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# Study the Drying Behavior of Red Pepper (*Capsicum annuum* L.)

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## ABSTRACT

The experiment was carried out in the laboratories of the Department of Food Engineering and the Department of Plantation Spices Medicinal & Aromatic Crops, and the Central Horticultural Laboratories, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India during 2018–2019 and 2019–2020. With an objective of study the performance of drying methods at different temperatures on physical and quality parameters of dry chilli. The experiment was conducted in Randomized Complete Block Design (RCBD) replicated thrice with seven treatments of different drying methods viz., sun drying, solar drying and oven drying at 50°C, 55°C, 60°C, 65°C and 70°C. The experimental results were maximum fruit length (7.00 cm), fruit diameter (10.22 mm), chroma (38.13), minimum total color difference (11.82) and browning index minimum (85.81) were found in the oven drying at 65°C and the fruit weight (0.81 g) was maximum observed in the sun drying method. However, the minimum bulk density (0.31 g $cc^{-1}$) and the maximum dehydration ratio (3.88) were detected by oven drying at 70°C. The highest β-carotene content (224.41 μg 100 $g^{-1}$) was observed during oven drying at 50°C, where as minimum β carotene content was recorded by sun drying. In sun drying method low quality due to oxidation as the dried chilli was exposed directly to light and sun. An increase in drying air temperature and long period of drying time has a negative effect on quality of dry chilli.

**KEYWORDS:** β-Carotene content, browning index, dehydration ratio, red pepper

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***Data Availability Statement:*** Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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## 1. INTRODUCTION

Red pepper (*Capsicum annuum* L.) is one amongst the generally used peppers and belongs to the family Solanaceae. Red chilli peppers are rich sources of vitamins and minerals (Tunde, 2010). In order to extend the shelf life of chill pepper usually dried. drying methods are sun drying, solar drying, hot air drying, microwave drying and freeze drying methods. The traditional sun drying takes 7–10 days depending on the weather conditions, chillies become contaminated with dust, dirt, rainfall, animals, birds, rodents, insects and microorganisms (Hossain and Gottschalk, 2009). Underneath these conditions, losses can reach up to the range of 40–60% of total quantity. To enhance dried chilli quality, mechanical dryers can use such as oven and solar dryers are introduced for drying chilli in order to decrease the drying time. (Vega-Galvez et al., 2008, Tasirin et al., 2007; Mangaraj et al., 2001). Most have used air temperatures of between 50–80°C. It's been found that the upper temperatures resulted in reduced drying time and increase in the effective moisture Vega-Galvez et al., 2008; Tasirin et al., 2007; Kaleemullah and Kailappan, 2005; Doymaz and Pala, 2002; Hossain and Bala, 2002). However, using high temperatures for drying produces a low quality of chilli, with losses of volatile compounds, nutrients and color (Di Scala and Crapiste, 2008). Overall drying rate increased with temperature in dyers, drying of green chilli took place in falling rate period (Kumar et al., 2017, Sanjuan et al., 2003). Raquel and Maria (2012) found that the increase in drying temperature reduced the hardness drastically. Kamble et al. (2013) recorded that in the solar dryer at three position viz., lower, middle and upper drying trays using thermocouples and average temperature was observed in the range of 25 to 55°C. Reis et al. (2013) observed that the higher temperatures increase shelf life and decrease the volume of the product, preserve macronutrients and degrade micronutrients. Toontom et al. (2012) observed that capsaicin was the main compound responsible for the oral hotness sensation, while 1-penten-3-one compound was found to be an indicator of strong pungent odour. The intermittent microwave convective drying provided considerable savings in drying time when compared to convective air drying (Soysal et al., 2009). In solar tunnel dried samples, drying time was highly reduced when compared to the commercial samples (Lee et al., 2004). Wiriya et al. (2009) recorded that drying air temperatures of dried chill reported best colour attributes with two stage temperatures of 70°C and 50°C. Satyanarayana and Vengaih (2010); Sadhna and Bharti (2005) reported that the drying temperature of 55°C was best for preventing the pigment loss during drying. Kim et al. (2006), Nagaraja et al. (2000) noticed that the Modified Method of drying showed higher colour values. Oberoi et al. (2005) the colour retention was significantly better in the chillies dried using batch type dryer as compare to conventional sun drying. The β-carotene, color were significantly affected by the drying method (Maurya et al., 2018). Gupta et al. (2017) observed that the quality of the product reduced significantly during sun drying and mechanical drying at 70°C.3 different temperatures (50°, 60° and 70°C) use in both dryers. Vacuum dried samples at 55°C retained the highest quality parameters, while the samples dried at 75°C in a cabinet dryer (Daghan et al., 2018). Fudholi et al. (2013) found that red chilies were dried down from approximately 80% (w.b) to 10% (w.b) moisture content within 33 h. compared with 65 h of open sun drying. Nimrotham et al. (2017) noticed the solar drying and low temperature system takes 52 h to reduce the moisture content of about 74%–13.5% (w.b). The study was with an objective of study the performance of drying methods at different temperatures on physical and quality parameters of dry chilli.

## 2. MATERIALS AND METHODS

The experiment was conducted during 2018–2019 and 2019–2020 in the laboratories of the Department of Food Engineering and Department of Plantation, Spice, Medicinal & Aromatic crops, Bidhan Chandra Krishi Viswavidhyalaya, West Bengal, India. The experiment was conducted in Randomized Complete Block Design (RCBD) replicated thrice with seven treatments of different drying methods viz., sun drying, solar drying and oven drying at 50°C, 55°C, 60°C, 65°C and 70°C.

Statistical analysis according to the procedure described by Panse and Sukhatme(1967). The appropriate standard error of the mean SE (m) and the critical difference (CD) were calculated with a probability level. Number of treatments seven and three repeats with a sample size of 500 g each, the experimental treatments were sun drying, solar drying, oven drying temperature at 50°C, oven drying temperature at 55°C, oven drying temperature at 60°C, oven drying temperature at 65°C and oven drying temperature at 70°C. The peppers (BCCH Selection-4) were procured form research field, harvested at the ripe red stage, brought to the lab and kept in the shade for an hour to remove field heat. Bruised, diseased and damaged peppers were discarded, and healthy peppers were washed in tap water to remove adhered dirt, fresh chillies were subjected to sun drying, solar drying and oven drying methods.

### *2.1. Drying methods*

#### *2.1.1. Sun drying*

Sheets of black polyethylene were completely cleaned and the samples were placed in direct sunlight during the day between 9:00 a.m. and 5:00 p.m. with initial moisture content between 76.87% and 80.68%. The samples were given regular turnings to obtain uniform drying. The moisture loss was recorded after one hour with an electronic balance. Drying was continualuntil the sample reached steady weight. The drying time and rate depended on the ambient temperature. Ambient temperature and relative humidity are also measured periodically. The moisture content values were calculated based on dry matter basis.

*2.1.2. Solar drying*

Solar drying was carried out from the sample of peppers placed in a single layer on a black polyethylene sheet. The samples were covered with glass films. Moisture loss was recorded at hourly intervals throughout the drying period. Drying was carried out continuously until the sample reached a constant weight. The weight of the sample was measured on an accurate electronic balance. Water content values were calculated on dry matter.

*2.1.3. Oven drying*

The pepper sample was placed in one of the chambers of the hot air oven and the thermostat was set at 50°C, 55°C, 60°C, 65°C and 70°C according to the requirements of the experiment that day. The initial moisture content of the peppers was between 75.87% and 81.37%. The moisture content readings were taken at 60-minutedrying period intervals with an accurate electronic balance calculated on the dry substance and expressed as a percentage.

Then the following parameters have taken in to considerations for observation.

*2.2. Fruit length (cm)*

The length of the fruits from ten randomly selected samples in triplicate of each treatment was measured by verniercallipers from base to the tip of the fruit before drying and after drying

*2.3. Fruit diameter (mm)*

The diameter of the fruits from ten randomly selected samples in triplicate of each treatment was measured by verniercallipers at middle portion, base and apex of the fruit before drying and after drying.

*2.4. Weight (g)*

Fresh and dry weight of chilli fruits from each treatment for ten randomly a sample in triplicate was recorded before drying and after drying and average values was calculated.

*2.5. Bulk density (gc c⁻¹)*

Bulk density was estimated by 100 gram of chilli was taken in a volumetric container and volume of the sample was recorded.

Bulk density =Weight of sample/Volume occupied …… (1)

*2.6. Chroma*

The chroma or saturation of a color is a measurement tool for determining level of its intense or the degree of saturation of colour and is proportional to the strength of colour.

$C=\sqrt{(a^2+b^2)}$ …………………………………………………. (2)

*2.7. Browning index (BI)*

Browning index represent the purity of brown color andmeasured as an important parameter associated with browning.

$BI=[100(X-0.31)]/0.17$ …………………………………. (3)

Where, $x=(a+1.75L)/(5.645L+a-0.3012b)$

*2.8. Total colour difference (ΔE)*

The measure of change in visual awareness of two given colorsΔE a metric for understanding how the human eye perceives color variation.

$\Delta E=\sqrt{((L_0-L)^2+(a_0-a)^2+(b_0-b)^2)}$ ………….. (4)

Where $L_0,a_0,b_0$, refer to the Hunter colour parameters of fresh chilli sample. L, a, b refer to the Hunter colour parameter of dried chilli sample.

*2.9. Dehydration ratio*

Drying ratio was calculated by taking the ratio of weight of chillies loaded for drying in order and that the dried chillies immediately after drying.

$Dr=W_1/W_2$ ……………… (5)

Dr=Drying ratio

$W_1$=Initial weight of chillies before drying (g)

$W_2$= final weight of dried product (g)

*2.10. β-Carotene*

Composite pulp of randomly selected sampled per replication from both fresh and dried were used to estimate β-Carotene content in the laboratory following standard biochemical methods (Ranganna, 2000).

## 3. RESULTS AND DISCUSSION

*3.1. Fruit length (cm)*

No significant difference was found between the treatments as they were influenced by different drying methods and temperatures along the length of the fruit. Clearly indicates that in table1. The length of the fruit (7.00 cm) was found to be maximum in the oven drying at 65°C, while the minimum length of the fruit (6.88 cm) was found in thesun drying. Similar results without alteration of pod length have been reported by Joy et al. (2001) Pandiyaraj et al. (2017), Yogeshkumar et al. (2018) and Vaishnavi et al. (2018) without significant influence on pod length due to drying methods. The same results were also found in different drying methods such as open yard sun drying, solar drying and try drying (Papa kumari, 2001).

*3.2. Fruit diameter (mm)*

The fruit diameter (10.22 mm) was found maximum in oven drying at 65°C, while minimum fruit diameter (10.09

mm) was recorded in sun drying, data was revealed in table 1. Even though there was no significant difference among the treatments.These results were in agreement with those reported by Mangaraj et al. (2001); Garg and Krishnan (1974). Similar trend was recorded by Chakrabarty and Islam (2017), Murmu et al. (2017) and Nahak et al. (2018). Similar results were found by Papa kumari (2001) among different drying methods such as open yard sun drying, solar drying and try drying no significant differenceamong the dying methods. These results were in accordance with Prasad (2008) it was showed a non significant influence of sun drying, poly house and oven drying methods on pod diameter due to drying methods. However increasing trend was observed in dried chilli compared with fresh chilli.

### *3.3. Fruit weight (g)*

The weight of the fruit was not significantly influenced by the different drying methods and temperatures; Data illustrated in Table 1. The fruit weight was (0.81 g) observed maximum in sun drying method, while the lowest fruit weight (0.77 g) was recorded in the oven drying at 70°C. Prasad (2008) noted that there was no significant influence on weight due to different drying methods such as sun drying, polyhousedrying methods and oven drying. It might be due to residual moisture content and contaminated with dust and dirt which increases the weight of the samples. Similar trend followed in Sharma and Sridevi (2016), Sahu et al. (2016), Pandiyaraj et al. (2017) and Maurya et al. (2017a).

Table 1: Effect of drying methods and temperatures on fruit length (cm), fruit diameter (mm), fruit weight (g), bulk density (gc $c^{-1}$), chroma ($C^*$) and total colour difference (ΔE) of dry chilli

| Treatments | Fruit length (cm) | Fruit diameter (mm) | Fruit weight (g) | Bulk density (gc $c^{-1}$) | Chroma ($C^*$) | Total colour difference (ΔE) |
|---|---|---|---|---|---|---|
| Fresh chilli | 7.29 | 8.29 | 3.22 | 0.71 | 48.75 | Mean |
| Sun drying | 6.88 | 10.09 | 0.81 | 0.35 | 18.90 | 35.06 |
| Solar drying | 6.92 | 10.15 | 0.79 | 0.34 | 23.90 | 29.04 |
| Oven drying at 50°C | 6.94 | 10.17 | 0.79 | 0.33 | 27.75 | 24.49 |
| Oven drying at 55°C | 6.95 | 10.19 | 0.79 | 0.32 | 30.28 | 21.27 |
| Oven drying at 60°C | 6.97 | 10.19 | 0.79 | 0.33 | 33.11 | 17.97 |
| Oven drying at 65°C | 7.00 | 10.22 | 0.80 | 0.32 | 38.13 | 11.82 |
| Oven drying at 70°C | 6.99 | 10.22 | 0.77 | 0.31 | 35.61 | 14.93 |
| SEm± | 0.037 | 0.039 | 0.015 | 0.011 | 0.316 | 0.316 |
| CD ($p$=0.05) | N.S | N.S | N.S | N.S | 0.983 | 0.983 |

$T_1$: Sun drying; $T_2$: Solar drying; $T_3$: Oven drying at 50°C $T_4$: Oven drying at 55°C; $T_5$: Oven drying at 60°C; $T_6$: Oven drying at 65°C; $T_7$: Oven drying at 70°C

### *3.4. Bulk density (gc $c^{-1}$)*

The bulk density (0.31 g $cc^{-1}$) was found to be minimum when oven drying at 70°C, while the maximum bulk density (0.35 g $cc^{-1}$) was recorded in the sun drying method in table 1. A similar trend was recorded by Hossain and Bala (1999) because the bulk density of chili peppers seems to depend on the water content and increases linearly with increasing water content. Singh et al. (2000) also found a similar trend with the higher bulk density of fresh bell pepper. The corresponding bulk density values of the dried peppers (at about 10% moisture) at 50°, 60° and 70°C respectively. Bulk density significantly decreased with the removal of moisture from the peppers. Kumar et al., 2017., Sanjuan et al., 2003) drying rate increased with temperature in dyers, drying of green chilli took place in falling rate period .

### *3.5. Chroma ($C^*$)*

Clearly indicates that in Table 1. The chroma value (38.13) was found to be maximum when oven drying at 65°C, whereas, the minimum chroma value (18.90) was indicated by sun drying. A similar trend was recorded by Vega-Galvez et al. (2009) the estimated chroma values of the fresh and dried rehydrated samples maintained 96% of the fresh pepper, the tint angle showed a 23% increase over the fresh sample, indicating discoloration of the color d origin of pepper. These results were in accordance with the findings of Wiriya et al. (2009) lower value of colour of dried chilli using with the sun drying method then the drying air temperatures of 50, 60, 70°C was observed. Turhan et al. (1997) and Lee et al. (1991) who have suggested that using high temperatures for drying air results in a dark brown color.

### *3.6. Total colour difference (ΔE)*

Total colordifference was statistically significant among the various drying methods and temperatures. Total colour difference (35.06) was showed maximum sun drying and minimum total colour difference (11.82) was recorded by oven drying at 65°C. Data illustrated in table 1. Present findings were supported by Maurya et al. (2018) and Topuz and Ozdemir (2007) total color difference clearly indicate that the minimum color loss was determinedwithin the freeze dried methodologywherever as it absolutely wastopin the sun drying method. On the other hand, sun drying was found to be most detrimental to those color attributes. This pigment oxidation and decomposition could also be higher exposure to oxygenfurther as intensive vaporization from the pepper surface. Similar results were obtained by Miranda et al. (2009), where high total color difference values were found at high drying temperatures due to the impact of high temperatures on heat-sensitive elements like proteins and carbohydrates amongst others. Aleksandra and Biserka (2004) and Naima et al. (2013) found that in sun drying the decrease in colour was due to the formation of browning compounds.

### 3.7. *Browning index (BI)*

The maximum browning index (96.42) was shown in the sun drying method; however the minimum browning index (85.81) was recorded by oven drying at 65°C. Data was showed Table 2. Similar results have been found that minimal color deterioration during the oven drying method is an indication of the suitability of this method for the preservation of nutraceutical foods (Ratti, 2001). On the other hand, non-enzymatic browning was another cause of red pepper color degradation in the other sample. This is because the temperature and time provided in this method were used to achieve the required moisture level in the dried chilli. However, the greatest degradation of color when drying in the sun. The red chilli pepper having higher brightness and redness values and mild yellowness values can be evaluated as more favorable and marketable products with respect to colour quality (Soysal et al., 2005; Ergunes and Tarhan, 2006). Kim et al. (2006), Ibrahim and Mehmet (2002) noticed that modified method of drying showed higher colour values of lightness, redness and yellowness than conventional method of drying.

### 3.8. *Dehydration ratio*

There was a significant effect of different drying methods and temperatures on dehydration ratio of chilli. Clearly indicates that in Table 2. Dehydration ratio (3.88) was produced mostwith the aid of using oven drying at 70°C, whereas dehydration ratio (3.20) changed intoconfirmedminimal in sun drying method. Similar results were found by Toontom et al. (2012) reported that initial average moisture content and water activity of fresh chilli, dehydration ratio changed intodetermined to be much less in control. This is probablybecause ofhigher value of residual moisture content material after dying which adds to the weight of sample. Similar results were found by Bakane et al. (2014) dehydration ratio was found to be less in control. This might be due to higher value of residual moisture content after dying which adds to the weight of sample.

Table 2: Effect of drying methods and temperatures on browning index (BI), dehydration ratio and β carotene content (μg 100 $g^{-1}$) of dry chilli

| Treatments | Browning index (BI) | Dehydration ratio | β Carotene content (μg100 $g^{-1}$) |
|---|---|---|---|
| Fresh chilli | 93.15 | Mean | 354.05 |
| Sun drying | 96.42 | 3.20 | 173.76 |
| Solar drying | 93.49 | 3.32 | 176.99 |
| Oven drying at 50°C | 90.50 | 3.44 | 224.41 |
| Oven drying at 55°C | 88.80 | 3.52 | 215.99 |
| Oven drying at 60°C | 88.32 | 3.63 | 209.18 |
| Oven drying at 65°C | 85.81 | 3.77 | 197.29 |
| Oven drying at 70°C | 86.80 | 3.88 | 188.38 |
| SEm± | 0.967 | 0.019 | 0.841 |
| CD ($p$=0.05) | 3.013 | 0.058 | 2.62 |

$T_1$: Sun drying; $T_2$: Solar drying; $T_3$: Oven drying at 50°C $T_4$: Oven drying at 55°C; $T_5$: Oven drying at 60°C; $T_6$: Oven drying at 65°C; $T_7$: Oven drying at 70°C

### 3.9. *β Carotene content (μg 100 $g^{-1}$)*

β Carotene content (μg 100 $g^{-1}$) was ascertained considerably varied among the various drying methods and temperatures. Data revealed in Table 2. The β carotene content (224.41 μg100 $g^{-1}$) was found to be maximum in oven drying at 50°C, whereas minimum β carotene content (173.76 μg 100 $g^{-1}$) was ascertained by sun drying. Scala and Crapiste (2008) also reported that an increase in drying air temperature had a negative effect on quality of carotenoids. Chilli drying may lead to degradation of β-carotene. The maximum loss in β-carotene was reported in sun drying. The loss of carotenes throughout drying can be attributed to high exposure to oxidation due to the long drying period. The speedy heating rate and less time period offered. These results agree with Lin et al. (1998) previous reports on carrot and Tinoco et al. (2013) kiwifruit puree. Same results were observed by Maurya et al. (2018). Similar trend was recorded by Gupta et al. (2017) quality of the product reduced significantly during sun drying and mechanical drying at 70°C.

## 4. CONCLUSION

The utmost fruit length (7.00 cm), fruit diameter (10.22 mm), chroma (38.13), minimum total color difference

(11.82) and browning index (85.81) were found in oven drying at 65°C, fruit weight was (0.81 g) maximum in sun drying method. However minimum bulk density (0.31 gc $c^{-1}$) and maximum dehydration ratio (3.88) were showed by oven drying at 70°C. Highest β carotene content (224.41 µg 100 $g^{-1}$) was observed in oven drying at 50°C; wherever as minimum β carotene content was recorded by sun drying.

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