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Effect of drying on quality characteristics of dried tomato powder

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Abstract
The purpose of this study is investigate the drying characteristics of the tomatoes to prepare tomato powder. The drying characteristics of tomato slices were carried out in this study. The effect of processing parameters such as the drying temperature and drying time required for drying of tomato slices were studied and final dry weight of the tomato slices were estimated. In this study, the effect of drying on quality characteristics i.e. Proximate Compositon, Functional Properties and Phytochemicals were analyzed. From the above study the drying of tomato slices in were regularly tested for proximate composition and functional properties of dried tomato powder. The results indicated that moisture (5.5%), fat (3.9 %,) ash (7.3 %), and Lycopene (1.41%) etc. respectively.

Keywords: tomato, proximate compositon, functional properties and phytochemicals

1. Introduction

India ranks second in fruits and vegetables production in the world after China. Its share in the world's production is 12.6% and 14% in case of fruits and vegetables respectively. India had produced 8,44,11,000 million tonnes of fruits on 71,36,000 ha area and 17,02,48,000 million tonnes of vegetables on 96,09,000 ha area during 2013-14 (NHB, 2014). The main objective of fruit and vegetable processing is to supply wholesome, safe, nutritious and acceptable food to consumers throughout the year. Fruit and vegetable processing projects also aim to replace imported products like squash, yams, tomato sauces, pickles etc (Dauthy, 1995).

Fruits and vegetables are important ingredients of the human food as they provide, apart from calories, the much-needed vitamins and micronutrients in the diet. India's varied agro-climatic conditions provide an enormous scope for cultivation of almost all varieties of tropical, sub-tropical and temperate fruits and vegetables. As of now, all horticultural crops put together, account for 12 million hectares (7% of the cropped area) of the country, the estimated produce from which is 100 million tonnes per annum contributing 18 per cent of the gross agricultural output (GOI, 1995).

Tomatoes are cultivated in more than 150 countries around the world on approximately 4 million hectares (ha). The total average annual production over the period 1999-2003 was approximately 108 million tonnes. The main producer is China with approximately 3 million tones or 21.8% of the total production. USA follows, with approximately 12 million tonnes or 10.6% of the total production (IHD, 2003). Tomato is considered as one of the most important vegetables produced in commercial agriculture because of income generated from export. A huge quantity of these produce goes waste due to lack of handling, storage, transportation and processing facilities. The total losses of fruits and vegetables are estimated to be 20-40 per cent amounting to nearly Rs. 30000 million per annum which calls for proper preservation and processing facilities in areas where surplus quantities are grown. Many methods of food preservation relie on removal of water in order to decrease water activity below a level that causes growth retardation of spoiling microorganisms. Decreased water content also influences unwanted chemical reactions affecting not only the nutritive value of food but also its sensory properties (Gowda, 1995).

Drying is an important and traditional process to remove the moisture from the food. The basic principle reason is that microorganisms such as bacteria, fungi, mold required water for their growth and multiplication, which causes food spoilage and decay. Since water as a potential vehicle for pathogens in the food chain and it has to be removed to increase the shelf life of the food products. Drying and dehydration is an ideal process applicable to all food materials such as fruits, vegetable, cereals, pulses, milk, meat, fish etc to remove the moisture content. The moisture is an important factor in agricultural and food materials affects the shelf life of the product which due to microbial spoilage, oxidation and physical structure of the foods.

Drying is an excellent way to preserve food and solar dryers are appropriate food preservation technology for sustainable development. Drying was probably the first ever food preserving method used by man, even before cooking. It involves the removal of moisture from agricultural produce so as to provide a product that can be safely stored for longer period of time.

2. Materials and Methods

The present research work was conducted at the Department of Food Science and Technology, College of Food Technology, Vasanthrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

2.1 Materials

2.1.1 Raw materials

The fully ripened, freshly harvested Vaishali tomato varieties were selected for the study. Sugar, citric acid and other ingredients were purchased from the local market of Parbhani (MS), India.

2.1.2 Chemicals

All the chemicals used in the present investigation were of analytical grade. They were obtained from Department of Food Science and Technology, College of Food Technology, V.N.M.K.V, Parbhani.

Procedure

The tomato slices were initially pre-heated in tray drier to the required temperature (70℃ and 80℃). The weighed sample is spread out, generally quite thin on trays in which a way that the hot air moves evenly through all particles of sample. Heating may be by an air current sweeping across the trays, by conduction from heated trays or heated shelves on which the trays lie, or by radiation from heated surfaces. Most tray dryers are heated by air, which removes the moist vapours.

Process for Preparation of Tomato Powder by cabinet Drying

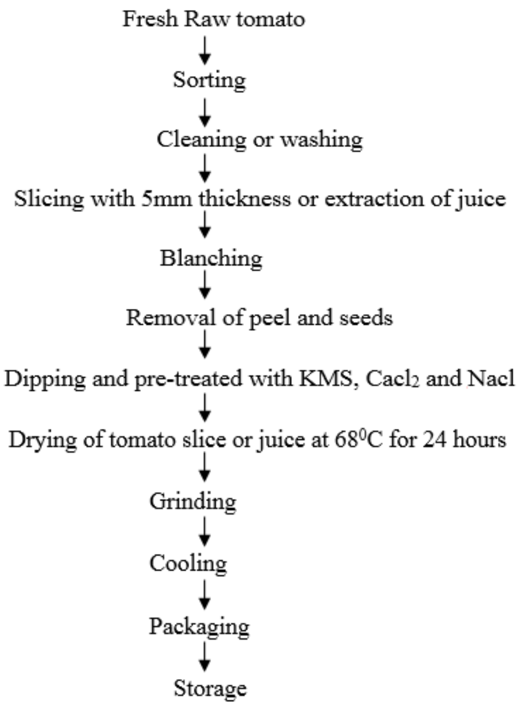

Fig 1: Process for preparation of tomato powder by cabinet drying

2.1.3 Determination of Moisture content

Moisture content of the prepared tray dried powder was estimated as per AOAC (2005) [3] method by using following formula.

This was repeated for all the powders samples till constant weight was achieved.

Calculations

$$\text{Moisture (\%)} = \frac{(W_2 - W_1) - (W_2 - W_3)}{(W_2 - W_1)} \times 100$$

Where,
W_1 = Initial weight of petridish (g)
W_2 = Weight of the petridish with sample before drying (g)
W_3 = Weight of the petridish with sample after drying (g)

2.1.4 Determination of Ash

Ash content of the prepared tray dried powder was estimated as per AOAC (2005) method.

2.1.5 Determination of Protein

The crude protein content of the sample was estimated according to the micro Kjeldhal method AOAC (2005), calculated as percent nitrogen of product and multiplied with 6.25 to obtain the protein content.

2.1.6 Determination of Fat

Fat content was estimated as crude ether extract of the dry material using automatic Soxtherm extraction unit (AOAC, 1997) [4].

2.1.7 Determination of Crude fiber

The crude fiber content of samples was determined by boiling with 1.25% dilute H_2SO_4, washed with water, further boiled with 1.25% dilute NaOH and the remaining residue after digestion was taken as crude fiber (AOAC, 1990) [2].

2.1.8 Determination of carbohydrate

Carbohydrate content was computated by subtracting the total of moisture, protein, fat, ash and crude fiber from 100 (AOAC, 1980) [1].

Carbohydrate (g) = 100 – (Moisture + protein + fat + ash + crude fiber)

Computation of energy: Energy content was computated by multiplying protein, fat and carbohydrate values obtained from analysis by 4, 9 and 4 respectively and expressed in Kcal / 100 g (AOAC, 1980) [1].

Energy (Kcal) = (Protein×4) + (Fat×9) + (Carbohydrates×4)

2.2 Analysis of functional properties of tomato powder

2.2.1 Determination of Water absorption index and water solubility index

Water absorption index (WAI) and water solubility index (WSI) were carried as per procedure given by (A.O.A.C., 1975).

2.2.2 Determination of water solubility index and oil absorption index

Water solubility index and Oil Absorption index was determined as outlined by Sangnark and Noomhorm (2004).

2.3 Analysis of phytonutrients of tomato powder

2.3.1 Determination of lycopene content

Principle: The carotenoids in the sample were extracted in acetone and taken up in petroleum ether. Lycopene has absorption maxima at 473 nm and 503 nm. One mole of lycopene when dissolved in one liter of petroleum ether (40-60 °C B.P) and measured in a spectrophotometer at 503 nm absorbance. A concentration of 3.1206 µg lycopene / ml gives unit absorbance (Ranganna, 2003).

Determination of Chlorophyll content

Determination of Chlorophyll content was carried out by the method given by Ranganna, (2003).

2.3.2 Determination of Carotene content

Determination of Carotene content and total carotenoids was carried out by the method given by Ranganna, (2003).

3. Results and Discussion

Tomatoes and tomato products are used as ingredients in many traditional dishes, because of the compatibility with other food ingredients and high nutritional value. Besides the use of tomatoes and tomato products for direct human consumption, tomatoes and its byproducts serve as raw materials for several secondary products. A very valuable constituent of tomato is the red pigment carotenoid lycopene, an exceptionally efficient quencher of singlet oxygen and therefore an important anti-oxidant. Lycopene, as well as other valuable substances such as beta-carotene, alphacarotene alpha-tocopherol, gamma-tocopherol and delta-tocopherol can be effectively. Extracted from tomato skins, seeds, and other by-products using supercritical fluid extraction technology.

3.1 Physical composition of tomato fruit

Proximate composition generally represents the nutritional quality of product. It is necessary to determine the proximate composition of tomato so as to judge its effect on final product after utilization as a novel ingredient. The physical composition of tomato was conducted were presented in Table 1.

Table 1: Physical composition of tomato fruit

Parameters	Tomato
Flesh (%)	77.20 ± 5.50
Skin (%)	15.70 ± 5.00
Seed (%)	6.60 ± 1.00
Edible Index (%)	95.2 ± 3.20
Waste Index (%)	4.8 ±0.50

*Each value is average of three determinations

The results obtained with respect to composition revealed that, the flesh percent *i.e.* yield of tomato pulp was about 77.20±2.50 per cent, while the seed per cent 6.60±1.00 and skin percent was found to be 15.70±2.00 respectively. Well matured tomatoes were used in present investigations which were found to be cherrish red in color. The edible index of tomato was found 92.6±3.20% whereas, waste index was found 17.4±0.50%. The composition of tomatoes found to be in line with results of earlier investigator Gopalan *et al.*, (2012).

3.1.3 Chemical Characteristics of tomato pulp

The tomato fruit was analyzed for its chemical characteristics i.e. TSS, pH, acidity and brix/acid ratio. The results were presented in Table 2.

Table 2: Chemical characteristics of tomato pulp

Parameters	Tomato pulp
TSS (^{0}Bx)	2.9 ± 0.05
pH	4.21 ± 0.05
Acidity (%)	0.38 ± 0.05
Brix/Acid ratio	4.68 ± 0.05

*Each value is average of ten determinations

The total soluble solid (TSS) and pH of tomato pulp were found to be 2.9±0.05^{0}Bx and 4.21±0.05 respectively. The acidity of tomato pulp (0.38±0.05%). The brix/acid ratio was found 4.68±0.05. The physical properties of tomatoes were found similar with results of Costescu *et al*. (2006).

3.1.4 Effect of drying on proximate composition of tomato powder

The prepared tomato powder were concentrate the nutrient composition with removal of moisture, it is invariably accompanied by various other components *viz*, proteins, fat, ash and carbohydrate depending on a number of factors like method of drying, maturity of tomato, environmental conditions etc. Some of these impart desirable qualities to the finished products. The proximate composition of tomato powder obtained by different drying methods was presented in table 3.

Table 3: Effect of drying on proximate composition of tomato powder

Drying method	Result
Moisture (%)	5.51±1
Protein (%)	13.96±1
Fat (%)	2.80±0.50
Ash (%)	10.78±1
Crude fiber (%)	9.2±1
Carbohydrate (%)	49.78±2

* Each value represents the average of three determinations

The moisture content of a powder plays a significant role in the flow and other mechanical properties of the food. However, it depends largely on the method, extent of drying and the humidity in the surrounding atmosphere (Lawal, 2004). Moisture content of tomato powder by different drying methods was varied from 5.42 to 5.80 per cent and it was within the range of 4 to 8 per cent that is recommended for commercial tomato powder. Foam mat drying showed highest moisture content (5.80%) as compared to spray (5.42%) and cabinet (5.51%). The moisture content was not significantly affected by the drying method. Similar result was observed by Mozumder *et al.*, (2012) [11].

It was cleared from table that, the protein content of starch ranged from 12.36 to 13.96 per cent. The protein content was found highest in cabinet drying followed by foam mat and spray drying. The decreased protein content may be attributed to partial removal of protein from starch as salt bind with protein during drying. Changes kin 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) [12].

The data pertaining in table showed that, fat content was found to be 2.80 per cent for cabinet drying, 3.00 per cent for foam mat drying and 3.20 per cent for spray drying. The fat content of foam mat dried powder were slightly higher than the cabinet whereas lower than the spray dried tomato powder. The high fat in spray dried powder was attributed to its lowest moisture content over cabinet and foam mat dried powder (Mozumder *et al.,* 2012) [11]. The crude fibers in tomato powder were obtained in the range from 9.2 to 9.86 per cent. Ash content of tomato powder 10.36 to 10.82 per cent. The variation in the values of ash and fat content could be attributed to drying method and degree of homogenization. The soluble solids of tomatoes are predominantly sugars, which in turn are important contributors to flavor. The starch content of tomato fruit depends upon maturity, cultivar and ripening conditions and varies from 1-1.22% in immature fruit to 0.1-15% in red ripe fruit. The texture of the fruit is satisfactory only when pectase, calcium and pectin are in sufficient quantities.

The chemical composition of fresh tomato fruits depends upon factors such as cultivars, maturity, light, temperature, season, climate, soil fertility, irrigation and cultural practices. The relative concentrations of the chemical constituents of tomato fruit are important in assessing the quality with respect to color, texture, appearance, nutrient value, taste and aroma. Similar results were also reported by Narsing Rao *et al.,* (2008) [12], who found that ash content of tomato was 10.72 g/100g, protein 12.65% and 9.78 g/100g.

3.1.5 Effect of drying on functional properties of tomato powder

Table 4: Effect of drying on functional properties of tomato powder

Sl. No	Parameter	Tray Drying method
1	WHC (g/g)	10.87 ± 0.50
2	WAC (g/g)	8± 0.50
3	OAC (g/g)	4.8 ± 0.50
4	Swelling capacity (ml/g)	2.56 ± 0.50

The water holding capacity refers to the amount of water the gel system retained within its structure without the application of any external force, except for gravity and atmospheric pressure, while the water absorption capacity refers to the amount of water, which remains bounded after application of external force such as centrifugation (Shanna *et al.,* 2002) [14]. The water holding capacity was observed highest in case of cabinet drying (10.87±0.50 g/g). It provides more information on the phytochemicals, which will help to understand their behaviour in foods (Adiotomre *et al.,* 1990 and Guillon and Champ, 2000) [5, 9].

3.1.6 Effect of drying on chlorophyll and carotene content of tomato powder

The chlorophyll content is essential to imparts green color and helps in growth and reproduction of tomato. The chlorophyll content was important to analyze as it effects on color characteristics and nutritional quality of finished products. The effect of drying methods on chlorophyll and carotene content were analyzed and obtained results were presented in Table 5.

Table 5: Effect of drying on chlorophyll, carotene and lycopene content of tomato powder

Parameter	Fresh tomato	Tray Dried tomato powder
Total Chlorophyll (mg/g)	1.5958	0.3401
Chlorophyll a (mg/g)	0.5614	0.1207
Chlorophyll b (mg/g)	1.0344	0.2194
Carotene (mg/g)	7.7266	5.5736
Lycopene (mg/g)	95.62	68.85

* Each value represents the average of three determinations

From Table 14, it was observed that the chlorophyll content was affected by the tray drying method. The total chlorophyll content in fresh tomato was found to be 1.5958 mg/g which were reduced in cabinet (0.3401 mg/g drying. It was concluded that, the chlorophyll content were found increasing trends. The fresh tomato had 0.5614 mg/g chlorophyll a and 1.0344 mg/g chlorophyll b contents. The chlorophyll a content in cabinet dried tomato powder was found to be 0.1207mg/g respectively. The chlorophyll b was highly retained in tray drying (0.2194 mg/g) as compare to spray (0.2996 mg/g) and foam mat (0.2560 mg/g) drying. It has also been reported that chlorophyll shows antioxidant activity, and it has been suggested that chlorophyll reduces free radicals by acting as a H+ donor to break the chain reaction that causes cellular oxidation. Thus, the increased concentration of phenolic compounds implies an increased antimicrobial activity.

The total lycopene content in fresh tomato was found to be 95.62 mg/g which were reduced in cabinet (68.85 mg/g) drying. Moreover, lycopene in raw tomatoes is present mainly as all-*trans*-lycopene. Heat treatment disintegrated tomato tissue and increased exposure to oxygen and light, which resulted in the destruction of lycopene (Shi and Le Maguer, 1999) [16]. These changes are mainly due to heat stress imposed by the relatively harsh thermal processes required to achieve the shelf-life stability of processed tomato products. In case of spray drying, high temperature and large amount of air dissolved in the tomato juice during the breaking and straining operations can quickly destroy substantial amounts of lycopene. The results suggest that length of heating is a critical factor controlling the degradation of lycopene

The results are in agreement with the findings of Sheshma and Raj (2014), who found that lycopene content of tomato juice were 86-100 µg/g which was reduced in solar (93.68 µg/g) and tray drying (76.45 µg/g).

4. Conclusion

Drying process was done at temperature of 55^0C for 7 to 8 hours. The treated samples were dried to bone mass stage ground in the grinder, Storage study was also carried out for a period of 2 months. Tomato powder was safe for consumption up to 2 months at ambient storage temperature, where it was packed in HDPE bag and stored at ambient temperature & were regularly tested for proximate composition and functional properties of dried tomato powder. The results indicated that moisture (6%), fat (3.9 %,) Ash (7.3 %), Vitamin C (125.00mg) and Lycopene (1.41%) etc. respectively.

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