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Effect of Conventional and Oven Drying on the Physicochemical Properties of Two Tomato Cultivars Fruit Powder

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Abstract The aim of the present study was to investigate the effect of conventional and oven drying on the physicochemical properties of Aseela and Galeela tomato cultivars fruit powder. Most of the studied parameters were significantly affected by the employed drying processes. The results showed that the bulk density of the fresh tomato from the two cultivars was (0), whereas in the shade-dried tomato, the bulk density was 0.60 % and 0.54% in Galela tomato powder (GTP) Asela tomato powder (ATP), respectively. However, in the oven dried method, bulk density was 0.66 and 0.56 in GTP and ATP, respectively. It was found that the shaded dried tomato of the variety Asela took longer time to dissolve (190 sec), followed by (140 sec) for the variety Galela, while in oven-dried tomato, the cultivar Galela took longer time to dissolve (230sec), followed by (220 sec) for the cultivar Asela. The total soluble solids (T.S.S.) of fresh tomato (FT), shade dried tomato and oven dried tomato prepared from Galela tomato cultivar was 5%, 11.10% and 7.37%, respectively. Whereas was in tomato powder prepared from Asela cultivar, the T.S.S. of FT, shade dried and oven dried was 6 %, 12.77% and 8.80%, respectively. soluble solids from 4.79 to 6.02%, depending on the cultivar. The results of titrable acidity was found to be 0.37, 0.70 and 0.60% in FT, shade dried tomato and oven dried tomato powder, respectively for the variety Galela, and 0.37, 0.80, 1.0 % for the variety Asela. The obtained results clearly indicate that the investigated oven dry tomatoes compared to the shade dry cultivars have a satisfying quality and nutritional value.

Keywords Shade Drying, Wettability, Sinkability, Solubility, Bulk Density

1. Introduction

Vegetables and fruits can be processed and preserved by drying. Drying preserves food because the microorganisms that spoil food need water to grow. Drying also concentrates a food's nutrients and preserves them for times when fresh food is not available. Improved technologies, such as solar dryers, retain higher quantities of vitamins in food than can be retained using the traditional method of sun drying[1].

Drying is one of the oldest methods of food preservation. Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. Water content of properly dried food varies from 5 to 25 percent depending on the food. Successful drying depends on: enough heat to draw out moisture, without cooking the food, dry air to absorb the released moisture, and adequate air circulation to carry off the moisture[2].

Shade drying requires full air circulation. It should not be undertaken inside conventional buildings but in an open-sided shed purposely built for shade drying. Most foods to be dried are sliced (e.g. peppers, okra, onions, tomatoes, eggplants, yams, sweet potatoes and carrots), as sliced food generally dries faster. Drying ovens are designed to remove moisture. Typical applications are pre-treating and painting. Such ovens are also sometimes known as kilns, though they do not reach the same high temperatures as are used in ceramic kilns[3].

Tomatoes (*Lycopersicon esculentun* Mill) are classified according to their use as fresh consumption and processing. Both categories of tomato should be sound, firm, mature, having deep uniform red color, free from cracks and green shoulders and poisonous material and eventually should be nationally valuable. Furthermore, tomato for table use should be juicy, characterized by high total soluble solids, fairly low acidity, high non-fibrous pulp content[4].

Tomato powders are often used as an ingredient in the foods such as sauces and soups. Several food technology studies have been carried out to optimise the processing and storage of the tomato products by preventing the heat and oxidative damage on the antioxidants[5]. The aims of this study were to study the effect of conventional and oven

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drying on the physicochemical properties of two tomato cultivars fruit powder.

2. Materials and Methods

2.1. Preparation of the Raw Material

Two cultivars of tomato (Galela and Asela) were collected in polyethelene bags (plastic containers) from green houses of the Date Palm Technology Co, Shambat, Khartoum, during May 2011. The tomato fruits were sorted from injured and deteriorated fruits, washed under running tap water and weighed. The cleaned fruits were cut into small slices (one cm in length) using sharp sterilized stainless steel knives, and then were placed into trays pending dehydration process.

2.2. Dehydration of Tomato Slices

The tomato slices were spread on perforated stainless steel trays (45cm wide, 75cm long and about 7cm height (for the under shade samples) and (34 cm wide, 50 cm long and about 5 cm height (for the drier samples). One and half (wet weight) of tomato slices were loaded on a perforated stainless steel trays and left to dry under shade with the aid of fans for 4 days. The rest of the samples were put into oven drier under different temperature (90, 80, 70, 65 and 60ºC) for two days.

2.3. Preparation of Tomato Powder

The dried tomato slices were collected, reweighed and ground using alcohol cleaned household grinder and stored in deep freezer into sealed plastic bags prior to further analysis.

2.4. Physicochemical Properties

2.4.1. Evaluation of the Reconstitution Characteristics for the Tomato Powder

Reconstitution characteristics which included Wettability and sinkability, solubility, bulk density, sorption isotherm rate of tomato powder were carried out for fresh tomato and tomato powder samples prepared from the two tomato cultivars.

2.4.2. Wettability and Sinkability

Wettability and sinkability of powders are difficult to separate and they were done in one test. The test was started by spreading five grams of air dried tomato powder on the surface of a filter paper (No. 5), held tightly between the gaps of two small food cans (just enough to pull) where the cans were opened at both ends. The assembly of the two cans and the filter paper were mounted on a glass beaker (500 ml) containing 500 ml distilled water that; paring in mind; the height of the surface of the beaker and end of the apparatus is 3 inches. They were left to immerse and then; the time for the powder to be wetted was recorded, on the other hand time taken by the powder to sink down was also recorded[6].

2.4.3. Solubility Rate

The solubility was determined according to Neff and Morries[6] by adding 5grams of the samples to 150 ml of distilled water at room temperature (35 $\pm$ 0.5ºC) in a 400ml beaker, the mixture was immediately stirred using a magnetic stirrer at 1000 rpm to assured systematic stirring, meanwhile the time for complete solubility was counted.

2.4.4. Bulk Density

The bulk density is expressed in grams/ml as described by Neff and Morris[6]. Twenty grams sample of the developed powder were weighed and then transferred to a graduate 100 ml measuring cylinder and mounted on screen vibrator, shaken for five minutes. The bulk density was obtained by measuring the volume occupied in the cylinder.

2.4.5. Color Intensity (Optical Density)

Two grams of developed powder of tomato produced were weighed (in triplicate). The samples were transferred to 250 ml Beakers, then 100 ml of 50% ethanol were added and the beakers were covered with paraffin film, left for overnight at room temperature with occasional shaking. The solutions were filtered through Buchner funnel using Whatman filter paper (No.1). The optical density was measured by the spectrophotometer (Analyzer-9) at 420nm using 0.22cm diameter tube[7].

2.4.6. Determination of Total Soluble Solids (TSS) Content and Titratable Acidity (TA)

Total soluble solids (TSS) were determined for each sample according to AOAC[8] method using an Atago DR-A1digital refractometer (Atago Co. Ld., Japan) at 25°C and expressed as percentage. Titratable acidity (TA) was obtained by titrating 5 ml of tomato powder with 0.1 N NaOH up to pH 8.1. The result was expressed as grams of citric acid per 100 g of fresh tomato weight.

2.4.7. Determination of pH

The pH was measured using Hanna pH meter at ambient temperature 35 ±5. Five grams of the raw material and equivalent weight in grams of the soluble matter in the raw material of tomato dried powder considering moisture content differences, The samples were dissolved in 50 ml distilled water and filter through Whatman filter paper No.1. Then the pH meter calibrated within the range of 4 – 9 pH and the pH of the samples was measured in triplicates.

2.4.8. Sorption Isotherm

The method was described by Wink[9] (1964) as follows; Ten grams sample were weighted accurately in petri dishes 7cm in diameter and placed in closed desiccators in which the relative humidity was controlled by saturated salt solution. The saturated salt solution used were; sulphuric acid (0%R.H.); potassium acetate (23% R.H.) magnesium chloride (33%R.H.); potassium carbonate (43% R.H.); magnesium nitrate (52%R.H.); sodium nitrate (75%R.H.) and potassium chloride (86%R.H.) the temperature was kept at 30°C ± 2. The initial moisture content of the samples was determined periodically, at an intervals of 24 hours until constant weights in three successive weightings. The equilibrium moisture content were calculated and then plotted in the Y- axis against the water activity in the X-axis .(water activity was drawn from the values of the equilibrium relative humidity divided by 100).

Preparation of methanolic extract

For preparation of methanolic extract, dried tomato slices (10 g) were stirred with 100 mL MeOH at 30°C for overnight. The extract was filtered through Whatman no. 1 filter paper for removal of seed particles. The residue was re-extracted with 60 mL methanol. The obtained extracts were filtered again and concentrated under vacuum at 40°C. These methanolic extracts were used for phenolic and antioxidant analyses.

Determination of total phenolic and flavonoid contents

The total phenolic compounds were measured using Folin-Ciocalteu method according to Elfalleh *et al*.,[10]. In this method, from each sample, 0.5 mL of methanolic extract solution was added to 0.5 mL of Folin- Ciocalteu reagent (Prolabo, Paris France), followed by 4 mL of 1M sodium carbonate. Then, the test tubes were incubated at 45°C for 5 min and cooled in cold water. Absorbance was measured at 765 nm, using a spectrophotometer (Shimadzu, Kyoto, Japan). The results were compared to a gallic acid calibration curve, and the total phenolic compounds were determined as mg gallic acid equivalents per 100g dry weight basis (GAE mg/ 100g DW).

Total flavonoids were also measured spectrophotometrically according Elfalleh *et al*.,[10]. This method based on the formation of a complex flavonoid – aluminium, having the maximum absorbance at 430 nm. Rutin was used to make a calibration curve. One mL of methanolic extract was mixed with 1 mL of 2% $AlCl_3$ methanolic solution. After incubation at room temperature for 15 min, the absorbance of the reaction mixture was measured at 430 nm using a a spectrophotometer. The flavonoids content was expressed as mg rutin equivalents per 100 g dry weight basis (mg RE/100 g DW).

Determination of total carotenoid contents

The quantification of carotenoids as xanthophylls and carotenes entail with the determination of chlorophyll (Chl) Chla and Chlb by UV-VIS spectroscopy. Chlorophyll and carotenoids were extracted from tomato fruit using a method modified by Gitelson *et al.*[11] Briefly, samples were put into a pre-chilled tube, and ground for 3 min in 1 mL extraction buffer (80% acetone: Tris-HCl[1%, w/v]). After the pigments were completely extracted by the buffer, an additional 1 mL extraction buffer was used to wash the pestle. All extraction solutions were combined and debris was removed by centrifugation. A volume of 1 mL of the supernatant was diluted to 3 mL final solution. The light absorbance of the final solution was measured at 663, 647 and 470 nm. The concentrations of carotenoids and chlorophyll were calculated as described by Lichtenthaler [12]. All experiments were done in triplicate and the carotenoids contents were converted to mg per kg of fresh weight.

3. Results and Discussion

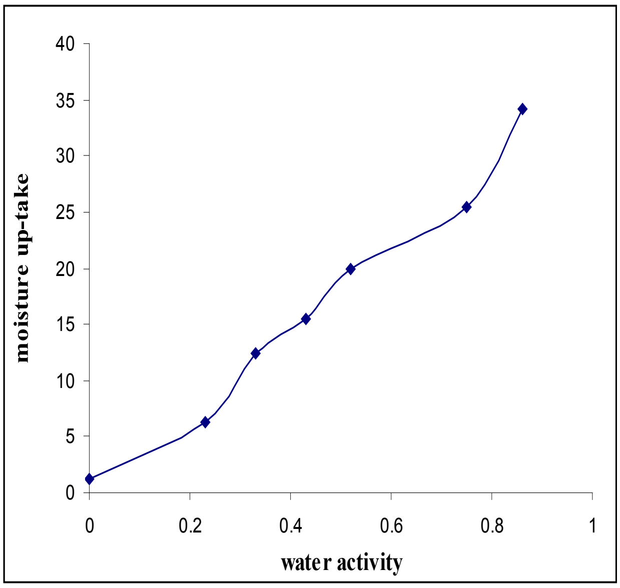
The physicochemical properties of the shade-dried tomato powder and oven-dried tomato are shown in Table (1) and Fig. 1-2.

As shown in Table (1), the bulk density of the fresh tomato from the two cultivars was (0), whereas in the shade-dried tomato, the bulk density was 0.60 % and 0.54% in Galela tomato powder (GTP) Asela tomato powder (ATP), respectively. However, in the oven dried method, bulk density was 0.66 and 0.56 in GTP and ATP, respectively. The bulk density values were greater than those of spray dried as reported by Asanathia and Konstantinos[13].

Table 1. Effect of drying method on some physical properties of two tomato cultivars

Variety	Drying method	Solubility (sec.)	Bulk density (g/ml)	Colour	T.S.S (%)	T.A (%)	pH
Galela	Fresh	0.00^{d} ±0.00	0.00^{e} ±0.00	0.29^{e} ±0.01	5.00^{f} (±0.00)	0.37^{e} (±0.06)	4.54^{a} (±0.01)
	Shade	140.00^{c} ±17.32	0.60^{b} ±0.01	0.34^{c} ±0.00	11.10^{b} (±0.66)	0.70^{c} (±0.00)	4.21^{c} (±0.03)
	Oven	230.00^{a} ±17.32	0.66^{a} ±0.01	0.41^{b} ±0.00	7.37^{d} (±0.32)	0.60^{d} (±0.00)	4.03^{f} (±0.01)
Asela	Fresh	0.00^{d} ±0.00	0.00^{e} ±0.00	0.28^{f} ±0.00	6.00^{e} (±0.00)	0.37^{e} (±0.06)	4.50^{b} (±0.01)
	Shade	190.00^{b} ±17.32	0.54^{d} ±0.01	0.32^{d} ±0.00	12.77^{a} (±0.25)	0.80^{b} (±0.00)	4.13^{d} (±0.01)
	Oven	220.00^{a} ±17.32	0.595^{c} ±0.02	0.48^{a} ±0.01	8.80^{c} (±0.26)	1.00^{a} (±0.00)	4.08^{e} (±0.00)

Any two Mean±SD values bearing different superscript in a column are significantly different (P≤0.05) according to DMRT.
TSS: Total soluble solids; T.A: titrtable acidity



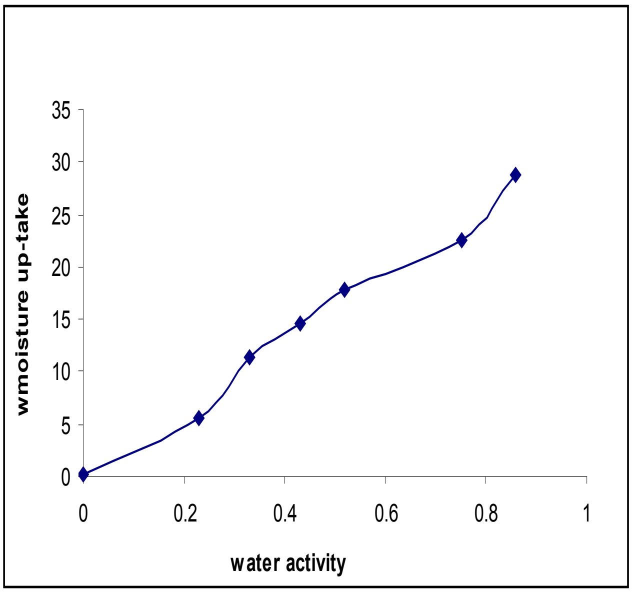


Figure 1. (A)Water Sorption Isotherm for Galela drier dried tomato at35±5.0°C (B): Water Sorption Isotherm for Galela shade dried tomato at35±5.0°C

The results for solubility rate are shown in Table (1). It was found that the shaded dried tomato of the variety Asela took longer time to dissolve (190 sec), followed by (140 sec) for the variety Galela, while in oven-dried tomato, the variety Galela took longer time to dissolve (230sec), followed by (220 sec) for variety Asela. However, solubility values of oven dried tomato powder were in close agreement to those reported by Asanathia and Konstantinos [13] who reported a range of 119 to 213 s in spray dried tomato.

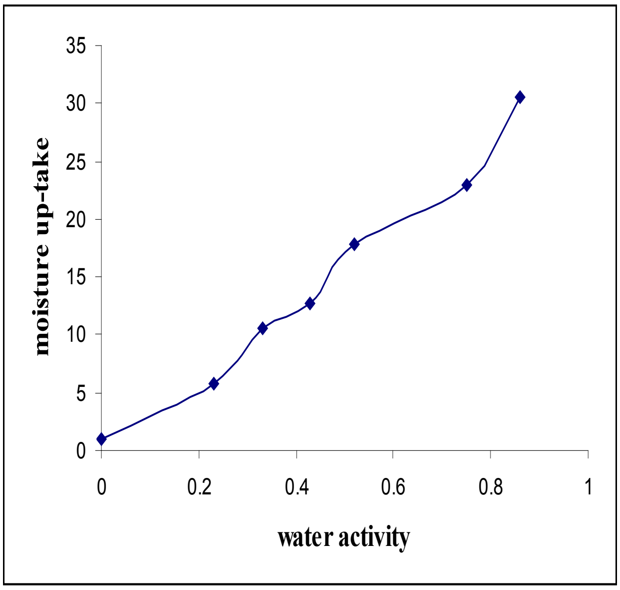
The results for colour intensity were 0.29, 0.34 and 0.41 for fresh, shade-dried and oven-dried tomato powder prepared from Galela tomato powder (GTP), respectively, while those of tomato powder prepared from Asela cultivar (ATP) were 0.28, 0.32 and 0.48, respectively. The colour of foods is one of the most important sensory attributes for the product acceptance. Lycopene is responsible for the red colour of the tomatoes and can be degraded by the thermal processing. During drying, this property can be affected by the air conditions (temperature, flow rate), feed conditions (enzyme inactivation, additives, feed rate), and atomisation speed, amongst other factors Desobry *et al*.,[14]; Cai and Corke[15]. Tomatoes contain two pigments for photosynthesis—chlorophyll, which is green, and lycopene, which is red. When tomatoes start to grow, they contain much less lycopene than chlorophyll, which gives them their green color. But when harvest season arrives, the days shorten and temperatures drop, causing chlorophyll to dissolve and lycopene to take over the shade of the fruit. During this time, sugar levels rise, acid levels drop, and the tomato softens. It becomes ready to eat.

The total soluble solids (T.S.S.) of fresh tomato (FT), shade dried tomato and oven dried tomato prepared from Galela tomato cultivar was 5%, 11.10% and 7.37%, respectively. Whereas was in tomato powder prepared from Asela cultivar, the T.S.S. of FT, shade dried and oven dried was 6 %, 12.77% and 8.80%, respectively. It is obvious that total soluble solids in fresh tomato ranged from 5 to 6% and the obtained results are in accordance with previous studies. According to Tudžarov[16], the quantity of total soluble solids in his investigated cultivars ranged from 3.46 to 4.18%, while Hossai *et al*.[17] reported values for total soluble solids from 4.79 to 6.02%, depending on the cultivar.

The results of titrable acidity was found to be 0.37, 0.70 and 0.60% in FT, shade dried tomato and oven dried tomato powder, respectively for the variety Galela, and 0.37, 0.80, 1.0% for the variety Asela. The acidity value (pH) statistically showed non- significant variation as presented in the Table (1).

The water sorption isotherm is the relation between the equilibrium moisture content of a material (expressed as mass of water per unit mass of dry matter) and water activity, at a given temperature. Such relationships are the key to understanding the water sorption properties of food. Equations for fitting these data are of special interest in many aspects of food preservation by dehydration. Numerous mathematical equations have been reported in literature for describing water sorption isotherms of food materials. They vary a lot in terms of origin (empirical, semi-empirical or theoretical) and range of applicability. The main objective of constructing the sorption isotherm is to study the stability of the dried product under different equilibrium relative humidity, i.e. different equilibrium moisture content (Karel, 1975). The results of the sorption isotherm constructed for the tomato powder at different levels of relative humidity showed that the powder should be stored under condition of relative humidity 35% with precaution in packaging.

Table (2) shows the effect of drying method on polyphenols, flavonoides and carotenoides contents of fresh and dried tomato cultivars samples (Galela and Asela cultivars). The polyphenolic contents were lower in fresh tomatoes in comparison with those of dried samples from the two tomato cultivars. However, the highest phenolics content (422.22 mg/100g) was found in Asela tomato dried by shade drying method.



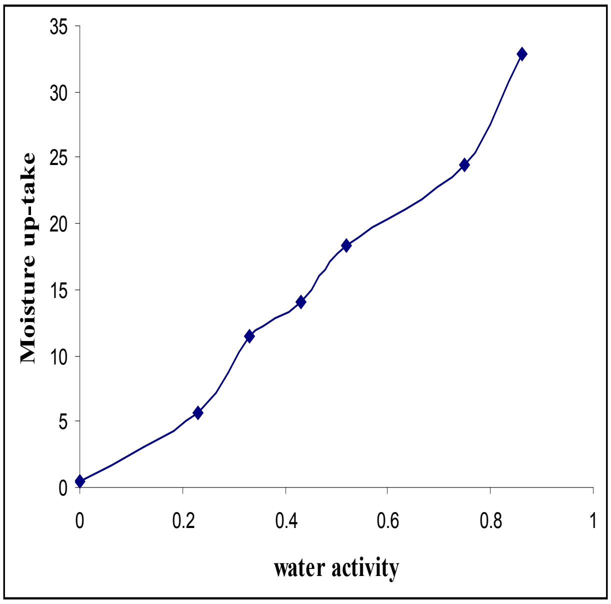


Figure 2. (A): Water Sorption Isotherm for Asela dried tomato sample at35±5.0°C B: Water Sorption Isotherm for Asela shade dried tomato sample at 35±5.0°C

Total flavonoids content (Table 2) in the different dried tomatoes samples from the two tomato cultivars were higher than those of fresh tomatoes. The highest total flavonoids contents were 75.204mg RE/100 g DW for Asela shade dried tomatoes followed by that of Galela shade dried tomato, Asela oven dried tomato and Galela oven dried tomato which were 71.82 204, 66.62 and 60.54mg RE/100 g DW).

The total carotenoids content of fresh Galela and Asela fresh tomatoes was 0.74 and 0.78 µg/100 g MF, respectively (Table 2). Total carotenoids contents were higher in dried tomatoes samples with the two drying methods. The highest (1.63µg/100 g MF) was recorded in Asela tomato samples dried by shade, while the lower value was that of Galela fresh tomatoes (0.74 µg/100 g MF. It has been reported (Christensen *et al*.,[11] that terpenoids which is flavuor compounds in tomato fruit, are primarily derived from oxidative degradation of carotenoids. This can explain differences in flavour of fresh and dried tomatoes.

Table 2. Effect of drying method on polyphenols, flavonoides and carotenoides contents

Variety	Drying method	Polyphenols (mg/100g)	Flavonoids (mg/100 g)	Carotenoids (µg/100g)
Galela				
	Fresh	72.52	08.82	0.74
	Shade	268.12	60.54	1.27
	Oven	215.42	71.82	0.95
Asela				
	Fresh	84.56	09.02	0.78
	Shade	422.22	75.20	1.63
	Oven	352.52	66.62	1.20

4. Conclusions

In order to protect physicochemical properties and nutritional quality of tomato during dehydration process, investigation was carried out using two drying methods; shade drying and oven drying to dry samples of two tomato local tomato cultivars, Galela and Asela. Based on the results, drying of tomato has resulted in producing tomato powder with satisfactory quality and nutritive value. Drying process using the two techniques, shade and oven have an obvious impact on the physico-chemical properties of dried tomato.Both shade drying and oven drying can reduce the drying time and successfully would be used to produce good quality dried tomatoes. However, most of the physicochemical properties were not much affected by the type of tomato cultivar. Future studies to are needed to ensure safety, stability, optimum storage conditions, and suitable packaging requirements.

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