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Drying characteristics of chemical treated slit green chillies under different dryer

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Abstract
Chilli is a highly perishable vegetable with a short shelf-life and commonly encountered postharvest problems; to deal such problems, drying was done using tray dryer and hot air oven. Three different temperatures (50, 60 & 70 °C) use in both dryers. Before drying chillis were slitted and treated with Butylated hydroxyanisole and Potassium Carbonate solution. Overall drying rate increased with temperature in both dyers. Drying of dipsol green chilli took place in falling rate period. Initial moisture content of the green chilli was an average of 84.20±1 % w.b.

Keywords: dipsol slit green chilli, drying, tray dryer, hot air oven, moisture content, moisture ratio & average drying rate

Introduction
Chili (*Capsicum annuum* L.) is a spice, a fruit vegetable widely cultivated in the world and which importance in human food is capital (Dias *et al.*, 2013; Wahyuni *et al.*, 2013) [2, 10]. Chillies are cultivated mainly in tropical and sub-tropical countries like India, Japan, Mexico, Turkey, United States of America and African countries (Panda, 2010) [6]. It is grown for its pungent fruits which are used both as green and ripe to impart pungency and flavour to the food. Pungency, one of the important attributes of *Capsicum* species is due to the presence of alkaloid 'capsaicin' in the fruit. It is used primarily in the flavouring of pickles, meats, barbecue sauces, ketchup, cheese, snack food, dips, chilli cake, salads, and sausages (Pugalendhi *et al.*, 2010) [7]. In India, only two species viz. *Capsicum annum* and *Capsicum frutescens* are known and most of the cultivated varieties belong to the species *Capsicum annum* (Pal *et al.*,2008) [7]. Chilli was introduced in India by the Portugese in Goa in the middle of 17th century and since then it had rapidly spread throughout the country (Topuz and Ozdemir, 2007) [9]. Throughout the world, chili is consumed fresh, dried or in powder (El-Ghoraba *et al.*, 2013) [3]. It is rich in proteins, lipids, carbohydrates, fibres, mineral salts (Ca, P, Fe) and in vitamins A, D3, E, C, K, B2 and B12 (El-Ghoraba *et al.*, 2013) [3]. The fruits are an excellent source of health-related phytochemical compounds, such as ascorbic acid (vitamin C), carotenoids (provitamin A), tocopherols (vitamin E), flavonoids, and capsaicinoids that are very important in preventing chronic diseases such as cancer, asthma, coughs, sore throats, toothache, diabetes and cardiovascular diseases (El-Ghoraba *et al.*, 2013; Wahyuni *et al.*, 2013) [3, 10].
The most important reasons for popularity of dried products are longer shelf-life, product diversification as well as substantial volume reduction to decrease transportation cost. This could be further expanded by improvements in product quality and process applications (Simal *et al.*, 1997) [8]. Lantz (1946) [4] reported that slicing or slitting pods of red chilli reduced the drying time by half, and there was no loss of initial color. Lease and Lease (1962) carried out an experiment on whole and sliced pods and found that drying of sliced pods reduced the drying time by 50% and superior initial color was obtained.

Materials and Methods
The main objective of this experiment is to study the drying characteristics of dipsol slit green chillis. The experiments were carried out in the Food Processing Laboratory of the department of agricultural engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250110, (U.P.) India.

Drying Methods: The chilli samples were treated with Butylated hydroxyanisole and Potassium Carbonate solution than dried using tray dryer and hot air oven at three different temperatures, viz. (50, 60 & 70 ℃).

Cabinet tray dryer: A Cabinet type mechanical tray dryer (Industrial Dryer, M/s Navyug Udhyog Pvt. Ltd Ambala) was used to conduct drying experiment. The heating air circulated inside the cabinet with the help of circulating fan. The thermostatic controller (50-250 ℃) is attached with the heating unit to control the desired temperature for the drying experiment.

Hot air oven drying: The chilli samples were kept on hot air oven at 60, 70, 80±5 °C till no further weight loss occurred. Hot air oven (Instron, IN-301 Model) used is a double walled chamber of size 78×27×116 (in centimeter). Outer chamber is made of stainless steel. Hot air ovens are electrical devices used in sterilization. The oven uses dry heat to sterilize articles. Generally, they can be operated from 50 to 300 ℃ (122 to 572 °F).

Drying characteristics analysis

Moisture content: Moisture content and total solids will be determined by method of AOAC (1990) [2]. The moisture content (% W.B.) of sample was calculated by using following equation:

$$\text{M C\% (w. b.)} = \frac{(\text{initial weight} - \text{final weight})}{\text{initial weight}} \times 100$$

Measurement of Moisture ratio: Moisture ratio (MR) will be calculated as follows:

$$\text{MR} = \frac{\text{M} - \text{M}_\text{e}}{\text{M}_\text{a} - \text{M}_\text{e}}$$

Where

M_e - Equilibrium moisture content, %db

M - Moisture content at any time, %db

M_a - Moisture content at the start of drying, %db

Average drying rate: The average drying rates at different times were computed using formula suggested by Mishra (1991) [6].

Result and Discussion

Results of Dipsol slit green chillis drying with tray dryer and hot air oven at three different temperatures, are presented in following heads. Samples were dried until they stop loosing moisture. Moisture content (wb %), dehydration ratio and average drying rate was measured. Dehydration ratio is an important factor, which shown bulk reduced in weight of the sample.

Drying characteristics in tray drying: Dipsol slit Green chilli dried using tray dryer at three different temperature viz. 50, 60 & 70 ºC.

Moisture content (wb %) ranges from 84.20 to 6.78 at 50 ºC. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 2.37 to 0.01 respectively after 540 minute. (Table 1). At 60 ºC, moisture content (wb %) ranges from 84.20 to 7.66. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 1.98 to 0.03 respectively after 540 minute. (Table 2). Moisture content (wb %) ranges from 84.20 to 7.66 at 70 ºC. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 2.24 to 0.02 respectively after 480 minute. (Table 3).

Table 1: Drying characteristics behavior of dipsol slit chilli at 50 ^{0}C under cabinet tray dryer.

Time (MIN)	MC (wb) %	MC (db) %	Moisture ratio	Average drying rate
0	84.20	532.91	1.00	
60	79.61	390.51	0.73	2.37
120	72.52	263.92	0.49	2.11
180	60.50	153.16	0.28	1.85
240	34.17	51.90	0.08	1.69
300	22.93	29.75	0.04	0.37
360	10.99	12.34	0.01	0.29
420	9.46	10.44	0.01	0.03
480	7.06	7.59	0.00	0.05
540	6.78	7.28	0.00	0.01

Table 2: Drying characteristics behavior of dipsol slit chilli at 60 ^{0}C under cabinet tray dryer.

Time (MIN)	MC (wb) %	MC (db) %	Moisture ratio	Average drying rate
0	84.20	532.91	1.00	
60	80.54	413.92	0.77	1.98
120	75.35	305.70	0.57	1.80
180	68.40	216.46	0.40	1.49
240	59.23	145.25	0.26	1.19
300	45.33	82.91	0.14	1.04
360	21.00	26.58	0.03	0.94
420	12.22	13.92	0.01	0.21
480	9.00	9.89	0.00	0.07
540	7.66	8.29	0.00	0.03

Table 3: Drying characteristics behavior of dipsol slit chilli at 70 ^{0}C under cabinet tray dryer.

Time (MIN)	MC (wb) %	MC (db) %	Moisture ratio	Average drying rate
0	84.20	532.91	1.00	
60	79.94	398.42	0.74	2.24
120	74.20	287.66	0.53	1.85
180	64.89	184.81	0.34	1.71
240	49.84	99.37	0.18	1.42
300	26.51	36.08	0.06	1.05
360	12.22	13.92	0.02	0.37
420	8.71	9.54	0.01	0.07
480	7.66	8.29	0.00	0.02

Drying characteristics hot air oven drying: Dipsol slit Green chilli dried using hot air oven dryer at three different temperature viz. 50, 60 & 70 ºC.

At 50 ºC moisture content (wb %) ranges from 84.20 to 13.42. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 1.56 to 0.05 respectively after 660 minute (Table 4). Moisture content (wb %) ranges from 84.20 to 11.73 at 60 ºC. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 1.61 to 0.03 respectively after 660 minute (Table 5). At 70 ºC, moisture content (wb %) ranges from 84.20 to 11.73. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 2.05 to 0.04 respectively after 600 minute (Table 6).

Table 4: Drying characteristics behavior of dipsol slit chilli at 50 ^{0}C under Hot Air oven.

Time (MIN)	MC (wb) %	MC (db) %	Moisture ratio	Average drying rate
0	84.20	532.91	1.00	
60	81.47	439.56	0.82	1.56
120	78.21	358.86	0.66	1.34
180	73.83	282.12	0.52	1.28
240	68.15	213.92	0.38	1.14
300	60.00	150.00	0.26	1.07
360	48.32	93.51	0.15	0.94
420	39.23	64.56	0.09	0.48
480	30.55	43.99	0.06	0.34
540	20.60	25.95	0.02	0.30
600	15.73	18.67	0.01	0.12
660	13.42	15.51	0.00	0.05

Table 5: Drying characteristics behavior of dipsol slit chilli at 60 ^{0}C under Hot Air oven.

Time (MIN)	MC (wb) %	MC (db) %	Moisture ratio	Average drying rate
0	84.20	532.91	1.00	
60	81.36	436.39	0.81	1.61
120	78.28	360.44	0.67	1.27
180	74.27	288.61	0.53	1.20
240	69.05	223.10	0.40	1.09
300	62.16	164.24	0.29	0.98
360	52.91	112.34	0.19	0.86
420	40.38	67.72	0.10	0.74
480	29.78	42.41	0.06	0.42
540	17.60	21.36	0.02	0.35
600	13.19	15.19	0.00	0.10
660	11.73	13.29	0.00	0.03

Table 6: Drying characteristics behavior of dipsol slit chilli at 70 ^{0}C under Hot Air oven.

Time (MIN)	MC (wb) %	MC (db) %	Moisture ratio	Average drying rate
0	84.20	532.91	1.00	
60	80.39	409.97	0.76	2.05
120	76.04	317.41	0.58	1.54
180	69.37	226.42	0.41	1.52
240	62.04	163.45	0.29	1.05
300	51.01	104.11	0.17	0.99
360	35.51	55.06	0.08	0.82
420	26.51	36.08	0.04	0.32
480	17.92	21.84	0.01	0.24
540	13.42	15.51	0.00	0.11
600	11.73	13.29	0.00	0.04

Conclusion

During drying of slit green chillies it took about 60 minute less time at 70 ºC as compare to 50 and 60 ºC to dry the sample completely in both type of dryer i.e. tray dryer and hot air oven. Hot air oven took more time to dry the sample as compare to tray dryer, which means that more moisture transfer took place in the case of tray drying than hot air oven drying.

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