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Packaging films on quality and shelf-life of Naga King Chilli (*Capsicum chinense*) under different storage conditions

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Abstract

The quality characteristics and shelf life of Naga King Chilli (*Capsicum chinense*) was studied using four different packaging materials *viz*. LDPE of 10µ, 15µ and 30µ thickness, and HDPE-100µ thickness at two storage conditions, *i.e*. ambient (19-25 °C, RH 50-80%) and low temperature (5±1 °C, and RH 45-50%). The physico-chemical characteristics of chillies showed significant ($p < 0.05$) changes in terms of weight loss, firmness, colour and ascorbic acid content. An increase in total phenolics and carotenoids content, whereas decrease in flavonoids and capsaicin content was observed with increase in storage period for both the temperatures. The best observations were recorded for chillies packed in LDPE (30µ) bags stored at 5±1 °C with low weight loss, high fruit firmness, high retention of chlorophyll, capsaicin, phenolics and ascorbic acid content and a shelf life of 30-35 days followed by the chillies packed in LDPE (30µ) bags stored at room temperature for 25-30 days. The control (No packaging) on the other hand could be stored for 5-10 days and 10-15 days at ambient and low temperature respectively. Prepacked chilli has almost double the shelf life as compared to unpacked fruits.

Keywords: Naga King Chilli, packaging films, shelf life, postharvest quality, storage condition

Introduction

Naga King Chilli (*Capsicum chinense*), a native to the North-Eastern part of India, is cultivated in Assam, Nagaland and Manipur and in small pockets in the remaining states. It is used in different food formulations like flavouring curries due to its high-quality fragrance and pungency and also for various medicinal treatments like headache, night blindness, rheumatism, arthritis, gastritis, ankylosing spondylitis, digestive diseases and to reduce chronic congestion.

In a state like Arunachal Pradesh, King Chilli, inspite of being a high valued economic crop with good production and multiple health benefits, it is difficult to maintain the quality after harvest. It has a shelf life of 4 to 5 days and become unfit for human consumption due to microbial attacks under humid condition of the region. Marketability and shelf life could be improved by prepackaging fruits and vegetables in affordable size polymeric films and storage at low temperature which inhibit respiration, delay ripening, decrease ethylene production, reduce chilling injury, retard softening and maintaining colour (Gonzalez and Tiznado 1993; Chitravathi *et al.* 2015; Mahajan *et al.* 2016; Ben-Yehoshua *et al.* 1983) [12, 7, 4, 20].

Therefore, keeping in view the foregoing considerations, the present work was undertaken to study the effect of different packaging materials *i.e.* LDPE 10µ, 15µ and 30µ, HDPE-100µ and low temperature storage on the shelf life of Naga King Chilli.

Materials and Methods

The present investigation was undertaken at the College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh, under the Department of Post Harvest Management during the months between February and April, 2017.

Sample preparation and storage condition: Freshly harvested, mature green Naga King Chilli (*Capsicum chinense*) of uniform size free from blemishes, adhering sand or soil or foreign matters were obtained from the Pasighat local market. The chillies were washed with tap water to remove dirt and precautions were taken while handling the produce to minimize abrasions and bruising. The chillies were then surface dried at room temperature by spreading it on blotting paper for 20-30 minutes.

The chillies were packed in different packaging materials and were stored under two different conditions *viz.* Room temperature (19-25 ºC, RH 50-80%) and low temperature condition (5±1 ºC, RH 45-50%).

The combination of pre-packaging and storage temperature are presented as

T_1 Open condition (unpacked) + Room temperature
T_2 Styrofoam tray overwrapped with plastic film of 10µ + Room temperature
T_3 Styrofoam tray overwrapped with plastic film of 15µ + Room temperature
T_4 Low Density Polyethylene bag of 30µ + Room temperature
T_5 High Density Polyethylene bag of 100µ + Room temperature
T_6 Open condition (unpacked) + Low temperature
T_7 Styrofoam tray overwrapped with plastic film of 10µ + Low temperature
T_8 Styrofoam tray overwrapped with plastic film of 15µ + Low temperature
T_9 Low Density Polyethylene bag of 30µ + Low temperature
T_{10} High Density Polyethylene bag of 100µ + Low temperature

Size of Styrofoam tray was 13.2cm × 20.5cm, LDPE-30µ was 13.5cm × 17.6cm and HDPE-100µ was 19cm × 9cm. Number of chillies per packet/ tray was 8-12 chillies (No. varies because of packed area). The shrink film wrapped trays were passed through a shrink wrapping machine (Chamber machine: 15×20 inch) at 250ºC for 3-5 seconds. Then, the chilli in different packages were stored in dry place on racks at room temperature and low temperature condition in the laboratory of the Department of Post-Harvest Management along with the control (unpacked). Each treatment was performed in triplicates.

Observation were recorded on PLW(%), Firmness (Gonzalez *et al.* 1999) [11], Colour (Nyanjage *et al.* 2005) [24], Chlorophylls (Witham *et al.* 1971) [30], Carotenoids (Chitravathi *et al.* 2015) [7], Ascorbic acid (Jagota and Dani 1982) [17], Capsaicin content (Balasubramanian *et al.* 1982) [2], Total phenolics (Malick and Singh 1980) [21], Total flavonoids (Sahu and Saxena 2013) [26], Sensory quality (Lopez-Galvez *et al.* 1997) [19] and Marketability (Assumi *et al.* 2009) [1].

The statistical analysis of various characters studied in this experiment was carried out as per the procedure appropriate to the design of experiment *i.e.* 2 factor factorial Completely Randomized Design by adopting the Statistical procedures given by Gomez and Gomez (1984) [10]. Significance of differences between means for different treatments was tested and DMRT for the treatment comparison was worked out.

Result and Discussions

Physiological loss in weight (%) A significant ($p<0.05$) difference in weight loss was observed among the packed and unpacked chillies which increases with advancement of storage period (Fig.1). However, the chillies packed in different packaging films show the lowest weight loss compared with the control (unpacked) which might be due to decrease in transpiration rate, higher RH inside the bags and increase in CO_2 concentration. The higher PLW in fruits stored in ambient temperature than fruits stored in refrigerated storage is in conformity with the findings of Rongsennungla *et al.* (2012) [25] which may be due to increased rates of water loss. A similar trend was also observed in the case of bell peppers packed with different packaging materials (Tano *et al.* 2008) [28]. T_5 (High Density Polyethylene bag of 100µ + Room temperature) and T_{10} (High Density Polyethylene bag of 100µ + Low temperature) had the least PLW (0 and 1.68% respectively) throughout the storage period irrespective of the storage condition compared with other treatments. Although HDPE packaging reduces water loss, post harvest diseases could be enhanced by high humidity created in the bags. Also, there is increased CO_2 concentration due to the impermeability of the polymeric film.

Firmness Firmness follows the declining trend corresponding with advancement in storage period (Fig.1). However, for control (unpacked) in both the storage temperature *i.e.* ambient and low temperature condition (5±1ºC) the fruits experience a faster loss in firmness during storage as compared to the packaged fruits. The texture, in particular, crispness is an important quality attribute to the consumer. Flaccid development was found to be directly associated with water loss. Minimum loss of firmness and freshness of packaged fruits may be due to maintenance of a modified atmosphere around the fruits which in turn reduces senescence and aging and thus helps in retention of surface appearance (Nyanjage *et al.* 2005) [24]. The loss of firmness was also affected by the storage condition with low temperature stored fruits maintaining better firmness compared to the ambient condition stored fruits. Low temperature storage limits tissue softening. Similar results were obtained by Cheng *et al.* (2008) [5] and Edusei *et al.* (2012) [8] in the case of *C. annuum* during storage and Manolopoulou *et al.* (2010) [22] in the case of bell peppers at 10 ºC.

Colour, chlorophyll and carotenoids Colour change in fruits stored under low temperature condition (5±1ºC) was slower than fruits under ambient storage condition (Fig.1). These might be due to the effect of low temperature on the metabolic process within the fruits. This restricts the transmission of respiratory gases where the accumulation of CO_2 around the fruits counteracts with the ethylene action and colour development. Similar trend has also been reported by Rongsennungla *et al.* (2012) [25]. Packaged fruits remain green even upto 30 to 35 days at low temperature (5±1ºC) and 4-5 days at ambient condition while unpacked fruits was green for upto 10 days at low temperature (5±1ºC) and 1-2 days at ambient condition. This is in conformity with the findings of Gonzalez *et al.* (1999) [11] in bell pepper. Higher loss in green colour at ambient temperature may be caused by ripening which leads to increased breakdown of chlorophyll and synthesis of β-carotene and lycopene pigments.

The chlorophyll content of Naga King Chilli fruits decline during storage irrespective of different packaging films (Table 1). However, the decline was more pronounced in control as compared to the packed fruits. Among the different packaging materials, LDPE packed fruits registered the maximum chlorophyll content followed by Styrofoam tray overwrapped with plastic film of 15µ and on the other hand control fruits had the lowest chlorophyll content. The decrease in chlorophyll during storage may be due to chlorophyll degradation as a result of chlorophyllase enzymes activity leading to senescence. The maintenance of higher chlorophyll content due to packaging might also be due to reduction in respiratory activity cause by modified atmosphere within the package which allow the maintenance or retention of green colour (Nyanjage *et al.* 2005) [24]. Retention of green colour in Naga King Chilli was found to be better in low storage condition as compared to the ambient condition. Low temperature restricts the metabolic activities like respiration, rate of ripening and deterioration in fruits and vegetable (Edusei *et al.* 2012) [8].

Carotenoid content varied significantly ($p<0.05$) among the various packed chilli during the consecutive days of storage and their accumulation continuous even after a full red external colouration has been reached(Table 1). Results presented are in agreement with the findings of Hornero-Mendez *et al.* (2000) [14] on different cultivars of already ripe sweet peppers. There was a sharp increase in carotenoids content in all the chilli samples during storage, with chillies stored at ambient condition showing highest carotenoid content as compared to low temperature stored chillies. These might be due to faster ripening at higher temperature. Biosynthesis of carotenoids during ripening has been found paralleled by the degradation of chlorophyll pigment.

Ascorbic acid Ascorbic acid experienced a linear decline irrespective of packaging film and declined progressively with senescence (Table 1). The decrease in ascorbic acid during storage may be due to the oxidation of L – Ascorbic acid into dehydro ascorbic acid. Fruits packed in polyethylene bags showed higher level of ascorbic acid as compared to the unpacked one's which might be due to the slower metabolic process and slower rate of ripening as a result of passive modified atmosphere generated within the packaged, thus leading to slower conversion of ascorbic acid. The control fruits (unpacked) recorded the lowest ascorbic acid content. The ascorbic acid level can vary with preharvest climatic conditions, genotypic differences, maturity and postharvest handling procedures. The results are in good agreement with those obtained by Ghasemnazhad *et al.* (2011) [9] in the case of bell peppers. Slower decrease in ascorbic acid content was observed in low temperature storage condition as compared to ambient condition which is in line with the finding of Jecheon *et al.* (2001) [18]. Better quality fruits could be obtained from storage under low temperature leading to slower transpiration, metabolic processes and reduce rate of rotting which might have contributed towards better shelf life of the fruits.

Capsaicin The dominant pungency principle unique to the genus, Capsicum, is Capsaicin (8-methyl-n-vanillyl-6-non-enamide). It not only imparts flavour but also has therapeutic uses for its anticarcinogenic properties. A significant difference ($p<0.05$) in the capsaicin content was observed in both control and prepacked chilli during storage at ambient and low temperature ($5\pm1^{o}C$) storage condition (Table 2). Retention of capsaicin content was observed in chillies packed in polymeric film to a better extend as compared to unpacked chillies due to delay in the process of senescence. Capsaicin content was found to increase during storage and this accumulation was found to be maximum at colour break stage (green-yellow); and as the fruit ripened further (yellow-red), the capsaicin content began to decrease which is in line with the finding of Chitravathi *et al.* 2015 [7]. The decline in capsaicinoid concentration after the colour break (yellow-red) may be due to photo oxidation (Iwai *et al.* 1979) [16] or inhibition of capsaicinoid synthesis due to degradation by peroxidase during ripening (Hall & Yeoman 1991) [13].

Total phenolics and total flavonoids An increase in total phenolic content was observed during subsequent days of storage for all the treatments at ambient and low temperature condition (Table 2). Control samples showed higher phenolic content during storage as compared to the pre package chillies. The increase in phenolics content in chillies during ripening may be due to the conversion of flavonoids to secondary phenolic compounds (Chitravathi *et al.* 2014) [6]. The results are in good agreement with those reported by Ghasemnazhad *et al.* (2011) [9] and Edusei *et al.* (2012) [8]. A decrease in total flavonoid content was observed in packed and unpacked chillies during storage at ambient and low temperature condition ($5\pm1^{o}C$) (Table 2). The flavonoid content gradually decreased in chillies during green to red ripening stages. The onset of capsaicinoid accumulation in chilli pepper fruit has been found related to the disappearance of flavonoids (Sukrasano and Yeoman 1993) [27]. Flavonoid loss during maturation reflects its metabolic conversion to secondary phenolic compounds or degradation via enzyme action (Barz and Hoesel 1977) [3]. A decline in flavonoid concentration was also observed for *Capsicum chinense* by Menichini *et al.* (2009) [23].

Sensory and marketability Fruits sensory quality decline to varying degrees during storage depending on treatments (Fig.1). In general, packaged fruits show better appearance and quality than unpacked once. The best results with regard to quality attributes was shown by T_9 (Low Density Polyethylene bag of 30μ + Low temperature) followed by T_4 (Low Density Polyethylene bag of 30μ + Room temperature) and T_8 (Styrofoam tray overwrapped with plastic film of 15μ + Low temperature) those fruits remained hydrated and green even after 30^{th} to 35^{th} day followed by 25^{th} to 30^{th} and 20-25^{th} day respectively. These results agree with reports where film packaging was effective in reducing quality loss of bell pepper (Gonzalez and Tiznado 1993; Wall and Berghage 1996) [12, 29]. The effect of shrink polymeric film in maintaining sensory quality of fruits and vegetable might be due to its role in maintaining colour, firmness and freshness due to creation of modified atmospheric condition inside the package.

Percentage (%) marketability of all the treatments decreased with time due to loss of firmness, colour deterioration and microbial degradation by the passage of storage(Fig.1). Delayed senescence due to reduced respiration rate and retention of firmness and chlorophyll pigments increase the marketability of packaged chillies compared to unpacked ones at low temperature as well as in ambient condition. A similar finding was also observed in green chillies packed in Anti fog (RD45) film (Chitravathi *et al.* 2015) [7].

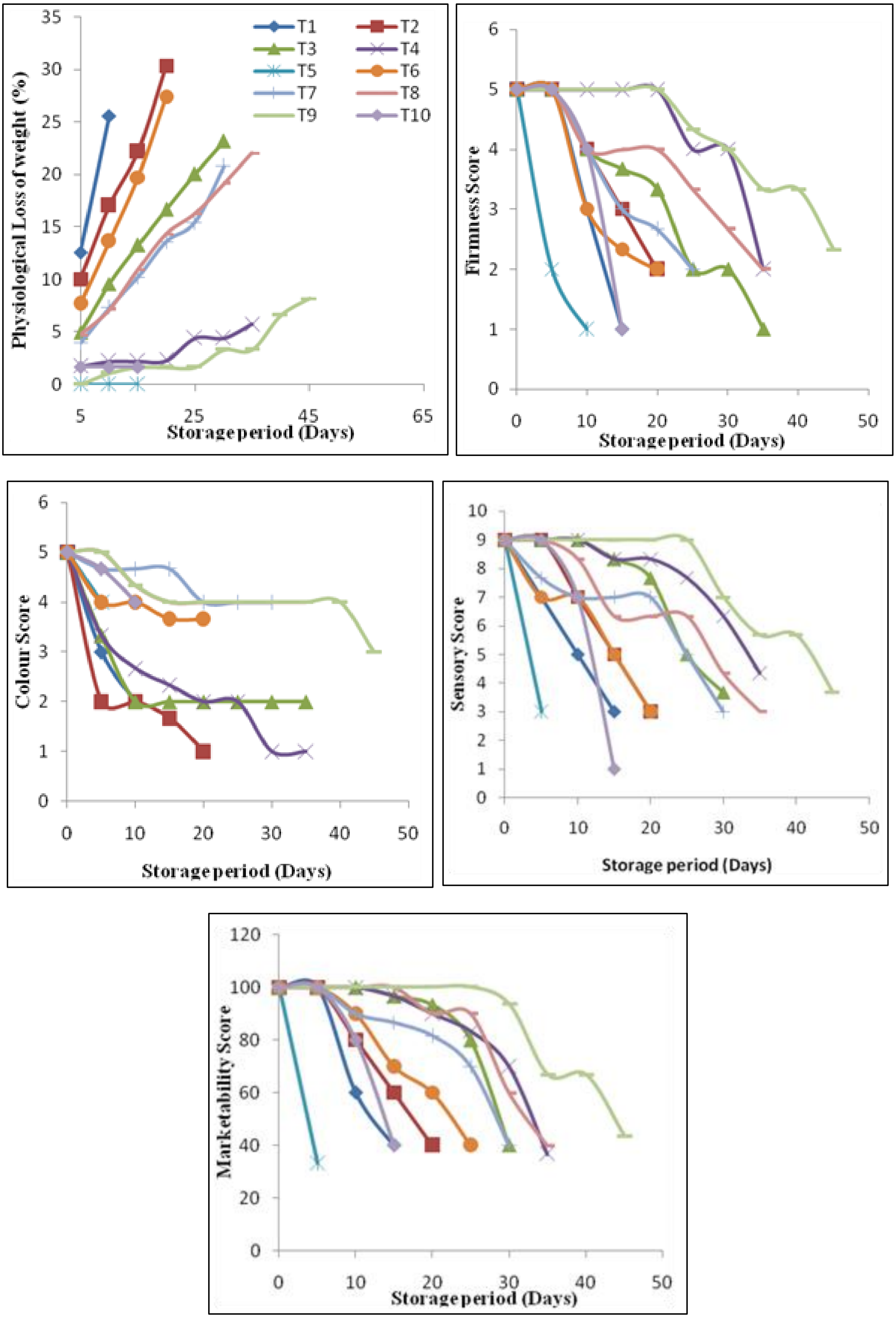

Fig 1: Effect of packaging on different parameters of Naga King Chillies at ambient (19-25 ºC) and low temperature (5±1 ºC) storage in different packaging films

Table 1: Physico- chemical attributes of Naga King Chillies at ambient (19-25 °C) and low temperature (5±1 °C) storage in different packaging films

Parameters	Storage period (days)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Total chlorophyll (mg/100g)	0	16.27	16.27	16.27	16.27	16.27	16.27	16.27	16.27	16.27	16.27
	10	3.28	8.22	8.80	7.64	-	9.58	13.68	12.27	12.04	12.72
	20	-	0.85	7.27	4.23	-	7.80	10.42	9.62	9.63	-
	30	-	-	3.04	2.14	-	-	7.10	7.70	8.11	-
	40	-	-	-	-	-	-	-	-	6.78	-
Carotenoids content (mg/100g)	0	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17
	10	27.22	10.50	5.82	5.34	-	7.89	6.25	5.27	4.40	5.19
	20	-	23.20	15.49	7.72	-	8.71	7.22	6.89	6.28	-
	30	-	-	21.07	12.13	-	-	8.28	8.20	8.06	-
	40	-	-	-	-	-	-	-	-	8.77	-
Ascorbic acid content (mg/100g)	0	169.89	169.89	169.89	169.89	169.89	169.89	169.89	169.89	169.89	169.89
	10	47.55	77.85	70.35	81.30	-	84.90	92.10	99.45	114.15	90.18
	20	-	51.45	51.90	50.40	-	41.40	71.10	79.80	96.45	-
	30	-	-	21.90	20.33	-	-	47.85	61.20	73.80	-
	40	-	-	-	-	-	-	-	-	68.85	

T1 = Open condition (unpacked) + Room temperature T7 = Styrofoam tray overwrapped with plastic film of 10µ + Low temperature
T2 = Styrofoam tray overwrapped with plastic film of 10µ + Room temperature T8 = Styrofoam tray overwrapped with plastic film of 15µ + Low temperature
T3 = Styrofoam tray overwrapped with plastic film of 15µ + Room temperature T9 = LDPE-30µ + Low temperature
T4 = LDPE-30µ + Room temperature T10 = HDPE-100 µ + Low temperature
T5 = HDPE-100µ + Room temperature (-) = Samples discarded.
T6 = Open condition (unpacked) + Low temperature

Table 2: Physico-chemical attributes of Naga King Chillies at ambient (19-25 °C) and low temperature (5±1 °C) storage in different packaging films

Parameters	Storage period (days)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Capsaicin Content (%)	0	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	10	0.40	0.41	0.34	0.28	-	0.40	0.22	0.20	0.22	0.34
	20	-	0.05	0.33	0.25	-	0.13	0.33	0.32	0.3	-
	30	-	-	0.23	0.20	-	-	0.17	0.27	0.28	-
	40	-	-	-	-	-	-	-	-	0.19	-
Total phenolic content(mg/100g)	0	113.49	113.49	113.49	113.49	113.49	113.49	113.49	113.49	113.49	113.49
	10	188.29	152.41	128.25	118.37	-	145.70	131.48	120.24	115.52	129.64
	20	-	169.35	140.98	137.37	-	168.85	145.35	129.52	125.88	-
	30	-	-	184.62	174.48	-	-	160.93	140.92	156.69	-
	40	-	-	-	-	-	-	-	-	163.31	-
Total flavonoids content(mg/g)	0	15.54	15.54	15.54	15.54	15.54	15.54	15.54	15.54	15.54	15.54
	10	4.33	3.85	3.31	3.77	-	9.95	9.30	12.71	12.25	10.60
	20	-	1.50	2.51	2.78	-	5.16	5.93	8.30	8.41	-
	30	-	-	2.21	2.48	-	-	3.12	5.21	7.05	-
	40	-	-	-	-	-	-	-	-	5.80	-

T_1 = Open condition (unpacked) + Room temperature T_7 = Styrofoam tray overwrapped with plastic film of 10µ + Low temperature
T_2 = Styrofoam tray overwrapped with plastic film of 10µ + Room temperature T_8 = Styrofoam tray overwrapped with plastic film of 15µ + Low temperature
T_3 = Styrofoam tray overwrapped with plastic film of 15µ + Room temperature T_9 = LDPE-30µ + Low temperature
T_4 = LDPE-30µ + Room temperature T_{10} = HDPE-100 µ + Low temperature
T_5 = HDPE-100µ + Room temperature (-) = Samples discarded.
T_6 = Open condition (unpacked) + Low temperature

Conclusion

Pre-packaging of fresh Naga King Chilli in polymeric films of different thickness showed beneficial effect on the postharvest life of Chilli. Thus, from the present studies it can be concluded that fresh Naga King Chilli packed in Low Density Polyethylene bag of 30µ can be successfully stored at 5±1 °C for 30-35 days with minimum loss in weight, higher fruits firmness, highest retention of chlorophyll, capsaicin, phenolics, ascorbic acid with good sensory score followed by the same packaging material T_4 (LDPE-30µ) in ambient condition and chilli packed in T_8 (Styrofoam tray overwrapped with plastic film of 15µ) at 5±1°C with the fruits maintaining its marketability up to 25-30 days and 20-25 days respectively. On the other hand, the control (unpacked) Naga King chillies maintain its marketable quality only upto 5-10 days and 10-15 days at ambient and low temperature condition respectively. Therefore, pre-packed chilli has almost double the shelf life as compared to unpacked fruits.

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