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Effect of Drying Methods and Storage Conditions on Nutritional Value and Sensory Properties of Dehydrated Tomato Powder (*Lycopersicon esculentum*)

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Authors' contributions

This work was carried out in collaboration between all authors. Author OJL designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors YPA and INA managed the analyses of the study. Author KAO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The effects of two drying methods, (oven drying and sun drying) of tomatoes and storage conditions of the products were studied to assess their effects on chemical, nutritional quality and sensory properties. Eleven kilograms of Fresh tomatoes were obtained from Ankpa metropolis central market, Kogi state Nigeria. The fruits were washed, weighed, and divided into two equal parts ($5^1/_2$ kg), one part was sliced into a non sticky pot, dehydrated, pressed through colander and re-dehydrated into a thick moulding consistency, it was sliced and oven dried at 60°C at a constant stirring using skewer. The second portion of the tomato fruits was blanched in 100°C hot water, sliced and sun dried. The Nutrient composition was determined using standard methods, the microbiological examinations were carried out using culture plate methods and sensory evaluation was evaluated using 9 points hedonic scales. Moisture contents in oven dried and sun dried tomato

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powders fluctuated between 8 – 10% and was slightly higher in the sun dried tomato product. The chemical analysis of four macronutrients (protein, fat, crude fibre and carbohydrates) were completed and the results were expressed as percentage dry matter. Significantly higher protein (3.70%), fat (0.82%) and crude fibre (6.37%) were found in the oven dried tomato product ($P<0.05$) compared with the respective values obtained in the sun dried tomato product and the carbohydrate contents was 77% in both. The chemical analysis of the five Phytochemicals; total flavonoid, tannins, Phenolic acid, and alkaloid were reported and their mean levels were significantly higher in the oven dried tomato compared with the values in sun dried tomato product. The microbiological examination showed that under storage conditions for 3 months, the total viable counts were of oven dried and sun dried ($5.7x10^3$cfu) and ($7.7x10^5$cfu) per gram of tomato, respectively. Under storage conditions for 6 months, the total viable counts increased slightly in the sun dried tomato product. Fungal growth was not visible in both tomato products after 3 months of storage. Yet, under storage conditions for 6 months, mean values were $1.9x10^3$ and $2.1x10^5$ colony forming units per g of oven dried and sun dried tomato, respectively. Sensory evaluation which included four parameters, i.e., revealed taste, flavour, consistency, colour beside overall acceptability were significantly superior ($P<0.05$) in the oven dried tomato product over the sun dried.

Keywords: Tomato fruits; dehydration methods; macronutrients; microbiological safety; phytochemicals; sensory evaluation.

1. INTRODUTION

The use of modern technologies and equipments for drying food material is escalating because it prolongs shelf life or good keeping quality and retains the bioactive nutrients. These bioactive nutrients can combat nutritional related diseases and promote a state of well-being of the consumer. Tomatoes (*Lycopersicon esculentum)* contribute to a healthy and well-balanced diet as they are rich in dietary fibres and other nutrients. Tomatoes are perishable crops of which deterioration starts immediately after harvest and continued till they experience spoilage due to high moisture contents and enzymatic activities. In Nigeria, tomato has short shelf life and considerable amounts of harvested tomatoes (over 50%) are lost yearly due to poor storage system, poor transportation coupled with inadequate processing facilities and lack of processing enterprises [1]. According to [2] marketing of fresh tomato during the season is a great problem which needs to be handled. The percentage of tomatoes going into waste annually with no attentions paid to the loss of nutrients can lead to heavy revenue loss to farmers, decrease in market value, underutilization and to malnutrition due to food insecurity. Tomato as fruits vegetables and other green leafy vegetables can be dried using various methods (According to [3,4,5]). Dehydration does not check losses only but, related disease. The objective of the present study is to dry tomatoes and to compare the efficiency of two drying methods (oven versus sun drying) on the retention of nutrient contents, storage stability with regard to microbiological counts and sensory attributes.

2. MATERIALS AND METHODS

2.1 Sample Collection

Freshly and ripened harvested derika tomato fruits were purchased from Ankpa metropolis market, Kogi state Nigeria.

2.2 Sample Preparation

The fruits were sorted and washed. Eleven kilogram was weighed and divided into two equal portions of 5.5 kg each. The first portion was sliced, deseeded and poured into a non-sticky stainless pot and heated for $1^1/_2$hours under direct flame for dehydration. The cooked tomato was mashed into slurry and was pressed through a 55 mm colander. Heating continued until a mouldable texture was reached. The condensate was sliced into 1 g sizes on trays and placed in a 200°C pre-heated dry air electric oven and the temperature was lowered to 60°C and dried to constant weight while stirring at an interval of every 30 minutes for two hours. It was cooled under laboratory condition, pounded and milled using type 8k 31 Kenwood blender, packed and labelled ‘’oven dried’’.

The second portion was blanched by pouring hot water of 100°C on the tomato fruits and drained immediately, it was allowed to cool and was sliced into ½ cm (5 mm) thick using fruit slicer for uniform sizes. The sliced tomatoes were put in

aluminium trays of 120 x 60 cm and were dried under direct sun light for 7 days with daily shaking. The dry tomato was finely grounded using harmer mill grinding engine, packed and labelled ''sun dried''. Both tomato products (oven dried and sun dried) were kept for 3 and 6 months for laboratory investigation.

2.3 Sensory Evaluation of Dehydrated Tomato Powder

Sensory evaluation was carried out using [6] methods of 9 point hedonic scale, with 9 = like extremely and 1 dislike extremely. Both powdered products were reconstituted into tomato puree by suspending in 35 and 17 mL of water and tomato sauce was produced and tested using a panel test of 6 adult volunteers. Each volunteer recorded his response were based on the intensity of the taste, colour, flavour, texture and overall acceptability.

2.4 Storage Conditions

The two tomato grounded products were packed and sealed with model No me-200H 220 v AC 50/60 Hz 260 w impulse sealer in black opaque polyethylene bags to prevent radiant energy and light rays that can affect the storage negatively and stored in an ambient temperature for 3 and 6 months. Samples were withdrawn at the 3rd month and 1 g each was weighed out and the polyethylene bags were resealed immediately. The weighed sample was examined microbiologically. The same procedure was repeated at the 6th month of storage.

2.5 Microbiological Examinations

From the oven and sundried tomato samples stored for 3 and 6 months, 1 gram was homogenized in 17 mL of sterile peptone water to prepare the stock solution. One millilitre of serial dilutions (10^2 and 10^3) was inoculated on nutrient agar plates and cultured at 37°C for 24 hours. The bacteria were identified on the basis of their cultural, morphological properties and biochemical tests. The number of colony forming units (cfu) on each plate was counted using colony counter and expressed as cfu/g according to [7].

2.6 Total Fungal Counts

The total fungal count were completed by growth in Petri dish based on potato dextrose agar (PDA) supplemented with 10% tartaric acid to inhibits bacterial growth. It was incubated at room temperature (28±2°C) for 4 days. The colony forming units were counted and expressed as cfu/g. The different colony on each plate was isolated purified and stored on potato dextrose agar (PDA) for fungi determination and for further characterization and identification. The fungal isolates were characterized by their cultural and morphological properties based on mycelium structure, conidiophores presence and shapes according to [7].

2.6.1 Chemical analysis procedures

Triplicate values were expressed on dry weight basis.

2.7 Proximate Composition

The chemical analysis of ash, fibre carbohydrates and protein contents were determined according to AOAC methods. Moisture content was determined using vacuum oven method [8]. Crude protein was determined using the micro–Kjeldahl method [9]. Fat content was estimated using Soxhlet extraction method [10]. Ash was determined by incineration in muffle furnace at 550°C for 8 hours [11]. The available carbohydrate content was determined by subtracting 100 from the sum of moisture, protein, fat and ash contents [12].

2.8 Crude Fibre Determination

Crude fibre content was determined by a non - non-enzymatic method [9]. Two grams of the dried sample was defatted with petroleum ether and boiled under reflux for 30 minutes with 200 mL of solution containing 1.5 g of H2SO4 /100 mL of the solution. The solution was filtered through linen on a fluted funnel and washed with boiling water until the washing was no longer acidic. The residue was transferred to a beaker and boiled for 30 minutes in 200 mL of solution containing 1.25 g of carbonate-free NaOH per 100 mL. Final residue was filtered through a thin but closed pad of washed and ignited asbestos in porcelain crucible. It was dried in electric oven, weighed, incinerated, cooled and reweighed;

The loss in the weight after incineration x 100 was calculated as the percentage (%) of the crude fibres.

$$\% \text{ crude fibre} = \frac{\text{Loss in weight (g) x 100}}{\text{Original mass (2.0)}}$$

2.9 Chemical Analysis of Flavonoid

One gram was extracted repeatedly with 100 ml of 80% methanol at room temperature [12]. The filtrate was transferred to a beaker and allowed to evaporate to dryness and the weight was weighed. The % flavonoid was calculated using the formula below;

$$X = \frac{w_2 - w_1 \times 100}{w_3}$$

Where x = percentage flavonoid, w_1 = weight of empty beaker, w_2 = weight of empty beaker + methanol extract; w_3 = weight of sample.

2.10 Alkaloid Determination

The alkaline precipitation gravimetric method was used for the determination of alkaloids [13]. Obadoni Two grams were soaked in 20 ml 10% ethanolic acetic acid and left for 4 hours at room temperature followed by filtration. The filtrate was concentrated by evaporating it over a steam bath to ¼ of its original volume. Concentrated ammonia solution was added drops wise. The resulting alkaloid precipitate was recovered by filtration using a previously weighed filter paper and the precipitate was washed with 1% ammonia solution and dried in the oven at 60°C for 30 min, cooled in desiccators and reweighed. The weight of alkaloids was determined by difference and expressed as a percentage of the weight given by following formula;

$$\% \text{ alkaloid} = W_1 - W_2 \times 100$$

Where;

W_1 = Weight of filter paper
W_2 = weight of paper + alkaloid precipitate.

2.11 Determination of Phenolic Acid

A sample of 2.5 g was boiled with 25 ml of ether water, 2 ml ammonium hydroxide and 5 ml amyl alcohol was added sequentially. The solution was made up to the mark with distilled water and allowed to stand for 30 min for colour development. The absorbance of the solution was read at 505 nm using a UV spectrophotometer and tannic acid was used as the standard [14].

2.12 Saponin Contents Determination

A total of 50 mL of the sample was weighed into a conical flask and 100 cm^3 of 20% aqueous ethanol was added to the sample. The sample was heated over a hot water bath for 4 hours with continuous stirring at about 55°C. The mixture was filtered and the residue re-extracted with another 200 mL of 20% ethanol. The combined extracts were reduced to 40 mL over water bath at 90°C. The concentrated filtrate was transferred into a 250 mL separating funnel and 20 mL of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. Sixty millilitre of n-butanol was added. The combined n-butanol extract was washed twice with 10 mL of 5% aqueous sodium chloride. The resultant solution was heated in a water bath. After evaporation, samples were dried in the oven to a constant weight and the weight of Saponin was determined [14].

2.13 Tannic Acid Determination

One gram was mixed with 40 ml of 50% methanol. The mixture was shaken vigorously and placed in a hot water bath at 80°C for 1 h. The extract was filtered into 100 ml volumetric flask, 20 ml distilled water, 2.5 ml Folin-Denis reagent and 10 ml of 17% sodium carbonate was added and shaken vigorously. The mixture was then made up to the mark with distilled water and allowed to stand for 20 min for colour development. The absorbance was read at 760 nm on a U- Vis spectrophotometer [15]. Standard tannic acid was prepared with concentration 0-10 ppm for plotting the standard curve. The relation of R2 = 0.9826 was obtained. The concentration of tannin in the unknown sample was obtained from the regression equation Y = 0.0593x – 0.0485, Where; x = absorbance 760 nm, Y = tannic acid equivalent.

2.14 Statistical Analysis

All data obtained were expressed as the arithmetic mean ± standard deviation, differences between means were considered significant at $P \leq 0.05$, [16] multiple comparison tests were used for the comparison of means using SPSS version 17.0 package.

3. RESULTS AND DICUSSION

3.1 Results

The summative analysis of oven dried (O D) and sun dried (S D) samples show that the moisture content in S D (10.63±0.21%) is significantly higher at ($P<0.05$) than the respective mean

moisture content in the O D (8.58±0.07%). On the other hand, the O D sample was significantly higher (P<0.05) in the mean contents of protein (3.70± 0.07%), fat (0.82 ±0.02%) and crude fibre (6.37 ± 0.15%) compared with the respective contents found in the S D tomato product.

Table 2 presents the contents of 5 Phytochemicals in O D and S D tomato powder.

The results show that the O D mg per 100 g tomato powder was significantly higher (P<0.05) in the mean contents of flavonoid (34.85± 0.13), Phenolic acid (178.3±0 2.10), tannin (15.50 ± 0.4), alkaloid (1.93± 0.16) and Saponin (0.19± 0.01) compared with the respective contents found in the (S D) tomato product.

The results of the microbiological examination of the tomato power stored for 3 months at room temperature (Table 3) show that the total viable count was more than 100 fold excess in the (S D) tomato powder (7.7 x 10^5 cfu / g) compared with the respective mean value found in the (O D) tomato powder (5.7 x 10^3 cfu / g). After 6 months of storage, the mean viable bacteria counts increased by 10.5% in the (O D) tomato powder (6.3 x 10^3 cfu / g); while the mean counts was reduced by 5.2% in the (S D) tomato powder (7.3 x10^5cfu / g). With regard to fungal and yeast growth, colonies appeared only in tomato products stored for six months with equal infection rates of 1.95 x 10^5 cfu / g and 2.06 x 10^5 cfu / g in O D and S D tomato powders.

The results of the sensory evaluation (Table 4) demonstrate that the (O D) tomato product is significantly superior (P<0.05) to (S D) tomato product in all five attributes.

3.2 Discussion

The results of proximate composition of two studied tomato powder %; oven dried (O D) and sun dried (S D) on dry basis, showed that moisture of 8.58±0.07% (O D) was lower than 10.63±0.21% S D if compared, from observation, the increased moisture in S D product can negatively affect the keeping quality of the products by contributed to increase in the growth of bacteria and fungi colony forming units / g. The findings in this study conforms with the study of [17], who reported that products with 10% moisture content contained no microbial growth but, fungal growth of 3 cfu/10 g was observed in products of 13.5% moisture also [18] in the study of Effect of moisture content and storage conditions on the storability of garri. The current study revealed that fat content (0.82 ±0.02%) protein (3.70± 0.07%) were found to be significantly higher in (O D) than (S D) and this increase in nutrients content can contribute greatly to energy value that can reduce calorie malnutrition, even though higher increase in fat was observed in O D, was not enough to negatively affect the storage stability of the product. The fibre content of the O D product 6.37 ± 0.15 was higher than (S D) 5.15 ± 0.10; the increase in fibre in O D can reduce circulating cholesterol and increase glucose tolerant level. The findings in this study agrees with [19] in the study of firm ripe plantain fruits flour addition on chemical, sensory and microbial quality of fura powder. Similarly, the effect of (O D) tomato which retained higher Phytochemicals in the 5 studied Phytochemicals of tomato powder can neutralize the free radicals and inhibit the oxidative activity.

All the parameters tested in terms of (taste, flavour, consistency, colour and overall acceptability) showed that oven dried was most preferred and were significantly different at p≤ 0.05 compared with the respective results obtained in S D tomato product. The higher acceptability and other tested parameter were based on intensity. O D processing method can be industrially modified.

Table 1. Proximate composition of oven dried and sun dried tomato products

Proximate analysis	Tomato powder oven dried (%)	Tomato powder sun dried %
Moisture	8.58±0.07^a	10.63±0.21^b
Crude protein	3.70± 0.07 ^{b}	2.60 ±0.07^a
Fat	0.82 ±0.02^b	0.53 ± 0.02^a
Ash	3.53±0.0^a	3.88± 0.08^a
Carbohydrates	77.00 ± 0.30^a	77.21 ±0.43^a
Crude fibre	6.37 ± 0.15^b	5.15 ± 0.10^a

(%), Values represent means of triplicate values ± s∂ (standard deviation), Means in each row with different superscripts are significantly different at P≤0.05

Table 2. Phytochemical analysis of dehydrated tomato powder (mg/100 g)

Parameters	Tomato powder oven ried(mg)	Tomato powder sun dried(mg)
Flavonoid	34.85± 0.13[b]	25.63±0.17[a]
Phenolic acid	178.3±0 2.10[b]	93.93 1.77[a]
Tannin	15.50 ± 0.4[b]	9.11 0.03[a]
Alkaloid	1.93± 0.16[b]	0.87 0.06[a]
Saponin	0.19± 0.01[b]	0.13 0.01[a]

Values represent means of triplicate values ± sð (standard deviation), Means in each row with different superscripts are significantly different at P≤0.05

Table 3. Microbiological examination of tomato powder under storage for 3 and 6 months

Tomato powder	Duration of storage (3 months)		Duration of storage (6 months)	
	Total Bacteria (cfu /g)	Mould & yeast (cfu g)	Total bacteria (cfu /g)	Mould & yeast (cfu/g)
Oven dried	5.7 x $10^{3\,a}$	ND	6.3x10^{3a}	1.95 x $10^{5\,a}$
Sundried	7.7 x $10^{5\,b}$	ND	7.3 x 10^{5a}	2.06x $10^{5\,a}$

Values represent means of triplicate values ± sð (standard deviation), Means in vertical column with different superscripts are significantly different at P≤0.05

Table 4. Sensory properties of oven dried and sun dried tomato powder

Parameters	Taste	Flavour	Consistency	Colour	Overall acceptability
Oven dried	7.04±0.20[a]	8.2±0.20[a]	7.00±0.04[a]	8.00± 0.20[a]	8.01±0.20[a]
Sun dried	6.16±0.22[b]	5.03±0.15[b]	5.15±0.26[b]	7.31±0.14[b]	7.0±0.14[b]

Values represent means of triplicate values ± sð (standard deviation), Means in vertical column with different superscripts are significantly different at P≤0.05

4. CONCLUSION

The study has revealed that oven drying significantly increased the nutrient component of dehydrated tomato powder and decreased cfu/g of bacteria which could enhance the keeping quality of the products and consumer's higher acceptability in this study can increase higher utilization of the products. The results obtained showed that the oven dried (O D) method for the production of tomato powder is promising and warrants further studies to be scaled up for mass production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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