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Effect of different pretreatments, drying methods and packaging materials on physico-chemical properties of red chilli (*Capsicum annuum* L. var. Warangal Chapata)

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Abstract
A study was carried out to study the effect of pretreatments, drying methods and packaging materials on physico-chemical properties of red chilli (*Capsicum annuum* L. var. Warangal Chapata). Treatment T_8 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags had retained maximum values for surface colour measurement (L*, a* and b*) of fruit and capsanthin (ASTA units), whereas minimum values for browning index and non-enzymatic browning over the storage period. Maximum and minimum values for rehydration ratio were recorded in Treatment T_{10} - Hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags and T_1 - Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags respectively. The physico-chemical properties of red chilli (*Capsicum annuum* L. var. Warangal Chapata) can be best preserved with Treatment T_8 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags.

Keywords: Chilli, Calcium chloride ($CaCl_2$), Sodium metabisulfite ($Na_2S_2O_5$), Ethyl oleate, Potassium carbonate (K_2CO_3), Sun drying, Hot air oven drying (50°C), Gunny bags, White HDPE polypropylene bags

Introduction
Chilli (*Capsicum annuum*), a versatile plant, is grown globally and serves as a vegetable, spice, flavouring and colouring agent (Reyes-Escogido *et al*., 2011) [23]. Chilli peppers are packed with beneficial compounds like capsanthin, capsaicin, carotenoids, oleoresins and phenolics, along with other important antioxidants (Maeda *et al*., 2013) [16]. Chapata chilli, also known as "tomato chilli" has a very low Scoville score of 3,100-6,500 SHU due to its minimal capsaicin content. Although its fresh, ripe pods are popular for pickles, its high oleoresin content (6.37-6.75%) gives it a vibrant red colour, making it excellent for producing paprika oleoresin-a natural food and beverage colouring. It is mainly cultivated in Warangal, Hanamkonda, Mulugu and Jayashankar Bhupalpally districts of Telangana state.

Chilli can be preserved for long time in dried form. Dried chilli is one of the most widely used condiments for colouring and flavouring in Asian cuisines. Sun drying is a widely used, traditional method for drying chillies. This process typically takes between 7 to 20 days, depending on the weather and chilli variety, to reduce moisture content to 10-15 per cent (Toontom *et al*., 2012) [26]. However, prolonged sun drying can yield lower-quality product. This is because extended exposure to air and light causes the chillies to lose their vibrant red colour and vitamin-C (Kamal *et al.*, 2019) [10]. Hot air oven drying is the most popular method for drying chillies because it's relatively fast and heats the product uniformly (Kumar *et al*., 2019) [11].

Chemical reagents such as sodium metabisulfite and sodium sulfite are often added to blanching water to preserve colour and quality of dried chillies as sulfite inhibits the non- enzymatic browning reaction (Gurung *et al.*, 2020) [8]. In addition, soaking in sodium metabisulfite combined with calcium chloride produced highest colour value (Take-Ajaykumar *et al*., 2012) [24]. Blanching of chilli with potassium carbonate results in better retention of vitamin C content and colour (Tavakolipour and Mokhtarian, 2016) [25]. Pretreatment with ethyl oleate resulted in

quick drying and red colour is preserved better than those of untreated ones (Doymaz and Pala, 2002) [4].
Packaging plays a crucial role in preserving the vibrant colour of dried chillies. Traditionally, dried chillies are stored in gunny bags (Anjaneyulu and Sharangi, 2022) [2].

Materials and Methods

Freshly harvested chillies (variety: Warangal chapata) at red ripe stage were procured directly from farmers field which is located in Rampur, Narsampet. The experiment was conducted to study the effect of pretreatment combinations such as (calcium chloride (0.5%) + sodium metabisulfite (0.5%) and ethyl oleate (2%) + potassium carbonate (1%)), drying methods (sun drying and hot air oven drying at 50°C) and packaging materials (gunny bags and polypropylene HDPE white bags) on red chillies. It comprised twelve (12) treatment combinations, namely: T_1 - Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags; T_2 - Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags; T_3 - Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + gunny bags; T_4 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags; T_5 - Sun drying + gunny bags; T_6 - Sun drying + polypropylene HDPE white bags; T_7 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags; T_8 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags; T_9 - Hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + gunny bags; T_{10} - Hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags; T_{11} - Hot air oven drying + gunny bags; T_{12} - Hot air oven drying + polypropylene HDPE white bags. The experiment was laid out in a Completely Randomized Design (CRD), replicated thrice, and the samples were stored for 60 days.

Surface colour measurement of fruit (L*, a*, b* values)

The colour of the chilli pod was calibrated using a Colourimeter of 8/D geometry (Model: CIE 15.2, GB/T3978) fitted with a diameter of 8 mm flat aperture and 4 mm tip aperture. The instrument was calibrated using the white tiles provided. Consequent changes of colour were quantified in the L*, a*, b* colour space. L*, represents lightness of the fruit sample colour ranging from 0 (black) to 100 (white) scale. The a* value represents the red-green axis, negative value of a* denotes a green colour, whereas, the positive value indicates red-purple colour. The b* value corresponds to the yellow-blue axis, positive value of b* is indicative of yellow colour and the negative value is of blue colour (McGuire, 1992) [19]. The colour of dried chilli pods was measured at 0, 30 and 60 days of storage.

Browning index (BI)

Browning index represents the purity of brown colour and is considered as an important parameter associated with browning (Lopez *et al*., 1997) [15]. BI was measured for chilli pods at 0, 30 and 60 days of storage.

$$BI = \frac{\{100(x - 0.31)\}}{0.17}$$

Where, $x = \frac{(a+1.75L)}{5.645L+a-0.312b}$

Here, L, a and b represent the surface colour values measured using a colourimeter.

Rehydration Ratio (RR)

The dried red chilli slices (1g = W_{dried})) were placed in distilled water at 40 °C for 6 h, using a solid to liquid ratio of 1:50. The samples were then removed, drained for 30 s and weighed (W_{reh}). All measurements were done in triplicates (Vega-Galvez *et al*. 2008a) [28].

$$RR = \frac{W\,reh \times X\,reh - W\,dried \times X\,dried}{W\,dried \times (1 - X\,dried)}$$

Where, W_{reh} = weight of the sample after the rehydration process
W_{dried} = is the weight of the sample after the drying process
X_{reh} = moisture content on a wet basis
X_{dried} = moisture content on a wet matter.

Non-enzymatic Browning (NEB)

The methodology applied for determination of non-enzymatic browning compounds (NEB) was proposed by El-Hamzy and Ashour (2016) [5]. The rehydration water obtained from the above process, was first clarified by centrifugation at 3200 rpm for 10 min. The supernatant was diluted with an equal volume of ethanol at 95% and centrifuged again at 3200 rpm for 10 min. The browning index (absorbance at 420 nm) of the clear extracts was determined in quartz cuvettes using a spectrophotometer.

Capsanthin (ASTA units)

The capsanthin content of fruits measured in ASTA (American Spice Trade Association) units was determined using the procedure outlined by ASTA (1995) [3].
100 mg of sieved fine chilli powder was weighed into a volumetric flask. Acetone was added and flask was closed tightly with stopper, then contents were kept for 16 h at room temperature in dark and shaken intermittently. Solution was filtered using Whatman filter paper and final volume was made up to 100 ml. Absorbance of final extract was read at 460 nm using acetone as blank, using UV- VIS Spectrophotometer. Detailed procedure is represented in Plate 3.5. ASTA colour units were calculated as per the formula given below,

$$ASTA = \frac{\text{Absorbance at 460 nm} \times 16.4}{\text{Weight of sample in grams}}$$

Statistical analysis

The experimental data pertaining to various parameters were statistically analyzed by adopting a completely randomized as per the procedure outlined by Panse and Sukhatme (1985) [20]. The appropriate standard error of mean SE(m) and the critical difference (CD) were calculated at 5 per cent level of probability.

Results and Discussion

Surface colour measurement of fruit (L*, a*, b* values)

From results it has been revealed that significant differences were observed among the treatments on surface colour measurement of fruit at 0, 30 and 60 days of storage. L*, a* and b* values were decreased during the storage period with mean values of 42.46, 38.56 and 35.89 (L*), 64.30, 55.45 and 45.22 (a*) and 33.24, 27.98 and 23.72 (b*) as represented in Table 1.

At 0 days of storage

L*, a* and b* values were found significantly highest in Treatment T_8 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags (45.25, 73.17 and

36.51) and lowest was recorded in T_5 - Sun drying + gunny bags (39.07, 54.55 and 30.53) respectively.

At 30 days of storage

L*, a* and b* values were found significantly highest in Treatment T_8 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags (42.95, 65.75 and 32.11) and lowest was recorded in T_5 - Sun drying + gunny bags (33.26, 44.30 and 24.49) respectively.

At 60 days of storage

L*, a* and b* values were found significantly maximum in Treatment T_8 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags (40.41, 56.94 and 26.90) and minimum was recorded in T_5 - Sun drying + gunny bags (30.64, 33.90 and 20.11) respectively.

Pretreatments significantly improved the colour of dried chilies, as observed by Vega-Galvez *et al*. (2008a) [28], by reducing browning pigment formation which is indicted by higher L (lightness) values. The addition of calcium chloride further stabilizes red colour by reducing drying time and minimizing thermal degradation and oxidation of carotenoids, a finding consistent with Davoodi *et al*. (2007) and with sodium metabisulfite's role in inhibiting browning. Previous research conducted by Maurya *et al*. (2018) [18] and Topuz *et al*. (2011) [27], showed that sun drying significantly degrades chilli colour. This substantial colour loss, indicated by changes in L*, a* and b* values, is primarily due to pigment oxidation and decomposition, intensified by high oxygen exposure and rapid moisture vaporization from the chilli's surface during the sun drying process.

Browning index (BI)

Significantly lowest value for browning index was found in Treatment T_8 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags (91.64, 86.74 and 78.91) and highest value was recorded in T_5 - Sun drying + gunny bags (98.73, 94.41 and 88.43) at 0, 30 and 60 days of storage respectively as depicted in Table 2.

Browning in dried chilies is primarily due to the Maillard reaction (between sugars and amino acids) and pigment oxidation, intensified by oxygen exposure during drying and storage, as noted by Lee *et al*. (1991) [13] and Pooja *et al*. (2023) [21]. However, blanching combined with sodium metabisulfite and calcium chloride pretreatment effectively preserves colour purity. Sodium metabisulfite inhibits browning by binding to reactive compounds (Take-Ajaykumar *et al*. 2012) [24], while calcium chloride improves colour stability by increasing water mobility and reducing drying time (Wiriya *et al*. 2009) [30]. Untreated samples and those stored in gunny bags show increased browning due to greater oxygen and light exposure, promoting both Maillard reactions and enzymatic browning, as noted by Pooja *et al*. (2023) [21].

Rehydration ratio

During the storage rehydration ratio was increased for all treatments, with means of 4.96, 5.16 and 5.33 at 0, 30 and 60 days of storage respectively as represented in Table 3.

The considerable variations observed in all treatments for rehydration ratio with significantly maximum values were found in Treatment T_{10} - Hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags (5.20, 5.45 and 5.75) and minimum value were recorded in T_1 - Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags (4.69, 4.89 and 5.00) at 0, 30 and 60 days of storage respectively.

Samples pretreated with saline solutions such as $CaCl_2$ allow chillies to maintain the initial texture, leading to cellular structure stability, thus lower values for rehydration ratio were obtained, which is in line with research done by Lewicki *et al*. (1998) [14] and Vega-Galvez *et al*. (2009a) [28].

Non-enzymatic browning

Data reveals that non-enzymatic browning was increased for all treatments during the storage, with means of 0.35, 0.44 and 0.54 at 0, 30 and 60 days of storage respectively as depicted in Table 4.

Significantly lowest value for non-enzymatic browning was found in Treatment T_8 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags (0.21, 0.24 and 0.28) and highest value was recorded in T_5 - Sun drying + gunny bags (0.59, 0.78 and 1.03) at 0, 30 and 60 days of storage respectively.

During drying, enzymatic and non-enzymatic browning are key reactions. Pretreatment methods like blanching or chemical treatments can prevent enzymatic browning by deactivating enzymes (Gupta *et al*. (2002) [7]; Hossain and Bala, (2002) [9]. However, non-enzymatic reactions, such as the Maillard reaction between amino acids and reducing sugars, intensify at higher temperatures and moderate moisture levels. These reactions create the colours and flavours that indicate quality changes in food (Manzocco *et al*. 2001) [17].

Non-enzymatic browning in chilli samples significantly increased with storage time across all treatments. Open sun-dried samples exhibited the highest non-enzymatic browning levels. This rise in non-enzymatic browning during storage is attributed to pigment oxidation and decomposition, likely due to greater oxygen exposure as intense moisture vaporization occurred on the chilli's surface, as reported by Gupta *et al*. (2002) [7], Kumari *et al*. (2003) [12] and Wani, (2015) [29].

Capsanthin (ASTA units)

Capsanthin was decreased in all treatments during the storage, with means of 93.59, 86.76 and 83.19 at 0, 30 and 60 days of storage respectively as represented in Table 5.

Significantly highest values for capsanthin were found in Treatment T_8 - Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags (108.90, 105.83 and 101.52 ASTA units) and lowest values were recorded in T_5 - Sun drying + gunny bags (78.14, 64.89 and 61.84 ASTA units) at 0, 30 and 60 days of storage respectively.

Findings are consistent with reporting's of Prasad, (2008) [22]; Wani, (2015) [29]; Pooja *et al*. (2023) [21]; Fikiru *et al*. (2024) [6] and Ambrose *et al*. (2024) [1] in red chilli. Pretreatment combinations yielded the highest ASTA colour values because they protected the samples from oxidation and chemical reactions that form browning compounds, as proved by (Wani, 2015) [29]. Sun-dried chilies consistently without any pretreatment showed a lower ASTA colour value, a finding supported by Prasad, (2008) [22] and Ambrose *et al*. (2024) [1]. The vibrant red in chilies comes from carotenoids like cryptocapsin, capsanthin and capsorubin. The stability of carotenoids during storage depends on the variety, drying and storage temperature, exposure to light and the permeability of oxygen. In the present study, the extractable colour content decreased as the storage duration increased in all packaging materials, in accordance with Fikiru *et al*. (2024) [6]. Specifically, capsanthin, being sensitive to light and prone to oxidation, degraded more in gunny bags due to higher oxygen exposure during storage, as proved by Pooja *et al*. (2023) [21].

Table 1: Effect of different pretreatments, drying methods and packaging materials on surface colour measurement of fruit (L*, a*, b*) during storage of red chilli (*Capsicum annuum* L. var. Warangal Chapata)

Treatments	L* during storage				a* during storage				b* during storage			
	0 days	30 days	60 days	Mean	0 days	30 days	60 days	Mean	0 days	30 days	60 days	Mean
T_1	43.96^{ab}	38.66^{d}	35.79^{de}	39.47	66.18^{cd}	54.24^{e}	43.29^{fg}	54.57	30.85^{e}	27.93^{cde}	24.76^{b}	27.85
T_2	43.78^{ab}	40.17^{bc}	38.42^{b}	40.79	66.71^{c}	58.11^{de}	47.6^{de}	57.48	34.41^{bc}	27.97^{cd}	24.38^{c}	28.95
T_3	41.40^{bc}	37.95^{e}	34.57^{e}	37.97	61.48^{e}	52.19^{f}	41.63^{g}	51.77	32.71^{c}	26.73^{e}	21.89^{f}	27.11
T_4	41.54^{b}	39.27^{c}	36.37^{d}	39.06	63.01^{d}	57.46^{def}	45.84^{e}	55.43	31.5^{ef}	27.35^{d}	23.78^{d}	27.54
T_5	39.07^{c}	33.26^{g}	30.64^{h}	34.36	54.55^{fg}	44.30^{i}	33.90^{i}	44.25	30.53^{f}	24.49^{h}	20.11^{h}	25.47
T_6	39.19^{cd}	35.95^{f}	32.52^{g}	35.85	54.98^{f}	46.69^{h}	37.62^{h}	46.43	31.82^{d}	25.6^{gh}	20.76^{g}	25.63
T_7	45.21^{ab}	40.11^{bc}	38.39^{bc}	41.25	72.40^{a}	60.83^{c}	50.45^{c}	61.23	36.20^{ab}	30.03^{b}	21.76^{fg}	29.43
T_8	45.25^{a}	42.95^{a}	40.41^{a}	42.86	73.17^{ab}	65.75^{a}	56.94^{a}	65.29	36.51^{a}	32.11^{a}	26.90^{a}	31.73
T_9	44.38^{ab}	39.21^{cd}	37.16^{c}	40.25	68.90^{b}	58.91^{d}	47.85^{d}	58.55	33.52^{b}	28.34^{c}	25.76^{abc}	29.20
T_{10}	44.31^{ab}	41.19^{b}	39.52^{ab}	41.67	68.46^{bc}	62.37^{b}	52.94^{b}	61.26	34.49^{bc}	30.16^{b}	26.03^{ab}	30.20
T_{11}	40.74^{c}	36.15^{f}	32.88^{g}	36.59	61.24^{e}	50.77^{g}	40.83^{g}	50.94	33.67^{bcd}	26.19^{f}	23.17^{e}	27.68
T_{12}	40.69^{c}	37.80^{e}	34.02^{f}	37.50	60.47^{ef}	53.74^{ef}	43.74^{f}	52.65	32.69^{cd}	28.83^{c}	25.35^{abc}	28.96
Mean	42.46	38.56	35.89		64.30	55.45	45.22		33.24	27.98	23.72	
S.E (m) ±	0.58	0.27	0.36		0.35	0.34	0.34		0.24	0.30	0.35	
CD @ 5%	1.70	0.79	1.05		1.04	1.34	0.99		0.70	0.88	1.03	
C.V (%)	2.37	1.06	1.73		0.95	1.06	1.30		1.24	1.85	2.55	

Treatment details:	
T_1 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags	T_7 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags
T_2 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags	T_8 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags
T_3 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + gunny bags	T_9 -Hot air oven drying+ ethyl oleate (2%) + K_2CO_3 (1%) +gunny bags
T_4 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags	T_{10} -Hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags
T_5 -Sun drying + gunny bags	T_{11} -Hot air oven drying + gunny bags
T_6 -Sun drying + polypropylene HDPE white bags	T_{12} -Hot air oven drying + polypropylene HDPE white bags

Table 2: Effect of different pretreatments, drying methods and packaging materials on browning index of fruit (L*, a*, b*) during storage of red chilli (*Capsicum annuum* L. var. Warangal Chapata)

Browning index during storage				
Treatments	**0 days**	**30 days**	**60 days**	**Mean**
T_1	94.58^{abc}	90.70^{bc}	84.40^{d}	89.89
T_2	95.38^{abc}	89.59^{b}	81.63^{c}	88.87
T_3	96.22^{abc}	92.84^{c}	81.85^{cd}	90.30
T_4	95.32^{abc}	91.45^{bc}	80.93^{bcd}	89.23
T_5	98.73^{bcd}	94.41^{de}	88.43^{e}	93.86
T_6	96.82^{b}	93.85^{d}	85.04^{de}	91.57
T_7	92.29^{abc}	88.44^{ab}	78.96^{bc}	85.99
T_8	91.64^{a}	86.74^{a}	74.98^{a}	85.02
T_9	94.73^{abc}	88.38^{ab}	79.81^{bc}	87.64
T_{10}	94.45^{abc}	89.10^{abc}	78.91^{b}	87.49
T_{11}	97.78^{bc}	93.63^{cd}	83.09^{cde}	91.50
T_{12}	96.03^{abc}	92.83^{c}	82.67^{cd}	90.51
Mean	95.25	91.00	81.72	
S.E (m) ±	1.18	0.66	0.87	
CD @ 5%	4.67	2.61	3.46	
C.V (%)	2.15	1.26	1.85	

Treatment details

T_1 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags	T_7 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags
T_2 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags	T_8 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags
T_3 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + gunny bags	T_9 -Hot air oven drying+ ethyl oleate (2%) + K_2CO_3 (1%) +gunny bags
T_4 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags	T_{10} -Hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags
T_5 -Sun drying + gunny bags	T_{11} -Hot air oven drying + gunny bags
T_6 -Sun drying + polypropylene HDPE white bags	T_{12} -Hot air oven drying + polypropylene HDPE white bags

Table 3: Effect of different pretreatments, drying methods and packaging materials on rehydration ratio during storage of red chilli (*Capsicum annuum* L. var. Warangal Chapata)

Rehydration ratio during storage				
Treatments	**0 days**	**30 days**	**60 days**	**Mean**
T_1	4.69^{e}	4.89^{j}	5.00^{h}	4.86
T_2	4.72^{e}	4.98^{i}	5.13^{g}	4.94
T_3	4.94^{c}	5.17^{ef}	5.30^{d}	5.14
T_4	4.95^{c}	5.23^{cd}	5.41^{c}	5.20
T_5	5.05^{b}	5.08^{gh}	5.21^{ef}	5.11
T_6	5.07^{b}	5.20^{de}	5.44^{c}	5.23
T_7	4.85^{d}	5.04^{h}	5.17^{fg}	5.02
T_8	4.83^{d}	5.12^{fg}	5.25^{de}	5.07
T_9	5.16^{ab}	5.34^{b}	5.58^{b}	5.37
T_{10}	5.20^{a}	5.45^{a}	5.75^{a}	5.45
T_{11}	5.05^{b}	5.14^{f}	5.29^{d}	5.16
T_{12}	5.03^{b}	5.27^{c}	5.42^{c}	5.24
Mean	4.96	5.16	5.33	
S.E (m) ±	0.02	0.02	0.02	
CD @ 5%	0.07	0.05	0.05	
C.V (%)	0.77	0.61	0.56	

Treatment details

T_1 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags	T_7 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags
T_2 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags	T_8 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags
T_3 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + gunny bags	T_9 -Hot air oven drying+ ethyl oleate (2%) + K_2CO_3 (1%) +gunny bags
T_4 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags	T_{10} -Hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags
T_5 -Sun drying + gunny bags	T_{11} -Hot air oven drying + gunny bags
T_6 -Sun drying + polypropylene HDPE white bags	T_{12} -Hot air oven drying + polypropylene HDPE white bags

Table 4: Effect of different pretreatments, drying methods and packaging materials on non-enzymatic browning (O.D) during storage of red chilli (*Capsicum annuum* L. var. Warangal Chapata)

Non-enzymatic browning (O.D) during storage				
Treatments	**0 days**	**30 days**	**60 days**	**Mean**
T_1	0.34^{c}	0.40^{d}	0.47^{d}	0.41
T_2	0.33^{c}	0.37^{c}	0.41^{c}	0.37
T_3	0.38^{d}	0.47^{f}	0.58^{f}	0.48
T_4	0.39^{de}	0.44^{ef}	0.52^{e}	0.45
T_5	0.59^{ef}	0.78^{h}	1.03^{j}	0.80
T_6	0.58^{e}	0.76^{g}	0.94^{i}	0.76
T_7	0.20^{ab}	0.26^{ab}	0.31^{ab}	0.26
T_8	0.21^{a}	0.24^{a}	0.28^{a}	0.25
T_9	0.25^{bc}	0.34^{bc}	0.43^{cd}	0.34
T_{10}	0.24^{b}	0.31^{b}	0.39^{b}	0.31
T_{11}	0.33^{c}	0.44^{ef}	0.61^{h}	0.46
T_{12}	0.34^{cd}	0.42e	0.52^{g}	0.43
Mean	0.35	0.44	0.54	
S.E (m) ±	0.01	0.01	0.01	
CD @ 5%	0.03	0.03	0.04	
C.V (%)	4.93	3.72	4.41	

Treatment details

T_1 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags	T_7 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags
T_2 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags	T_8 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags
T_3 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + gunny bags	T_9 -Hot air oven drying+ ethyl oleate (2%) + K_2CO_3 (1%) +gunny bags
T_4 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags	T_{10} -Hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags
T_5 -Sun drying + gunny bags	T_{11} -Hot air oven drying + gunny bags
T_6 -Sun drying + polypropylene HDPE white bags	T_{12} -Hot air oven drying + polypropylene HDPE white bags

Table 5: Effect of different pretreatments, drying methods and packaging materials on capsanthin content (ASTA units) during storage of red chilli (*Capsicum annuum* L. var. Warangal Chapata)

Capsanthin content (ASTA units) during storage				
Treatments	**0 days**	**30 days**	**60 days**	**Mean**
T_1	93.10^{bc}	85.04^{e}	80.39^{e}	86.18
T_2	94.44^{b}	92.71^{c}	90.91^{c}	92.69
T_3	90.31^{bcd}	83.18^{ef}	78.08^{ef}	83.86
T_4	90.18^{bcd}	88.51^{d}	88.48^{d}	89.05
T_5	78.14^{de}	64.89^{hi}	61.84^{gh}	68.29
T_6	78.40^{d}	68.28^{h}	64.34^{g}	70.34
T_7	104.80^{b}	99.99^{b}	95.94^{b}	100.24
T_8	108.90^{a}	105.83^{a}	101.52^{a}	105.42
T_9	104.69^{b}	97.60^{b}	93.64^{b}	98.64
T_{10}	106.22^{ab}	102.66^{ab}	99.13^{ab}	102.67
T_{11}	86.75^{cd}	74.54^{g}	69.51^{f}	76.93
T_{12}	87.17^{c}	77.91^{f}	74.47^{efg}	79.85
Mean	93.59	86.76	83.19	
S.E (m) ±	1.25	1.46	1.64	
CD @ 5%	3.66	4.29	4.80	
C.V (%)	2.31	2.91	3.41	

Treatment details

T_1 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags	T_7 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + gunny bags
T_2 -Sun drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags	T_8 -Hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags
T_3 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + gunny bags	T_9 -Hot air oven drying+ ethyl oleate (2%) + K_2CO_3 (1%) +gunny bags
T_4 -Sun drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags	T_{10} -Hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + polypropylene HDPE white bags
T_5 -Sun drying + gunny bags	T_{11} -Hot air oven drying + gunny bags
T_6 -Sun drying + polypropylene HDPE white bags	T_{12} -Hot air oven drying + polypropylene HDPE white bags

Conclusion

It can be concluded from the present investigation that, the different pretreatments, drying methods and packaging materials significantly influenced the drying characteristics and physico-chemical properties of red chilli (*Capsicum annuum* L. var. Warangal chapata).

T_{10} (hot air oven drying + ethyl oleate (2%) + K_2CO_3 (1%) + gunny bags) has retained maximum values for rehydration ratio over storage period. However, T_8 (hot air oven drying + $CaCl_2$ (0.5%) + $Na_2S_2O_5$ (0.5%) + polypropylene HDPE white bags) has exhibited maximum values for surface colour measurement values (high L*, a* and b*) for dried chilli fruit and capsanthin whereas, least values for browning index and non-enzymatic browning.

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