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Drying characteristics of 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. Overall drying rate increased with temperature in both dyers. Drying of 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: green chilli, drying, tray dryer, hot air oven, moisture content, moisture ratio & average drying rate

Introduction
Chilli (*Capsicum annum* L.) from family Solanaceae, is one of the universal spices and is grown in almost all states of India for domestic market and export purpose. The native home of chilli is considered to be Mexico with secondary origin of Guatemala (Sigge *et al.*, 2001) [8]. 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 Portuguese in Goa in the middle of 17th century and since then it had rapidly spread throughout the country (Topuz and Ozdemir, 2007)[9]. Major chilli growing countries are India, China, Indonesia, Korea, Pakistan, Egypt, Mexico, USA, Italy and Hungary. Andhra Pradesh is the largest producer of chilli in India and contributes about 26 per cent to the total area under chilli, followed by Maharashtra (15%), Karnataka (11%), Orissa (11%), Madhya Pradesh (7%) and other states contributing nearly 22 per cent to the total area under chilli (Akpinar, 2002) [1]. Chilies are excellent source of Vitamin, A, B, C and E with minerals like molybdenum, manganese, folate, potassium, thiamin, and copper. Chili contains seven times more vitamin C than orange. It prevents the heart disease by dilating blood vessels.
Drying is defined as the process of moisture removal due to simultaneous heat and mass transfer. Moreover it's one of the oldest methods of food preservation (Gupta *et al.*, 2002) [4]. Chilli is very sensitive to temperature. Normally, conventional hot air drying temperature is maintained between 50-70°C. Due to the long drying process, the problem of darkening of colour, loss in flavor and decrease in rehydration ability occurs. Longer shelf life, product diversity and substantial volume reduction are the reasons for popularity of dried fruits and vegetables and this could be expanded further with improvements in product quality and process applications (Jasim and Shivare, 2001) [5]. To prevent significant quality loss and to achieve fast and effective dehydration various drying techniques have been developed. These improved methods could increase the current degree of acceptance of dehydrated foods in the market (Arora and Bharti, 2005) [3].

Materials and methods
The main objective of this experiment is to study the drying characteristics of green chilli. 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 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 green chilli drying with tray dryer and hot air oven at three different temperatures, are presented in following heads. Samples were dried untill 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: Green chilli dried using tray dryer at three different temperature viz. 50, 60 & 70 ºC.

Moisture content (wb %) ranges from 84.20 to 10.35 at 50 ºC. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 1.90 to 0.01 respectively (Table 1). At 60 ºC, moisture content (wb %) ranges from 84.20 to 8.41. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 1.98 to 0.02 respectively (Table 2). Moisture content (wb %) ranges from 84.20 to 9.71 at 70 ºC. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 1.87 to 0.03 respectively (Table 3).

Table 1: Drying characteristics of green chilli in tray dryer at 50 ºC.

Time	MC (wb) %	Moisture Ratio	Average Drying Rate
0	84.20	1.00	
60	80.74	0.78	1.90
120	76.42	0.60	1.59
180	70.05	0.43	1.50
240	59.23	0.26	1.48
300	42.55	0.12	1.19
360	21.04	0.03	0.79
420	15.73	0.01	0.13
480	13.42	0.01	0.05
540	10.99	0.00	0.05
600	10.35	0.00	0.01

Table 2: Drying characteristics of green chilli in tray dryer at 60 ºC.

Time	MC (wb)%	Moisture Ratio	Average Drying Rate
0	84.20	1.00	
60	80.55	0.77	1.98
120	76.27	0.60	1.55
180	69.70	0.42	1.52
240	58.42	0.25	1.49
300	42.02	0.12	1.13
360	20.40	0.03	0.78
420	13.42	0.01	0.17
480	10.99	0.01	0.05
540	9.46	0.00	0.03
600	8.41	0.00	0.02

Table 3: Drying characteristics of green chilli in tray dryer at 70 ºC.

Time	MC (wb) %	Moisture Ratio	Average Drying Rate
0	84.20	1.00	
60	80.79	0.78	1.87
120	76.51	0.60	1.58
180	70.47	0.44	1.45
240	61.46	0.28	1.32
300	48.20	0.16	1.11
360	28.99	0.06	0.87
420	14.59	0.01	0.40
480	10.99	0.00	0.08
540	9.71	0.00	0.03

Drying Characteristics hot air oven drying: 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 15.28. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 1.61 to 0.01 respectively (Table 4). Moisture content (wb %) ranges from 84.20 to 13.66 at 60 ºC. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 1.53 to 0.03 respectively (Table 5). At 70 ºC, moisture content (wb %) ranges from 84.20 to 15.17. Moisture ratio and average drying rate were ranged from 1.00 to 0.00 and 1.60 to 0.01 respectively (Table 6).

Table 4: Drying charecteristics of green chilli in hot air oven dryer at 50 ºC.

Time	MC (wb) %	Moisture Ratio	Average Drying Rate
0	84.20	1.00	
60	81.36	0.81	1.61
120	77.75	0.64	1.45
180	72.89	0.49	1.34

240	66.68	0.35	1.14
300	57.64	0.23	1.07
360	45.52	0.13	0.88
420	38.04	0.08	0.37
480	28.99	0.04	0.34
540	20.00	0.01	0.26
600	16.84	0.00	0.08
660	15.73	0.00	0.03
720	15.28	0.00	0.01

Table 5: Drying characteristics of green chilli in hot air oven dryer at 60 ºC.

Time	MC (wb) %	Moisture Ratio	Average Drying Rate
0	84.20	1.00	
60	81.53	0.82	1.53
120	77.90	0.65	1.48
180	73.64	0.51	1.22
240	69.02	0.40	0.94
300	63.04	0.30	0.87
360	55.49	0.21	0.76
420	46.89	0.14	0.61
480	36.16	0.08	0.53
540	26.94	0.04	0.33
600	17.39	0.01	0.26
660	15.17	0.00	0.05
720	13.66	0.00	0.03

Table 6: Drying characteristics of green chilli in hot air oven dryer at 70 ºC.

Time	MC (wb) %	Moisture Ratio	Average Drying Rate
0	84.20	1.00	
60	81.37	0.81	1.60
120	77.59	0.64	1.51
180	72.28	0.47	1.42
240	64.89	0.32	1.27
300	55.65	0.21	0.99
360	44.66	0.12	0.75
420	34.85	0.07	0.45
480	27.36	0.04	0.26
540	20.00	0.01	0.21
600	15.73	0.00	0.11
660	15.17	0.00	0.01

Conclusion

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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