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Comparative Study of the Effect of Different Drying Methods on Physicochemical Properties of Tomatoes

Salaudeen, Olaniyi Hammed[1]*, Omale, Paul Abuh[1] and Daraojimba, Izuchukwu Augustus[1]

[1]Joseph Sarwuan Tarka University, Makurdi, Benue State

Corresponding Author: Olatokehammed@gmail.com

ABSTRACT

This study was conducted in the Department of Agricultural and Environmental Engineering Laboratory to compare the effect of drying methods on physico-chemical properties of tomato (*Solanumly copersicum*). Two drying methods at two different temperatures 50 ^{0}C and 100 ^{0}C on two varieties of tomatoes were carried out. The two varieties were processed into powdered form and some of the physico-chemical properties (moisture content, pH, protein, crude ash, soluble solids, and ascorbic acid) were tested. At 50 ^{0}C, moisture content ranged from 7.85 – 8.08, protein ranged from 11.04 – 12.12, pH ranged from 5.58 – 5.92, crude ash ranged from 8.70 - 12.02, soluble solids ranged from 1.42 – 1.78 and ascorbic acid ranged from 6.55 – 7.49 while at 100 ^{0}C moisture content ranged from 6.90 – 7.41, protein ranged from 10.12 – 10.79, pH ranged from 5.27 – 5.36, crude ash ranged from 9.50 - 9.93, soluble solids ranged from 1.84 – 2.10 and ascorbic acid ranged from 8.59 – 9.23. The analysis of variance was done on this experimental result and it was discovered that variety, drying methods and drying temperature all had significant effects on the investigated physico-chemical properties of tomato powder at ($p<0.05$. From the result generated from the different varieties and the different drying methods used it suggests that the oven drying method is better amongst the two drying methods because it retained more percentages of the physico-chemical properties than the microwave method but they are both safe for human consumption.

Keywords: Drying, Physico-chemical, tomato, varieties.

INTRODUCTION

Tomato (*Solanumly copersicum*) fruit is a widely grown vegetable crop used in various food products such as sauce, ketchup, squash and jam (Boumendjel *et al*., 2011). It is a basic ingredient of many meals in Nigeria especially, the sauces and stews which accompany most traditional dishes. The fruit can also be consumed raw in salads or used to make juices (Ramos *et al*., 2013). Tomato is rich in essential nutrients such as vitamins and minerals (Khandaker *et al*., 2016). Tomato fruit is a commonly cultivated vegetable crop that finds application in a range of food items, including sauces, ketchup, jams, and squash (Boumendjel *et al.,* 2011). It is a staple in a lot of Nigerian recipes, particularly the stews and sauces that go with most traditional foods. The fruit can also be used to produce drinks or eaten raw in salads (Ramos *et al*., 2013). Vital nutrients including vitamins and minerals are abundant in tomatoes (Khandaker *et al.,* 2016). About 1.8 metric tonnes of tomatoes are produced in Nigeria each year (Idah *et al.,* 2007). The Northern States of Nigeria are known to produce more tomatoes than the rest of the country. Unfortunately, post-harvest losses cause a large (20–50%) portion of these produce to be lost after harvest (Aderibigbe *et al*., 2018). According to Mercier *et al*., (2017), handling during the whole harvest to retail process accounts for the majority of post-harvest losses in horticulture fruit crops. In the retail market, mechanical injuries, improper

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handling and transportation, poor storage, and on-display duration are the main causes of losses. Preventing food losses between harvest and consumption is therefore a critical first step towards attaining a higher degree of food increase and security.

Tomatoes are processed to make a variety of products, including pulp and concentrated juice, which require expensive technology to produce high-quality results. Tomatoes are versatile and can be kept for extended periods of time by processing. Thus, the primary need of the current competitive market is the development of low-cost processing procedures to make shelf-stable convenience products (Nadia Bashir *et al.,* 2014). Tomato processing involves post-harvest procedures such as drying, which is the most effective and practical method for preserving and processing food because it significantly reduces the moisture content of the final product, thereby preventing microbial deterioration (Babu *et al.,* 2009). Among the drying methods, open sun drying is a tried-and-true, low-tech, affordable, and dependable food preservation technique.

According to Jangam (2011) in other to enhance the quality and value of the dried foodstuffs, the conventional open sun drying method should be substituted with modern industrial drying methods such as freeze and hot air drying. Convective hot-air drying is widely used as a preservation technique on industrial scale. Nevertheless, drying at elevated drying temperatures (60-1100^{0}C) and long exposure time (2-10hrs) leads to the degradation of some nutritional properties (loss in ascorbic acid, lycopene, flavonoids). Moreover, some physical properties are also affected during the drying process, for instance, increase in shrinkage and hardiness, decrease in both the rehydration capacity and bulk density of the dried product, severe damage of the sensorial properties like flavour and colour (Omale *et al.,* 2020). However, both physical and sensory properties are very important attributes dried products that often receive appreciation from the customers.

Numerous researchers, including Neenah *et al*., (2009), Idah et al. (2015), and Adubofuor *et al.,* (2010). Tomatoes are a very perishable agricultural crop that can have their shelf life extended by drying them extensively. Tomatoes can be dried to produce useful goods. The dried form is used as a raw material for several commercial products in addition to being an ingredient in functional foods (Omale *et al.,* 2020). In order to achieve the best possible utilization, it is now necessary to ascertain how these drying techniques affect the physicochemical properties.

Various drying methods, such as solar and hot-air drying, are among the cutting-edge approaches used by various researchers nowadays to dry and preserve tomatoes (Mohammed *et al*., 2017). Nevertheless, certain techniques necessitate the use of expensive technology and equipment, which might not be accessible in developing, low-income nations like Nigeria.

MATERIALS AND METHODS

Plant Materials

We bought fresh, ripe, and mature round cashew head tomatoes and long cashew head tomatoes—both of which are grown specifically in Benue State, Nigeria—from a farm there. After manually washing the tomato fruits under running water to get rid of dirt and soil, they were sorted, set on a plastic net to drain any remaining water, and then cut into 5 mm-thick slices using a sharp stainless-steel knife in a direction perpendicular to the vertical axis. When the tomatoes arrived, their moisture content was measured.

Figure 1: Sorted Round cashew head tomato

Figure 2: Sorted Long cashew head tomato

Preparation of the Sample

Oven drying

Hot-air oven drying of tomatoes was carried out at the Department of Agricultural and Environmental Lab (Joseph Sarwan Tarka University Makurdi) using an oven (New Life Laboratory oven). Tomatoes were cut into approximately 5 mm thick slices and placed in two cabinets at temperatures 50 °C and 100 °C. Fruit slices were dried from initial moisture content (wet basis) to final moisture. The dried fruit slices were ground into powder using a clean household grinder and parameters determined and recorded. The readings were taken in three replications.

Microwave drying

Microwave drying of tomato was carried out at the Department of Agricultural and Environmental Lab (Joseph Sarwan Tarka University Makurdi) using a microwave (Newclime Laboratory microwave). Tomatoes were cut into approximately 5 mm thick slices and placed in two cabinets at temperatures of 50 °C and 100 °C. Fruit slices were dried from initial moisture content (wet basis) to final moisture. The dried fruit slices were ground into powder using a clean household grinder and parameters determined and recorded. The readings were taken in three replications.The sliced, dried and grounded tomatoes were shown in figure 3,4,5,6,7 and 8.

Figure 3: Sliced Long cashew head tomatoes

Figure 4: Sliced Round cashew head tomatoes

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Figure 5: Oven dried tomato slices

Figure 6: Microwaved dried tomato slices

Figure 7: Grinded oven dried tomato powder

Figure 8: Grinded microwaved dried tomato powder

Determination of the Physico-chemical Properties of Tomato

Determination of Moisture Content

The moisture content of a fruit specifies the water content exists in the wet sample which is one of the factors that affects the physical properties and shelf life of the product. Generally, there are two methods for determining the moisture content of a product; wet and dry based. In this study wet based method was used and Sacilik *et al., (*2006) method was adopted.

$$M_{wb} = \frac{mi - mf}{mi} \times 100 \quad (1)$$

Where, *mi* and *mf* are initial and final weight of samples respectively.

Determination of pH

The pH of the tomato paste was measured using a pH meter. The pH which is calibrated using buffers of pH 9, pH 7 and pH 4. The readings were recorded directly from the pH-meter.

Determination of Total Soluble Solids

The samples were measured using a digital refractometer. A measured amount of tomato powder was dissolved in 5 mL distilled water. The homogenized samples were picked with the aid of a dropper from the conical flask and dropped on the dried and clean prism of the refractometer. The results were directly read on the numerical part of the refractometer at a temperature of 20 °C for all samples. The refractive index was also recorded from the same refractometer at the same time.

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Determination of Crude Ash

Each weighted sample was put into porcelain crucible and placed in furnace for 4 hours at a temperature of 550 °C. The furnace was allowed to cool at temperature below 200 °C and maintained for 20 minutes. Ash crucible was taken out of the furnace, placed in a desiccator to cool and weighed. Crude ash content of the formulated tomato paste was calculated using the below formula:

$$\% Ash = \frac{Weight\ of\ ash}{Weight\ of\ sample} \times 100 \quad (2)$$

Determination of Ascorbic Acid Content

The Ascorbic acid (AA) content was measured using UV-VIS spectrophotometer. The spectrophotometer was adjusted to zero by using distilled water. For the absorbance measurements of the sample extracts, the AA concentration of the sample was determined by the calibration graph.

Determination of Protein

A titration method (Kjeldahl method) was used for determination of protein concentrates. In this method, the protein content (%) was calculated as Eq. 3 and 4: The protein concentrates obtained after titration will be by multiplying the total nitrogen by a conversion factor of 6.25. (Ayuba *et al.,* 2010)

Calculation

$$\%\text{Nitrogen(wet basis)} = \frac{(A-B)\times 1.4007}{G} \times 100 \quad (3)$$

A= Vol.(mL) std. HCl × normality of std. HCl,
B = Vol.(mL) std. NaOH × normality of std.,
G = Weight of sample (g)

$$\%\text{Crude protein} = \%\text{Nitrogen} \times 6.25 \quad (4)$$

Statistical Analyses

The means and standard deviations of each test parameter for physicochemical data was calculated. Using the Statistical Package for Social Sciences (SPSS v20), Two-way analysis of variance (ANOVA) was employed to compare the means of all determined parameters.

RESULTS

The laboratory analysis results of the effect of drying methods on physicochemical properties of two varieties of tomato (round cashew head tomato and long cashew head tomato) dried using two drying methods (Oven Drying and Microwave Drying) at 50 °C and 100 °C are presented in table 1, 2, 3, 4, 5 and 6 respectively.

Table 1: Average value of Moisture Content

Sample	Drying Method	Temperature 50	Temperature 100
RCH Tomato	Oven	7.85	6.90
	Microwave	8.33	7.25
LCH Tomato	Oven	7.56	6.89
	Microwave	8.08	7.41

*RCH - Round Cashew Head Tomato, *LCH- Long Cashew Head Tomato

Table 2: Average Value of Protein

Sample	Drying Method	Temperature 50	Temperature 100
RCH Tomato	Oven	12.12	10.79
	Microwave	11.67	10.64
LCH Tomato	Oven	12.06	10.54
	Microwave	11.04	10.12

RCH - Round Cashew Head Tomato, LCH- Long Cashew Head Tomato

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Table 3: Average Value of pH

Sample	Drying Method	Temperature ^{O}C	
		50	100
RCH Tomato	Oven	5.92	5.36
	Microwave	5.60	5.32
LCH Tomato	Oven	5.86	5.29
	Microwave	5.58	5.27

RCH - Round Cashew Head Tomato LCH- Long Cashew Head Tomato

Table 4: Average Value of Crude Ash

Sample	Drying Method	Temperature ^{O}C	
		50	100
RCH Tomato	Oven	8.70	9.50
	Microwave	12.22	9.97
LCH Tomato	Oven	8.53	9.05
	Microwave	12.02	9.93

RCH - Round Cashew Head Tomato LCH- Long Cashew Head Tomato

Table 5: Average Value of Soluble Solids

Sample	Drying Method	Temperature ^{O}C	
		50	100
RCH Tomato	Oven	1.78	2.10
	Microwave	1.48	1.98
LCH Tomato	Oven	1.75	2.10
	Microwave	1.42	1.84

RCH - Round Cashew Head Tomato LCH- Long Cashew Head Tomato

Table 6: Average Value of Ascorbic Acid Content

Sample	Drying Method	Temperature ^{O}C	
		50	100
RCH Tomato	Oven	7.49	9.23
	Microwave	6.69	9.59
LCH Tomato	Oven	7.46	8.92
	Microwave	6.55	8.59

RCH - Round Cashew Head Tomato LCH- Long Cashew Head Tomato

DISCUSSION

Effects of Drying Methods on Moisture Content

The mean moisture content for round cashew head tomato using oven drying method at $50^{0}C$ and $100^{0}C$ were 7.85 and 6.90 accordingly while the moisture content for round cashew head tomato using microwave drying method at $50^{0}C$ and $100^{0}C$ were 8.33 and 7.25 accordingly.

In a similar manner, the moisture content for long cashew head tomato using oven drying method at $50^{0}C$ and $100^{0}C$ were 7.56 and 6.89 while the moisture content for long cashew head tomato using microwave drying method $50^{0}C$ and $100^{0}C$ were 8.08 and 7.41 accordingly.

Progressive decrease on moisture content as the temperature increases from $50^{0}C$ to $100^{0}C$ was noticed. The analysis of variance was done on this experimental result and it was discovered that variety, drying methods and drying temperature all had significant effects on the moisture content of tomato powder at ($p<0.05$).

Moisture content of tomato powder by different drying methods was varied from 6.89 to 8.08 per cent and it was within the range of 4 to 8 per cent that is recommended for commercial tomato powder. Similar result was observed by Mozumder *et al.,* (2012)

Effects of Drying Methods on Protein

The protein in round cashew head tomato using oven drying method at $50^{0}C$ and $100^{0}C$ were 12.12 and 10.79 accordingly while the protein for round cashew head tomato using microwave drying method at $50^{0}C$ and $100^{0}C$ were 11.67 and 10.64 accordingly.

In a similar manner, the protein in long cashew head tomato using oven drying method at $50^{0}C$ and $100^{0}C$ were 12.06 and 10.54 while the protein for long cashew head tomato using microwave drying method $50^{0}C$ and $100^{0}C$ were 11.04 and 10.12 accordingly.

Progressive decrease in protein as the temperature increases from $50^{0}C$ to $100^{0}C$ was noticed.

The analysis of variance was done on this experimental result and it was discovered that variety, drying methods, drying temperature all had significant effects on the protein of tomato powder at ($p<0.05$).

Changes in protein content might be related to reactions i.e., non-enzymatic browning which was found to be more in fresh tomato than dried powder. Similar results were reported by Narsing Rao *et al.,* (2008)

Effects of Drying Methods on pH

The pH level for round cashew head tomato using oven drying method at 50°C and 100°C were 5.92 and 5.36 accordingly while the pH for round cashew head tomato using microwave drying method at 50^0C and 100^0C were 5.60 and 5.32 accordingly.

In a similar manner, the pH level for long cashew head tomato using oven drying method at 50^0C and 100^0C were 5.86 and 5.29 while the pH for long cashew head tomato using microwave drying method 50^0C and 100^0C were 5.58 and 5.27 accordingly.

Progressive decrease on pH level as the temperature increases from 50^0C to 100^0C was noticed.

The analysis of variance was done on this experimental result and it was discovered that variety, drying methods, drying temperature all had significant effects on the pH level of tomato powder at ($p<0.05$). Similar results were observed by Puranik *et al*., (2012)

Effects of Drying Methods on Crude Ash

The crude ash for round cashew head tomato using oven drying method at 50^0C and 100^0C were 8.70 and 9.50 accordingly while the crude ash for round cashew head tomato using microwave drying method at 50^0C and 100^0C were 12.22 and 9.97 accordingly.

In a similar manner, the crude ash for long cashew head tomato using oven drying method at 50^0C and 100^0C were 8.53 and 9.05 while the crude ash for long cashew head tomato using microwave drying method 50^0C and 100^0C were 12.02 and 9.93 accordingly.

Progressive increase in crude ash as the temperature increases from 50^0C to 100^0C while using oven drying method and progressive decrease while using microwave drying method was noticed.

The analysis of variance was done on this experimental result and it was discovered that variety, drying methods, drying temperature all had significant effects on the crude ash of tomato powder at ($p<0.05$). Similar observation was reported by Jayathunge *et al*., (2012)

Effects of Drying Methods on Soluble Solids

The soluble solids for round cashew head tomato using oven drying method at 50^0C and 100^0C were 1.78 and 2.10 accordingly while the soluble solids for round cashew head tomato using microwave drying method at 50°C and 100°C were 1.48 and 1.98 accordingly.

In a similar manner, the soluble solids for long cashew head tomato using oven drying method at 50^0C and 100^0C were 1.75 and 2.10 while the soluble solids for long cashew head tomato using microwave drying method 50^0C and 100^0C were 1.42 and 1.84 accordingly.

Progressive increase in soluble solids as the temperature increases from 50^0C to 100^0C was noticed.

The analysis of variance was done on this experimental result and it was discovered that variety, drying methods, drying temperature all had significant effects on the soluble solids of tomato powder at ($p<0.05$). Similar reports were made by Mozumder *et al.,* 2012, which is also conform with the report of Khater *et al*., 2019

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Effects of Drying Methods on Ascorbic Acid

The ascorbic acid for round cashew head tomato using oven drying method at 50^0C and 100^0C were 7.49 and 9.23 accordingly while the ascorbic acid for round cashew head tomato using microwave drying method at 50^0C and 100^0C were 6.69 and 9.59 accordingly.

In a similar manner, the ascorbic acid for long cashew head tomato using oven drying method at 50^0C and 100^0C were 7.46 and 8.92 while the ascorbic acid for long cashew head tomato using microwave drying method 50^0C and 100^0C were 6.55 and 8.59 accordingly.

Progressive increase in ascorbic acid as the temperature increases from 50^0C to 100^0C was noticed.

The analysis of variance was done on this experimental result and it was discovered that variety, drying methods, drying temperature all had significant effects on the soluble solids of tomato powder at ($p<0.05$). Similarly reports were made by Mozumder *et al.,* 2012 and reports of Ai *et al.*, 2022.

CONCLUSION

The study analyzed various physico-chemical properties of tomatoes, including moisture content, pH, protein, crude ash, soluble solids, and ascorbic acid. Findings indicate that these properties are affected by drying methods and temperatures. Both oven drying and microwave drying led to a decrease in moisture content and protein levels while influencing pH values differently. Additionally, oven drying resulted in higher crude ash, ascorbic acid, and soluble solids content compared to microwave drying. Overall, the study suggests that oven drying is more effective in retaining physico-chemical properties, though both methods are deemed safe for human consumption.

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