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EFFECT OF PRE-TREATMENTS ON COLOUR AND QUALITY OF SUN- AND SOLAR TUNNEL-DRIED CHILLI (*Capsicum annum* L.) var. KASHMIR LONG-1

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ABSTRACT

A study was carried out to assess the effects of drying methods and chemical pretreatments on product quality of chilli, *Capsicum annum*, (var. Kashmir Long-1). Pretreated chilli was open sun-dried and solar tunnel dried upto optimum moisture levels and assessed for various physicochemical changes. The results revealed that among the pretreated samples, 2.5% potassium carbonate + 1% ground nut oil + 0.1% gum acacia + 0.001% butylated hydroxy anisol L^{-1} for 15 min had highest ascorbic acid (41.08 mg 100 g^{-1}), capsaicin (1.077% db) and reducing sugar (0.617% db) contents; and lowest moisture (9.85%) and non-enzymatic browning (0.123) values. All the treatments significantly enhanced the L* (31.56), a* (25.23), b* (13.44), C* (27.35), h* (27.6) and ΔE* (3.89) values in solar tunnel-dried samples. However, in sun-dried samples lower ascorbic acid (39.98 mg 100 g^{-1}), capsaicin (0.939% db) and reducing sugar (0.591% db) contents and higher moisture (10.43%), non-enzymatic browning (0.146), L* (30.52), a* (24.23), b* (12.68), C* (28.59), h* (28.0), and ΔE* (3.86) values were observed. Drying time of solar tunnel-dried samples was 48 h as compared to 72 h in case of sun-dried samples. The most efficient drying method was solar tunnel drying as it retained the nutritional properties and colour characteristics and reduced the drying time.

Key words: Ascorbic acid, browning, capsiacin, colour measurement, drying chilli

INTRODUCTION

Chilli (*Capsicum annum* L.) belongs to the family Solanaceae and is one of the universal spices grown in almost all over the world, especially in India for domestic market and export purpose. The native home of chilli is considered to be Mexico with secondary origin as Gautemala (Sigge *et al.*, 2001). In India, only two species of chillies *viz*., *C. annum* and *C. frutescens* are known and most of the cultivated varieties belong to the species *C. annum* (Pal *et al.*, 2008). Chilli is grown on an area of 1.8 million ha in the world, with annual production of about 7 million t (Satyanarayana and Vengaih, 2010; Geetha and Selvarani, 2017). Chillies possess beneficial alkaloid compounds 'capsaicin' which give it a strong spicy pungent character (Sadhna *et al.*, 2006). The colour of chillies is due to the presence of red pigmented carotenoids, the main being capsanthin, capsorubin, zeaxanthin and cryptoxanthin. These pigments are stable in intact plant tissue. However, during drying carotenoids show auto-oxidation due to heat, light and oxygen (Mangaraj *et al.,* 2001). It is a rich source of vitamin A, C and E. Recently Russian scientists have identified Vitamin P in green chillies which reportedly prevents heart diseases by dilating blood vessels (Gallardo *et al.,* 2010).

Harvesting of chilli is done when the pods are well ripened and partially withered on the plant itself. The harvested pods are kept in heaps either indoor or in shade away from direct sunlight for 2 or 3 days so as to develop uniform red colour and then sun dried on clean dry polythene sheets, cemented/concrete drying yards, etc. Pods are spread out in thin layers for uniform drying with frequent stirring to prevent mould growth and discolouration. The initial moisture content of chillies ranged from 300-400% (db) which is very high for processing and storage. Therefore, reduction of moisture in chilli to a safe level of 8-9% (db) becomes necessary before their processing and storage (Ahmad and Shivare, 2001). Improved drying system could be used to ensure cleanliness and uniform drying and colour of the product. The dried pods are heaped and covered by clean gunny bags/polythene sheets (Hossain and Bala, 2002; Famurewa *et al.,* 2006).

Drying has been used for decades in chemical and food processing industries for long term preservation of final products to prevent the loss of minerals and pigments during drying (Santombi and Sharma, 2008). Control of browning is one of the most important issues in food industry as colour is a significant attribute of food which influences consumer decision (May *et al.,* 1999). To prevent quality loss and achieve effective dehydration various drying techniques have been developed that increase the current degree of acceptance of dehydrated foods in market (Arora and Bharti, 2005). Solar tunnel drying is also done to produce more consistent quality product taking less time and minimizing crop losses. The present comparative study was aimed to assess the effects of drying methods and chemical pre-treatments on quality parameters of chilli.

MATERIALS AND METHODS

Fresh harvested chillies cv. Kashmir Long-1 were procured form the Division of Vegetable Science, SKUAST-K, Shalimar, Srinagar (J&K). The harvested chillies at red ripe stage were brought to food processing laboratory for pretreatment with chemical dips. The treatments comprised of: i) control, ii) 0.5% citric acid dip (20 min), iii) 1% potassium metabilsulphite (KMS) + 0.5% citric acid (20 min), iv) 2% KMS + 0.5% citric acid (20 min), v) 2.5% potassium carbonate (K_2CO_3) + 2% ethyl oleate (5 min), vi) 5% K_2CO_3 + 2% ethyl oleate (5 min), vii) 7.5% K_2CO_3 + 2% ethyl oleate (5 min), and viii) 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% butylated hydroxyl anisol (BHA) L^{-1} (15 min). The samples were then divided in three equal lots replicated three times to assess the effect of open sun- and solar tunnel-drying. For open sun-drying, pretreated chillies were loaded on aluminum trays ($90 \times 60 \times 7.5$ cm^3) and kept on polythene sheets in open ground. Similarly, for solar tunnel-drying the loaded trays were put in solar dryer which consisted of frame work of 19 mm G.I. pipes provided with 5 independent units joined together with nuts and bolts at selected points to form a tunnel-like structure with a length of 450 cm, breadth of 300 cm and a height of 240 cm at the center (Fig. 1). The dryer was covered with an ultra-violet stabilized white polyethylene (800 gauge; 200 µ) and floor was covered with black polythene. The dryer was provided with a single door and ventilator holes in cross direction to facilitate air movement. The dryer had a capacity to accommodate 18-20 trays ($90 \times 60 \times 7.5$ cm^3) in a single layer. The chillies were loaded @ 500 g $tray^{-1}$ and dried to approx. 11% moisture.

Analytical method

The length, breadth and fresh weight of fruits from 20 randomly selected samples in triplicate of each treatment was measured by a Vernier caliper (Digital Vernier caliper, Swastika) and electronic weighing balance. The seed per cent was calculated by ratio of weight of dried seed and weight of dried whole chillies multiplied by 100. Moisture content was estimated by standard method AOAC,

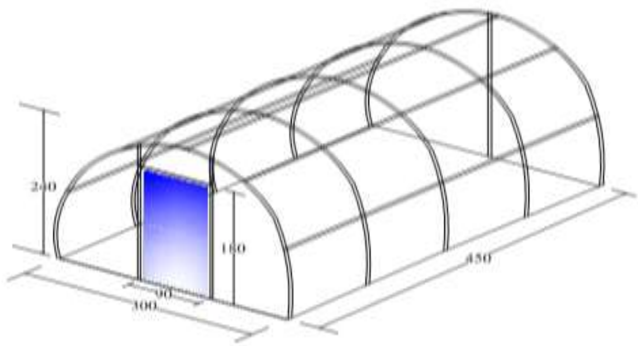

Fig. 1: A schematic diagram of solar tunnel dryer

1995). Ascorbic acid was estimated as per Ranganna (1986) using 2, 6-dichloro-phenol indophenol dye. The capsaicin content of red chillies was determined by phosphor-molybedic acid method using capsaicin standard curve on spectrophotometer [105 Cistronic, ECIL] (Thimmaiah, 2006). Reducing sugars were estimated by phenol sulphuric acid method. The absorbance of solution was measured at 490 nm in spectrophotometer using glucose as standard solution (Dubois *et al.,* 1956). Non-enzymatic browning (NEB) of red chillies was determined as per Lee *et al.* (1991). The absorbance of filtrate was recorded at 420 nm by a spectrophotometer using 60% alcohol as blank. The L*, a* and b* colour values were observed by Hunter colorimeter (Model CR-2000, Minolta, Osaka, Japan), equipped with a 8-mm measuring head and a c illumination (6774 K). The meter was calibrated using the manufacturer's standard white plate (Sigge *et al.,* 2001). The total color difference (ΔE^*) for the dried chilli samples were calculated using following equations:

$$\Delta E^* = \sqrt{(L^* - L0^*)^2 + (a^* - a0^*)^2 + (b^* - b0^*)^2}$$

where Lo^*, ao^* and bo^* were control values.

Hue angle (h) and chroma (C*) were also calculated using equations as under:

$$h = \tan^{-1}(b/a)$$

$$C^* = (a^{*\,2} + b^{*2})$$

Drying analysis

Chillies were sun- and solar tunnel-dried at ambient relative humidity and 1.2 m sec^{-1} air velocity. The moisture ratio of chillies during drying experiment was calculated using the following equation:

$$MR = M - M_e / M_o - M_e$$

Where, M is moisture content (% dry basis), M_e is equilibrium moisture content (% dry basis) and M_o is initial moisture content (% dry basis)

The drying rate of chillies was calculated by the following equation (Akpinar, 2002).

$$\text{Drying rate} = M_{t+dt} - M_t / dt$$

Where, M_{t+dt} is moisture content at t+ dt (% dry basis)

Statistical analysis

The data was analyzed by analysis of variance analysis using OPSTAT package program (OPSTAT software for windows). When variance analysis showed significant difference ($p<0.05$) among the means, the least difference test was used to evaluate means (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

Physicochemical characteristics of fresh chillies

The physicochemical characteristics of fresh chilli (*Capsicum annum*) var. Kashmir Long-1 revealed that freshly harvested red chilli had an average length of 11.21 cm, breadth of 1.57 cm and average fruit weight of 9.06 g with seed content of 34% (Table 1). Chilli contained 80.7% moisture (wb) and 417.8% (db) and 0.648% (db) reducing sugar. It had an ascorbic acid of 49.4 mg 100 g^{-1} (db),

Table 1: Physicochemical characteristics of fresh chilli var. Kashmir Long-1

Parameters	Mean±SE
Length (cm)	11.21±0.23
Breadth (cm)	1.57±0.04
Weight (g)	9.06±0.19
Seed (%)	34.00±0.70
Moisture (%)	417.75 (db), 80.68 (wb) ±1.67
Ascorbic acid (mg 100 g^{-1} db)	49.40±1.03
Capsaicin content (% db)	0.38±0.007
Reducing sugar (% db)	0.648 ±0.01
Capsanthin (ASTA value)	98.38±2.04
L*	32.67±0.43
a*	20.91±0.27
b*	35.80±0.47

0.38% capsaicin (db) and 98.38 ASTA units capsanthin. The colour values revealed that it had L*, a* and b* values of 32.666, 20.913 and 35.805, respectively.

Nutritional quality of open sun- and solar tunnel-dried chilli

The data on the effect of pre-treatments and drying methods on moisture content of chilli revealed maximum moisture content in open sun-dried samples without any pre-treatment (14.45% db), whereas 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} pre-treated chilli recorded lowest moisture content of 10.43% db (Table 2). The moisture in chilli samples at the completion of solar tunnel-drying was maximum (13.43% db) in control samples and minimum (9.85% db) in the samples treated with 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} (Table 3). The pretreatment appeared to have promoted the quality of dried chillies as it removes wax layer on chilli surface and allows the water in chillies to diffuse from the surface hence increases the drying rate (Kyung *et al.*, 2012).

The ascorbic acid content in pre-treated open sun-dried samples varied from 38.70 to 39.98 mg 100 g^{-1} db (Table 2); whereas solar tunnel-dried samples had 39.62 to 41.08 mg ascorbic acid 100 g^{-1} db (Table 3). The highest ascorbic acid contents in open sun- and solar tunnel-dried samples were in treatment 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1}. Markus *et al.* (1999) reported that ascorbic acid loss was due to the formation of caramelized products in red pepper by long time of drying.

Open sun-dried samples pre-treated with 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} had a maximum of 0.939% capsiacin (db) as compared to the higher capsaicin content of 1.077% (db) in solar tunnel-dried chillies (Table 2 & 3). Pretreatments and solar drying lead to efficient drying that prevented the major colour changes in dried chillies (Naima *et al.*, 2013).

Table 2: Effect of pretreatments on nutritional quality of open sun-dried chillies var. Kashmir Long-1

Treatments	Moisture (% db)	Ascorbic acid (mg 100 g^{-1} db)	Capsaicin (% db)	Reducing sugar (% db)	NEB (OD 420 nm)
Control	14.45	38.52	0.893	0.582	0.150
0.5% CA dip (20 min)	13.65	38.70	0.893	0.583	0.149
1% KMS + 0.5% CA dip (20 min)	13.05	39.00	0.897	0.584	0.148
2% KMS + 0.5% CA dip (20 min)	12.52	39.13	0.901	0.587	0.148
2.5% K_2CO_3 + 2% EO (5 min)	12.04	39.30	0.910	0.587	0.147
5% K_2CO_3 + 2% EO (5 min)	11.43	39.26	0.918	0.587	0.147
7.5% K_2CO_3 + 2% EO (5 min)	10.94	39.90	0.925	0.590	0.147
2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% butylated hydroxyl anisol L^{-1} (15 min)	10.43	39.98	0.939	0.591	0.146
Mean	12.30	39.23	0.910	0.586	0.148
$CD_{0.05}$	0.623	0.795	0.039	0.022	0.006

*CA = Citric acid; KMS = Potassium metabilsulphite; EO = Ethyl oleate; db = Dry basis; NEB = Non-enzymatic browning

Table 3: Effect of pretreatments on nutritional quality of solar tunnel-dried chillies var. Kashmir Long-1

Treatments	Moisture (% db)	Ascorbic acid (mg 100 g^{-1} db)	Capsaicin (% db)	Reducing sugar (% db)	NEB (OD 420 nm)
Control	13.43	39.47	0.975	0.611	0.125
0.5% CA dip (20 min)	12.75	39.62	0.993	0.613	0.125
1% KMS + 0.5% CA dip (20 min)	12.02	39.92	0.999	0.614	0.124
2% KMS + 0.5% CA dip (20 min)	11.64	40.11	1.010	0.614	0.124
2.5% K_2CO_3 + 2% EO (5 min)	11.43	40.38	1.016	0.615	0.124
5% K_2CO_3 + 2% EO (5 min)	10.59	40.25	1.033	0.616	0.124
7.5% K_2CO_3 + 2% EO (5 min)	10.19	40.93	1.053	0.616	0.124
2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% butylated hydroxyl anisol L^{-1} (15 min)	9.85	41.08	1.077	0.617	0.123
Mean	11.47	40.22	1.020	0.615	0.124
$CD_{0.05}$	0.623	0.795	0.039	0.022	0.006

*CA = Citric acid; KMS = Potassium metabilsulphite; EO = Ethyl oleate; db = Dry basis; NEB = Non-enzymatic browning

The maximum and minimum reducing sugar content observed in open sun-dried samples were 0.591 and 0.582% db in 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} pretreated and control samples, respectively (Table 2). In comparison, solar tunnel-dried samples recorded highest reducing sugar content of 0.617 in 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} pretreated samples (Table 3). The results are in agreement with Ahmad *et al.*, 2013) who used pretreated the samples with 7.5% K_2CO_3 + 2% ethyl oleate (5 min) solution.

The non-enzymatic browning (NEB) value was maximum (0.150) in open sun-dried samples without any pre-treatment (Table 2). The NEB values of pre-treated samples varied from 0.146 (2.5% K_2CO_3 + 1% ground nut oi l + 0.1% gum acacia + 0.001% BHA L^{-1} to 0.149 (0.5% citric acid dip for 20 min). In solar tunnel-dried samples a minimum NEB value of 0.123 was found in samples pretreated with 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} pre-treatment, followed by 0.124 in 7.5% K_2CO_3 + 2% ethyl oleate (5 min) pretreated samples (Table 3). Topuz and Ozdemir (2004) reported that solar drying results in lesser pigment oxidation and decomposition as compared to sun drying.

Effect of pretreatments and drying methods on colour of sun- and solar tunnel-dried chillies

The colour parameters of chilli samples after open sun- and solar tunnel-drying as influenced by pretreatment applications are presented in Table 4 & 5. In open sun-dried samples, maximum L*, a* and b* value of 30.52, 24.23 and 12.68 was observed in the samples pretreated with 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} solution (Table 4). The results are in close proximity with those reported by Shivare *et al.* (1981). The untreated samples had C* value of 26.10, whereas in treated samples the C* value varied from 26.24 to 28.59. Maximum h* value of 28.70 was observed in control samples. The untreated samples had ΔE* as nil, whereas treated samples had ΔE* values of 0.41 to 3.86. The treated samples had highest L*, a*, b*and c* values. In solar tunnel-drying, the maximum L* value of 31.56 was observed in the samples pretreated with 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} solution (Table 5). The untreated samples had a* value of 22.81 whereas treated samples had a* values ranging from 23.01 to 25.23. The untreated samples had b* value of 12.50, whereas treated samples had b* values in the range of 12.62 to 13.44. Maximum b* value (13.44) was recorded in the samples pretreated with 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} solution. Maximum C* value of 27.35 and ΔE* value of 3.89 was recorded in the samples pretreated with 2.5% K_2CO_3

Table 4: Effect of pretreatments and drying methods on L*, a* and b* values of open sun-dried chillies

Treatments	L*	a*	b*	C*	h*	ΔE*
Control	27.65	21.76	11.78	26.10	28.70	0
0.5% CA dip (20 min)	28.07	21.96	11.87	26.24	28.70	0.41
1% KMS + 0.5% CA dip (20 min)	28.37	22.36	12.76	26.67	28.60	0.98
2% KMS + 0.5% CA dip (20 min)	28.76	22.75	12.12	27.30	28.40	1.51
2.5% K_2CO_3 + 2% EO (5 min)	29.15	23.13	12.22	27.41	28.20	2.04
5% K_2CO_3 + 2% EO (5 min)	29.46	23.47	12.35	27.84	28.20	2.58
7.5% K_2CO_3 + 2% EO (5 min)	29.84	23.88	12.56	28.25	28.00	3.13
2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} (15 min)	30.52	24.23	12.68	28.59	28.00	3.86
Mean	28.98	22.94	12.20	27.30	28.35	1.82
$CD_{0.05}$	0.29	0.34	0.09	0.30	0.02	0.24

CA = Citric acid; KMS = Potassium metabilsulphite; EO = Ethyl oleate; db = Dry basis; NEB = Non-enzymatic browning, L = Ranges from white to black, a*= Red to green, b* = Yellow to blue, C* = Chroma, h* = Hue, ΔE* = Colour difference

+ 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} solution. Maximum h* value of 28.40 was found in untreated sample. The stability of carotenoids during storage has been shown to depend on drying conditions with the rate of deterioration increasing with increase in drying temperature (Figen and Mustafa, 2001). Similar results have been reported by Zhan (1996), Hossain and Bala (2002) and Weerachai *et al.* (2002).

Drying studies

Open sun- and solar-tunnel drying: The mean maximum and minimum temperature recorded during drying session was 22 and 12°C, whereas relative humidity over drying period ranged from 28 to 75% (Table 6). Pre-treatments had profound influence on the final moisture content of chillies. After 84 h open sun-drying, the untreated samples had maximum moisture content of 14.45% db as compared to the moisture content of 10.94 to 13.65% db in treated samples. The samples pretreated with 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} solution had 10.43% db moisture at the end of 83 h, followed by 10.94 and 11.43% db after 84 h in the samples pretreated with 7.5% K_2CO_3 + 2% ethyl oleate (5 min.) and 5% K_2CO_3 + 2% ethyl oleate (5 min.) solutions, respectively.

Table 5: Effect of pretreatments and drying methods on L*, a* and b* values of solar tunnel-dried chillies

Treatments	L*	a*	b*	C*	h*	ΔE*
Control	28.70	22.81	12.50	24.74	28.4	0.00
0.5% CA dip (20 min)	29.05	23.01	12.62	24.96	28.4	0.47
1% KMS + 0.5% CA dip (20 min)	29.42	23.42	12.76	25.38	28.2	0.96
2% KMS + 0.5% CA dip (20 min)	29.82	23.78	12.84	25.78	28.0	1.52
2.5% K_2CO_3 + 2% EO (5 min)	30.17	24.15	12.97	26.16	27.8	2.08
5% K_2CO_3 + 2% EO (5 min)	30.51	24.54	13.14	26.52	27.8	2.56
7.5% K_2CO_3 + 2% EO (5 min)	30.88	24.93	13.28	26.98	27.7	3.14
2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} (15 min)	31.56	25.23	13.44	27.35	27.6	3.89
Mean	30.01	23.98	12.94	25.98	27.99	1.83
$CD_{0.05}$	0.23	0.29	0.11	0.31	0.07	0.37

CA = Citric acid; KMS = Potassium metabilsulphite; EO = Ethyl oleate; db = Dry basis; NEB = Non-enzymatic browning, L = Ranges from white to black, a*= Red to green, b* = Yellow to blue, C* = Chroma, h* = Hue, ΔE* = Colour difference

Table 6: Effect of pretreatments and methods of drying on moisture content (db) of chilli samples var. Kashmir Long-1

Treatments	Open sun-dried		Solar tunnel-dried	
	Moisture (% db)	Drying time (h)	Moisture (% db)	Drying time (h)
Control	14.45	84	13.43	60
0.5% CA dip (20 min)	13.65	84	12.75	60
1% KMS + 0.5% CA dip (20 min)	13.05	84	12.02	60
2% KMS + 0.5% CA dip (20 min)	12.72	84	11.64	60
2.5% K_2CO_3 + 2% EO (5 min)	12.04	84	11.43	60
5% K_2CO_3 + 2% EO (5 min)	11.43	84	10.59	60
7.5% K_2CO_3 + 2% EO (5 min)	10.94	84	10.19	60
2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} (15 min)	10.43	72	9.85	48
Mean	12.34		11.49	
$CD_{0.05}$	0.39		0.27	

*CA = Citric acid; KMS = Potassium metabilsulphite; EO = Ethyl oleate; db = Dry basis

There was 28.58% reduction in drying time of chilli samples dried in solar tunnel-dryer which had maximum and minimum temperatures of 38 and 29°C, respectively. The maximum and minimum relative humidity recorded in solar tunnel-dryer were 55 and 15%, respectively, during drying studies. Untreated chillie samples in solar tunnel dryer possessed a moisture content of 13.43% db after 60 h of drying as compared to 10.19 to 12.75% db moisture content in the samples pretreated with 7.5% K_2CO_3 + 2% ethyl oleate (5 min.) to 0.5% citric acid dip (20 min.) solution (Table 6). Minimum moisture content of 9.85% db after 48 h was recorded in samples pretreated with 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} solution. Similar results were observed by James *et al.* (2017).

In open sun-dried samples, the initial weight of chilli was 500 g which was reduced to 118.34 g after 84 h drying. The average moisture content decreased from 441.46 to 15.27% db. At the beginning, the drying rate and moisture ratio (MR) was 0 and 1, the drying rate varied from 1.685 to 5.014 and MR decreased from 1 to 0.0676. However, the completion of solar tunnel-drying took 48 h which showed a decrease in weight from 500 to 133.33 g. The initial average moisture content recorded was 436.86% db which was reduced to 39.72% db after 48 h drying. The drying rate varied from 0 to 1.8395 and MR decreased from 1 to 0.1042. Similar findings have also been reported by Kaleemullah and Kailappan (2006).

Drying curves: The graphs were obtained by plotting weight changes, moisture ratio (Fig. 2) and drying rates v/s time to get the drying curves. Half of the moisture was removed during first hour of

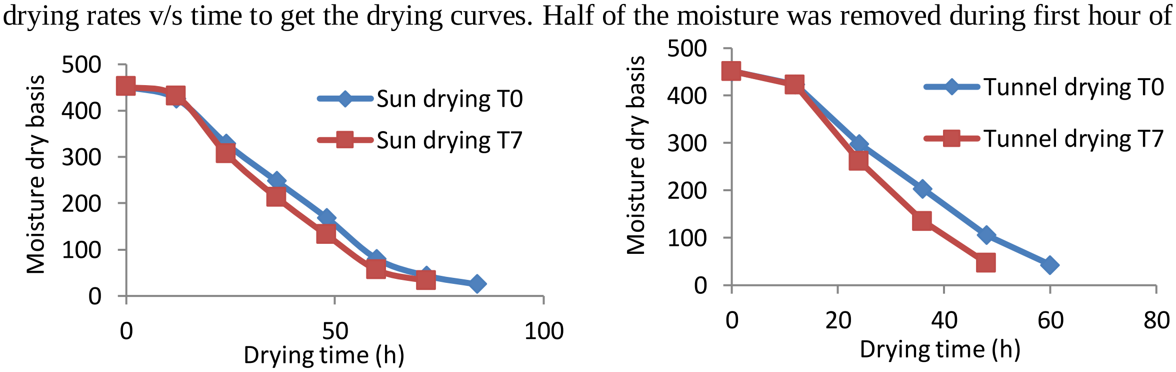

Fig. 2: Drying curves depicting the changes in moisture v/s time during sun- and tunnel-drying; T_0: 0.5% CA dip (20 min) and T_7: 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} (15 min)

drying. All chilli samples had moisture content in the range of 80-85%. Results showed that as drying proceeded a gradual decrease in water content occurred due to its evaporation. Initially >30% moisture content was evaporated from all the samples in first 30 min and >70% in the first 2 h of drying. Effect of increasing temperature on drying of samples was evident and it showed that increase in temperature decreased the duration of drying which is also supported by Sugandh *et al.* (2017).

Conclusion: From the present study it may be concluded that traditional method of open sun-drying of chillies is unhygienic and subjected to dust/dirt, microbial contamination, rains, etc., during drying process which may spoil the whole lot. Also, drying time is long and the quality of dried product is inferior with respect to the appearance and colour of pods. The present study revealed that pre-drying treatment of chillies with 2.5% K_2CO_3 + 1% ground nut oil + 0.1% gum acacia + 0.001% BHA L^{-1} (15 min) and 7.5% K_2CO_3 + 2% EO (5 min) as compared to control helped to reduce the drying time as well as maintained the quality of chillies. Open sun-dried pre-treated chillies took 72 h to dry to a moisture level of 10.43-13.65% as compared to 84 h taken by control samples. Solar tunnel-drier provided a low cost drying alternative for drying chillies under hygienic conditions. The drier reduced the drying time and solar tunnel-dried pre-treated samples took 48 to 60 h to dry to the moisture content of 9.85 to 13.43%.

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