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# Drying characteristics of green chilli and quality attributes of developed powder

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**Abstract**
The purpose of this study was to look into the drying characteristics of green chillies and to assess the quality of developed green chilli powder. The three samples were prepared namely chemically treated sample ($S_1$), blanched sample ($S_2$) and control sample ($S_3$). All the samples were dried by a convective tray dryer at temperature 45, 50, 55 and 60 °C. Higher temperatures took much less time than the time taken at lower temperature. Overall drying rate was higher for chemically treated samples at all temperatures. Chemical treatment resulted at reducing the loss of ascorbic acid and visual colour. For a chemically treated sample, the maximum retention of ascorbic acid content was observed at 45 °C. Lowest a* value was obtained at 55 °C for chemically treated sample.

**Keywords:** Green chilli drying, chemical treatment, Ascorbic acid retention

## Introduction
Green chilli is a fruit of a plant belonging to the *Solanaceae* family. Because of their harsh acidic flavour and colour, these fruits are utilised as a spice all over the world. These fruits are often cultivated as cash crops due to their wide demand in restaurants, food industries and for culinary purposes as they add pungency and taste to the dishes. These are also associated with several health benefits due to presence of essential vitamins and minerals such as calcium, phosphorus, thiamine, riboflavin and niacin [1]. Chillies are excellent source of vitamin A, B, C and E [2]. Chillies pungency is attributed to the alkaloid "capsaicin," which is found in the pericarp and placenta of the fruit and gives it a strong spicy pungent flavour [3]. The hotter the chilli, the more capsaicin it contains. Capsaicin is being researched as a possible treatment for sensory nerve fibre problems such as arthritis, psoriasis, and diabetic neuropathy [4]. Vitamin C is abundant in fresh chillies, *i.e.* 111 mg per 74 g which makes them very effective as immune system stimulants and healing agents especially for cellular damage. They have a preventive effect, as stomach ulcers are mostly caused by bacteria and its antibacterial action kills such bacteria. They have beneficial effect on the circulatory system.
Chilies have a moisture content of 65-80 percent when harvested, depending on whether they have been partially dried on the plant or harvested while still succulent. Due to high moisture content they are perishable having a limited shelf life, attacked by fungus and diseases. Therefore, the use of chilli is limited for a short period of time. Preservation of a perishable commodity not only retards its degradation but also permits its availability round the year. Drying process reduces the moisture to a predetermined limit and prevents the growth of microorganisms causing harm to food products. It has been reported that among the several drying techniques, hot air circulation around the commodity is commonly used [5]. Prolonged drying process leads to the problem of darkening and loss in flavor. Thermal drying often degrades product attributes, such as colour, texture, ascorbic acid, beta-carotene, phenolics, and other nutrients, due to the production of browning pigment and direct contact with air and light [6]. Pretreatment is an important step which helps in the easy processing of the products. Blanching, chemical treatments such as citric acid, ascorbic acid, osmotic solutions, sulphitation, and other pretreatments used before drying have been proposed, resulting in improved chilli quality [7]. This paper carries ahead the previous researches and discusses the use of a convective tray dryer for dying green chilli. It also discusses the quality attributes of green chilli powder developed as a value added product by different drying techniques

## Materials and Methods

### Sample Preparation

Green chilli of G4 variety (*Capsicum annuum* L.) were purchased from local market of Udaipur, Rajasthan. Fresh green chillies of uniform thickness (6 mm dia.) were sorted from the degraded and spoiled ones. The selected chillies were washed destalked and cut into 2 cm size. Based on the given pretreatment, three samples of chillies were prepared as follows:

**Table 1:** Samples prepared for conducting the research work

| S. No. | Representation | Types of sample | Preparation |
|---|---|---|---|
| 1. | $S_1$ | Chemically treated sample | Blanching followed by dipping in 0.3% sodium meta bisulphite and 1% calcium chloride solution for 10 minute |
| 2. | $S_2$ | Blanched sample | Blanching only |
| 3. | $S_3$ | Control sample | Whole untreated sample |

250 g of green chilli was used for preparation of each sample. Blanching was done at 90 °C hot water for 3 minute. The ratio of amount of chilli sample (g) to the amount of pretreated solution (lt) was 1:4. A laboratory operated (3 phase, 4.5 kW) convective type tray dryer was used for drying the samples. The drier was set at required temperature before putting the samples inside the drier. After the dryers achieved desirable condition, the samples were placed inside the dryer. Samples were dried at temperatures 45, 50, 55 and 60 °C. The weights of the samples were noted regularly after 5 minutes for first 30 minutes, 10 minutes for another 30 minutes and 30 minutes for the rest of the period till they achieved equilibrium moisture content. Dried chilli samples were grinded into powder form with the help of a domestic grinder.

### Drying characteristics

Drying characteristics of green chilli were studied by analyzing the data obtained during drying process. Moisture content, drying rate and moisture diffusivity values were measured and compared for each of the sample after drying.

### Moisture content determination

The moisture content of chilli was determined as per the procedure outlined in AOAC (2005) [8]:

$$MC = \frac{M_w}{M_d} \times 100$$

Where,

MC = Moisture content on dry basis (%)
$M_w$ = Weight of the moisture at any time (g)
$M_d$ = Weight of the dry matter (g)

### Drying Rate determination

Drying rate of the chillies at a given time was calculated as per the formula discussed by (Bakane, 2007) [9]:

$$D_r = \frac{W_r}{W_d \times T}$$

Where,

$D_r$ = Drying rate (g/g dm-h)
$W_r$ = Weight of the moisture removed during the time interval (g)
$W_d$ = Weight of the dry matter (g)
T = Time interval of drying (h)

### Moisture diffusivity determination

Moisture diffusivity for green chilli was calculated with the help of formula reported by Crank, 1975 through Fick's second law of diffusion [10]:

$$\ln(MR) = \ln(0.692) - 5.78\frac{D_{eff}\, t}{L^2}$$

**Where**

MR = Moisture ratio
$D_{eff}$ = Effective moisture diffusivity
T = time
L = Characteristic dimension

### Quality evaluation

Quality of dehydrated green chilli powder was evaluated by determining water activity, colour and ascorbic acid content. The method outlined as per Ranganna (2001) was used to determine the amount of ascorbic acid in the sample [11]. The colour values were measured using a Hunter lab colorimeter in terms of L*, a* and b*. Water activity was measured by means of a portable and battery powered Lab swift water activity meter.

## Results and Discussions

### Effect of drying parameters on moisture content of chilli

As shown in Table 4, moisture content varied exponentially with drying time. Maximum moisture removal was observed for higher temperatures. Moisture content varied from 660.28-7.43 percent (db) for sample type $S_1$, 657.14-8.29 percent (db) for sample $S_2$ and 614.28-8.46 percent (db) for sample $S_3$ at 60°C each. The highest and shortest drying time were obtained as 1620 minute for $S_3$ (at 45°C) and 450 minute for $S_1$ (60°C) respectively (Table 3). Chemically treated samples ($S_1$) consumed less time than control samples ($S_3$).

**Table 2:** Different Parameters of fresh Green chilli

| Parameters | Values |
|---|---|
| Chilli variety | $G_4$ |
| Length (cm) | 5.64 ± 1.17 |
| Moisture % (wb) | 86-89 |
| Ascorbic acid (mg/100 g) | 135 |
| Color parameter | |
| L* | 41.53 |
| a* | -7.43 |
| b* | 15.41 |

### Effect of temperature on drying rate of chilli

Observation of the plots drawn in Table 5 followed a similar trend of falling drying rate. The drying rate was higher at the initial stages of drying when compared with the later part. The drying rate subsequently reduced with time at all temperatures. It was higher for higher temperature at same moisture content. Drying rates decreased from 2.40 to 1.2 g moisture/ g-dry matter-h at temperature ranging from 60 to 45 °C respectively for sample $S_1$ (Table 3). Similarly, it varied

from 1.71 to 1.1 g moisture/ g-dry matter-h for sample $S_2$ and 1 to 0.62 g moisture/ g-dry matter-h for $S_3$ for the same temperature range.

**Effect of temperature on moisture diffusivity**

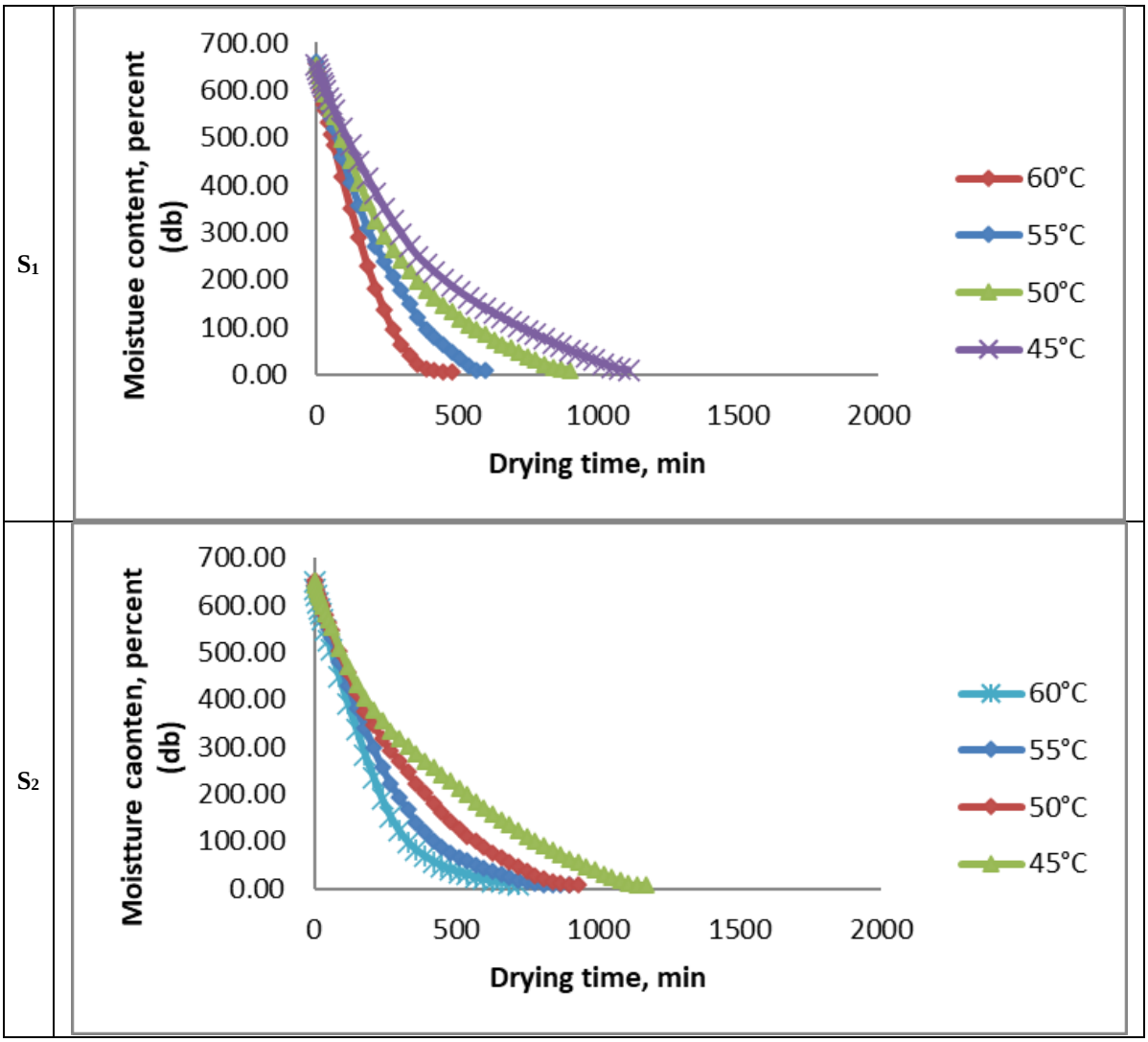
Values of ln(MR) varied almost linearly aginst drying time with inverse slope. For each temperature the straight lines fitted satisfactorily with the coefficient of relation ($R^2$) which varied from 0.86 to 0.99. Higher drying temperature attained steeper slopes than lower temperature and hence had higher negative values of ln (MR). Also, the chemically treated sample showed higher diffusivity than control samples indicated by higher negative values of ln (MR) for a given time duration.

Moisture diffusivity values ranged from 1.71 x $10^{-8}$ to 4.67 x $10^{-9}$ $m^2/s$ at temperature ranging from 60 to 45°C for $S_1$ (Table 3). Similarly, it ranged from 1.08 x $10^{-8}$ to 7.78 x $10^{-9}$ $m^2/s$ for $S_2$ and 9.34 x $10^{-9}$ to 3.11 x $10^{-9}$ $m^2/s$ for $S_3$ at similar range of temperature. With increase in drying air temperature moisture diffusivity values also increased which is in accordance with the result reported by Azzouz *et al*. (2002) for convective drying of grapes [12].

**Table 3:** Drying characteristics of different chilli samples

| Drying characteristics | Sample | Temperature (°C) | | | |
|---|---|---|---|---|---|
| | | 45 | 50 | 55 | 60 |
| Final moisture content %(db) | $S_1$ | 10.01 | 9.45 | 8.86 | 7.43 |
| | $S_2$ | 10 | 9.29 | 8.03 | 8.29 |
| | $S_3$ | 10.05 | 9.71 | 9.43 | 8.46 |
| Drying time (minute) | $S_1$ | 1110 | 900 | 600 | 480 |
| | $S_2$ | 1170 | 930 | 900 | 720 |
| | $S_3$ | 1590 | 1260 | 1080 | 960 |
| Peak Drying rate (g moisture/g dm-h) | $S_1$ | 1.27 | 1.37 | 1.71 | 2.40 |
| | $S_2$ | 1.1 | 1.20 | 1.37 | 1.71 |
| | $S_3$ | 0.62 | 0.69 | 0.79 | 1.03 |
| Diffusivity values ($m^2/s$) | $S_1$ | 7.78 x $10^{-9}$ | 9.34 x $10^{-9}$ | 9.34 x $10^{-9}$ | 1.71 x $10^{-8}$ |
| | $S_2$ | 9.34 x $10^{-9}$ | 7.78 x $10^{-9}$ | 9.34 x $10^{-9}$ | 1.08 x $10^{-8}$ |
| | $S_3$ | 3.11 x $10^{-9}$ | 4.67 x $10^{-9}$ | 6.23 x $10^{-9}$ | 9.34 x $10^{-9}$ |

**Table 4:** Variation in moisture content with respect of drying time



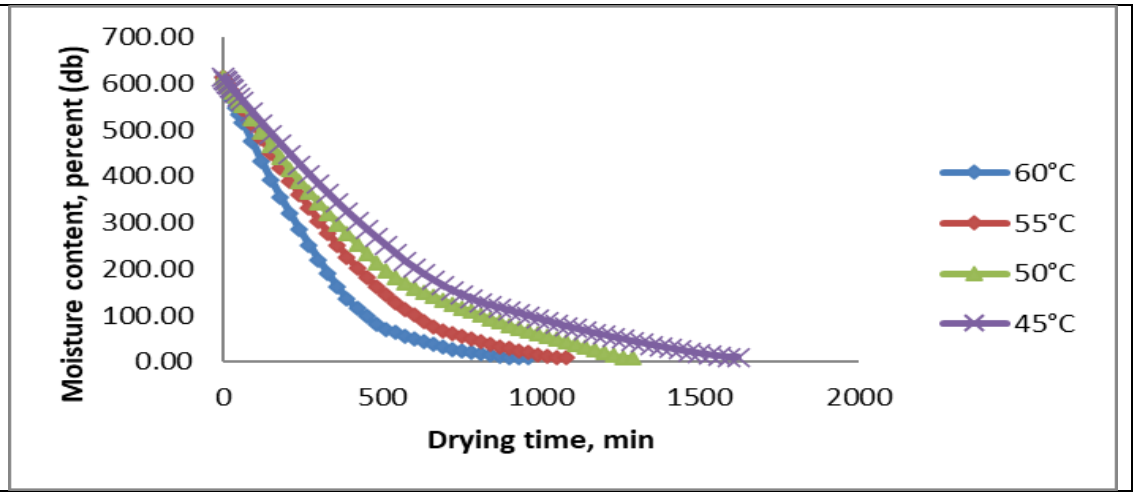
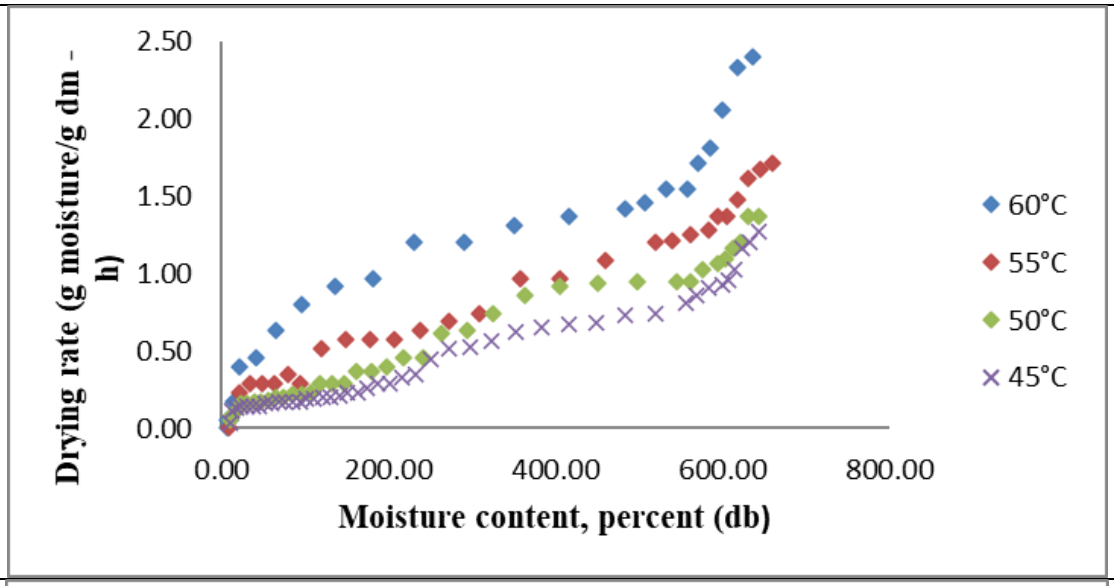
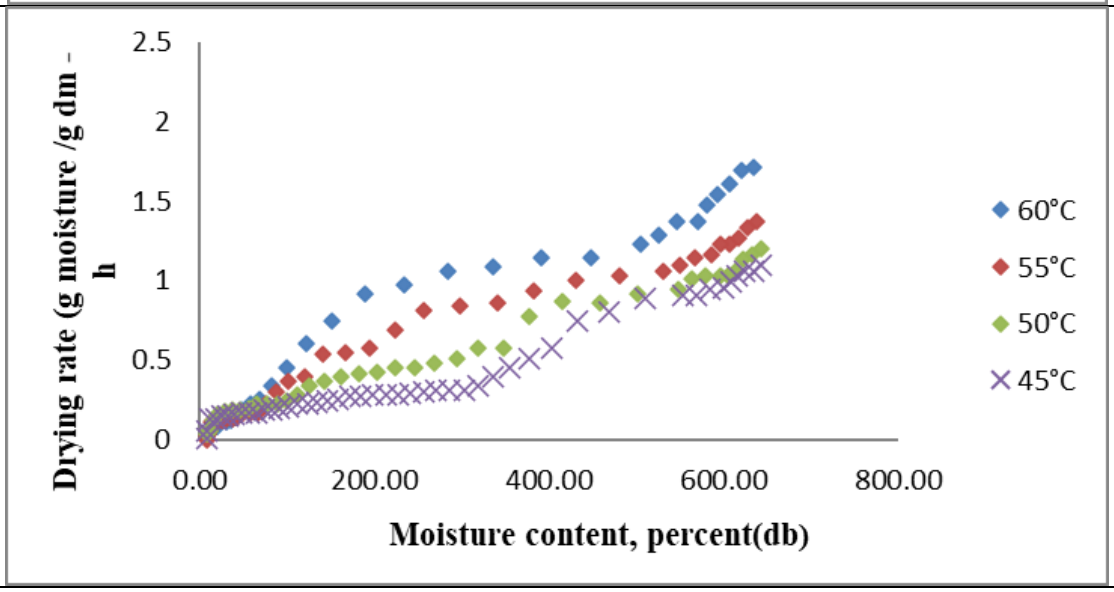
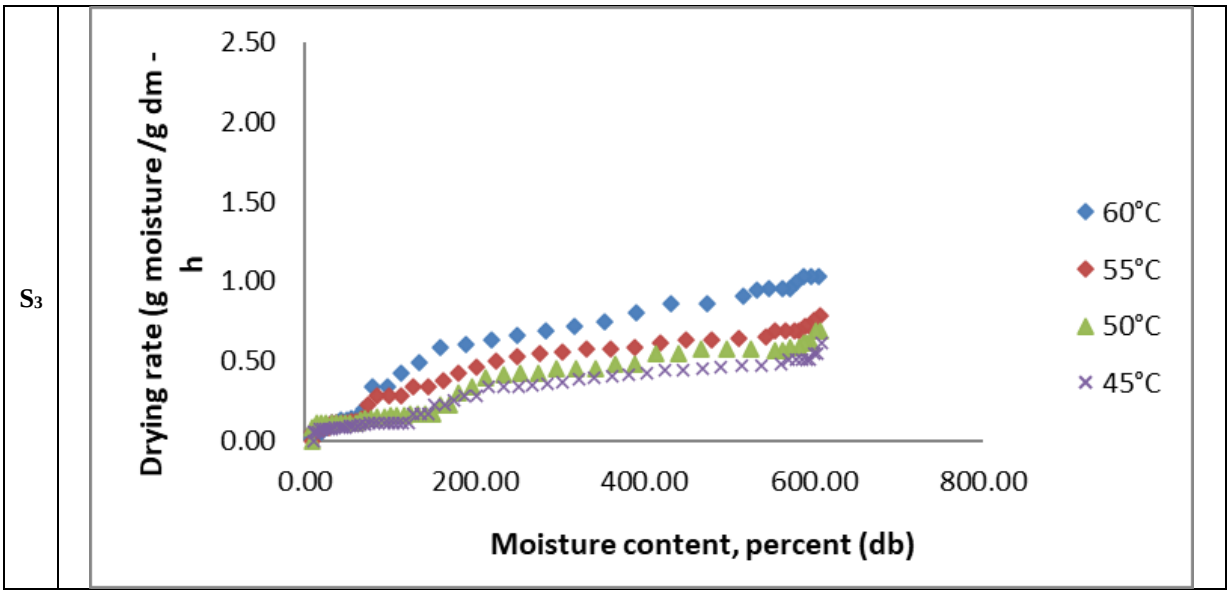
| | |
|---|---|
| $S_3$ |  |



**Table 5:** Variation in drying rate with respect to moisture content (db)

| | |
|---|---|
| $S_1$ |  |
| $S_2$ |  |




**Quality evaluation**

**Water activity**

As shown in Table 6 that water activity values ranged from 0.145 to 0.186 and all were under the safe limit to avoid microbial activities. The minimum value of water activity was obtained as 0.145 for sample $S_1$ at 60 °C and maximum value was as 0.186 for $S_2$ at 45 °C. Lower values correspond to a faster rate of moisture evaporation at higher temperatures which in turn influences the reduced water activity of the product.

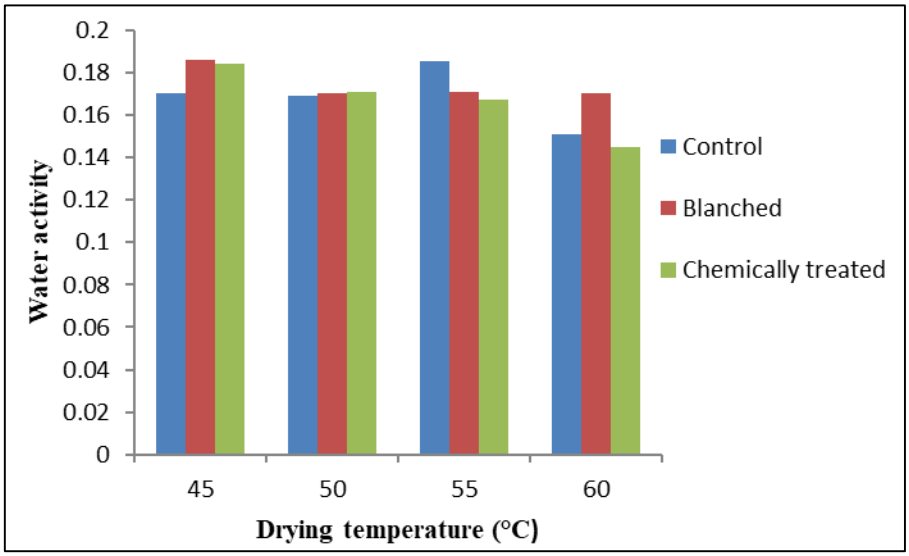



**Fig 1:** Variation in water activity values

**Color**

The values of color parameters L*, a* and b* for all the samples are presented in Table 6. The L*, a* and b* values of fresh green chilli mentioned in Table 2 were used as the reference for color measurement. Color values were severely affected by the higher drying temperature. The recorded values of parameter L* varied within the range of 58.69 to 63.73. Similarly, parameter a* ranged from 0.98 to 3.49 and parameter b* from 18.48 to 28.82. Lowest value of a* was obtained for sample $S_1$ at 55°C indicating retention of green color more than other samples. This is in agreement with Ahmed *et al. 2000*, which stated the similar retention of color for lye treated samples of chilli.

**Table 6:** Quality attributes of different samples of chilli powder

| Quality attributes | Samples | Temperature | | | |
|---|---|---|---|---|---|
| | | 45 °C | 50 °C | 55 °C | 60 °C |
| Water activity | $S_1$ | 0.184 | 0.171 | 0.167 | 0.145 |
| | $S_2$ | 0.186 | 0.170 | 0.171 | 0.170 |
| | $S_3$ | 0.170 | 0.169 | 0.185 | 0.151 |
| Ascorbic acid (mg/ 100 g) | $S_1$ | 68 | 67 | 65 | 64 |
| | $S_2$ | 64 | 57 | 56 | 55 |
| | $S_3$ | 60 | 55 | 57 | 60 |
| **Colour parameter** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| L* | $S_1$ | 62.48 | 60.23 | 62 | 63.07 |
| | $S_2$ | 58.69 | 59.65 | 60.05 | 62.73 |
| | $S_3$ | 63.73 | 60.12 | 61.57 | 63.10 |
| | | | | | |
| a* | $S_1$ | 1.95 | 1.61 | 0.98 | 1.32 |
| | $S_2$ | 3 | 1.52 | 1.56 | 1.47 |
| | $S_3$ | 3.49 | 1.98 | 1.70 | 2.12 |
| | | | | | |
| b* | $S_1$ | 28.82 | 26.9 | 24.5 | 18.48 |
| | $S_2$ | 25.08 | 27.08 | 27.08 | 23.24 |
| | $S_3$ | 22.02 | 25.82 | 27 | 26.1 |

**Ascorbic acid**

The highest ascorbic acid content retained was found at 45**°C** as 68 mg/100 g (Table 6) for chemically treated sample in heat pump dryer. Fig.2. compares the retention of ascorbic acid content for different chilli samples dried at different temperatures. Use of higher temperature resulted in more loss of ascorbic acid when compared with lower temperature. Nindo *et al*. (2003) showed the similar comparison and stated that heated air exposed products to oxidation which resulted higher losses of ascorbic acid content [14]. In addition to this, ascorbic acid values were relatively higher for samples $S_1$ than for others which indicate higher recovery of ascorbic acid through chemical treatment. This may be attributed to the explanation given by Deng *et al*. (2019) that sulphite solutions acted as an oxidising agents in preventing loss of ascorbic acid along with lipids and essential oils [15].

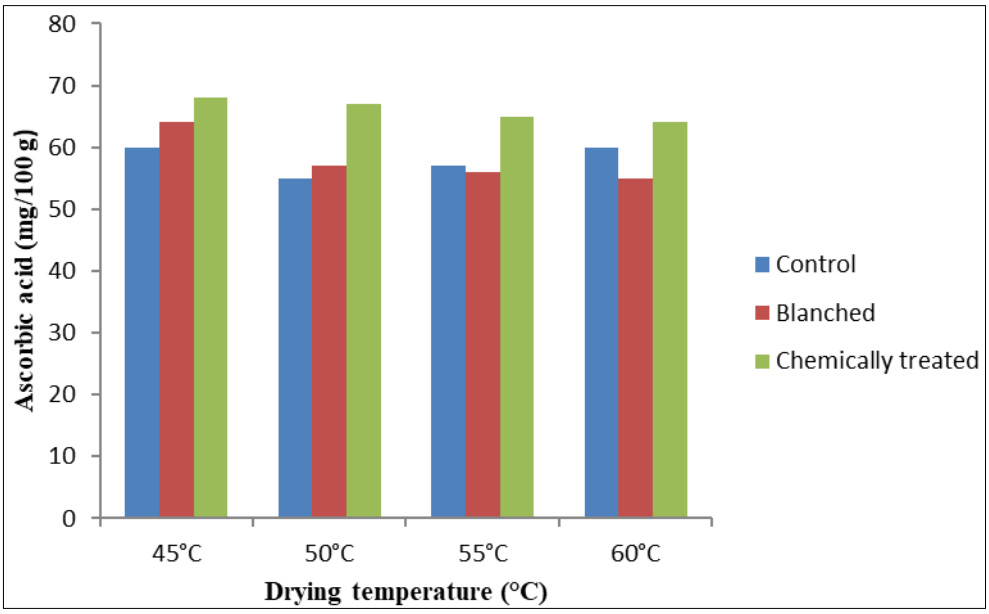



**Fig 2:** Variation in ascorbic acid content (mg/100 g)

**Conclusions**

Drying curves exhibited a steeper slope indicating increase in drying rate with increase in temperature and as a result there was substantial decrease in drying time. Moreover, chemically treated samples were dried much earlier than the control sample indicating the faster removal of moisture. In addition to this, moisture diffusivity was also higher for chemically treated samples than for control samples. The possible explanation to this may be given as on higher temperatures moisture diffuses rapidly because of increase in surface and sub-surface moisture evaporation. Values for water activity were slightly less for chemically treated samples and for increasing drying temperatures.

Color parameters were affected by high temperature. Chemically treated samples showed improved green color (a*) than other samples. Lowest value of a* was resulted at 55°C. Ascorbic acid content decreased with increase in drying air temperature for all samples. Similar results were also reported by Paul and Singh, 2013 which revealed that low operating temperature could preserve the most nutrients [16]. Ascorbic acid content was recorded higher for chemically treated samples and blanched samples were recorded for lower values than control samples. Higher losses in blanched samples may be due to the reason that ascorbic acid is highly water soluble and it may leach out during water treatment.

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**Conflict of Interests:** None

**Ethical Approval:** The study was approved by an organised advisory committee in the institution.

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