Biological Forum – An International Journal **15(12): 114-120(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Evaluating the effect of Packaging Materials and Storage Methods on Quality Attributes and Aflatoxin content of dried Byadgi chilli

Pooja[1*], M.D. Jameel Jhalegar[2], Thippanna K.S.[3], Ambreesh[4], Shiddanagouda Yadachi[5] and Abdul Kareem M.[6]

[1]Ph.D. Scholar, Department of Post Harvest Technology, College of Horticulture, Bengaluru, Karnataka, India
[2]Assistant Professor, Department of Post Harvest Management, College of Horticulture, Bagalkot (Karnataka), India.
[3]Assistant Professor, Department of Post Harvest Management, CHEFT, Devihosur (Karnataka), India.
[4]Assistant Professor, Department of Vegetable Science, College of Horticulture, Bidar (Karnataka), India.
[5]Assistant Professor, Department of Agricultural Engineering, CHEFT, Devihosur (Karnataka), India.
[6]Assistant Professor, Department of Plant Pathology, College of Horticulture, Sirsi (Karnataka), India.

(Corresponding author: Pooja)*
(Received: 16 September 2023; Revised: 09 October 2023; Accepted: 19 November 2023; Published: 15 December 2023)
(Published by Research Trend)

ABSTRACT: This study aimed to investigate the impact of different packaging materials and storage conditions on the quality characteristics of dried Byadgi red chilli. Chilli samples were stored in Low-Density Polyethylene (LDPE), Gunny bags, Nylon net bags and double-layer plastic bags under both cold (5±2 °C) and ambient conditions. Over a period of six months, monthly analyses were conducted to examine changes in ascorbic acid, capsanthin, aflatoxin B1 and browning index. Statistical analysis revealed that chilli stored in double-layer packaging material under cold storage conditions exhibited superior preservation characteristics. These samples retained the highest ascorbic acid and capsanthin content. Simultaneously, they demonstrated lower levels of aflatoxin B1 and reduced browning index.

Keywords: Byadgi chilli, storage, quality.

INTRODUCTION

Chilli, a popular spice botanically known as *Capsicum annuum* L., belongs to the family Solanaceae and is native to South America. Around the world, chilli is known by a wide range of names such as capsicums, bell peppers, cayenne peppers, pod peppers, hot peppers and red peppers. Chilli is known as the "Wonder Spice" because of its enormous appeal (Sowjanya *et al*., 2017). It is highly valued as a vegetable-cum-spice crop due to its aroma, taste, flavour and pungency. Chilli is also a rich source of essential nutrients such as vitamins C and E, provitamin A and carotenoids, providing significant nutritional benefits (Supriya *et al*., 2015). India cultivates chilli under diverse agroclimatic conditions, encompassing tropical, subtropical and temperate regions (Hazra *et al*., 2011).

After the chilli crop is harvested, farmers eagerly wait for good prices in the market, subjecting their produce to diverse modes of transportation, storage and marketing. However, during this crucial period, a prevailing challenge arises in the form of aflatoxin. Aflatoxins (AFs) are a group of mycotoxins and these are secondary metabolic products of *Aspergillus flavus*, *Aspergillus parasiticus*, *Aspergillus nomius* and *Aspergillus pseudotamariion* on a wide range of food products (Reddy *et al*., 2001). Aflatoxins, which are highly toxic and carcinogenic compounds, are formed at temperatures ranging from 12 to 40 °C, with a temperature range of 24-28 °C being ideal for toxin synthesis. Aflatoxin contamination is more likely in improperly dried chilli with a high moisture content (>14%) and storage at high temperatures (>20 °C) (Pattron, 2006; Richard, 2007). Therefore, the choice of proper packaging material and storage methods becomes paramount. The primary objective of the present study is to investigate the impact of different packaging materials and storage methods on the aflatoxin content and quality attributes of dried Byadgi chilli.

MATERIAL AND METHODS

Dried Chilli. Approximately, 90 kg of dried Byadgi kaddi chilli with an initial moisture content of 7-8 per cent was procured from the local chilli market of Bagalkot

Packaging and storage condition. Dried red Byadgi chilli (1.5 kg) were packed in four different types of packaging materials *viz.*, (i) Low-density polyethylene (LDPE) (ii) Gunny bag (iii) Nylon net bag and (iv) Double layer plastic bags. The samples were stored in cold (5±2 °C) and ambient conditions for six months with three replications. The analysis was carried out at monthly intervals using FCRD design.

Colour of the chilli (*L, *a**, *b**).** The colour of the chilli pod was measured using a Colour Flex EZ colourimeter (Model: CFEZ 1919, Hunter associates laboratory. Inc., Reston) fitted with a 45 mm diameter aperture. The instrument was calibrated using the black and white tiles provided. Colour was expressed in terms of *L** (lightness/darkness), *a** (redness/greenness) and *b** (yellowness/blueness).

Browning index (BI). The browning index (BI) represents the purity of brown colour and is considered an important parameter associated with browning (Lopez *et al*., 1997).

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

$$\text{Where } x = \frac{(a + 1.75\,L)}{5.645L + a - 0.3012b}$$

Ascorbic acid content. Ascorbic acid was estimated by the volumetric method. Exactly 5 ml of the working standard solution was pipetted into a 100 ml conical flask, to this 10 ml of 4 per cent oxalic acid was added and this was turned to a pink colour endpoint when titrated against the dye solution. The amount of the dye consumed was equivalent to the amount of ascorbic acid. One gram chilli sample was weighed and crushed using 4% oxalic acid. The extract was filtered through Whatman No. 41 filter paper and made the volume up to 100 ml, then 5 ml of the extract was pipetted out into a conical flask, then 10 ml of 4% oxalic acid was added and was titrated against the dye. The amount of ascorbic acid present in the sample was calculated using the following formula.

$$\text{Ascorbic acid content (mg100)} = \frac{\text{Titrate value} \times \text{dye factor} \times \text{vol. up made} \times 100}{\text{Weight sample} \times \text{vol. of sample taken}}$$

Capsanthin (ASTA units). The extractable colour value in dry chilli fruits was determined by measuring the absorbance of acetone extract of ground chilli fruit at 450 nm. Fifty milligrams of chilli powder was extracted with 50 ml of pure acetone. This solution was kept for 16 hours at room temperature in a dark area. Pure acetone was taken as blank.

To calculate the colour value, the absorbance of standard potassium dichromate ($K_2Cr_2O_7$) solution at 450 nm is taken. The standard $K_2Cr_2O_7$ solution is prepared by dissolving 50 mg in 100 ml of distilled water. The colour value is determined by using the following formula:

$$\text{Capsanthin (ASTA units)} = \frac{\text{O.D of sample} \times 200}{\text{Mg/ml of sample} \times \text{O.D of standard solution} \times 2}$$

Aflatoxin B1 content (µg/kg). The aflatoxin B1 content in chilli was measured by the indirect competitive ELISA method at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad.

Statistical analysis. The data with respect to all the above parameters were evaluated and subjected to statistical analysis using WASP software for Factorial Completely Randomised Design (FCRD) with a critical difference (CD at 1%) worked out.

RESULTS AND DISCUSSION

Browning index. The browning index was significantly lower (92.81) in the cold-stored (S_2) samples compared to the samples stored under ambient conditions (S_1) (102.10). This variation in browning intensity may be attributed to the increased rate of the Maillard reaction between sugars and amino acids present in the chilli. These findings are consistent with the observations reported by Lee, *et al*. (1991), who also noted a higher occurrence of non-enzymatic browning in dried chilli due to the Maillard reaction.

The Maillard reaction is a complex series of chemical reactions that takes place between reducing sugars and amino acids, leading to the formation of brown pigments and characteristic flavours. This reaction is known to be responsible for the browning and flavour development in various food products during processing and storage. In the case of chilli, the presence of both sugars and amino acids provides favourable conditions for the Maillard reaction to occur at an accelerated rate, leading to increased browning.

Chilli stored in a double-layer plastic bag kept in cold storage (P_4S_2) contributed to the lower (88.59) browning index at 180 days of storage (Table 1). It might be due to restricted oxygen exposure, controlled moisture level and potentially minimized light-induced browning. Furthermore, the cold storage conditions further suppressed enzymatic browning reactions. The synergistic effect of these factors resulted in a reduced browning index, preserving the visual appeal and quality of the chilli samples during storage.

Ascorbic acid (mg/100g). Ascorbic acid is widely recognized for its antioxidant and biologically active properties. Furthermore, it plays a crucial role, as an essential nutritional and functional constituent in dried chilli. Ascorbic acid is sensitive to light, heat and air exposure. Therefore, proper storage conditions should be maintained to minimize the degradation of ascorbic acid. In the present study, the ascorbic acid content of dried chilli decreased during storage in all the treatments. It is mainly because of ascorbic acid being oxidised into L-dehydroascorbic acid due to light and temperature (BeMiller and Whistler 1996). The results are in close proximity with Ahmad and Shivare (2001), Jasim and Shivare (2001), Eleyinmi *et al.* (2002), Gupta *et al.* (2002), Kumari *et al.* (2003), Wiriya *et al.* (2009) and Satyanarayana and Vengaih (2010). Daood *et al*. (1996) reported that ascorbic acid concentration in ground paprika decreased by 10 per cent after 30 days followed by 20 and 35 per cent after 60 and 120 days of storage respectively.

Table 1(a): Effect of different packaging material and storage conditions on browning index value of dried red chilli.

Treatments	Browning index											
	Initial			30 days			60 days			90 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	87.68	86.39	87.03	91.24^{b}	85.57^{d}	88.40^{d}	93.97^{cd}	86.07^{g}	90.44^{c}	95.25^{c}	88.13^{e}	91.69^{c}
P_2	86.64	86.36	86.50	91.75^{b}	87.89^{c}	89.82^{c}	94.09^{bc}	88.52^{f}	91.31^{c}	95.28^{c}	89.14^{e}	92.21^{c}
P_3	85.37	87.11	86.24	92.85^{b}	89.21^{c}	91.03^{b}	96.08^{ab}	91.36^{e}	93.72^{a}	98.32^{b}	92.23^{d}	95.28^{b}
P_4	87.34	85.49	86.41	91.18^{b}	85.14^{d}	88.16^{d}	92.44^{cd}	85.41^{g}	88.92^{d}	93.07^{cd}	86.73^{f}	89.90^{d}
P_5	87.14	85.79	86.47	94.56^{a}	91.19^{b}	92.88^{a}	97.40^{a}	92.06^{de}	94.73^{a}	101.98^{a}	92.57^{d}	97.28^{a}
Mean	**86.83**	**86.23**		**92.31^{a}**	**87.80^{b}**		**94.79^{a}**	**88.85^{b}**		**96.78^{a}**	**89.76^{b}**	
Comp aring mean	**S.Em ±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**	
P	0.749	NS		0.297	1.196		0.349	1.405		0.411	1.652	
S	0..474	NS		0.188	0.756		0.221	0.889		0.259	1.045	
P×S	1.060	NS		0.420	1.691		0.494	1.988		0.581	2.337	

Note: Values with the same superscripts with respect to different packaging materials, storage condition and their interactions are not significantly different by Duncan Multiple Range Test at P = 0.01

Note: P- Packaging material, S- Storage condition

P_1 – LDPE S_1 – Ambient
P_2 - Gunny bag S_2 - Cold
P_3 - Nylon net bag
P_4 - Double-layer plastic bag
P_5 – Control

Table 1(b): Effect of different packaging material and storage conditions on browning index value of dried red chilli.

Treatments	Browning index								
	120 days			150 days			180 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	95.78^{c}	90.15^{e}	92.97^{b}	97.06^{b}	91.34^{de}	94.20^{c}	97.49^{d}	91.89^{g}	94.69^{d}
P_2	97.17^{bc}	90.87^{de}	94.02^{b}	99.98^{b}	91.56^{d}	95.77^{c}	100.47^{c}	92.87^{fg}	96.67^{c}
P_3	102.56^{a}	93.47^{c}	98.01^{a}	105.17^{a}	93.98^{cd}	99.58^{a}	105.83^{b}	94.56^{ef}	100.19^{b}
P_4	93.21^{cd}	87.86^{f}	90.53^{c}	94.18^{c}	88.13^{e}	91.16^{d}	94.57^{ef}	88.59^{h}	91.58^{e}
P_5	104.56a	95.35^{c}	99.95^{a}	108.54^{a}	95.89^{bc}	102.21^{a}	112.15^{a}	96.14^{de}	104.15^{a}
Mean	**98.65^{a}**	**91.54^{b}**		**100.99^{a}**	**92.18^{b}**		**102.10^{a}**	**92.81^{b}**	
Comparing mean	**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**	
P	0.485	1.950		0.719	2.893		0.360	1.450	
S	0.307	1.234		0.455	1.830		0.228	0.917	
P×S	0.685	2.758		1.017	4.091		0.509	2.050	

Note: Values with the same superscripts with respect to different packaging materials, storage condition and their interactions are not significantly different by Duncan Multiple Range Test at P = 0.01

Note: P- Packaging material, S- Storage condition

P_1 – LDPE S_1 – Ambient
P_2 - Gunny bag S_2 - Cold
P_3 - Nylon net bag
P_4 - Double-layer plastic bag
P_5 – Control

During the experiment, significant minimum retention (80.73 mg/100g) of ascorbic acid was recorded in the chilli stored in ambient condition (S_1) whereas, maximum (91.20 mg/100g) retention of ascorbic acid was noticed in the chilli stored in cold storage (S_2) (Table 2). It might be due to the slowing down of the degradation process, including a breakdown of ascorbic acid. Ascorbic acid is highly susceptible to oxidation, which can lead to degradation. Cold storage environments typically have lower oxygen levels, reducing the chances of oxidation and thereby preserving the ascorbic acid content. Cold temperatures can inhibit the activity of enzymes responsible for ascorbic acid degradation. Cold storage can inhibit the growth and activity of microorganisms, reducing the enzymatic and microbial degradation of ascorbic acid. Excessive moisture can lead to hydrolysis and subsequent loss of ascorbic acid. Cold storage often involves controlled humidity levels, which can help prevent moisture-related degradation of ascorbic acid.

Among different packaging materials, the highest (91.22 mg/100g) retention ascorbic acid content was observed in chilli packed in double-layer plastic packaging material (P_4). This might be due to the double-layer plastic packaging material effectively blocking the UV light and reducing the permeation of oxygen and moisture. Double-layer plastic packaging materials can provide insulation and temperature stability, which is important for preserving the quality of chilli, helping to maintain the ascorbic acid content in the chilli.

Aflatoxin B1 (µg/100g). A consistent increase in the aflatoxin B1 (µg/100g) content of chilli was observed for up to 180 days of storage. At 180 days of storage, the highest aflatoxin content (9.75 µg/100g) was observed in the sample kept open/control (P_5) and the lowest content (3.98 µg/100g) was found in the samples stored in double layer plastic bag (P_4) samples. This might be due to double-layer plastic packaging material preventing or inhibiting the growth of fungi. This finding indicates that the most suitable packaging material (double-layer plastic bag) for chilli storage is which can extend the shelf life up to 6 months. Similar findings were reported by Abrar *et al*. (2023) and Kunreddy *et al*. (2023).

Table 2(a): Effect of different packaging material and storage conditions on ascorbic acid content of dried red chilli.

Treatments	Ascorbic acid (mg/100g)											
	Initial			30 days			60 days			90 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	121.56	120.38	120.97	108.94	110.79	109.87^{a}	104.15	108.87	106.51^{ab}	96.85	105.35	101.10^{a}
P_2	121.12	119.56	120.34	107.55	109.42	108.49^{ab}	101.32	106.57	$103.94b^{c}$	94.06	101.93	97.99^{b}
P_3	120.58	121.04	120.81	105.74	109.96	107.85^{b}	98.56	106.53	102.55^{c}	90.94	101.39	96.17^{b}
P_4	120.58	120.46	120.52	109.02	111.42	110.22^{a}	104.45	110.32	107.39^{a}	98.32	105.60	101.96^{a}
P_5	119.86	120.02	119.94	101.88	108.18	105.03^{c}	95.74	105.01	100.37^{d}	88.12	99.20	93.66^{c}
Mean	**120.74**	**120.29**		**106.63^{b}**	**111.98^{a}**		**100.84^{b}**	**107.46^{a}**		**93.658^{b}**	**102.69^{a}**	
Comparing mean	**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**	
P	0.282	NS		0.568	2.287		0.645	2.595		0.548	2.205	
S	0.178	NS		0.359	1.446		0.408	1.641		0.347	1.394	
P×S	0.399	NS		0.804	NS		0.912	NS		0.775	NS	

Note: Values with the same superscripts with respect to different packaging materials, storage condition and their interactions are not significantly different by Duncan Multiple Range Test at P = 0.01
Note: P- Packaging material, S- Storage condition
P_1 – LDPE		S_1 – Ambient
P_2 - Gunny bag		S_2 - Cold
P_3 - Nylon net bag
P_4 - Double-layer plastic bag
P_5 – Control

Table 2(b): Effect of different packaging material and storage conditions on ascorbic acid content of dried red chilli.

Treatments	Ascorbic acid (mg/100g)								
	120 days			150 days			180 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	93.40^{d}	98.15^{a}	**95.77^{b}**	91.02^{d}	94.66^{ab}	92.84^{b}	87.32^{d}	92.25^{a}	89.78^{b}
P_2	88.57^{e}	97.71^{ab}	**93.14^{c}**	84.56^{e}	94.36^{b}	89.46^{c}	79.66^{e}	91.93^{ab}	85.80^{c}
P_3	86.14^{e}	96.55^{b}	**91.34^{d}**	81.80^{f}	92.59^{c}	87.19^{d}	76.44^{f}	90.25^{bc}	83.35^{d}
P_4	96.30^{bc}	99.59^{a}	**97.95^{a}**	92.67^{c}	95.85^{a}	94.26^{a}	89.10^{cd}	93.35^{a}	91.22^{a}
P_5	82.39^{f}	94.22^{cd}	**88.31^{e}**	76.13^{g}	90.83^{d}	83.48^{e}	74.14^{g}	88.19^{d}	79.66^{e}
Mean	**89.36^{b}**	**97.24^{a}**		**85.23^{b}**	**93.66^{a}**		**80.73^{b}**	**91.20^{a}**	
Comparing mean	**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**	
P	0.386	1.551		0.240	0.966		0.350	1.410	
S	0.244	0.981		0.152	0.611		0.222	0.892	
P×S	0.545	2.194		0.340	1.367		0.496	1.995	

Note: Values with the same superscripts with respect to different packaging materials, storage condition and their interactions are not significantly different by Duncan Multiple Range Test at P = 0.01
Note: P- Packaging material, S- Storage condition
P_1 – LDPE		S_1 – Ambient
P_2 - Gunny bag		S_2 - Cold
P_3 - Nylon net bag
P_4 - Double-layer plastic bag
P_5 – Control

Among the storage conditions, a higher level of aflatoxin was noticed in the chilli stored in ambient condition (S_1) (8.33 µg/100g) compared to cold storage condition (S_2) (4.90 µg/100g) (Table 3) during 180 days of storage. It might be due to ambient storage conditions characterized by warm and humid conditions promoting fungal colonization and subsequent aflatoxin contamination. The results are in close proximity with Reddy *et al*. (2001). Capsanthin (ASTA units). The principal colouring matter of chilli fruit is the carotenoid pigment and the extent of colouring matter present in a variety is important for the spice industry (Bajaj and Kaur., 1980). Capsanthin is the primary pigment found in chilli, accounting for approximately 35 per cent of the total pigments present. These pigments are most abundant in the initial days of storage and gradually decrease in subsequent storage. Capsanthin content significantly varied between cold and ambient storage (Table 4).

Table 3(a): Effect of different packaging material and storage conditions on aflatoxin B1 value of dried chilli.

Treatments	Aflatoxin B1 (µg/kg)											
	Initial			30 days			60 days			90 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	0.24	0.25	0.25	1.53	0.89	1.21^{bc}	1.93	1.33	1.63^{bc}	2.57	1.86	2.21b
P_2	0.25	0.27	0.26	2.20	1.20	1.7^{a}	2.97	1.92	2.44^{a}	4.31	2.25	3.28^{a}
P_3	0.25	0.26	0.26	1.87	1.14	1.51^{ab}	2.85	1.68	2.26^{ab}	4.42	2.68	3.55^{a}
P_4	0.26	0.27	0.27	1.27	0.58	0.93^{c}	1.70	0.94	1.32^{c}	2.28	1.47	1.88^{b}
P_5	0.25	0.24	0.24	2.39	1.56	1.97^{a}	3.37	2.18	2.78^{a}	5.03	3.00	4.01^{a}
Mean	0.250	0.257		**1.85^{a}**	**1.07^{b}**		**2.56^{a}**	**1.61^{b}**		**3.72^{a}**	**2.25^{b}**	
Comparing mean	**S.Em ±**	**CD at 1%**		**S.Em ±**	**CD at 1%**		**S.Em ±**	**CD at 1%**		**S.Em ±**	**CD at 1%**	
P	0.014	NS		0.131	0.529		0.187	0.751		0.229	0.920	
S	0.009	NS		0.083	0.335		0.118	0.475		0.145	0.582	
P×S	0.019	NS		0.186	NS		0.264	NS		0.323	NS	

Note: Values with the same superscripts with respect to different packaging materials, storage condition and their interactions are not significantly different by Duncan Multiple Range Test at P = 0.01
Note: P- Packaging material, S- Storage condition
P_1 – LDPE S_1 – Ambient
P_2 - Gunny bag S_2 - Cold
P_3 - Nylon net bag
P_4 - Double-layer plastic bag
P_5 – Control

Table 3(b): Effect of different packaging material and storage conditions on aflatoxin B1 value of dried red chilli.

Treatments	Aflatoxin B1 (µg/kg)								
	120 days			150 days			180 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	3.52^{c}	2.03^{d}	2.78^{b}	5.26^{c}	2.89^{de}	4.08^{cd}	6.10^{cd}	3.95^{e}	5.02^{c}
P_2	5.98^{b}	2.87^{cd}	4.43^{a}	7.77^{ab}	3.87^{cd}	5.82^{b}	9.21^{b}	5.28^{d}	7.24^{b}
P_3	6.41^{ab}	2.66^{c}	4.54^{a}	7.31^{b}	3.61^{d}	5.46^{b}	9.06^{b}	5.11^{d}	7.09^{b}
P_4	3.08^{c}	1.88^{d}	2.48^{b}	3.86^{c}	2.26^{e}	3.06^{d}	4.93^{de}	3.03^{e}	3.98^{d}
P_5	7.15^{a}	3.14^{c}	5.14^{a}	9.27^{a}	5.08^{c}	7.17^{a}	12.35^{a}	7.14^{c}	9.75^{a}
Mean	5.23^{b}	2.52^{a}		**6.69^{a}**	**3.54^{b}**		**8.33^{a}**	**4.90^{b}**	
Comparing mean	**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**	
P	0.191	**0.768**		0.263	1.059		0.245	0.987	
S	0.121	**0.485**		0.167	0.669		0.155	0.624	
P×S	0.270	**1.086**		0.372	1.497		0.347	1.396	

Note: Values with the same superscripts with respect to different packaging materials, storage condition and their interactions are not significantly different by the Duncan Multiple Range Test at P = 0.01
Note: P- Packaging material, S- Storage condition
P_1 – LDPE S_1 – Ambient
P_2 - Gunny bag S_2 - Cold
P_3 - Nylon net bag
P_4 - Double-layer plastic bag
P_5 - Control

Chilli stored at cold storage (S_2) showed higher (131.16 ASTA units) retention of capsanthin compared to the ambient condition (S_1) (122.35 ASTA units). This is mainly due to non-enzymatic reactions which are high in ambient conditions and can lead to a decrease in capsanthin content. A similar finding was reported by Jyothi *et al*. (2008).

Among packaging materials, double layer plastic bag (P_4) has shown the highest (127.30 ASTA units) capsanthin content mainly due to reduced light exposure as capsanthin is sensitive to light, reduced oxygen exposure as capsanthin is prone to oxidation, improved moisture control as excessive moisture can lead to the growth of molds and fungi physical protection. These findings were similar to research conducted by Chen *et al*. (2022) and Nath, *et al*. (2019).

Table 4(a): Effect of different packaging material and storage conditions on capsanthin value of dried red chilli.

Treatments	Capsanthin (ASTA units)											
	Initial			30 days			60 days			90 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	143.39	144.43	143.91	134.96	139.45	137.21^{a}	130.15	137.59	133.87^{ab}	126.24	134.62	130.43^{ab}
P_2	143.71	143.56	143.64	132.45	138.51	135.48^{ab}	127.34	134.24	130.79^{bc}	123.10	131.25	127.17^{bc}
P_3	144.09	143.67	143.88	129.50	135.13	132.31^{bc}	124.28	132.13	128.20^{c}	119.45	129.56	124.50^{c}
P_4	143.77	143.71	143.74	137.56	140.33	138.95^{a}	133.25	138.45	135.85^{a}	130.27	135.16	132.72^{a}
P_5	143.39	144.97	144.18	125.25	132.55	128.90^{c}	118.24	128.95	123.60^{d}	112.72	125.23	118.98^{d}
Mean	**143.67**	**144.07**		**131.94^{b}**	**137.20^{a}**		**126.65^{b}**	**134.27^{a}**		**122.35^{b}**	**131.16^{a}**	
Comparing mean	**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**	
P	0.548	NS		0.890	3.582		0.807	3.247		1.007	4.053	
S	0.346	NS		0.563	2.266		0.510	2.053		0.637	2.563	
P×S	0.774	NS		1.259	NS		1.141	NS		1.424	NS	

Note: Values with the same superscripts with respect to different packaging materials, storage condition and their interactions are not significantly different by Duncan Multiple Range Test at P = 0.01
Note: P- Packaging material, S- Storage condition
P_1 – LDPE S_1 – Ambient
P_2 - Gunny bag S_2 - Cold
P_3 - Nylon net bag
P_4 - Double-layer plastic bag
P_5 - Control

Table 4(b): Effect of different packaging material and storage conditions on capsanthin value of dried red chilli.

Treatments	Capsanthin (ASTA units)								
	120 days			150 days			180 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	122.43	131.20	126.77^{ab}	120.84	129.48	125.16^{ab}	118.31	128.13	123.22^{a}
P_2	118.24	129.53	123.89^{bc}	116.22	126.83	121.53^{b}	112.45	124.18	118.32^{b}
P_3	114.67	125.46	120.07^{c}	110.43	122.59	116.51^{cd}	108.15	119.47	113.81^{cd}
P_4	126.45	133.02	129.73^{a}	124.24	131.18	127.71^{a}	124.53	130.07	127.30^{a}
P_5	109.92	121.47	115.69^{d}	106.57	118.47	112.52^{d}	104.45	116.67	110.56^{d}
Mean	**118.34^{b}**	**128.11^{a}**		**115.66^{b}**	**125.71^{a}**		**113.58^{b}**	**123.70^{a}**	
Comparing mean	**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**		**S.Em±**	**CD at 1%**	
P	0.843	3.320		1.000	4.024		1.020	4.105	
S	0.522	2.100		0.633	2.545		0.645	2.596	
P×S	1.167	NS		1.414	NS		1.443	NS	

Note: Values with the same superscripts with respect to different packaging materials, storage condition and their interactions are not significantly different by Duncan Multiple Range Test at P = 0.01
Note: P- Packaging material, S- Storage condition
P_1 – LDPE S_1 – Ambient
P_2 - Gunny bag S_2 - Cold
P_3 - Nylon net bag
P_4 - Double-layer plastic bag
P_5 - Control

CONCLUSIONS

After 180 days of cold storage, the dried red chilli stored in double-layer packaging material kept under cold storage conditions was found to be superior among packaging materials and storage conditions, because of the ability of double-layer packaging material to retain the highest ascorbic acid and capsanthin content, while simultaneously exhibiting lower levels of aflatoxin B1 content and browning index.

FUTURE SCOPE

The study holds the promise of influencing sustainable practices, bringing benefits to both producers and consumers. Additionally, exploring alternative packaging methods, like vacuum packaging and modified atmosphere packaging, can contribute to the assessment of their impact on aflatoxin content and quality attributes of chilli.

Acknowledgement. I would like to express my heartfelt gratitude to Dr. MD. Jameel Jhalegar (Major advisor), and the members of the advisory committee for their invaluable support Additionally, I extend my thanks to the Department of Post-Harvest Technology at the College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India, for providing the laboratory facilities and technical support.
Conflict of interest. None.

REFERENCES

Abrar, M., Ahsan, S., Nadeem, M., Liaqat, A., Chughtai, M.F.J., Farooq, M.A., Mehmood, T., Khaliq, A. and Siddiqa, A. (2023). Detection and quantification of aflatoxins in spices stored in different food packaging materials. *J. Stored Prod. Res.*, *101*, 102081.

Ahmad, J. and Shivare, U. S. (2001). Effect of pretreatment on drying characteristics and colour of dehydrated green chilli. *J. Food Sci Technol.*, *38*, 504-506.

Bajaj, K. L. and Kaur, G. (1980). Colorimetric determination of capsaicin in capsicum fruits with the Folin-Ciocalteu reagent. *Microchimica Acta*, *71*, 81-86.

BeMiller, J. N. and Whistler, R. L. (1996). Carbohydrate. In: Food Chemistry (O.R. Fenemma). NewYork Marcel Dekker Inc. 216-217.

Chen, Q., Qi, W., Peng, J., Tang, R., Liu, D. and Guo, X. (2022). The Vacuum and Light-Avoided Packaging Ameliorate the Decline in the Quality of Whole Chili during Storage. *J. Food Qual.*, *5*, 1-9.

Daood, H. G., Vinkler, M., Markus, F., Hebshi, E. A. and Bicas, P. A. (1996). Antioxidant vitamin content of spice red pepper (paprika) as affected by technological and varietal factors. *Food Chem*., *15*, 365–372.

Eleyinmi, A. F., Helaboye, N. A., Aiyeleye, F. B. and Akoja, S. S. (2002). Effect of different pre-drying operations on some nutritionally valuable minerals, ascorbic acid and rehydration index of Capsicum species. *Trop. Agric. Res.*, *51*(1), 143-148.

Gupta, P., Ahmed, J., Shivahare, U. S. and Raghavan, G. S. (2002). Drying characteristics of red chilli. *Agric. Engng. Abs., 20*(10), 1975-1987.

Hazra, P., Chattopadhyay, A., Karmakar, K. and Dutta, S. (2011). Modern technology in vegetable production. *New India Publishing Agency*, New Delhi, India. 478-485.

Jasim, A. and Shivare, U. S. (2001). Effect of pretreatment on drying characteristics and colour of dehydrated green chillis. *J. Food Sci.*Technol., *38*(5), 504-506.

Jyothi, K., Kumari, S. S., Reddy, P. V. and Shankar, C. R. (2008). Influence of temperature and relative humidity on quality constituents of dried chilli cultivars in storage. *EDITORIAL BOARD*, *10*, 425-486.

Kumari, P. D., Sankar, R. C., Satyanaryana, C. V. V. and Rao, B. V. (2003). Effect of chemical treatment and drying methods on drying time, pod length and pod damage of chilli (cv. LCA 235). *J. Food Sci. Technol.*, *40*(2), 233-235.

Kunreddy, M. R., Pidigam, S., Sudini, H., Amarapalli, G., Komatireddy, R. R. and Margam, V. (2023). Triple layer hermetic bags for safe storage of dry Chilli (*Capsicum annuum* L.) pods. *J. Food Sci.Technol.*, *60*(7), 1970-1980.

Lee, D., Chung S., Kim, H. and Yam, K. (1991). Nonenzymatic browning in dried red pepper products. *J. Food Quality*, *14*, 153-163.

Lopez, A., Pique, M. T., Boatella, J., Romero, A., Ferran, A and Garcia, J. (1997). Influence of drying conditions on the hazelnut quality; III. Browning. *Drying Technol.*, *15*, 989–1002.

Nath, P., Kale, S. J. and Meena, V. S. (2019). Influence of packaging material and storage temperature on colour quality and shelf life of red chilli powder. *Indian J. Hortic.*, *76*(3), 508-515.

Pattron, D. D. (2006). Aspergillus, health implication & recommendations for public health food safety. *Int. J. Food Saf.*, *8*, 19-23.

Reddy, S. V., Kiran Mayi D., Uma Reddy, M., Thirumala-Devi, K. and Reddy, D. V. R. (2001). Aflatoxins B1 in different grades of chillies (*Capsicum annum* L.) in India as determined by indirect competitive-ELISA. *Food additives & contaminants*, *18*(6), 553-558.

Richard, J. L. (2007). Some major mycotoxins and their mycotoxicoses—An overview. *Int. J. Food Microbiol.*, *119*(1-2), 3-10.

Satyanarayana, C. V. and Vengaiah, P. C. (2010). Development of large scale drying system for Chillies (*Capsicum annum*). *Agric.Eng. Int. CIGR J.*, *12*(1), 1-9.

Sowjanya, S., Kumari, R. V., Deekshitulu, V. V. R. and Suresh, J. (2017). Comparative Effect of Integrated Crop Management and Farmers' Standard Practice in Chilli Crop. *Int. J. Curr. Microbiol. App. Sci*., *6*(8), 2332-2337.

Supriya, S., Kannan, K., Ragupathi, N. and Velazhahan, R. (2015). Evaluation of chilli (*Capsicum annuum* L.) genotypes for resistance to *Aspergillus flavus* infection and aflatoxin production. *Biochem. Cell. Arch.*, *15*, 465-468.

Wiriya, P., Paiboon, T. and Somchart, S. (2009). Effect of drying air temperature and chemical pretreatments on quality of dried chilli. *Int. Food Res. J*., *16*, 441-454.

How to cite this article: Pooja, M.D. Jameel Jhalegar, Thippanna K.S., Ambreesh, Shiddanagouda Yadachi and Abdul Kareem M. (2023). Evaluating the effect of packaging materials and storage methods on quality attributes and aflatoxin content of dried Byadgi chilli. *Biological Forum – An International Journal, 15*(12): 114-120.