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Influence of expanded polyethylene biopolymer packaging on shelf life of capsicum

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Abstract

Capsicum is one of the most important vegetable crops of solanaceous family and grown across the country. Freshly harvested capsicum has very short shelf life (5-6 days) under ambient storage condition. The physicochemical characteristics and composition variations of capsicum has been assessed in two sizes (300g±10%) and (900g±10%) of 30µ flex fresh^{TM} expanded polyethylene biopolymer pouches at 3 ˚C, 10 ˚C and 90-95% RH under modified atmospheric storage. Minimum increase (6.02% and 4.35%) in PLW, minimum decrease in chlorophyll (70.3% and 75.5%) and minimum losses (47.6% and 40.3%) of ascorbic acid were obtained after 28 DOS, respectively at 3 ˚C. It was observed most acceptable consistency for both sizes of capsicum in pouches up to 21 DOS at 3 ˚C.

Keywords: Capsicum, Polyethylene biopolymer pouches, Nutritional quality, Shelf life

Introduction

Capsicum (*Capsicum annuum* L.) 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. 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. 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 et al. 2000). 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 and Horsham 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

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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, amino acids, etc. in fruits and vegetables (Rai et al. 2002). The present investigation has been carried out on extension of shelf life of the freshly harvested packaged capsicum in 30 µ Flexfresh^{TM} biopolymers of two sizes in MAP at 3^{o}C and 10^{o}C with 90-95% RH and evaluation of physico-chemical quality attributes of the product.

Materials and Methods

Capsicum genotype "Indira" (Hybrid) was harvested after 88 days of transplanting from the experimental farm of Indian Institute of Vegetable Research, Varanasi (UP). The freshly harvested capsicum fruits were graded on the basis of size, colour and texture. The 30µ Flexfresh^{TM} expanded polyethylene biopolymer of two grades A (300g±10%, 205 mm width and 250 mm height, oxygen transmission rate (OTR) 1250 cc/24h/500g) and B (900g±10%, 255 mm width and 350 mm height, OTR-2500 cc/24 h/500g) were procured from M/s UFLEX Ltd. Greater Kailash, New Delhi, India. The freshly harvested capsicum fruits were packaged in 30µ Flexfresh^{TM} hand sealed pouches of A and B and stored at 3^{o} and 10^{o}C with relative humidity of 90-95% under modified atmospheric storage along with unpackaged capsicum in triplicate; the products were analyzed at 7 days interval for physico-chemical and quality attributes for the entire storage period. Changes in the physical properties such as loss in fruit weight and moisture content were recorded during storage. Similarly, the changes in quality attributes such as total chlorophyll content and ascorbic acid were also carried out for packaged and unpackaged capsicum during storage at 3 and 10^{o}C. 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). Moisture content in all samples was determined by gravimetric methods as per Ranganna (2004). Total chlorophyll content in all samples was measured as per the method of Ranganna (2004) and expressed as mg/100g, dm. Moreover, 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). Sensory evaluation of packaged capsicum and control capsicum during storage at 3 and 10oC 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). 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 ± standard error.

Results and Discussion

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^{o}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^{o}C, respectively in both packaged capsicum (Figure 1, Table 1). 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

Table 1: ANOVA of the physico-chemical traits of capsicum under modified atmospheric packaging

Source	df	Moisture	Chlorophyll	Ascorbic acid	PLW
Storage period (A)	7	329.69**	290.99**	4583919.42**	955.64**
Temperature (B)	1	21.54**	30.13**	469.25**	62897.32**
Interaction (A×B)	7	10.66**	3.63**	5147.67**	129.89**
Fruit size (C)	2	216.57**	10.13**	396986.12**	6771.01**

Interaction (A×C)	14	6.29**	2.13**	26869.56**	71.61**
Interaction (B×C)	2	3.185**	1.31**	2021.23**	212.47**
Interaction (A×B×C)	14	6.62**	1.03**	21512.47**	9.94**
Error	286	5.88**	0.22	11075.19	11.53

*Significant (p<0.05), ** Significant (p<0.01)

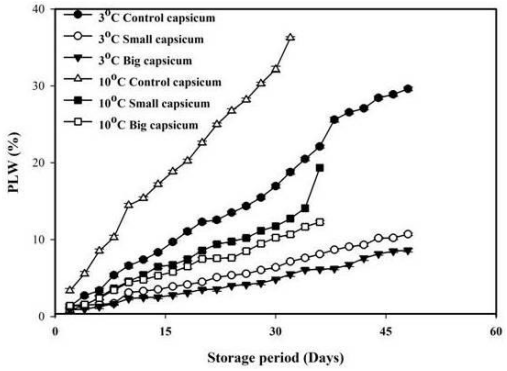

Figure 1: Effect of expanded polyethylene biopolymer packaging on PLW of capsicum fruit stored at 3 and 10°C

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.

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 (Figure 2).

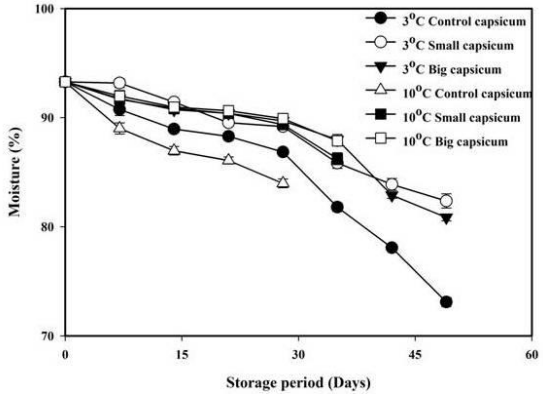

Figure 2: Effect of expanded polyethylene biopolymer packaging on moisture of Capsicum fruit stored at 3 and 10°C

Similar decrease in moisture content was also noted in packaged capsicum fruits after storage for 28 days a 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 (Figure 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 degradation is an important physiological process in plants that occurs during different phases of plant development. 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 (Figure 3, Table 1).

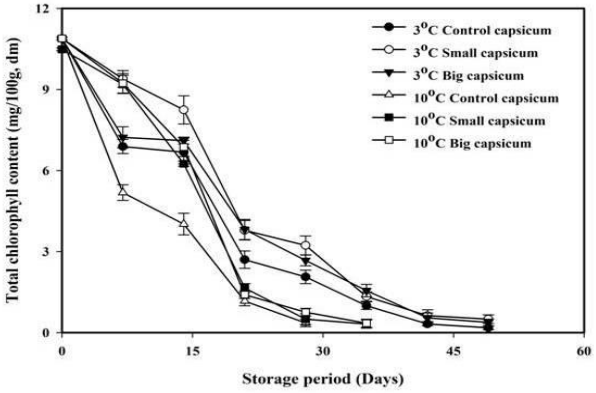

Figure 3: Effect of expanded polyethylene biopolymer packaging on chlorophyll content of Capsicum fruit stored at 3 and 10°C

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 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 and Mattheis 2003).

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 10ºC. 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 3ºC (Figure 4).

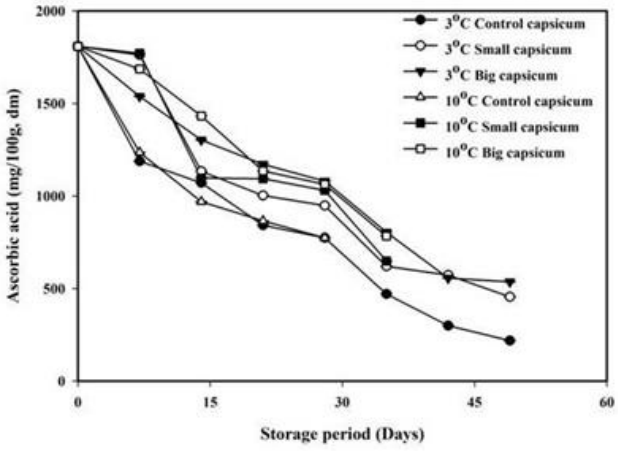

Figure 4: Effect of expanded polyethylene biopolymer packaging on ascorbic acid of Capsicum fruit stored at 3 and 10 °C

However, the losses were of higher magnitude during storage at 10ºC 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 10ºC, 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 3ºC 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.

Firmness in fruits is related to pectin, cellulose and hemicelluloses. These polysaccharides are susceptible to cellulase, pectin methyl esterase, polygalacturonase and ß 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). The firmness decreased from 4.71N-3.50N and 4.71N-2.70N during 28 days of storage at 3ºC in small and big size capsicum, respectively (Fig. 5).

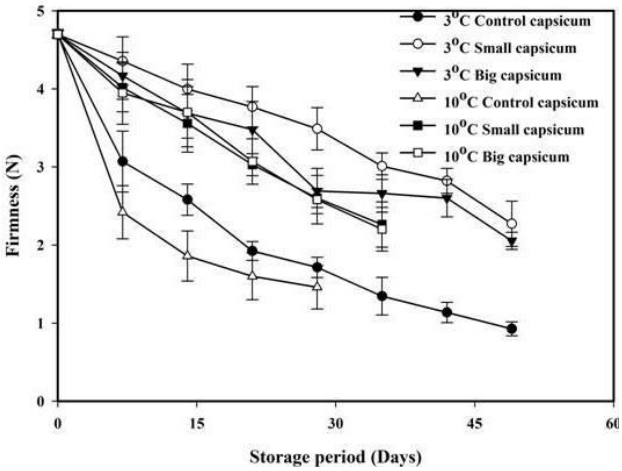

Figure 5: Effect of expanded polyethylene biopolymer packaging on firmness of Capsicum fruit stored at 3 and 10°C

However, the decrease in firmness was of higher magnitude during storage at 10ºC and it decreased from 4.71N-2.61N an 4.71N-2.59N in small and big size capsicum, respectively after 28 days of storage at 10ºC. There had been 63.5% and 69.0% decrease in firmness of control capsicum fruits after 28 days of storage at 3 and 10ºC, respectively (Fig. 5). 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).

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 3ºC (Fig. 6).

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 10ºC (Fig. 6). Control capsicum fruits exhibited maximum (91.2% and 89.8%) losses of sugar content after 28 days of storage at 3 and 10ºC, 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.

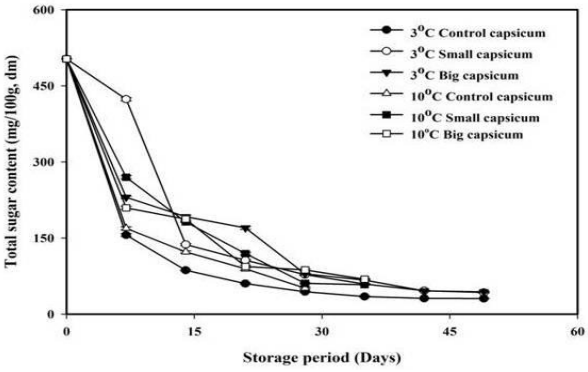

Figure 6: Effect of expanded polyethylene biopolymer packaging on sugar of Capsicum fruit stored at 3 and 10°C

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 10ºC. 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 3ºC (Fig. 7).

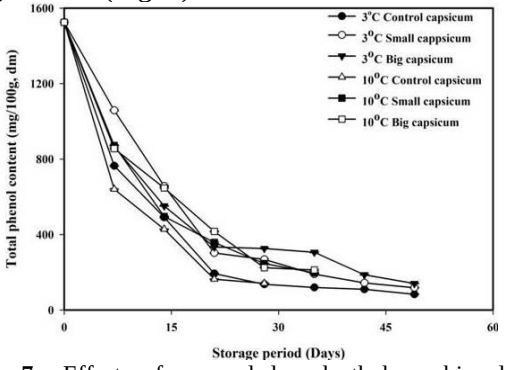

Figure 7: Effect of expanded polyethylene biopolymer packaging on phenolics of Capsicum fruit stored at 3 and 10°C

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 10ºC (Fig. 7). Total phenolics losses during storage in green chillies can be reflected due to its metabolic conversion to secondary phenolic compounds (Barz and Hoesel, 1977) or degradation via enzymatic action (Jimenez and Gracia-Carmona, 1999; Howard et al., 2000).

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 10ºC. This decrease was minimum (55.9% and 55.0%) during 28 days of storage at 3ºC in packaged capsicum samples of small and big sizes, respectively (Fig. 8).

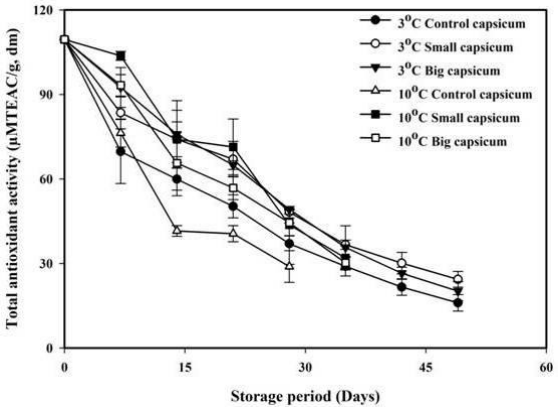

Figure 8: Effect of expanded polyethylene biopolymer packaging on antioxidant capacity of Capsicum fruit stored at 3 and 10°C

However, the decrease was of higher magnitude (60.1% and 59.4%) during 28 days of storage at 10ºC respectively in both sizes of packaged capsicum. Packaged capsicum fruits had delayed in the onset of senescence stage during storage at 3 and 10ºC 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).

Flex fresh packaged capsicum during storage at 3ºC have significantly ($p<0.05$) higher sensory score for overall acceptability as compared to storage at 10ºC. Senescence stage has also been visible during 28 days of storage in big size packaged capsicum at 3ºC. Kader (1986) also observed similar findings and reported that high CO_2 storage of broccoli tissue may result in membrane protection due to direct action of CO_2 on the membrane or by slowing senescence process. There had been no visible symptoms of chilling injury during storage of capsicum at 3ºC. Forney & 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 was 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. 9).

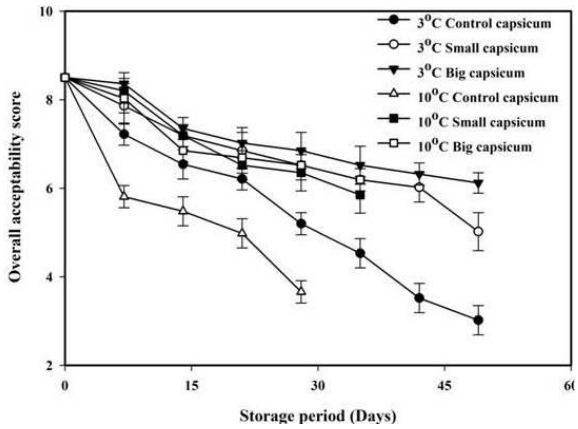

Figure 9: Effect of expanded polyethylene biopolymer packaging on overall acceptability score of Capsicum fruit stored at 3 and 10 °C

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 Extend 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. Low PLW, 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 and ascorbic acid was obtained in both sizes of packaged capsicum at 3°C.

सारांश

शिमला मिर्च सोलनेसियस कुल की सबसे महत्वपूर्ण सब्जी फसलों में से एक है जिसे पूरे देश में उगाई जाती है। ताजा तोड़ी गई शिमला मिर्च के फलों की स्व–जीवन अवधि बहुत कम (5–6 दिनों) होती है। शिमला मिर्च की भौतिक–रासायनिक गुणों और संरचना विविधताओं का आंकलन दो फलाकारों (300 ग्राम ± 10 प्रतिशत) एवं (900 ग्राम ± 10 प्रतिशत) में 30 माइक्रोग्राम फ्लैक्स फ्रेश विस्तारित पॉलीथीन बायोपॉलिमर थैलों के तहत 30 डिग्री सेन्टीग्रेड, 10 डिग्री सेन्टीग्रेड और 90–95 प्रतिशत सापेक्ष आर्द्रता के साथ संशोधित वायुमंडलीय भंडारण में किया गया है। पी.एल.डब्ल्यू. की न्यूनतम वृद्धि (6.02 प्रतिशत और 4.35 प्रतिशत), क्लोरोफिल में न्यूनतम कमी (70.3 प्रतिशत और 75.5 प्रतिशत) और एस्कॉर्बिक एसिड की न्यूनतम हानि (47.6 प्रतिशत और 40.3 प्रतिशत) 28 डी.ओ.एस. के बाद क्रमशः 3 डिग्री सेन्टीग्रेड तापमान पर प्राप्त हुयी। यह 3 डिग्री सेन्टीग्रेड पर 21 डी.ओ. एस. तक के थैलों में शिमला मिर्च के दोनों फलाकारों के लिए सबसे स्वीकार्य स्थिरता पायी गयी।

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