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RESEARCH PAPER
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Studies on drying and drying characteristics of tomato

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SUMMARY :

Dehydrated tomato products (pieces, slices) were prepared to study the effect of drying time on moisture content and drying rate. The tomato pieces and slices (5, 10, 15 mm thick) were treated with citric acid (0.1%) and NaCl (2%) and further dried in tray dryer (55 ± 2°C). Another sample was prepared by removing peel and cutting into pieces further dried in tray dryer at 55 ± 2°C. Drying curves were plotted and drying behaviour was studied. Total drying time of 12 to 28 h was required to dry the material to about 7 to 8.1 per cent, d.b. moisture content. Drying rate varied between 919.48 to 0.84 g/100 g for all tomato products. Drying of tomato pieces/slices was followed in the falling rate period. Dehydration ratio varied between 15.5:1 and16.9:1 for all dehydrated tomato products.

KEY WORDS : Tomato, Drying, Drying rate, Drying curves, Moisture content

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Tomato (*Lycopersicon esculentum* Mill.) is one of the most important protective food crops among the solanaceous fruit vegetables and occupies an outstanding place among the important vegetables in the world (Nithya and Premalatha, 2006). Tomatoes probably originated in the Peru-Equador region and are now in most climatic zones in Africa, tropical Asia, tropical America and the tropics (Kroll, 1997). In India it is grown in 0.458 M ha area with 7.277 Mt production and 15.9 Mt/ha productivity. The major tomato producing states are Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh and West Bengal (Anonymous, 2015). Tomato is known as protective as well as productive food because of its nutritive value and of its widespread production. It is a rich source of minerals, vitamins and organic acid, essential amino acids and dietary fibres (Anonymous, 2005). Bhosale (2000) reported that tomatoes are used for soup, salad, pickle, ketchup, puree, sauces and in many other ways. Use of tomato in daily diet either fresh or in the form of processed products helps to make good deficiencies of vitamins and minerals in human body. In the developed countries, 80 per cent of the fresh tomatoes are processed into varied products (Pathak and Mahajan, 1978). Being a climacteric and perishable vegetable, tomatoes have a very short life span, usually 2-3 weeks. Tomatoes are consumed widely throughout the world and their consumption has recently been demonstrated to possess health benefits because of their rich content of phytonutrients (Levy and Sharoni, 2004 and Hsu *et al.*, 2008). Epidemiological studies suggest that intake of tomatoes or processed tomato products in particular lowers the risk of prostate cancer

(Giovannucci *et al.*, 1995 and Campbell *et al.*, 2004).

Drying removes the moisture from tomato concentrating its flavour and bringing out its berry like essence (Anonymous, 2004). It inhibits the growth of micro-organisms in storage over fairly extended period. The preservation of foods by drying is based upon the fact that micro-organisms and their enzymes require optimal water content for their activity. In this method, the moisture content of foods is lowered to a point where the activities of food spoilage and pathogenic microorganisms are arrested (Gupta, 2006). Dried tomatoes because of its longer life and stability are found in many dry mixes such as soups and rices. Dried pieces and slices after rehydration can be used in salads, pizza and sandwiches. Many times due to glut in the market there is wastage of tomato. To overcome this problem drying of tomato is very useful. In view of this present study on drying of tomato was undertaken.

EXPERIMENTAL METHODS

Sample preparation :

The fully matured tomatoes were cleaned and graded manually to get uniform size and washed under tap water to remove the contaminants. They were further cut in to pieces (quadruplicate) and slices (5, 10 and 15 mm). The prepared samples (pieces and slices) were treated with 0.1 per cent citric acid and 2 per cent sodium chloride (Lewicki and Michaluk, 2004 and Baloch *et al.*, 1997). Another sample of peeled pieces was also prepared. For removal of peel tomatoes were blanched in boiling water for 2 min. After blanching peel was removed and tomatoes were cut into four pieces. The samples without treatment were taken as control.

Drying :

The pretreated samples were further dried in a tray dryer. The samples were placed in a single layer on the trays and drying was done at 55 ± 2°C. Moisture content of the samples was determined by standard oven method. The per cent moisture content was calculated by using following equation.

$$M_d = \frac{W_1 - W_2}{W_2} \times 100$$

where,

M_d = Moisture content, per cent dry basis

W_1 = Weight of wet sample, g

W_2 = Weight of bone dry sample, g

Drying characteristics :

Drying curves of moisture content vs. drying time, drying rate vs. drying time and drying rate vs. moisture content were plotted. Drying rate was calculated by using the equation given by Chakraverty and De (1981).

$$\text{Drying rate} = \frac{\text{Amount of moisture removed}}{\text{Time takne (h)} \times \frac{\text{Total bone dry weight of sample (g)}}{100}}$$

The drying rate, R was expressed as g of water removed/100 g bone dry matter_h.

Dehydration ratio :

Dehydration ratio was determined by using following equation.

$$\text{Dehydration ratio} = \frac{\text{Weight of raw material (g)}}{\text{Weight of dehydrated material (g)}}$$

EXPERIMENTAL FINDINGS AND ANALYSIS

The dehydrated tomato pieces could be obtained by drying for 28 h. The dehydrated tomato slices of 5, 10, 15 mm thick could be obtained by drying them for 12, 16, 22 h, respectively.

Drying behaviour of tomato products :

Drying curves between drying time and moisture content, drying time and drying rate and moisture content and drying rate were plotted and shown in Fig. 1 through Fig. 9.

Moisture content :

The initial moisture content of tomato pieces/slices was 1666.78 per cent, d.b. (94.34%, w.b.). They were dried upto moisture content 6.70 to 8.18 per cent, d.b. Upto about 10 hr drying period the decrease in moisture content was faster. Thereafter, it became slower. Reduction in moisture content of tomato products was observed faster in case of 5 mm thick slices compared to 10 mm thick and 15 mm thick slices. Reduction in moisture content of pieces was found slower compared to slices (Fig. 1 to 3). Reduction in moisture content was found faster in case of peeled pieces as compared to unpeeled pieces. All these curves show decreasing trend exponentially. There is no effect of pre-treatment (citric acid/NaCl) on reduction of moisture content. The total drying time of 24, 28, 12, 16 and 22 hr was seen for drying of peeled pieces, unpeeled pieces, 5, 10 and 15

mm thick slices, respectively.

Drying rate :

The drying rate was faster upto about 10 hr drying period. Thereafter it becomes slower. In case of 5 mm thick slices drying rate was found faster compared to 10 and 15 mm thick slices. The drying rate of pieces was found slower compared to slices (Fig. 4 to 6). In case of peeled pieces drying rate was faster as compared to unpeeled pieces (Fig. 4b). All these curves are exponential in nature. There is no effect of pre-treatment (citric acid/NaCl) on drying rate.

Falling rate period of drying :

Drying rate was decreased with decrease in moisture content for all the products. It is also seen that

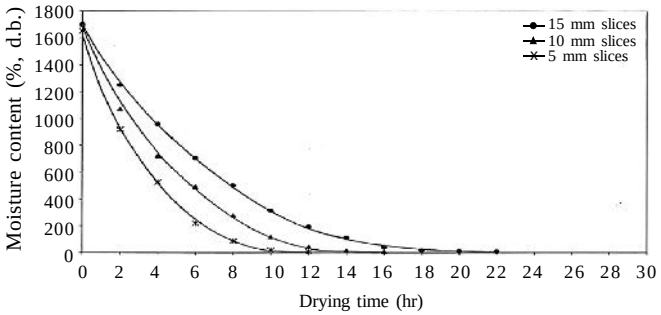

Fig. 1 (a) : Effect of drying time on moisture content of slices (control)

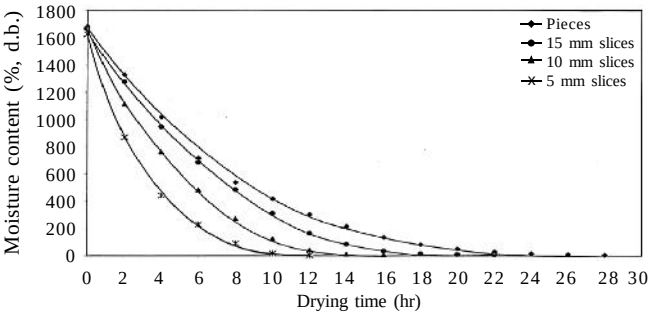

Fig. 2 : Effect of drying time on moisture content (citric acid treatment)

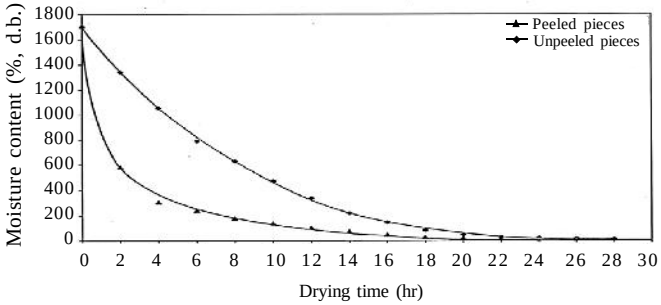

Fig. 1 (b) : Effect of drying time on moisture content of pieces (control)

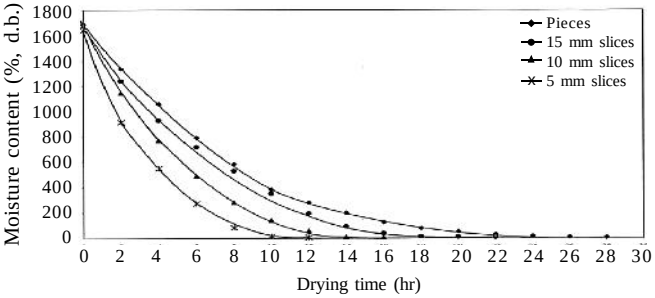

Fig. 3 : Effect of drying time on moisture content (NaCl treatment)

Table 1 : Drying time, moisture content and dehydration ratio of dehydrated tomato products

Product No.	Product	Treatment	Total drying time (h)	Moisture content (%, d. b.)	Dehydration ratio
CP_1	Pieces (peeled)	Blanching + peeling + 4 pieces of full tomato	24	7.65	16.3:1
CP_2	Pieces (unpeeled)	4 pieces of full tomato	28	8.10	15.6:1
CP_3	Slices	5 mm thick	12	7.52	16.8:1
CP_4	Slices	10 mm thick	16	7.91	16.4:1
CP_5	Slices	15 mm thick	22	7.89	16.3:1
T_1P_6	Pieces (unpeeled)	4 pieces of full tomato + citric acid (0.1%)	28	7.46	15.7:1
T_1P_7	Slices	5 mm thick + citric acid (0.1%)	12	7.10	16.9:1
T_1P_8	Slices	10 mm thick + citric acid (0.1%)	16	7.55	16.6:1
T_1P_9	Slices	15 mm thick + citric acid (0.1%)	22	7.63	16.3:1
T_2P_{10}	Pieces (unpeeled)	4 pieces of full tomato + NaCl (0.1%)	28	7.85	15.5:1
T_2P_{11}	Slices	5 mm thick + NaCl (2%)	12	7.46	16.7:1
T_2P_{12}	Slices	10 mm thick + NaCl (2%)	16	7.67	16.4:1
T_2P_{13}	Slices	15 mm thick + NaCl (2%)	22	8.07	16.2:1

the drying was followed in falling rate period of drying for all the products. The drying behaviour differs significantly in case of pieces and slices. There is no much effect of treatment (citric acid/NaCl) on drying.

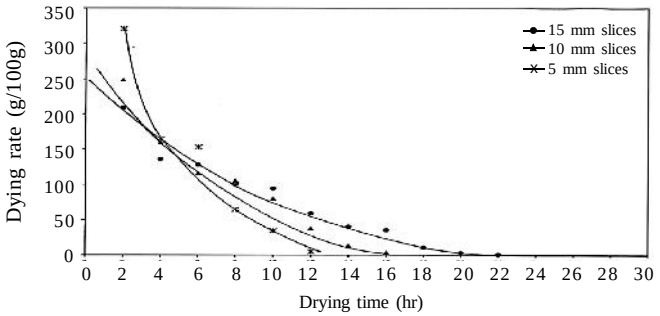

Fig. 4 (a): Effect of drying time on drying rate of slices (control)

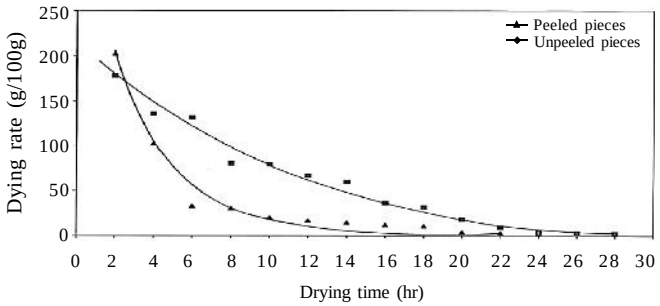

Fig. 4 (b): Effect of drying time on drying rate of pieces (control)

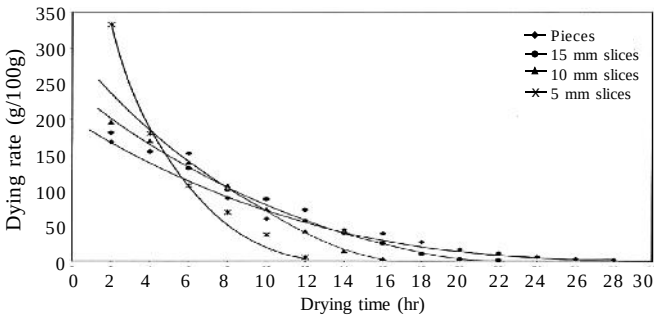

Fig. 5 : Effect of drying time on drying rate (citric acid treatment)

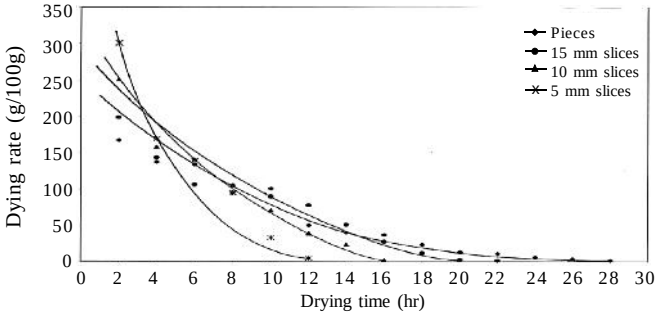

Fig. 6 : Effect of drying time on drying rate (NaCl treatment)

Dehydration ratio of dehydrated tomato products:

The dehydration ratio of different dehydrated tomato products was assessed and was found between 15.5:1 and 16.9:1 (Table 1).

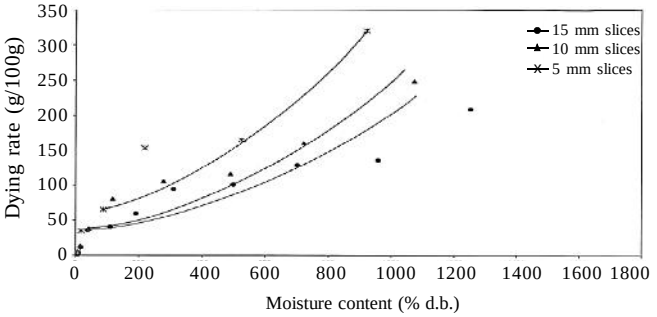

Fig. 7 (a): Effect of moisture content on drying rate of slices (control)

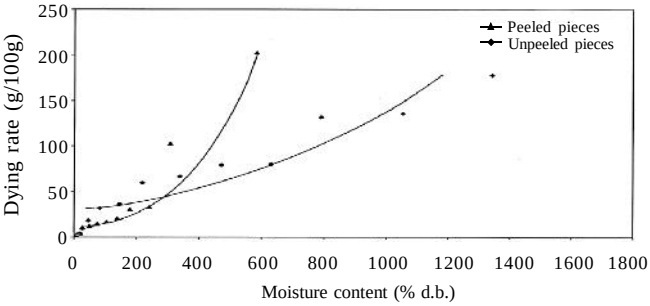

Fig. 7 (b): Effect of moisture content on drying of pieces (control)

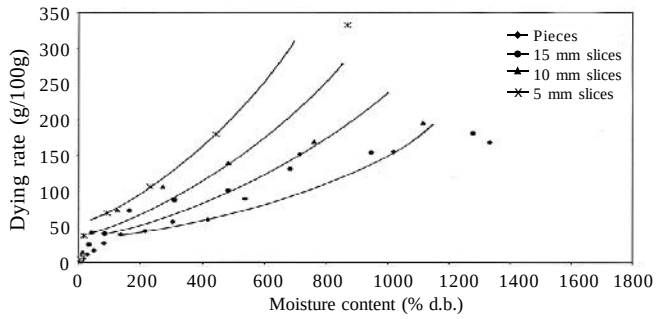

Fig. 8 : Effect of moisture content on drying rate (citric acid treatment)

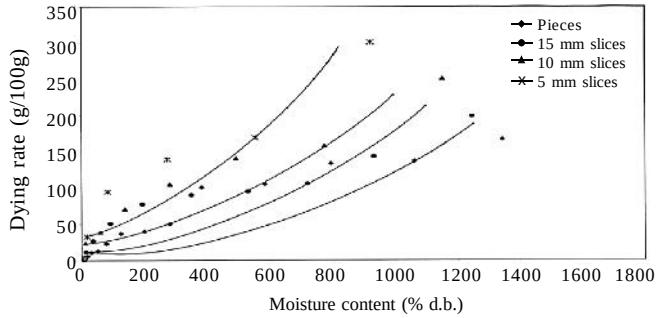

Fig. 9 : Effect of moisture content on drying rate (NaCl treatment)

Conclusion :

– Total drying time of 28, 24, 22, 16 and 12 hr was required for drying of unpeeled pieces, peeled pieces, 15 mm, 10 mm and 5 mm thick slices, respectively.

– Moisture content of dehydrated tomato products was found in the range between 7.10 and 8.10 per cent d.b.

– Drying rate varied between 919.48 to 0.84 g/ 100 g for all tomato products.

– Drying of tomato pieces/slices was followed in the falling rate period of drying.

– Dehydration ratio was varied between 15.5: 1 and 16.9: 1 for all tomato products

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