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Effect of Foam Mat Drying on Physicochemical Properties of Tomato Powder

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Abstract—*Tomato is one of the most widely grown and consumed vegetables throughout the world. It is an important source of minerals, iron, beta-carotene pigments, and antioxidants such as lycopene, phenolics, and vitamins (A and C) and has been linked with reduced risk of cancer and other disease. The purpose of this study is to determine the effect of drying temperature and foaming agent for production of tomato powder using foam mat drying. Sample were prepared using tomato pulp with incorporation of foaming agent at 0.05, 0.1, and 0.15% w/w concentration. Foamed tomato pulp was then dried using tray dryer at temperature 60ºC and 70ºC. Foaming agent of concentration 0.1% with 5 min whipping time was found optimum for the foam production. Dried samples were then analyzed for various physicochemical quality parameters viz. titratable acidity, pH, total soluble solids (TSS), color change, ascorbic acid content, moisture, bulk & tapped density. So, this study focuses mainly on the optimization of the concentration of the foaming agent and effect of foam mat drying on the quality of dried tomato powder.*

1. INTRODUCTION

Tomato is widely cultivated plant belonging to *Solanaceae* family. Tomatoes contain minerals, vitamins, proteins, essential amino acids (leucine, threonine, valine, histidine, lysine, and arginine), monounsaturated fatty acids (linoleic and linolenic acids), carotenoids (lycopene and β-carotenoids) and phytoster-ols (β-sitosterol, campesterol and stigmasterol). Antioxidant present in tomato like lycopene has anticancer property reduces the risk of cancer. India is the second largest producer of tomato after china. Overall production of tomatoes in India is 20300.19 tons in 2021-2022 [1]. Due to high moisture content, it is highly perishable in nature which poses a big problem for its storage and transportation that causes heavy losses. It creates glut during the production season and becomes scanty during the off-season. To overcome these post-harvest losses, it has to be processed into different products like tomato ketchup, tomato puree, tomato powder, etc. for its availability in the off-season. Preservation of tomato by drying is a common practice. In drying the tomato is subjected to heat which lowers the water content and reduced the growth of enzyme and microbes and increase product stability [2]. It also reduces the cost of packaging, transportation and storage. Different drying methods such as sun drying, tray drying, microwave drying, hot air drying is used to dry the food products but due to high temperature and long drying time causes the loss of nutritional properties and physical properties such as colour, texture and appearance etc. Foam mat drying is a method of drying in which liquid and semi solid food products like juices, puree and paste are transformed into the stable foam by adding foaming agent and dried under the thin layer condition.

However, foam mat drying has several advantages over other drying method. It is a relatively gentle process that can preserve the colour, flavour, and nutritional value of the food product because due to foaming it reduces the density of raw food material and drying time. Many researchers found that the drying rate will be faster due to the increased interfacial area of foamed materials [3]. It was found that the biochemical composition of foam mat dried powder was maximum than non-foam dried powder. Foam mat dried powder has almost similar flavour, colour and nutrients value like fresh sample. This study was carried out to select foaming agent concentration and evaluate the effect of different drying temperature on the physiochemical properties of foam mat dried powder.

2. MATERIALS AND METHODS

2.1 Sample Preparation of Tomato Pulp Foam

Tomato was washed under running tap water to remove unwanted material. After washing tomato was boiled in the hot water about 8 mins followed by dipping in cold water to loosen the skin and then skin was removed. After tomatoes peeling, cut into the halves to remove the seeds and after that it transfer into the mixer converted into pulp.The flow chart for the preparation of foam mat tomato powder is shown in Figure 1.Foaming is done by adding xanthan gum as a foaming agent in different concentration during whipping. An amount of 100 ml tomato pulp was taken for each sample along with the selected concentration of xanthan gum (0.05%, 0.1%, and 0.15%). Then the mixture was whipped at the whipper for 5 mins at maximum speed. After whipping the foamed tomato pulp was obtained.

2.2 Foaming Properties

The efficiency of foaming agent to convert the tomato pulp into stable foam was optimized by evaluating various foaming properties.

2.2.1 Foam Density (FD)

The density of the foamed tomato pulp was calculated as ratio of mass of foam to the volume of foam and expressed as g/cm^3 [4]. The density of tomato pulp was determined by weighing 100 ml of the pulp in a 100 ml measuring cylinder whereas for the foamed tomato pulp, 200 ml of foam was transferred into a 250 ml measuring cylinder and weighed.

The foam transferring was carried out carefully to avoid destroying the foam structure or trapping the air voids while filling the cylinder. The foam density was calculated using the following formula:

$$\text{Foam Density } (g/cm^3) = \frac{\text{mass of the foam (g)}}{\text{volume of the foam (cm}^3)}$$

2.2.2 Foam Expansion (FE)

It is the percentage increase of the volume of the pulp after foaming with required amount of the foaming agent and whipping time. The foam quality of foamed tomato pulp in terms of foam expansion was calculated according to the following equation [5]:

$$\text{Foam expansion } (\%) = \frac{V_1 - V_0}{V_0} \times 100$$

Where,
V_0= initial volume of tomato pulp before foaming (cm^3),
V_1= final volume of tomato pulp after foaming (cm^3).

2.2.3 Foam Stability (FS)

50 ml of foamed tomato pulp was placed in a 50 ml glass tube and kept undisturbed at normal atmosphere for 2 hours [6]. Then the decrease of the foam volume was noted after every 30 minute time interval. The reduction of the foam volume was noted to be used as an index for the determination of the stability after every 30 minutes by using following formula:

$$\text{Foam stability } (\%) = \frac{V_0}{V_1} \times 100$$

Where,
V_0= initial volume of tomato pulp before foaming (cm^3),
V_1= final volume of tomato pulp after foaming (cm^3).

2.3 Drying of Tomato Pulp Foam

The foamed tomato pulp is poured in a tray and placed in a tray dryer at 60°C, 65°C and 70°C for drying. After drying the dried tomato pulp was grinded to form powder and sieved by 80 mesh sieved to obtain fine powder.

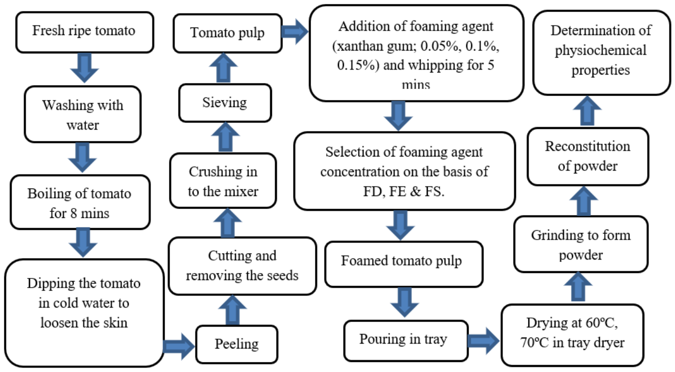

Figure 1 Flow chart of preparation of foam mat dried tomato powder.

2.4 Physicochemical Properties

The tomato powder was reconstituted to check the physiochemical properties. For reconstitution 2 gm of powder was mixed in 50 ml distill water in 100 ml glass beaker in room temperature and the mixture was agitated with the vortex at high speed. After reconstitution the sample was used to determine the amount of ascorbic acid, lycopene, titratable acidity, pH, TSS, DPPH, color, bulk and tapped density.

2.4.1 Vitamin C

Vitamin C was determined using a HPLC method (Hypersil ODS column (250 × 4.6 mm) of particle size 5 µm; mobile phase: HPLC grade water with metaphosphoric acid of pH 2.2; detection at 245 nm; calibrated by external standard solution of L-ascorbic acid [7].

2.4.2 pH

The pH value of tomato powder was determined following the [8] official method using the digital pH meter which was calibrated with distilled water, between pH 7 and pH 14.

2.4.3 Titratable Acidity

Titratable acidity was determined according to [9] by titrating 50 ml of the homogenate samples against 0.1 N NaOH. First, the distilled water (1 L) used for titration was titrated with 0.1 N NaOH, and the volume of 0.1 N NaOH consumed by water titration was considered a blank. The volume of 0.1 N NaOH used for titration of the sample was noted and after correcting the blank, the percentage of citric acid is calculated by using following formula:

$$\textit{Citric acid}(\%) = \frac{V \times 0.0064 \times 100}{W}$$

2.4.4 Total Soluble Solids

Determination of total soluble solid (TSS) was followed by the method described by [10] with some modification. 1.0 g of tomato powder dissolved in 25ml distilled water. Then, the TSS was determined with the help of digital refractometer (HI96801) and was expressed as Brix (B) at room temperature. The measurement repeated three times and average values were taken.

2.4.5 DPPH Radical Scavenging Activity

The DPPH of tomato powder was determined according [11] with some modification. To make methanol extract, 2.5 gm tomato powder was dissolved in 10 ml of 70% methanol in a conical flask. The mixture was the vortex shaker. Then the mixture was centrifuged at 3500 rpm with a centrifuge for 15 min and filtered with whatman No. 1 filter paper. After that 1 ml of extracted sample was taken in a test tube with 4 ml DPPH solution and shaken, and then the sample was kept in dark room for 30 mins. Absorbance was notice at 515 nm at a UV- spectrophotometer. DPPH solution was taken as a control. Scavenging activity was calculated by following formula.

$$\%\, scavenging\ of\ DPPH = \frac{1 - Absorbance\ of\ sample\ \times 100}{Absorbance\ of\ control}$$

2.4.6 Bulk and Tapped Density

Bulk density was determined by loading 20 g of the powder into a 100 mL graduated cylinder.

The volume occupied by the powder was measured without tapping the container. The tapped density was determined by tapping the loaded cylinder 10 times onto a rubber mat from a height of 15 cm and the final volume was recorded for further calculations [12]. The bulk density and tapped density were calculated using the following formula:

$$Bulk\ density(\rho_B) = \frac{Mass\ of\ tomato\ powder, gm}{Volume\ of\ tomato\ powder, cm^3}$$

$$Tapped\ density(\rho_T) = \frac{Mass\ of\ tomato\ powder, gm}{Final\ tapped\ volume, cm^3}$$

2.4.7 Color

The color of tomato powder was assessed using a handheld colorimeter (Lovibond LC-100 Spectrocolorimeter) with illuminant C and 2degree observer and 8 mm aperture. The CIE L*a*b* color space was used for the determination of color parameters. The L*, a*, and b* values represent "lightness" with a range from 0 (black) to 100 (white), "redness" or "greenness" with a range from 260 (green) to 160 (red), and "yellowness" or "blueness" with a range from 260 (blue) to 160 (yellow), respectively. Three samples were tested to determine the mean L*, a*, and b* values, and for each one, three readings were taken at different a* b* color measurements.

2.5 Statistical Analysis

All drying experiments were conducted in triplicate and expressed in terms of mean and standard deviation.

3. RESULT AND DISCUSSION

3.1 Selection of Foaming Agent Concentration

Foam properties like foam density, foam expansion and foam stability were studied and on the basis of these properties, selection of concentration of foaming agent was done. It was found that the foam density and foam stability increased with the increase in concentration of foaming agent, while foam expansion increased upto 0.1% and decreased beyond it. Moreover, it has been reported that the optimum foam density for foam mat dried powder should range between 0.2 to 0.6 g/cm^3. Results indicated that xanthan gum with 0.1% had nearly optimum foam density (0.698 g/cm3) and maximum foam expansion (30%). Thus, 0.1% of foaming agent concentration with 5 min whipping time was selected for the foam preparation.

Table 1. Selection of foaming agent concentration on the basis of foaming properties.

Conc. of foaming agent (%)	FD (g/cm^3)	FE (%)	FS (%)
0.05	0.667	20	90.40
0.10	0.698	30	98.30
0.15	0.815	15	98.31

3.2 Effect of drying temperature on physicochemical properties

Total soluble solids (TSS), pH, Vitamin C, titratable acidity (TA), moisture, DPPH, Bulk (ρ_B) & tapped density (ρ_T) of reconstituted powder at different drying temperature are presented in Table 2. TSS of reconstituted powder varied from 3.86 to 4.5ºBrix. It was found that TSS content in foam mat dried powder decreased with the increase of temperature because of the reduction of some heat sensitive components present in the powder. Similar results have been reported in foam mat dried tomato powder [13] and mango powder [14]. The pH of foam mat dried tomato powder is inversely related to the drying temperature. pH ranged between 4.5 to 4.7 for foam mat dried powder, as it decreased with the increasing temperature, as with the rise in temperature, molecular vibrations increases resulting in reduced aptitude of formed hydrogen and thus subsequently resulted in reduced pH of the reconstituted powder. Ascorbic acid of foam mat dried reconstituted powder also decreased with increasing temperature. The range of ascorbic acid of reconstituted powder was 2.65 to 3.02. This indicated that heat sensitive ascorbic acid decreased with rise in temperature. It has been found that hot air drying of tomato reduces the ascorbic acid content significantly at high temperature [15]. Similar types of results were also found by other researchers for passion fruit aril [16], pulses [17], muskmelon [18] and foam mat dried mango powder [19] following heat treatment. It was observed that titratable acidity of foam mat dried tomato powder was increased with increasing temperature because high drying temperature increased molecular vibrations which reduce formation of hydrogen bond hence increases the acidity of tomato powder. The range of TA was 0.38 to 0.42. Additionally, moisture of powder decreased with increasing temperature, while DPPH of reconstituted powder increased with increasing temperature. DPPH of the reconstituted powder ranged between 58.42 to 66.47%. These results also support the findings by other researchers [20, 21]. The bulk density of foam mat dried tomato powder varied between 0.4598 to 0.4890 gm/cm³ whereas the tapped density ranged from 0.6598 to 0.6395 gm/cm³. Also, the density was found to decrease with increase in temperature. The reduction in density of the dried powder is attributed to the rapid moisture removal at higher drying temperature [22]. Similar kinds of results were also observed for drying of tamarind powder using drum drier [23].

Table 2: Effect of drying temperature on physicochemical properties of tomato powder.

Quality parameters	60°C	65°C	70°C
TSS	4.5±0.08	4.0±0.07	3.86±0.04
pH	4.7±0.05	4.65±0.06	4.5±0.09
Vitamin C	3.02±0.06	2.86±0.05	2.65±0.07
TA	0.38±0.08	0.4±0.07	0.42±0.09
Moisture	3.20±0.07	2.95±0.05	2.60±0.08
DPPH	58.42±0.12	63.54±0.18	66.47±0.15
ρ_B	0.4890±0.0002	0.4688±0.0003	0.4598±0.0001
ρ_T	0.6589±0.0003	0.6498±0.0001	0.6395±0.0002

3.3 Effect of drying temperature on color

Color is the one of the most important property of food products as it greatly affects the consumer acceptance; tomato powder is used in various food products such as tomato sauce, puree, ketchup etc. Result indicated the decreasing trends after drying of the tomatoes powder, maximum L* value was found in 60°C and continuously decreases as drying temperature increases. L value ranged from 61.4 to 63.5.The reduction in the L value maybe correlated with the formation of brown pigment during drying [24]. The values of a and b also decreased with increase in drying temperature. Carotenoid degradation and Maillard reaction may also cause colour change during drying [25, 26].

Table 3:Effect of drying temperature color of tomato powder

Drying temperature (°C)	Color values*		
	L	a	b
60	63.5±1.5	23.5±1.2	37.2±1.7
65	62.0±1.8	22.8±1.1	36.5±1.3
70	61.4±1.4	21.5±1.1	35.0±1.4

4. CONCLUSION

In this study xanthan gum was used as a foaming agent. The foaming parameters such as concentration of xanthan gum were optimized to obtain foam with low density, high expansion and stability. The tomato foam prepared was dried at three levels of temperature to obtain tomato powder. The high temperature has negative impact on the quality of the prepared powder. Based on the maximum retention of physiochemical properties, the optimum combination of foaming agent and temperature was found 0.1% at 60°C. Based on this study; we can conclude that foam mat dried tomato powder could be an excellent alternative to tomato preservation.

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