



Nutritional Quality and Shelf Life Extension of Capsicum (*Capsicum annum*) in Expanded Polyethylene Biopolymer

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ABSTRACT

Freshly harvested capsicum has limited shelf life (5-6 days) under ambient storage conditions. The functional quality of capsicum has been assessed in two sizes (300g±10%) and (900g±10%) of 30µ flex fresh™ expanded polyethylene biopolymer pouches at 3 and 10°C and 90-95% RH under modified atmospheric storage. In both small and big size pouches, composition of oxygen and carbon dioxide varied from 18.8-19.9% and 18.8-19.4% and from 2.2-0.7% and 2.0-1.4%, respectively during 28 days of storage at 3°C. Positive and significant correlation was observed between overall acceptability and CO₂ composition however, negative correlation was observed with O₂ composition. Minimum increase (6.02% and 4.35%) in PLW, minimum decrease in firmness (4.71N-3.50N and 4.71N-2.70N), minimum decrease in chlorophyll (70.3% and 75.5%) and minimum losses (47.6% and 40.3%) of ascorbic acid were obtained after 28 days of storage in small and big size capsicum, respectively at 3°C. The decrease in total phenol and antioxidant activity was 82.4% and 78.6% and 60.1% and 59.4%, respectively after 28 days of the storage at 3°C of small and big size capsicum, respectively. Judges observed most acceptable consistency and OAA score for both sizes of capsicum in pouches up to 21 days of storage at 3°C.

Key words: Capsicum, Gaseous composition, Nutritional quality, Polyethylene biopolymer pouches, Shelf life.

INTRODUCTION

Capsicum (Bell pepper) have long been advocated with health enhancing attributes such as clearing the lungs and sinuses, protecting the stomach by increasing the digestive juice flow, triggering the brain to release endorphins thus considering as natural pain killers. The regular consumption of capsicum also helps in neutralizing the acid causing cavity and its antioxidant activity protects the body against cancer (Ekwere and Udo, 2018). Freshly harvested capsicum are good sources of vitamin A, C, K, carotenoids and flavonoids which prevent body from cell damage, cancer, ageing and support to boost up the immune functions. It also possesses the inflammation reducing properties associated with arthritis and asthma. It may further help in lowering the blood pressure and cholesterol levels. The capsaicin in capsicum can boost the immunity and thus reduces the risk of stomach ulcers. It also exhibits analgesic, anti-bacterial and anti-diabetic properties (Dias, 2012). Cardiovascular benefits are linked with bile acid binding properties which ultimately reduce the blood cholesterol level (Ekwere and Udo, 2018). Capsicum is also used to treat intestinal disorders such as diarrhea and dysentery (Szallasi and Blumberg, 1999, Joshi *et al.*, 2011).

Capsicum is a good source of antioxidants, fibers and minerals such as potassium, manganese, iron and magnesium. Among its all variants of antioxidants, phytochemicals, polyphenols deserve the special mention. Their levels vary during growth and maturation (Estrada, Bernel *et al.* 2000). Potassium is an important component of cell and body fluids that helps in controlling heart rate and blood pressure. Manganese is used by the body as co-factor for the antioxidant enzyme superoxide dismutase (Dias, 2012).

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After harvesting and before consumption, capsicum undergoes quantitative and qualitative losses. Various factors such as storage temperature and humidity affect the nutritional quality of capsicum before consumption. Moreover, post-harvest quality of capsicum is also influenced by some important harvesting practices such as harvesting time, optimal maturity of harvest, methods of harvesting, proper handling and minimization of microbial load during storage (Rai *et al.* 2002). Generally, capsicum fruits are transported from field to market in gunny bags and during long distance transport and handling in the market. Capsicum fruits suffer from various quality changes such as loss of skin glossiness and green colour, surface shrinkage and drying of pedicel resulting in less consumer acceptance which adversely affect the shelf life. Many times,

traders perform unhygienic practices like wetting / repeated sprinkling of water and application of petroleum based oil to make them attractive. Such malpractices adversely affect the safety of human health. Moreover, vegetable traders store the capsicum in wetted gunny bags at higher temperature which also adversely affect the quality and safety of produce (Scully *et al.* 2006).

The commodity specific packaging techniques help in preserving the nutritional and sensory qualities of whole capsicum for longer storage period under controlled environmental conditions of temperature and humidity. Among the commodity specific techniques, modified atmosphere packaging (MAP) has been an ideal technology for extending the shelf life of fruits and vegetables of high commercial value. It involves the better replacement of pack air with a suitable gaseous composition of oxygen and carbon di oxide owing to the diffusion of gases into and out of the package due to the effects of product and microbial metabolism. It also affects the quality parameters such as retention of green natural colour, glutathione, ascorbic acid, sugars, amino acids, etc. in fruits and vegetables (Rai *et al.*, 2002). The modification of gaseous environments results in reduced respiration rates combined with lesser rates of ethylene production which results in better retention of green colour, texture and maintenance of sensory attributes for longer time (Kader *et al.*, 1989). The present investigation has been carried out to package the freshly harvested capsicum in two sized 30 μ Flexfresh™ biopolymers and subsequently physico-chemical; sensory properties and quality attributes were assessed at 3°C and 10°C with 90-95% RH under MAP storage.

MATERIALS AND METHODS

Materials

Capsicum genotype “Indira” (Hybrid) was harvested after 88 days of transplanting from the experimental farm of Indian Institute of Vegetable Research, Varanasi (UP), India. The freshly harvested capsicum fruits were graded on the basis of size, colour and texture. The 30 μ Flexfresh™ expanded polyethylene biopolymer of two sizes (300g \pm 10%, 205 mm width and 250 mm height, oxygen transmission rate (OTR) 1250 cc/24h/500g) and (900g \pm 10%, 255 mm width and 350 mm height, OTR-2500 cc/24 h/500g) were procured from M/s UFLEX Ltd. Greater Kaillash, New Delhi, India.

Experimental treatments

The freshly harvested capsicum fruits were packaged in both sizes of 30 μ Flexfresh™ and sealed with hand sealer and stored at 3 and 10°C with relative humidity of 90-95% under modified atmospheric storage. Three replications of packaged and unpackaged capsicum were analyzed after 7 days of interval for sensory, physico-chemical and quality attributes during storage.

Analysis during storage of capsicum

Changes in the physical properties such as loss in fruit weight, firmness and moisture content were recorded during

storage. Similarly, the changes in quality attributes such as total chlorophyll content, ascorbic acid, total phenol and antioxidant activity were also carried out for packaged and unpackaged capsicum during storage at 3 and 10°C.

Gaseous composition of head space gases

The gaseous composition of O₂ and CO₂ in both sizes of polymers during storage at 3 and 10°C was monitored with headspace gas analyzer (Checkmate 9900, PBI Dansensor Co., Denmark) by drawing up 1 ml of air samples. Sampling has been carried out by a hypodermic needle through the septum of the packaging film.

Physiological loss in weight (PLW)

The weight of all packaged and control capsicum fruits was recorded on scientific weighing machine (Denver Instrument APX-60; d=0.1 mg) at every 2 days of interval during storage and expressed in terms of g/100g loss of initial weight (Chitravathi *et al.* 2014).

Fruit firmness

The firmness of all packaged and control capsicum fruits was measured during storage by texture analyzer using needle probe (P₂N) of 25 kg load cell with pre and post-test speed of 2.0 mm/s and 1.0 mm/s, respectively (Texture Expert Exceed, Ver. 2.64. Stable Microsystem, U.K.).

Moisture content

Moisture content in all samples was determined by gravimetric methods as per Ranganna (2004).

Chlorophyll content

Total chlorophyll content in all samples was measured as per the method of Ranganna, 2004 and expressed as mg/100g, dm.

Ascorbic acid

Ascorbic acid content in packaged and unpackaged capsicum was measured by dye reduction method and expressed as mg of ascorbic acid/100g, dm (Ranganna, 2004).

Total sugar content

The sugar content in packaged and unpackaged capsicum during storage was determined by di-nitro-salicylic acid as per the standard method of Thimmaiah, 1999) and expressed as mg/100g, dm.

Total phenolic content

Total phenolic content was estimated spectrophotometrically using Folin-Ciocalteu reagent (Singleton *et al.*, 1999) and expressed as mg of Gallic acid equivalent/100 g, dm.

Trolox equivalent antioxidant capacity (TEAC)

The antioxidant activity in different samples during storage was studied through the evaluation of free radical scavenging effect on stable DPPH (2, 2-diphenyl-1-picrylhydrazine) radical (Brand-Williams *et al.*, 1995) and expressed as μ mol TEAC/g, dm).

Sensory evaluation

Sensory evaluation of packaged capsicum and control capsicum during storage at 3 and 10°C was evaluated by a panel of trained judges on 9-point Hedonic scale by grading for flavour, colour and appearance, body and texture and overall acceptability score (Lawless and Haymann 1998).

Statistical analysis

Experiments were set up in factorial CRD design with three factors (storage time, fruit size and temperature) and three replicates. Data were analyzed statistically (ANOVA-analysis of variance) using SPSS (version 16.0) and presented as mean \pm standard error.

Association analysis

Correlation and regression was performed between gaseous composition (O_2 and CO_2) and overall acceptability for their interrelationship.

RESULTS AND DISCUSSION

In-pack gaseous composition

Gaseous composition of oxygen and carbon dioxide is very important in assessing the shelf life of horticultural crops. The gaseous atmosphere consists of 20.95% oxygen and 0.036% carbon dioxide. During modified atmospheric storage, the gaseous composition varies as per the type of packaging material and storage temperature. The gaseous composition of oxygen in both sizes of packaged capsicum varied 18.8-19.9% and 18.8-19.4%, respectively during 28 days of storage at 3°C (Fig 1a). Gradual increase in carbon dioxide (0.7% and 1.4%) was observed in small and big size packaged capsicum, respectively during 28 days of storage at 3°C. However, oxygen gas composition varied from 11.7-20.5% and 16.2-20.4% in small and big size packaged capsicum, respectively up to 28 days of storage at 10°C (Fig 1a). Earlier studies revealed the depletion of O_2 to 4.45% and evolution of CO_2 to 9.85%, respectively between the start from day 7 and by the end of 49 days of storage at $8 \pm 1^\circ C$ during active modified storage of capsicum (Singh *et al.*, 2014). It is evident that the levels from 19.4-19.9% O_2 and 0.7-1.4% CO_2 were maintained in small and big size packaged capsicum after 28 days of storage at 3°C which maintains the desired gaseous composition for longer shelf life of capsicum. During storage, the concentration of O_2 decreases and CO_2 increases depending upon the packaging barrier. Limited respiration is always desirable during storage of vegetables which helps in building the

desired concentration of CO_2 inside the package, thus preventing the mould growth (Kader *et al.*, 1989). Another report of Rai *et al.* (2008) also reported that steady state of gaseous composition of 15.3%, 13.4% and 5.1% for O_2 and 2.1%, 3.8% and 8.6% for CO_2 was maintained after packaging 100, 200 and 300 g of broccoli in polypropylene pouches.

Positive and significant correlation was observed between overall acceptability and CO_2 composition while overall acceptability was recorded significantly and negatively correlated with O_2 composition taking into account to storage periods, fruit sizes and temperature conditions (Table 1). Other workers also reported that low O_2 and high levels of CO_2 could have been largely responsible for increased retention of chlorophyll in broccoli (Rai *et al.* (2008). Regression analysis yielded following equation which can be utilized to predict overall acceptability with measured gaseous composition (O_2 and CO_2) under MAP:

Equation:

Overall acceptability score =

$$(0.766 \times CO_2) - (0.014 \times O_2) + 6.429 \quad (R^2 = 0.79)$$

PLW

ANOVA analysis revealed significant differences among different storage periods, temperature conditions and fruit sizes for PLW. Interaction of storage periods and temperatures, temperatures and fruit sizes as well three way interaction of three factors (storage periods, temperature conditions and fruit sizes) for PLW were also found significant ($p < 0.01$, Table 2). Respiration is one of the important physiological processes to maintain the living nature of commodity after harvest during the storage. However, the increase in respiration and transpiration processes result in weight losses during storage. MAP regulates the storage conditions to maintain the quality of fresh produce for longer time at definite low temperature. However, the increase in PLW was maximum (11.09% and 9.44%) during 28 days storage at 10°C in small and big size packaged capsicum, respectively whereas, PLW increase was minimum (6.02% and 4.35%) during 28 days of storage at 3°C, respectively in both packaged capsicum (Fig 1b). Mahajan *et al.* (2016) also supported our findings and reported that shrink film packaged capsicum fruits registered the lowest average PLW of 3.4% and ranged between 2.2 to 4.7% after 5 to 15 days of storage as compared to control fruits where PLW was recorded highest and ranged between 3.6 to 13.2% under super market conditions. The less reduction in weight loss during storage of capsicum inside the flexfresh packaging film can be attributed due to restricted respiration process in capsicum fruits and the quality of capsicum, shelf life and marketability of produce can be maintained for longer time.

Firmness

Significant differences were found among storage periods, temperature conditions and fruit sizes for firmness as revealed by ANOVA. All the two interactions as well as three way interactions of three factors storage periods,

Table 1: Correlation of O_2 and CO_2 level with overall acceptability (OAA) score*.

Source	O_2	CO_2	Overall acceptability
O_2	1	-	-
CO_2	-0.825**	1	-
OAA	-0.656**	0.785**	1

• Carl-person correlation ** Significant ($p < 0.01$).

temperature conditions and fruit sizes) for firmness were also found significant ($p < 0.01$, Table 2). Firmness in fruits is related to pectin, cellulose and hemicelluloses. These polysaccharides are susceptible to cellulase, pectin methylesterase, polygalacturonase and β -galactosidase which ultimately results in the breakdown of these polymers to the formation of smaller particles, hence the reduction of firmness and integrity of the fruit tissues and water losses in fruits and vegetables (Lazan *et al.*, 1995; Brummell and Harpster, 2001; Abu-Goukh and Bashir, 2003). Cell wall degrading enzymes decreases the firmness of fruits and vegetables during storage. The firmness decreased from 4.71N-3.50N and 4.71N-2.70N during 28 days of storage at 3°C in small and big size capsicum, respectively (Fig 1c). However, the decrease in firmness was of higher magnitude during storage at 10°C and it decreased from 4.71N-2.61N and 4.71N-2.59N in small and big size capsicum, respectively after 28 days of storage at 10°C. There had been 63.5% and 69.0% decrease in firmness of control capsicum fruits after 28 days of storage at 3 and 10°C, respectively (Fig 1c). Manolopoulou *et al.* (2010) also reported the decrease in firmness of control bell pepper samples as compared to treated bell pepper under modified atmospheric storage. The restriction in metabolic activities under modified atmospheric storage is associated with less activity of cell wall degrading enzymes in tomatoes which subsequently resulted in retention of firmness for longer time (Chauhan *et al.* 2013).

Moisture

ANOVA studies revealed significant variation ($p < 0.01$) between storage periods and fruit sizes for moisture content (Table 2). All the interactions of three factors for moisture content (both two way and three way) were found to be non-significant. The retention of moisture is important factor in assessing the quality and shelf life determination in fruits and vegetables during storage. Moisture content decreased from 93.28-88.89% and from 93.28-90.0% in small and big size capsicum fruits, respectively after 28 days of storage at 3°C (Fig 1d). Similar decrease in moisture content was also noted in packaged capsicum fruits after storage for 28 days at 10°C. However, there had been higher moisture losses (93.28-87.15% and 93.28-84.26%) in control capsicum fruits after storage for 28 days at 3°C and 10°C, respectively (Fig 1d). Lownds *et al.* (1994) also reported that increased rate of water loss in capsicum resulted in softening of tissues and reduced shelf life.

Chlorophyll content

There were significant differences ($p < 0.01$) observed for chlorophyll content among storage periods, temperature and fruit sizes. These factors also interacted significantly (both two way and three way) as revealed by ANOVA analysis (Table 2). Chlorophyll degradation is an important physiological process in plants that occurs during different phases of plant development. The identification and structure determination of first colorless non-fluorescent chlorophyll

Table 2: ANOVA of the physico-chemical and sensory traits of capsicum under modified atmospheric packaging.

Source	df	Firmness	Moisture	Chlorophyll	Ascorbic acid	Total sugar	TPC	Antioxidant	Flavor	C and A	OAA	df	PLW
		MSS	MSS	MSS	MSS	MSS	MSS	MSS	MSS	MSS	MSS		MSS
Storage period (A)	7	18.81**	329.69**	290.99**	4583919.42**	450237.67**	2816104.58**	13240.32*	49.78**	51.76**	31.43**	23	955.64**
Temperature (B)	1	4.91**	21.54**	30.13**	469.25**	769.17**	6427.95**	295.41**	53.16**	102.89**	7.96**	1	62897.32**
Interaction (A x B)	7	0.12**	10.66**	3.63**	5147.67**	2255.89**	5915.21**	110.17**	2.86**	2.61**	0.27	23	129.89**
Fruit size (C)	2	21.54**	216.57**	10.13**	396986.12**	27273.80**	159398.95**	1977.92**	48.48**	32.23**	45.46**	2	6771.01**
Interaction (A x C)	14	0.52**	6.29**	2.13**	26869.56**	6703.54**	8052.79**	114.72**	2.07**	0.68	1.68**	46	71.61**
Interaction (B x C)	2	0.38**	3.185**	1.31**	2021.23**	2082.21**	1929.95**	80.82**	5.26**	1.28	1.62**	2	212.47**
Interaction (A x B x C)	14	0.11**	6.62**	1.03**	21512.47**	2264.75**	6065.24**	29.8**	1.44**	1.14**	0.26	46	9.94**
Error	286	0.02**	5.88**	0.22	11075.19	380.18**	103644.31**	341.48**	0.61	0.46**	0.37	286	11.53

MSS – Mean sum of squares, * Significant ($p < 0.05$), ** Significant ($p < 0.01$).

catabolite from senescing barley was reported as final breakdown product (Krautler *et al.*, 1991). Control capsicum had maximum (96.7%) decrease in chlorophyll content during 28 days of storage at 10°C. However, minimum (70.3% and 75.5%) decrease in chlorophyll content was obtained in packaged small and big size capsicum,

respectively during 28 days of storage at 3°C (Fig 1e). Chitravathi *et al.* (2014) also reported that the retention of green colour in modified atmosphere packed chillies may be due to reduced respiration rate within package. The maintenance of green colour of capsicum is maintained for longer time due to creation of modified atmosphere in flex

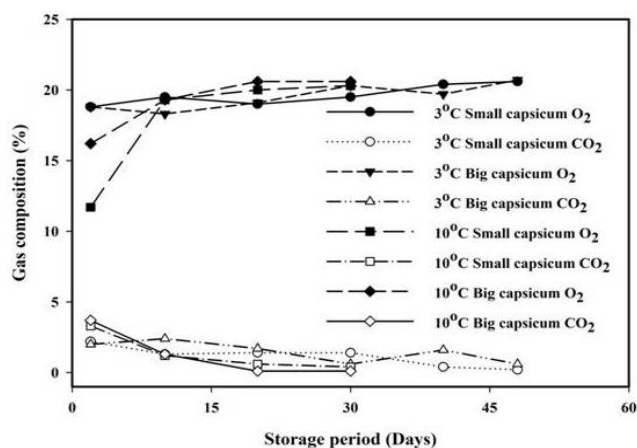


Fig 1(a): Changes in gaseous composition (%) during storage.

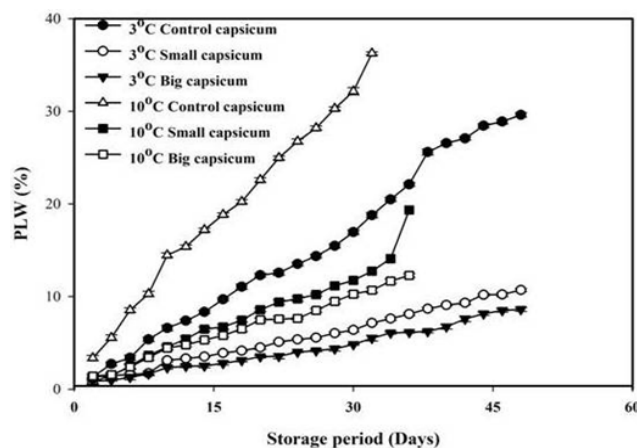


Fig 1(b): Changes in PLW (g/100g) during storage.

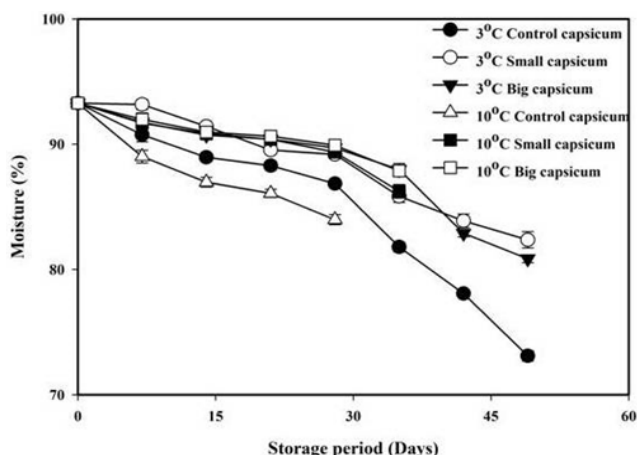


Fig 1(c): Changes in moisture (%) during storage.

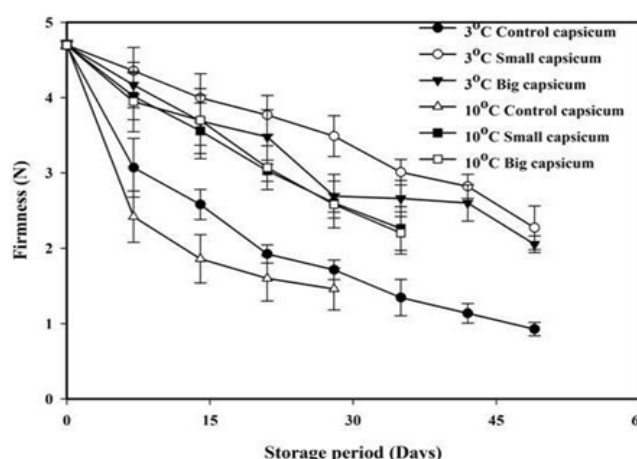


Fig 1(d): Changes in firmness (N) during storage.

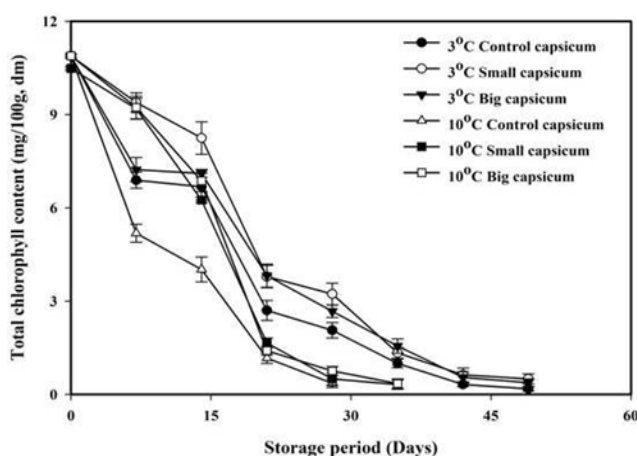


Fig 1(e): Changes in chlorophyll (g/100g, dm) during storage.

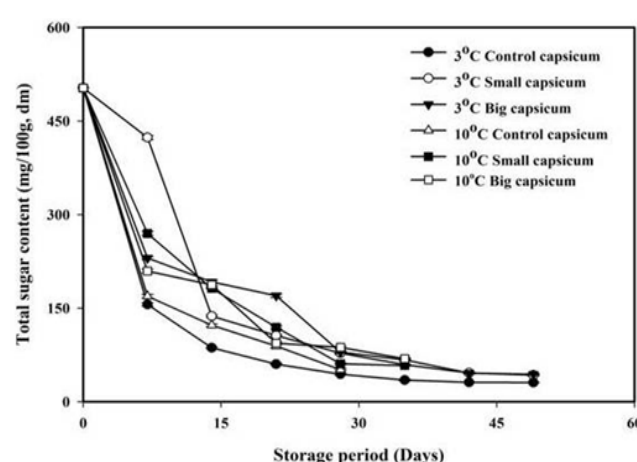


Fig 1(f): Changes in total sugar content (g/100g, dm) during storage.

Fig 1: Changes in physico-chemical properties of small and big size packaged capsicum.

fresh packaging material during storage for 28 days at 3°C. Furthermore, the decrease in chlorophyll during storage is expected due to chlorophyll degradation as a result of chlorophyllase enzyme activity (Gong *et al.*, 2003).

Ascorbic acid

Ascorbic acid content significantly varied ($p < 0.01$) with storage periods as well as fruit sizes. Interaction of storage period and fruit size, interaction of temperature and storage period was found to be significant ($p < 0.01$, Table 2). Ascorbic acid is one of the most important antioxidant which scavenges free harmful radicals and chelates heavy metals (Manas *et al.*, 2013). There has been decreasing trend of ascorbic acid in all the capsicum samples during storage at 3 and 10°C. The losses of ascorbic acid were 47.6% and 40.3% in small and big size packaged capsicum, respectively after 28 days of storage, at 3°C (Fig 1f). However, the losses were of higher magnitude during storage at 10°C and it was 43.0% and 41.2% in packaged capsicum samples of both sizes, respectively. Control capsicum fruits exhibited maximum losses (51.0% and 57.2%) during 28 days of storage at 3 and 10°C, respectively (Fig 1f). Ascorbic acid is usually degraded by oxidative

processes which are stimulated by light, oxygen, peroxides and ascorbate oxidase or peroxidase (Plaza *et al.*, 2006). Nutritional quality in terms of ascorbic acid as well as consumer acceptability for high valued capsicum can be retained for longer time during storage for 28 days at 3°C in flex fresh packaging material. This may be attributed due to less availability of O_2 and consequent increase in CO_2 level as a result of reduced respiration.

Total sugar content

Analysis of variance revealed that there were significant changes in total sugar content during storage at 3 and 10°C. Furthermore, significant variations were also noted for different storage periods, fruit sizes and interactions (both two way and three way) of all the three factors for total sugar content ($p < 0.01$, Table 2). The general decrease in sugar content was observed during storage. There had been 84.5% and 84.2% loss in total sugar content in packaged capsicum samples of both sizes after 28 days of storage at 3°C (Fig 1g). The losses was of higher magnitude of 87.9% and 82.7% in small and big size packaged capsicum, respectively after 28 days of storage at 10°C (Fig 1g). Control capsicum fruits exhibited maximum (91.2% and 89.8%)

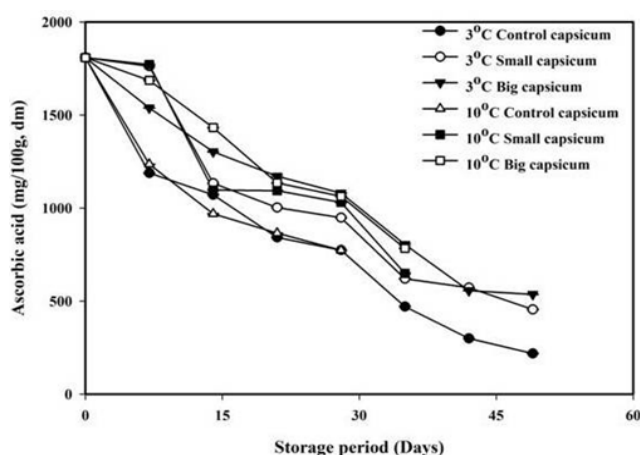


Fig 2(a): Changes in ascorbic acid during storage.

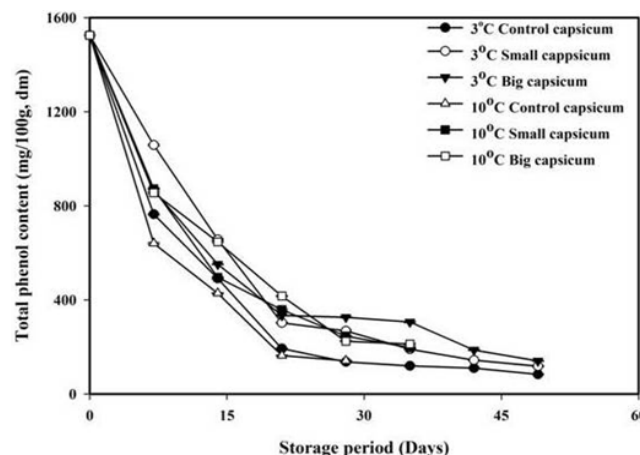


Fig 2(b): Changes in total phenol content during storage.

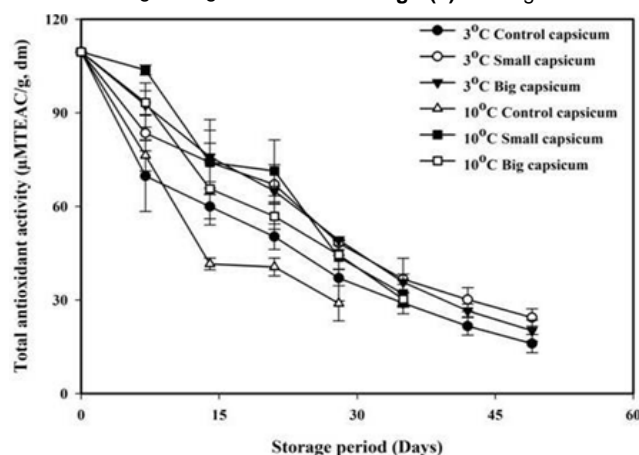


Fig 2(c): Changes in antioxidant activity during storage.

Fig 2: Changes in nutritional quality of small and big size packaged capsicum.

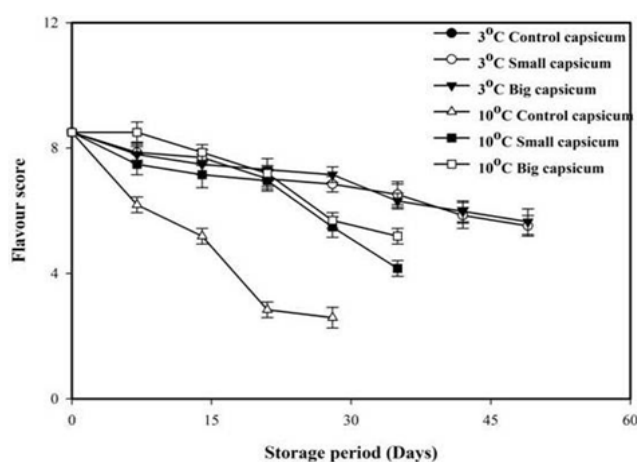


Fig 3(a): Changes in flavour score during storage.

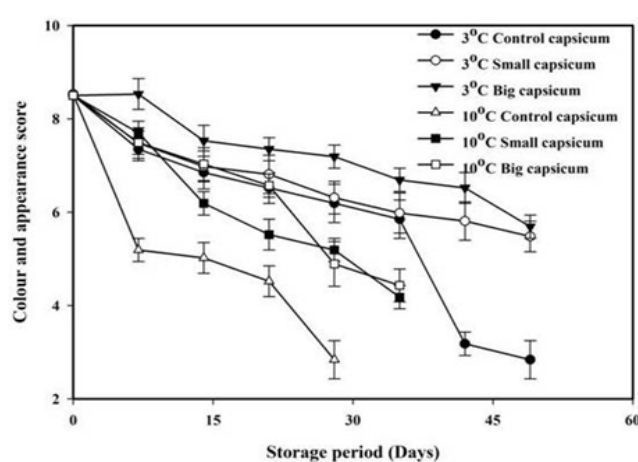


Fig 3(b): Changes in colour and appearance score during storage.

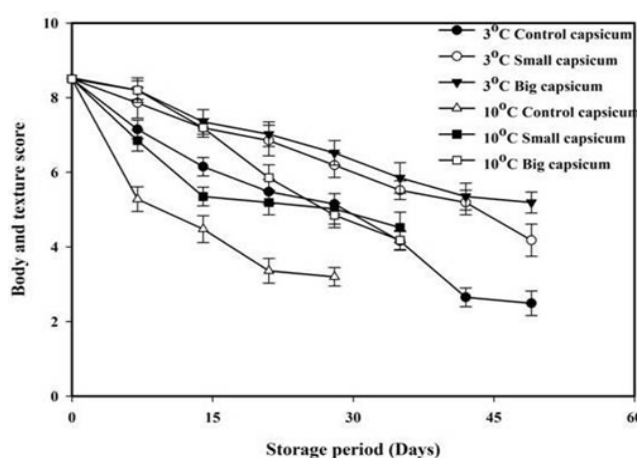


Fig 3(c): Changes in body and texture score during storage.

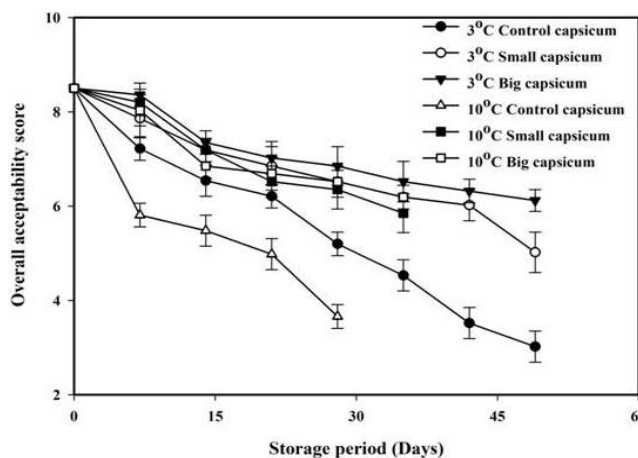


Fig 3(d): Changes in overall acceptability score during storage.

Fig 3: Changes in sensory properties during storage.

losses of sugar content after 28 days of storage at 3 and 10°C, respectively. Workneh *et al.* (2001) also reported the similar observations and reported that there has been general decrease in sugar content in packaged carrot samples in Low density polyethylene and polypropylene pouches.

Total phenolics

Total phenolics content varied significantly ($p < 0.01$) at different storage periods. Non-significant variation was noted among the storage temperatures and fruit sizes (Table 2). Total Phenolics compounds are secondary metabolites and possess a wide spectrum of biochemical activity. They have been reported to exhibit antioxidant activity which allows them to scavenge both active oxygen species and electrophiles and chelate metal ions. These compounds have the potential for auto-oxidation and capability to modulate certain cellular enzyme activities (Howard *et al.*, 2000; Marinova *et al.*, 2005). There had been decrease in total phenol content in all the packaged samples during storage at 3 and 10°C. The decrease in total phenol content was 82.4% and 78.6% in small and big size packaged

capsicum samples, respectively during 28 days of storage at 3°C (Fig 1h). However, higher decrease in total phenolics content of 83.8% and 85.3% was obtained in small and big size capsicum fruits during 28 days of storage at 10°C (Fig 1h). Total phenolics losses during storage in green chillis can be reflected due to its metabolic conversion to secondary phenolic compounds (Barz and Hoesel 1977) or degradation via enzymatic action (Jimenez *et al.*, 1999; Howard *et al.*, 2000).

Antioxidant activity

Total antioxidant activity varied significantly ($p < 0.01$) with respect to different storage periods, temperatures and fruit sizes. However, the interaction of above three factors was also significant ($p < 0.01$) (Table 2). Antioxidant activity signifies the nutritional value of fruits and vegetables and has potential health benefits with consumption of antioxidant rich fruits and vegetables (Concellon *et al.* 2012). Antioxidant activity decreased in all the packaged capsicum samples during storage at 3 and 10°C. This decrease was minimum (55.9% and 55.0%) during 28 days of storage at 3°C in packaged capsicum samples of small and big sizes,

respectively (Fig 1 i). However, the decrease was of higher magnitude (60.1% and 59.4%) during 28 days of storage at 10°C respectively in both sizes of packaged capsicum. Packaged capsicum fruits had delayed in the onset of senescence stage during storage at 3 and 10°C and the decrease in antioxidant activity were minimum in packaged capsicum as compared to control capsicum fruits. These results were in agreement of Shaha *et al.* (2013).

Sensory quality

ANOVA studies for flavour, colour and appearance, body and texture and overall acceptability score revealed that there were significant variation ($p < 0.01$) among the levels of all three factors (storage periods, fruit sizes and temperature of storage) for assessing the sensory properties (Table 2). Flex fresh packaged capsicum during storage at 3°C have significantly ($p < 0.05$) higher sensory score for flavour, colour and appearance, body and texture and overall acceptability as compared to storage at 10°C. Flavour sensory score decreased during storage at 3 and 10°C. Maximum flavour score (7.17) was reflected during 28 days of storage in big size packaged capsicum at 3°C (Fig 2a.) However, packaged capsicum of both sized had acceptable flavour score of 7.0 during 21 days of storage at 10°C. Colour and appearance sensory score also decreased during storage in all packaged capsicum during storage at 3 and 10°C. Similar to flavour score, judges also observed 21 days acceptable colour and appearance score in small and big size packaged capsicum during storage at 3°C (Fig 2b). Senescence stage has also been visible during 28 days of storage in big size packaged capsicum at 3°C. Kader (1986) also observed similar findings and reported that high CO₂ storage of broccoli tissue may result in membrane protection due to direct action of CO₂ on the membrane or by slowing senescence process. However, acceptable colour and appearance score of 7 and 21 days was noted during storage of small and big size packaged capsicum, respectively at 10°C. Control capsicum had acceptable colour and appearance sensory score for 14 and 7 days during storage at 3 and 10°C, respectively. There had been no visible symptoms of chilling injury during storage of capsicum at 3°C. Forney and Lipton (1990) also supported our results and reported that capsicum fruits packaged in plastic bags created modified atmosphere within the package, thus reducing its susceptibility to chilling injury. Softening and wrinkle formation were started in control capsicum during 14 and 7 days of storage at 3 and 10°C, respectively. Judges reported most acceptable consistency and overall acceptability sensory score during 21 days of storage of small and big size capsicum at 3°C (Fig 2c and Fig 2d). However, only 14 days overall acceptability sensory score was noted in small and big size packaged capsicum at 3°C. Sharma *et al.* (2018) also reported that modification of gaseous environment affects the sensory properties of capsicum during storage of capsicum in xtend film and polyethylene films during storage of capsicum at 1.5, 7 and 17°C. Extended film packaged capsicum exhibited highest

sensory score over polyethylene films and control capsicum at all storage temperatures.

CONCLUSION

The packaging of freshly harvested capsicum in Flexfresh™ and storage at 3°C showed good commercial quality attributes such as reduced physiological loss, retention of moisture and glossiness appearance. Furthermore, the packaged capsicum exhibited more evolution of CO₂ during storage resulted in reduced respiration and maintenance of modified environment. Low PLW, less decrease in firmness, more retention of moisture, minimum decrease in chlorophyll content were reflected in packaged big size capsicum during 28 days of storage at 3°C. Similarly the retention of ascorbic acid, total sugar content, total phenols and ascorbic acid was obtained in both sizes of packaged capsicum at 3°C. Positive and significant correlation was obtained between overall acceptability and CO₂ composition during storage at 3°C.

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