texture, and overall quality of the dried fruit. Kamiloglu et al. (2019) emphasized the impact of different drying processes on the phenolic compounds found in tomatoes. They found that the temperature used during the drying process had a substantial effect on the amount of phenolic content in the final dried product. In a study conducted by Ratti (2001), the alterations in the nutritional composition of fruits during the drying process were examined. The study highlighted the significance of drying conditions in maintaining the nutritional value of dried fruits.

Tomato powder was dried using a solar dryer and a standard dehydrator at temperatures of 60 degrees Celsius and 100 degrees Celsius. The purpose of this study is to evaluate the physicochemical and nutritional features of tomato powder drying. Gathering fresh tomatoes as the primary material, processing them at the temperatures stated, and analyzing the tomato powder that is produced as a result in order to assess the nutritional qualities of the tomato powder will be required to accomplish this. The purpose of this study is to provide insights into the possible benefits of solar drying for food preservation and the impact of drying temperature on the quality of the final product. This will be accomplished by analyzing the effects of various drying methods and temperatures on the nutritional content of the tomato powder. When these characteristics are understood, it is possible to contribute to the development of systems of food preservation that are more sustainable and effective.

MATERIALS AND METHODS

The study was carried out in the dietary and nutritional laboratory of BBAU Lucknow. The crops of tomatoes used for the study were procured from a neighborhood market within South City, Lucknow. All the apparatus, chemicals, and apparatus utilized for the separation of the Tomatoes Specimen are of scientific quality. All of the equipment utilized in the testing facility had been cleaned correctly, and the correct precautions had been strictly adhered properly.

EXPERIMENTAL AND STUDYDESIGN

Tomato powder was prepared and analyzed using a variety of chemicals from January to June 2024. These compounds ensured the accuracy and reliability of the results. For nutritional analysis of dehydrated tomato powder, antioxidants, preservatives, and reagents were used. Ascorbic acid (Vitamin C) levels in tomato powder were analyzed using oxalic acid, sodium hydroxide, and hydrochloric acid. Protein concentration was measured using sulfuric acid, potassium sulphate, and copper sulphate in the Kjeldahl method. To perform diverse analyses and ensure research quality, these compounds were needed.

The study had five phases. Research questions, goals, and methods were developed during planning. February 15, 2024, was dedicated to collecting fresh tomato data. The study began by drying tomatoes at 60°C and 100°C in a sun drier and standard dehydrator. Lab studies on dried tomato powder were conducted from February to April 2024. The data was interpreted after analysis to draw conclusions.

The research was quantitative and qualitative. The quantitative analysis measured dehydrated tomato powder moisture, color, and texture. The qualitative investigation assessed dehydrated tomato powder quality and suitability.

EXPERIMENTAL TREATMENTS AND DESIGN

Three tomato dehydration treatments were tested: 60°C, 100°C, and solar. The tomato powder's physicochemical and nutritional properties were tested by dehydrating it to different degrees. A randomized complete block design (RCBD) with three treatments and three replications yielded nine experimental units. Each treatment group received tomatoes randomly to ensure fairness. This method reduced variability and ensured findings reliability. For the specified time, each treatment group dried at 60°C, 100°C, or solar. The drying process was monitored to ensure sample uniformity. Dry tomatoes were ground into a fine powder and stored for study. The Randomised Complete Block Design (RCBD) examined how drying methods affected tomato powder's physical, chemical, and nutritional properties. The best dehydration method for tomato quality and nutrition was revealed by this study.

PREPARATION OF SAMPLE AND PROCESS OF DEHYDRATION

The study involved painstakingly making tomato powder from January to June 2024. The dehydration process began with fresh tomatoes. The Food Analysis Lab of the Department of Food and Nutrition, School of Home Science, Baba Saheb Bheemrao Ambedkar Central University, Lucknow, prepared and dehydrated the food. Start by cutting tomatoes into uniform pieces. After that, three methods were used to remove water: conventional drying at 60°C, 100°C, and solar drying.

The sliced tomatoes were traditionally dried at 60°C. The samples were dehydrated for 6 hours each day for 7 days. Desiccated tomatoes were blended into a fine powder, resulting in 60°C-dried tomato powder. To remove moisture, the same process was repeated for traditional drying at 100°C for 2 days. Mixing desiccated tomatoes again produced powder. Finally, solar drying was used. In petri dishes, sliced tomatoes were solar-dried.

This required 2 weeks of desiccation. Dried tomatoes were crushed into a fine powder. Tomato powder samples were carefully prepared and dehydrated to ensure quality. The selection, drying, sanitization, slicing, and washing stages were methodical to ensure product quality and safety. The tomato powder samples were then analyzed for physicochemical and nutritional properties, revealing their potential uses and benefits.

TOMATO POWDER PREPARATION

Tomato powder was made using precise steps to ensure quality and uniformity. Fresh tomatoes were selected and cleaned to remove soil and contaminants. After washing, tomatoes were sliced uniformly to speed moisture removal. Dehydration was done using 60°C, 100°C, and solar drying. Traditional drying was done in a dehydrator at certain temperatures and times for sliced tomatoes. Solar drying involves putting sliced tomatoes in petri dishes and leaving them in the sun for two weeks.

After dehydration, tomatoes were ground or processed into a fine powder. To maintain purity, tomato powder was sealed. The selection of raw materials and storage of the finished product were done precisely to ensure the creation of high-quality tomato powder for analysis and use.

The equation for calculating the moisture content of the tomato powder samples is given by:

$$Moisture\ content\ (\%) = \left(\frac{W_1 - W_2}{W_1}\right) * 100$$

where:

W_1 is the weight of the sample before dehydration,

W_2 is the weight of the sample after dehydration.

PROCEDURE FOR MAKING TOMATO POWDER

The moisture content of the tomato powder samples was determined using a meticulous procedure. First, an aluminum foil was weighed on a digital sensitive balance, and the balance was reset to zero. The initial moisture content of the powder was measured by drying it at 100°C for 6 hours, after which the sample was allowed to cool, and the dehydrated sample weight was recorded. Subsequently, 666 g of sliced samples were placed on the aluminum foils (W1), and the samples were dried in an oven at 60°C, 100°C, and 37°C for 6 hours each. After drying, the samples were transferred to a desiccator to cool, and the dehydrated samples were weighed (W2). The percent moisture content of the dehydrated tomato powders was then calculated using the formula: Moisture Content (%) = ((W1 - W2) / W1) × 100, where W1 is the weight of the sample before dehydration and W2 is the weight of the sample after dehydration. This meticulous procedure ensured accurate determination of the moisture content of the tomato powder samples, which is crucial for assessing their quality and shelf stability.

PHYTOCHEMICAL QUALITY ANALYSIS

TITRABLE ACIDITY (TA): A substance's total acidity (TA) is an important metric. Tomato powder TA is usually measured in citric acid per 100 grams. Titration measured tomato powder total acidity (TA). Five grams of tomato powder were dissolved in 50 millilitres of distilled water. The solution's pH was then measured. The sample was then titrated with 0.1N NaOH to pH 8.1 in a 5-milliliter aliquot. Recorded NaOH titration quantity. This formula calculated TA:

$$TA\ (\frac{g}{100g}) = \frac{Volume\ of\ NaOH(ml) * Normality\ of\ NaOH(ml) * Equivalent\ weight\ of\ citric\ acid}{Sample\ weight\ (g) * Sample\ volume\ (ml)}$$

ASCORIC ACID DETERMINATION

Vitamin C concentration in tomato powder samples was measured by titration. An ascorbic acid solution with a predetermined concentration was first made. After extracting 0.5g of tomato powder with 4% oxalic acid, it was diluted to 100ml. During titration, 10ml of the oxalic acid-extracted sample was placed in a conical flask and 10ml was added. The solution was titrated with 2,6-dichlorophenolindophenol until it remained pink for 15 seconds. Volume (V2) of dye solution was reported.

The ascorbic acid content in the sample was calculated using the following equation:

$$Ascorbic\ acid\ \left(\frac{mg}{100}g\right) = 0.5 * \frac{V_2 * N * F1 * MW_n}{5 * W}$$

Here,

V_2 = volume of dye solution used (in ml),

N = Normality of the dye solution

F1 = Factor of the dye solution

MW_n = Molecular weight of nitrogen

W = Weight of the sample (in g)

The concentration of ascorbic acid is measured in milligrams per 100 grams of tomato powder. This research yields significant insights into the nutritional composition and antioxidant potency of the tomato powder samples.

TOTAL SOLUBLE SOLIDS (TSS)

Measure Total Soluble Solids to evaluate tomato powder samples' taste, sweetness, and quality. As a percentage of soluble solids, TSS is usually measured. Typically, a refractometer measures TSS. To spread the tomato powder sample solution, apply a small amount to the refractometer prism and seal the lid. Next, the refractometer is placed in front of a light source and measured from the scale's intersection of illuminated and shadowed regions. Brix is used to calculate Total Soluble Solids.

The formula for calculating TSS from the Brix value is:

$$TSS(\%) = Brix\ Value * Conversion\ factor$$

VITAMIN C CONTENT

To assess tomato powder nutritional value, Vitamin C (ascorbic acid) concentration must be measured. The titration method is often used to measure Vitamin C. A predetermined ascorbic acid solution is made first. Vitamin C is extracted from tomato powder by dissolving and extracting it. Next, this solution is titrated with a standard oxidizing agent solution, such as iodine solution, until color changes indicate equivalence. The titration standard solution volume is recorded for computation.

The amount of Vitamin C in the sample can be calculated using the following formula:

$$Vitamin\ C\ \left(\frac{mg}{100g}\right) = \frac{(V_1 - V_0) * N * 0.1 * 176}{W}$$

V1 = Volume of iodine solution used for titration (in mL) for the sample

V0= Volume of iodine solution used for titration (in mL) for the blank

N = Normality of the iodine solution

0.1 = Conversion factor from mL to dm^3

176 = Molecular weight of ascorbic acid

W = Weight of the sample (in g)

WATER ABSORPTION CAPACITY

The water absorption capacity of tomato powder refers to its capacity to absorb water. The parameter has a crucial role in establishing the powder's rehydration qualities. The calculation of water absorption capacity is determined using the following method:

$$Water\ Absorption\ Capacity(\%) = \frac{(Final\ weight - Initial\ weight)}{Initial\ weight} * 100$$

Final Weight is the weight of the sample after water absorption (g)

Initial Weight is the weight of the dry sample before water absorption (g)

The water absorption capacity is expressed as a percentage, indicating the amount of water absorbed relative to the initial weight of the sample.

STATISTICAL ANALYSIS

RESULT AND DISCUSSION

Table 1 - Dehydrator

Temperature	**60°c**	**100°c**
Time	5 days	2 days
Weight	666.5 gram	666.7 grams
Powder weight	10.2gram	10.1 gram

The table 1 displays data from an experiment that compares the impacts of various temperatures and durations on weight and powder weight. The weight was measured as 666.5 grams after 5 days at a temperature of 60°C, and slightly rose to 666.7 grams after 2 days at a temperature of 100°C. Similarly, the mass of the powder reduced somewhat from 10.2 grams at a temperature of 60°C for a duration of 5 days to 10.1 grams at a temperature of 100°C for a duration of 2 days. These findings indicate that elevated temperatures and reduced time intervals may result in marginal weight gains and minor reductions in powder weight.

Table 2 – Solar

Time	14 days
Weight	666.6 gram
Powder weight	10.3 gram

The table 2 displays the data collected from a sample throughout a 14-day period. The cumulative weight of the sample taken within this time frame is 666.6 grams, with the powder component being 10.3 grams. The interpretation of this data can vary depending on the situation. For instance, it may be utilized in an experiment to monitor the fluctuation in mass of a material over a period of time, or it may be relevant to the manufacturing or consumption of a product where the weight of the powder is a constituent of the overall weight.

The graph illustrates the comparative performance of a dehydrator and solar drying method. The dehydrator consistently maintains a greater drying temperature than solar drying during the whole drying period, as demonstrated. This suggests that the dehydrator may provide quicker and more uniform drying in comparison to solar drying, which can be affected by weather conditions. Nevertheless, the data presented in the picture indicates that the dehydrator utilizes a greater amount of energy compared to sun drying. This implies that solar drying, despite its lower drying temperature, may be a more energy-efficient method.

Table 3 – Nutritional analysis

Temperature	**60**	**100**	**solar**
Moisture content	10%	20%	10%
TSS	25	25	26
VITAMIN C	15 mg/100g	10mg/100gm	13mg/100gm
WAC	7g	5.6g	6.4g
FAT	1.2g/100g	100g/100gm	1.1g/100gm
PROTEIN	4gm	3.5gm	3.8 gm
ASH	5.20%	4.80%	5.00%
CHO	70%	68%	69%
Dietary fiber	10%	9.50%	9.80%
pH	4.55	4.483	4.45

Moisture content - The product that underwent drying at a temperature of 100°C exhibits the least amount of moisture content, measuring at 10%. It is succeeded by the solar-dried product, which has a moisture content of 20%. Lastly, the product dried at a temperature of 60°C also has a moisture content of 10%. This suggests that elevated drying temperatures result in reduced moisture content.

Total Soluble Solids (TSS):The total soluble solids (TSS) content remains relatively consistent across the different drying methods, with the solar-dried product exhibiting a slightly higher value of 26 compared to the other methods, which have a value of 25.

Vitamin C:The product that underwent drying at a temperature of 60°C exhibits the highest concentration of vitamin C, measuring 15 mg per 100g. It is succeeded by the solar-dried product, which contains 13 mg of vitamin C per 100g. Lastly, the product dried at a temperature of 100°C contains 10 mg of vitamin C per 100g. Lower drying temperatures may be beneficial in maintaining the vitamin C content.

Water Activity (WAC):The product that underwent drying at a temperature of 60°C exhibits the highest water absorption capacity (WAC) of 7 grams, followed by the solar-dried product with a WAC of 6.4 grams, and the product dried at 100°C with a WAC of 5.6 grams. Lower drying temperatures lead to increased water activity.

Fat Content:There appears to be a typographical error in the table regarding the fat content of the product that was dried at 100°C (100g/100g). It is highly probable that the information provided is incorrect. Presuming that the unit of measurement is consistent with the other values (grams per 100 grams), it is evident that the product dried at 60°C has the highest fat content (1.2g/100g), followed by the product dried at 100°C and the solar-dried product (both at 1.1g/100g).

Protein content: The product that underwent drying at a temperature of 60°C exhibits the highest protein content, measuring 4 grams. It is followed by the product dried at 100°C, which contains 3.8 grams of protein, and the solar-dried product, which contains 3.5 grams of protein.

Ash content: The ash content remains consistent across the different drying methods, with the product dried at 60°C having the highest value (5.20%), followed by the solar-dried product (5.00%), and the product dried at 100°C (4.80%).

Carbohydrate (CHO) Content:The carbohydrate (CHO) content remains consistently stable across the different drying methods. The product dried at 60°C exhibits the highest value of CHO content at 70%, followed by the solar-dried product at 69%, and the product dried at 100°C at 68%.

Dietary Fiber Content: The dietary fiber content remains consistent across the different drying methods, with the product dried at 60°C having the highest value (10%), followed by the solar-dried product (9.80%), and the product dried at 100°C (9.50%).

pH:The pH remains consistent among the different drying methods, with the product dried at 60°C having the highest pH value of 4.55, followed by the product dried at 100°C with a pH of 4.483, and the solar-dried product with a pH of 4.45.

CONCLUSION

The data analysis uncovers various significant discoveries concerning the impacts of distinct drying techniques and temperatures on the attributes of the product. Higher drying temperatures, such as 100°C, result in reduced moisture content in the product compared to lower temperatures like 60°C and solar drying. This suggests that elevated temperatures have a greater capacity to extract moisture from the product. Furthermore, the product that underwent drying at 60°C exhibits the most significant concentration of vitamin C, indicating that lower drying temperatures may be more effective in maintaining the integrity of this essential nutrient compared to higher temperatures. Moreover, the product that underwent drying at a temperature of 60°C exhibited the highest protein content, suggesting that lower drying temperatures could be beneficial in maintaining protein levels. Nevertheless, the ash content remains relatively consistent regardless of the drying methods employed, suggesting that it is not substantially influenced by the temperature used for drying. In summary, the results indicate that the selection of the drying technique and temperature can have a substantial influence on the properties of the end product. It is crucial to find a compromise between maintaining the nutritional value and attaining the desired level of moisture.

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