The Pharma Innovation Journal 2023; 12(12): 1683-1687

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 1683-1687

www.thepharmajournal.com
Received: 01-10-2023
Accepted: 09-11-2023

Effect of drying temperature on quality characteristics of dried tomato powder by using heat pump dryer at ambient storage

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Abstract
In this study tomato was subjected to different drying temperatures (control, 40°C, 50 °C and 60 °C) with slice thickness (6 mm, 8mm and 10mm respectively) to examine their effect on storage period (30 days, 60 days and 90days) on the chemical and bioactive parameters of dried tomatoes powder by using heat pump dryer. In this research, we tested that lycopene content, color (L*, a and b*), TSS, ascorbic acid and proximate analysis and water activity at ambient condition. At 60 °C results in better retention of lycopene (129.1 ± 0.60 mg/100 g), TSS (6.53±0.04 °Brix), proximate analysis (65.7±0.06%) L* (35.16±0.06) a* (27.2±0.99), ascorbic acid (32.96±0.2 mg/100 g) while minimum water activity a_w (0.43 ± 0.00) upto 90 days of storage. This study concluded that samples dried at a higher temperature (60 °C) showed effective retention of the bioactive components after drying and during the storage period.

Keywords: *Lycopersicum esculentum*, heat pump drying, temperature, slice thickness, ambient storage

1. Introduction
In recent years, the growing interest of consumers in natural food products enriched with bioactive components and functional qualities has witnessed a remarkable surge (Smith and Jones, 2020) [9]. This heightened interest can be attributed to the wide array of health benefits associated with such products. Among these, the tomato, a ubiquitous fruit, has gained prominence for its multifaceted properties, making it a subject of intense scrutiny. Renowned for its culinary versatility and nutrition, the tomato is a rich source of bioactive compounds, antioxidants, phenolic constituents, and essential nutrients (Raiola and Rigano, 2015; Partau *et al.*, 1998) [7, 12].
The tomato, scientifically known as *Solanum lycopersicum*, is a fruit that stands out with its vibrant hues and rich flavor profile. Its characteristics include a succulent, pulpy interior encased by a smooth, red or yellow skin. In addition to its culinary applications, the tomato is prized for its diverse health benefits, which stem from its unique phytochemical composition. Tomatoes are known to contain lycopene, a potent antioxidant recognized for its role in scavenging free radicals and contributing to overall health. Furthermore, the fruit has been linked to various health advantages, including anti-cancer properties, cardiovascular health support, and potential protective effects against several chronic diseases (Rao and Agarwal, 1999) [8].
In 2021 year, 189 tons of tomatoes were produced globally with a harvested area of five million hectares according to the Agriculture Science. In 2018-19, at India, tomato production area was 778 hectare and production amount were 19397 MT for third advanced estimate (NHB). In India, during raining seasons, tomatoes were very expensive to purchase and storage for shelf life.
Drying is an oldest technique to reduce postharvest losses, increasing shelf stable vegetables. However, disadvantage of tray drying is high temperature effect for the chemical, physical and nutritional changes that causes that quality degradation. A heat pump dryer is suitable for perishable fruits and vegetables in controlled drying conditions such as temperature, humidity and air velocity. HPD was demonstrated to be a mild drying technology suitable for retaining fresh aroma volatiles and flavors of tomato and comparable to FD. (2023, Journal of Food Composition and Analysis). The findings from this study will be instrumental in enhancing the overall efficiency and sustainability of tomato processing and preservation, ultimately benefiting both consumers and the agricultural industry.

This study investigated the effect of temperature and slice thickness on physiochemical attributes of tomato by using heat pump dryer.

2. Materials and Methods

2.1. Raw Materials and Sample Preparation

Fresh tomato fruits (*Solanum lycopersicum* L.) were procured from the farm of Entomology Department, RCA, MPUAT, Udaipur, Rajasthan, India. Tomato fruits were procured from entomology department thoroughly washed with tap water to remove dirt and dust particles adhering to the surface of fruits and to remove fungus problem. The selected fresh tomato fruits were sliced to 6mm, 8mm and 10mm thickness with sharp stainless-steel knife by using clipper. About 50 kg of the sliced samples were taken for drying to get tomato slices and powder.

2.2. Heat pump dryer

Heat Pump drier (Advance Agro Ripe Pvt. Ltd. PUNE (INDIA) (An ISO 9001-2015 and GMP Certified Company) situated in the Department of Food Processing and Engineering (PFE), CTAE was used for drying at varying temperature 40-60 °C. This machine can use for 12 trays and one tray can be available for 3 kg for fresh tomato slices. But one tray was good for 1-2 kg for tomato. And then one time for drying process should use 3 trays for this machine. Because of fungus problem and dehydration process can need as moisture. Due to for these reasons, I used three trays for one replication as (6mm,8mm and 10 mm) thickness with tomato slices at the same temperature. Moisture was reproducing as water from the outside of this machine. After starting this machine was not working immediately. After 5 hour, this machine was starting to run as hot air velocity. About 5-6 hour from starting time, we should use to rotate with fork to tomato slices in tray for good quality dried tomato slices and powder. Because, tomato is very fresh fruits and so many moisture content. And then, tray was not filter type. At 60 C° for (6mm) thickness required (10 hour) drying time, for (8 mm) thickness required (10) hour and for (10 mm) thickness required (10) hour to get dried tomato slices. At 50 C° for (6mm, 8mm and 10 mm) thickness required 18 hour drying time. At 40 C° for (6mm, 8 mm and 10 mm) thickness required 24 hour drying time. At (40 °C, 50 °C, 60 °C and control) temperature for (6mm, 8mm and 10 mm) thickness of fresh tomato slices were changed 0.8-1.0 kg from fresh weight to dried weight.

2.3. Method of powder making and storage

The dried tomato slices in heat pump drier were grounded in a mortar and pestle and then in a cyclotech grinder. It was filtered through a 32-mesh sieve to obtain fine powder. The dehydrated tomato slices and powder were sealed in HDPE bags and stored for 90 days at temperature in PHT, RCA, Udaipur, Laboratory. The effect of storage on the quality of dried tomato slices and powder were studied up to 3 months at monthly intervals.

2.4. Chemical analysis

To determine the effect of different drying temperatures on the quality of tomato various chemical parameters such as lycopene content, water activity, TSS, proximate analysis (carbohydrate), color (L*, a* and b*) and ascorbic acid were studied as per standard procedures.

2.4.1. Determination of lycopene content (mg/100 g)

Lycopene content of tomato samples was determined as described in (Suwanaruang 2016) [11] by extracting with ethanol: acetone: hexane (1:1:2) (v:v:v) mixture. Powdered tomato sample (0.1 g) was dissolved in 1-mL distilled water and vortexed in water bath for 1 hr at 30 °C. Then, 8.0 mL of acetone, ethanol, and hexane, (ratio 1:1:2) was added, capped, and vortexed again, followed by incubation in a dark place for 60 min. Then, one milliliter of distilled water was added to the samples and vortexed and allowed to stand and separate into phases. Ultraviolet–Visible spectrophotometer (T80, China) was used to measure the absorbance of the upper layers of the lycopene samples at wavelength of 503 nm. Lycopene content (mg/100 g dw) of the samples was then calculated using Equation 1.

Lycopene [mg/100 g dw] =Abs 503nm x 537x8x 0.55/0.1 x 172 --- (1)

Where, Abs503 nm is the absorbance at 503 nm; 537 = lycopene molecular weight in g/mole; 8 = the mixed solvent volume in milliliter; 0.55 = the volume ratio of the upper layer to the mixed solvents in milliliter; 0.10 = the weight of tomato added in gram; 172 = the extinction coefficient for lycopene in hexane in mM^{-1} (Anthon and Barrett, 2006) [13].

2.4.2. Determination of water activity (a_w) (%)

The water activity of fresh and dried tomato slices was measured by water activity meter (model Novasina AG, CH-8853 Lachen) at room temperature (23.4 ± 1°C).

2.4.3. Determination of TSS (%)

TSS of the samples was measured by refractometer (model, DR201- 95, Germany).

2.4.4. Determination of proximate analysis

Carbohydrate content was commutated by subtracting the total of moisture, protein, fat, ash and crude fiber from 100 (AOAC, 1980).

Proximate analysis = 100 – (Moisture + protein + fat + ash + crude fiber)

2.4.5. Determination of color change (L*, a* and b*)

The color values of dried red cabbage were determined using a digital colorimeter (Hunter Lab Color Flex, Hunter Associates Laboratory Inc., Reston, VA, USA). Prior to measurement, it was precalibrated using black and white tiles. The chromacity parameters a* (green [-] to red [+]), b* (blue [-] to yellow [+]), and the color parameters L* (L* = 0 for black and L* = 100 for white) were also assessed. Five randomly selected samples of each batch were analyzed and the mean and standard deviation (SD) of the 30 readings were recorded.

2.4.6. Determination of ascorbic acid (mg/100 g)

The Ascorbic acid was determined as described by (Liu *et al*.) with some modifications. The sample powder of 1.0 g was mixed with Oxalic acid-EDTA solution to 25 mL, and then centrifuged at 10 000 × g for 10 min to obtain the supernatant. Next, mixed 5.0 mL supernatant with 1.5 mL 3% metaphosphoric acid-acetic acid, 2.0 mL 5% sulfuric acid and

2.0 mL 5% molybdate-ammonium, and followed by adding distilled water to 25 mL. Then the above mixture was heated in a water bath at 30 °C for 20 min and kept in room temperature at 24 °C for 1 hr. Finally, the VC content was measured with the ultraviolet visible spectrophotometer at 700 nm.

3. Statistical analysis

The data obtained for each parameter were gathered in triplicate for tomato samples. Statistical analysis was conducted using ANOVA (Analysis of Variance) through JMP Software. In this analysis, the first factor under investigation was effect of different temperatures and the second factor was the tomato slices thickness. To assess differences in means, Tukey's test was applied. The data were presented as mean ± SD (standard deviation).

4. Results and Discussion

In present investigation revealed that a marginal drop in lycopene contents was seen after 90 days in tomato, the average values were recorded (114.9 ±0.20 to 131.73±0.37) for samples dried at 40, 60 and 50 °C. Table 1, shown that high values of lycopene (131.73 ± 0.37 (mg/100 g),131.06 ± 0.24 (mg/100 g) and 130.6 ± 0.25 (mg/100 g)) were recorded in tomato powder dried at 60 °C (8 mm) for the storage of 30 days,60 days and 90 days respectively it was at par with 60 °C (10mm) [130.84±0.38 (mg/100 g), 130.06±0.48 (mg/100 g), 129.63±0.41 (mg/100 g)], 60°C (6mm) [130.00±0.57 (mg/100 g), 130.43±0.60 (mg/100 g), 129.1±0.60 (mg/100 g)] as compared to control. Lycopene remains relatively stable during storage under room temperature conditions. Similar results have been observed by other scientists who observed no changes in the lycopene content of tomatoes after storage under low temperature (Liu *et al.*, 1999; Li *et al.*, 2020; Liu *et al.*, 2010) [6, 5, 10]. The stability of lycopene might be attributed to the thermal inactivation of enzymes that might expose lycopene to oxidants by destroying the cell wall (Kaur, 2020; Kader 2005) [3, 2]. The storage of powder under ambient temperature conditions induced no remarkable changes in the colour of tomato powder.

Table 1: Effect of drying temperature and slice thickness on lycopene content (mg/100 g) and water activity (a_w) of dried tomato powder at ambient storage.

Treatments	Lycopene content (mg/100 g)			Water activity (a_w)		
	30 DAYS	60 DAYS	90 DAYS	30 DAYS	60 DAYS	90 DAYS
Control (6mm)	115.00 ±0.00^{G}	115.2±0.2^{G}	114.9±0.20^{H}	0.56±0.00^{C}	0.57±0.00^{C}	0.58±0.00^{C}
Control (8mm)	116.66±0.66^{G}	116.36±0.61^{G}	116.06±0.61^{H}	0.58±0.00^{B}	0.59±0.00^{B}	0.60±0.00^{B}
Control (10mm)	120.00±0.57^{F}	119.63±0.52^{F}	119.43±0.58^{G}	0.60±0.00^{A}	0.61±0.00^{A}	0.63±0.00^{A}
40 °C (6mm)	121.40±0.30^{EF}	120.26±0.86^{F}	120.00±0.76^{FG}	0.50±0.00^{E}	0.52±0.00^{E}	0.53±0.00^{E}
40 °C (8mm)	128.86±0.59^{DE}	123.53±0.63^{DE}	123.3±0.65^{DE}	0.52±0.00^{D}	0.53±0.00^{D}	0.55±0.00^{D}
40 °C (10mm)	123.46±0.74^{E}	123.06±0.69^{E}	122.66±0.63^{EF}	0.53±0.00^{D}	0.54±0.00^{D}	0.55±0.00^{D}
50 °C (6mm)	126.40±0.30^{CD}	125.96±0.38^{CD}	125.66±0.32^{CD}	0.48±0.00^{F}	0.49±0.00^{F}	0.50±0.00^{F}
50 °C (8mm)	128.40±0.30^{BC}	128.00±0.30^{BC}	127.63±0.29^{BC}	0.48±0.00^{F}	0.50±0.00^{F}	0.51±0.00^{F}
50 °C (10mm)	127.80±0.41^{C}	127.33±0.44^{BC}	127.03±0.44^{BC}	0.49±0.00^{F}	0.50±0.00F	0.51±0.00^{F}
60 °C (6mm)	130.00±0.57^{A}	130.43±0.60^{A}	129.1±0.60^{A}	0.41±0.00^{G}	0.43±0.00^{G}	0.44±0.00^{G}
60 °C (8mm)	131.73±0.37^{A}	131.06±0.24^{A}	130.6±0.25^{A}	0.42±0.00^{G}	0.43±0.00^{G}	0.45±0.00^{G}
60 °C (10mm)	130.84±0.38^{A}	130.06±0.48^{A}	129.63±0.41^{A}	0.43±0.00^{G}	0.44±0.00^{G}	0.45±0.00^{G}

Data depicted in Table 1. Reveled that storage upto 90 days of storage water activity (a_w) increase on dried tomato powder as compared to control. As the temperature increased from 40 °C to 60 °C, there was a consistent and significant decrease in water activity levels. The tomato slices dried at 60 ºC shows minimum water activity a_w (0.41 ± 0.00) at 30 days of storage as compared to control group. However, during storage water activity increase on 90 days of storage 0.45±0.00 which was at par to 60 ºC 8mm, 60 ºC10 mm. The water activity (a_w) is a critical parameter in various fields, particularly in food preservation and quality control. Lower water activity a_w levels are associated with reduced microbial growth and a longer shelf life. However, Slice size on water activity was relatively having less effect as compared to the heat pump drying temperature. It was concluded that rapid drying, employs high-temperature results in lowering the water activity of the resulted product. Moreover, it elevates the non-enzymatic browning reactions (Chou and Chua, 2001) [1].

Table 2: Effect of temperature and slice thickness on TSS (ºBrix) and proximate analysis of dried tomato powder at ambient storage.

Treatments	TSS (ºBrix)			Proximate analysis (%)		
	30 DAYS	60 DAYS	90 DAYS	30 DAYS	60 DAYS	90 DAYS
Control (6mm)	5.87±0.00^{I}	5.51±0.04^{F}	5.15±0.09^{F}	65.6±0.50^{GH}	61.8±0.3^{GH}	60.96±0.50^{DEF}
Control (8mm)	5.83±0.00^{I}	5.49±0.03^{F}	5.14±0.03^{F}	65.2±0.11^{H}	61.16±0.14^{H}	60.46±0.12^{F}
Control (10mm)	5.61±0.01^{J}	5.27±0.02^{G}	4.92±0.02^{F}	65.86±0.17^{GH}	62.36±0.13^{H}	61.2±0.15^{DEF}
40°C (6mm)	6.48±0.00^{G}	6.10±0.03^{E}	5.79±0.03^{E}	66.1±0.05^{FGH}	63.86±19.9^{GH}	61.43±0.06^{DEF}
40°C (8mm)	6.37±0.00^{H}	6.03±0.04^{E}	5.65±0.06^{E}	66.4±0.11^{EFG}	64.0±0.1^{A}	61.6±0.05^{DEF}
40°C (10mm)	6.33±0.02^{H}	6.01±0.02^{E}	5.64±0.04^{E}	66.9±0.05^{DEF}	64.5±0.11^{A}	62.1±0.15^{CDE}
50°C (6mm)	6.87±0.01^{D}	6.52±0.03^{BC}	6.18±0.04^{BC}	67.33±0.05^{CDE}	64.96±0.03^{A}	62,5±0.08^{CD}
50°C (8mm)	6.77±0.01^{E}	6.39±0.04^{CD}	6.05±0.01^{BC}	67.63±0.08^{CD}	65.0±0.55^{A}	63.2±0.08^{BC}
50°C (10mm)	6.64±0.01^{F}	6.3±0.04^{D}	5.95±0.07^{CD}	68.1±0.05^{C}	64.5±0.70^{A}	62.06±0.76^{CDE}
60°C (6mm)	7.26±0.01^{A}	6.9±0.04^{A}	6.53±0.04^{A}	67.5±0.3^{B}	65.8±0.3^{B}	64.4±0.2^{AB}
60°C (8mm)	7.43±0.01^{B}	7.06±0.02^{A}	6.75±0.05^{A}	69.5±0.17^{A}	67.16±0.14^{A}	65.7±0.18^{A}
60°C (10mm)	6.96±0.01^{C}	6.61±0.03^{B}	6.24±0.01^{B}	70.63±0.08^{A}	68.36±0.13^{A}	65.93±0.06^{A}

Data depicted in Table 2 reveled that during storage upto 90 days maximum TSS was noticed in treatment [60 ºC (8 mm)] 6.75±0.04 ºBrix which was at par [60 ºC (6 mm)] 6.53±0.05 ºBrix With regards to proximate analysis, the dried tomato powder has the highest percentage of proximate analysis (70.63±0.08%, 68.36±0.13%, 65.93±0.06%) with the treatment (60 ºC and 10 mm thickness) for the storage time (30 days, 60 days and 90 days) it was at par 60 °C (8mm) i.e. 69.5±0.17%, 69.5±0.17%, 64.7±0.18% respectively as compared to control.

Table 3: Effect of temperature and slice thickness on Color L* and Color a* of dried tomato powder at ambient storage

Treatments	Color L*			Color a*		
	30 DAYS	60 DAYS	90 DAYS	30 DAYS	60 DAYS	90 DAYS
Control (6mm)	33.44±05^C	32.94±0.02^C	32.44±0.02^C	15.21±0.05^D	15.08±0.05^E	14.94±0.05^E
Control (8mm)	31.61±0.1^D	31.11±0.74^D	30.61±0.74^D	15.12±0.01^D	14.99±0.02^E	14.86±0.02^E
Control (10mm)	30.74±0.53^D	30.24±0.06^D	29.7±0.06^D	16.11±0.53^CD	15.97±0.54^E	15.84±0.53^E
40 °C (6mm)	33.8±0.03^C	33.3±0.11^C	32.8±0.01^C	17.2±0.03^C	17.06±0.02^CDE	16.93±0.02^CDE
40 °C (8mm)	33.65±0.11^C	33.15±0.02^C	32.65±0.02^C	19.98±0.11^C	16.85±0.11^DE	16.72±0.11^DE
40 °C (10mm)	33.58±0.10^C	33.04±0.02^C	32.54±0.02^C	16.79±0.10^C	19.13±1.22^BCD	18.99±1.22^BCD
50 °C (6mm)	34.48±0.01^BC	33.98±0.04^BC	33.48±0.04^BC	20.48±0.01^B	20.34±0.00^B	20.20±0.00^B
50°C (8mm)	34.33±0.14^BC	33.83±0.02^BC	33.33±0.02^BC	20.08±0.14^B	19.94±0.13^B	19.81±0.13^B
50°C (10mm)	34.03±0.37^C	33.53±0.08^C	33.03±0.08^C	19.63±0.37^B	19.49±0.36^BC	19.35±0.36^BC
60°C (6mm)	35.82±0.00^A	35.06±0.00^A	35.16±0.06^A	27.44±0.00^A	26.30±0.00^A	26.69±0.00^A
60°C (8mm)	36.16±0.01^A	35.66±0.33^A	35.16±0.33^A	27.47±0.12^A	27.33±0.99^A	27.2±0.99^A
60°C (10mm)	35.30±0.05^AB	34,80±0.05^AB	34.30±0.05^AB	26.96±0.21^A	26.83±0.21^A	26.17±0.21^A

Color is an important product characteristic, which has a significant effect on the consumer acceptability of the product. The impact of drying conditions on colour of tomato and sweet pepper powders was assessed. The lightness (L*), redness (a*) and yellowness (b*) of dried powders were determined. Data depicted in Table 3. and 4 revealed that drying temperature of heat pump had significant effect on the colour values of dried tomato at 30, 60, 90 days respectively. Dried tomato at 60 ºC with 8mm thickness showed maximum color value L* (36.16±0.00, 35.66±0.00, 35.16±0.06) at 30, 60, 90 days respectively which was at par (60 ºC 6mm) 35.82±0.01, 35.06±0.00, 35.16±0.06 as compared to control and 40 ºC temperature. Similarly, tomato dried at 60 ºC with slices 6, 8, 10 mm value of a* were at par and showed maximum retention upto 90 days of storage i.e 27.2±0.00 **[**60 ºC (8 mm)], 26.69±0.21 [60 ºC (6 mm)], 26.17±0.99 [60 ºC (10 mm)] as compared to control. This may be due to prolonged exposure to oxygen at 40 °C and control resulted more enzymatic browning. These results were in concordance with the results of Kerkhofs *et al.*, (2005) [4] and Toor and Savage (2006) [15]. Therefore, suitable drying temperature used for the dehydration of fruits and vegetables is necessary.

Table 4: Effect of temperature and slice thickness on color b* and ascorbic acid (mg/100 g) of dried tomato powder at ambient storage.

Treatments	Color b*			Ascorbic acid (mg/100 g)		
	30 DAYS	60 DAYS	90 DAYS	30 DAYS	60 DAYS	90 DAYS
Control (6mm)	15.85±0.04^A	15.72±0.035^A	15.59±0.03^A	23.7±0.1^F	23.35±0.05^F	22.75±0.05^F
Control (8mm)	15.75±0.04^A	15.72±0.035^A	15.59±0.03^A	22.6±0.11^G	22.33±0.1^G	21.8±0.1^G
Control (10mm)	15.75±0.04^A	15.62±0.035^A	15.59±0.03^A	22.4±0.11^G	22.16±0.2^G	21.56±0.1^G
40°C (6mm)	15.75±0.04^A	15.62±0.035^A	15.59±0.03^A	26.63±0.12^D	26.4±0.1^D	25.76±0.1^D
40°C (8mm)	15.65±0.04^A	15.52±0.035^A	15.49±0.03^A	26.2±0.11^D	25.86±0.2^D	25.3±0.2^D
40°C (10mm)	15.65±0.04^A	15.52±0.035^A	15.50±0.03^A	25.4±0.11^E	25.1±0.1^E	24.4±0.2^E
50°C (6mm)	15.55±0.04^A	15.42±0.035^A	15.39±0.03^A	29.5±0.17^B	29.2±0.1^B	28.66±0.1^B
50°C (8mm)	15.55±0.04^A	15.42±0.035^A	15.39±0.03^A	28.8±0.11^BC	28.46±0.1^BC	28.1±0.1^BC
50°C (10mm)	15.45±0.04^A	15.42±0.035^A	15.38±0.03^A	28.3±0.05^C	28.08±0.03^C	27.5±0.05^C
60°C (6mm)	15.85±0.04^A	15.56±0.035^A	15.39±0.03^A	33.7±0.32^A	33.13±0.1^A	32.7±0.1^A
60°C (8mm)	15.45±0.04 ^A	15.42±0.035^A	15.37±0.03^A	33.8±0.11^A	33.5±0.1^A	32.96±0.2^A
60°C (10mm)	15.35±0.04 ^A	15.32±0.035^A	15.35±0.03^A	35.53±0.03^A	33.2±0.05^A	32.73±0.06^A

Data depicted in Table 4 revealed that Vitamin C is also a vital nutritional parameter and important to determine the vitamin C content after any thermal treatment which is a heat sensitive (Surendar *et al.*, 2018) [10]. Among, all the drying temperature, the highest concentration of ascorbic acid was found in samples dried at [60 °C (8mm)] 32.96±0.2 mg/100 g, at par [60 °C (10 mm)] with the value of 32.73±0.06 mg/100 g, [60 °C (6 mm)] 32.7±0.1 mg/100 g as compared to control and other temperature of heap pump upto 90days of ambient storage.

5. Conclusion

This study demonstrated that convection hot air drying at 60 °C was could be associated with low molecular mobility that was linked to low water activity., Tomato powder was safe for consumption up to 3 months at ambient storage temperature, where it was packed in HDPE bag and stored at ambient temperature & were regularly tested for proximate composition and lycopene functional properties of dried tomato powder. This research evaluated the effects of heat pump drying method on the changes of overall quality, including physical properties, nutritional bioactive components and antioxidant activity of tomatoes. Data from this research suggested that tomato dried powder by HP (heat pump) at 60 °C showed to obtain high quality dried tomato powder with superior color and abundant antioxidants.

6. References

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