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EFFECTS OF STORAGE CONDITIONS AND PACKAGING MATERIALS ON THE FRUIT QUALITY OF SWEET PEPPER (CAPSICUM ANNUUM L.)

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ABSTRACT
Peppers are perishable and characterized by a short shelf life. This work aimed at investigating effects of packaging materials and storage methods on the physicochemical properties and fungal decay of sweet pepper. The cleaned and wholesome fruits (100) were packaged in polyethylene bag, banana leaf, and jute bag. Unpackaged fruits served as control. All the samples were then stored in refrigerator, evaporative cooling structure and at ambient condition (25±2 oC). A factorial combination of three (3) packaging materials and three (3) storage conditions using randomized complete block design with three replications were used. Weight loss and percentage decay were determined and physicochemical analyses were carried out. The results showed that banana leaves and polythene bags encouraged the highest and lowest weight loss of pepper fruits in evaporative cooling system and ambient condition respectively. The jute bags significantly reduced the percentage decay in refrigerator. There was no significant difference ($p \geq 0.01$) in the pH of all the fruits in refrigerator. Total soluble solids of all pepper fruits in evaporative cooling system and at ambient condition reduced as storage period increased. Titratable acid values of all the pepper fruits in refrigerator increased at Day 21 compared to the values recorded at Day 7 except in the fruits packaged in polythene bags that was decreased by 50%. Refrigerator and banana leaf influenced increase in ascorbic acid more than other storage conditions. Generally, the packaging materials and the storage conditions are not significantly ($p>0.01$) affected the colour parameters. It can be inferred that refrigerator and jute bag is the best storage method and packaging material as it minimizes loss and maintains quality.

Keywords: Banana leaf, *Capsicum annuum*, Colour, Decay, Refrigerator, Weight loss.

INTRODUCTION

Sweet pepper *(Capsicum annuum*) is an herbaceous annual plant that belongs to the family Solanaceae. Pepper fruits are a good source of antioxidants, vitamins C and E in addition to carotenoids and xanthophylls (Raju *et al.,* 2011). They are equally rich in phenolic compounds (Ozden *et al*., 2002; Hojo *et al.,* 2007). With its nutritional and medicinal contributions, it is believed to prevent certain types of cardiovascular diseases, atherosclerosis, cancer, and haemorrhage (Marin *et al*., 2004). Peppers have a low level of natural defense against biochemical and physiological deterioration in warm and humid places (FAO, 1981; Bayogan *et al*., 2017). During storage, the main factors for the quality degradation of sweet pepper include poor physical appearance, decay development, shriveling associated with water loss and its high susceptibility to chilling injury (Shehata *et al*., 2013).
Fresh green peppers are highly perishable and are preferentially consumed in fresh; in consequence, the fruit quality and shelf life are important factors in its commercial value. Temperature management is the most effective tool for extending the shelf life of fresh horticultural commodities. Cooling peppers as soon as possible after harvest will extend their shelf life. Once the fruit is cooled, peppers can be stored for two to three weeks under the proper conditions (Coolong, 2010).

Storage conditions play an important role in maintaining the quality of fruits and vegetables. However, cell metabolism continues during storage, and can influence the appearance, texture, taste, and nutritional value of the product. For this reason, the use of refrigeration and packaging of fruits in polythene packages are techniques that have an important effect on the post-harvest life of plants, reducing physiological processes, such as respiration (Edusei *et al.,* 2013). Techniques that allow extending the shelf-life of pepper are alternatives so that the production can be transported and reach the consumer with quality, reaching distant markets and opening new cultivation and marketing possibilities. The modified atmosphere with plastic or natural polymers allows to preserving fruits and vegetables in postharvest, reducing water loss, maintaining firmness and color (Ohiro *et al*., 2013) and, thus, improving the visual aspect of the product during commercialization. The use of packaging materials especially polyethylene bags provides better storage, ensures to maintain constant fruit storage up till the time of grinding. Packaging of pepper samples inside polyethylene bags and vacuum-packaging methods have proven to be more efficient for inhibiting water reintroduction and decreasing aeration (Alqbal *et al*., 2011; Ahn *et al.,* 2010).

In Nigeria, most growers and handlers keep the perishables at ambient conditions under which the physicochemical qualities of pepper can be maintained for only a short time (3-4 days) while some store them in cool rooms (4-8°C) that marginally extend their post-harvest life. The purpose of post-harvest handling system is to deliver good, appealing and nutritious food to the consumer in an economical manner. Handlers and consumers therefore give priority to the retention of fruit green colour, freshness and firmness as quality attributes during handling and storage.

Sweet pepper can be stored for moderately long periods at temperatures between 7˚C and 13˚C but lack of cold storage facilities is the major challenges to postharvest losses in developing countries. Cooling technology is generally expensive and requires electricity that is often unavailable (Kitinoja & Thompson, 2010), but many are based on evaporative cooling which has limited cooling capacity, especially in humid environments. Other factors of quality degradation of sweet pepper during storage include decay development, susceptibility to chilling injury and shriveling associated to rapid water loss. Water loss in commercial bell pepper has been identified as the main physiological factor limiting pepper fruit quality and prolonged storage (Maalekuu *et al*., 2003). It has also been subjected to postharvest losses which are very high in the developing world due to a number of factors, including harvesting at improper maturity time, rough handling and poor packaging leading to physical damage, lack of protection from water loss leading to wilting, shrivel and loss of saleable weight, inadequate transportation to market, and lack of cooling or cold storage capabilities (largely due to unreliable electrical power supplies) (Prasad and Paul, 2021). Post-harvest loss of pepper fruits is high and there is an urgent need to proffer solution and ensure all-year round availability of the fruits. Hence, the aim of this research work was to investigate the effects of storage methods and packaging materials on the physicochemical characteristics and decay of pepper.

MATERIALS AND METHODS

Collection of *Capsicum annuum*

Pepper fruits (*Capsicum annuum*) were obtained from Lasoju farm in Ilorin. The identification of the fruit was authenticated in the Herbarium Unit, Plant Biology Department, University of Ilorin. Based on visual maturity determination, green mature pepper with about 25% red skin was manually harvested with the aid of experienced personnel. The fruits were converged to Plant Pathology Laboratory, of Plant Biology Department, University of Ilorin.

Fruits were washed with running water to remove field heat, soil particles and to reduce microbial population. After surface drying with cheese cloth, the fruits were divided and sorted into uniform sizes.

Description of storage methods

The storage methods consist of four packaging materials; polyethylene bag, jute sac, banana leaf, control and three storage conditions; the refrigerator, ambient condition (AC) and evaporative cooling system (ECS) with three replications. Each unit of packaged fruits was packed in each packaging materials and stored in the three storage conditions. The evaporative cooling system (ECS) was prepared by inserting small clay pot into the bigger size pot and the space in between was filled with seed bed sand and covered with another pot. Wet towel was then spread over the cover pot to absorb the heat generated within the pot. The water was then sprinkled to provide humid condition for the samples stored inside. The evaporation of the water from the sand is expected to provide cool condition for samples in storage.

Experimental design

A factorial combination of four packaging materials: Polyethylene bag (PB), Jute sack (JB), Banana leaf (BL) and control (only plastic plate); and three storage environments refrigerator, evaporative cooling system (ECS) ambient condition) were used. Twelve treatments with three replications and one control in each condition were used in the study. The treatments were arranged in a randomized complete block design with three replications as Refrigerator + Polyethylene bag (FPB), Refrigerator + Jute sac bag (FJB), Refrigerator + banana leaf (FBL), Refrigerator + control (FCL), ECS + Polyethylene bag (EPB), ECS + jute sac bag (EJB), ECS + banana leaf (EBL), ECS + control (ECL), Ambient + Polyethylene bag (APB), Ambient + jute sac bag (AJB), Ambient + banana leaf (ABL) , Ambient + control (ACL).

Physicochemical Analysis of the Samples.

Temperature and Relative Humidity of the storage conditions

Temperature and relative humidity of the storage conditions (Evaporative cooling system, Refrigerator and for the ambient conditions) were measured during the storage period using a digital thermo-hygrometer (HTC-1 thermometer & hygrometer, China).

Weight Loss

Fruits were weighed daily using an electronic balance (Sartorius Type, L-610). The loss in weight (%) of the fruits was determined using the formula

$$\text{Weight Loss (\%)} = \frac{\text{Initial Weight} - \text{Final weight}}{\text{Initial Weight}} \times 10$$

Percentage Decay

Fruits showing symptoms of rots or fungal infection was counted as decay fruit. This was express as percentage decay fruits.

$$\text{Decay Fruits (\%)} = \frac{\text{Number of decay fruits}}{\text{Total number of fruits}} \times 100$$

Fruit Colour

Fruit skin colour assessment was conducted at intervals of 7 days using a Minolta colorimeter (model CR-300; Minolta Corp., Ramsey, NJ, USA). The values were obtained on a CIELAB scale (L*, a*, b*). The L* values represent lightness, colour values +a*: red; -a*: green; +b*: yellow; and -b*: blue of the fruit, respectively.

Determination of Physiochemical Properties

The pulp of 3 fruits from each treatment was blended and the homogenized pulp was used for the estimation of pH, total soluble solids (TSS), total titratable acidity (TTA) and Ascorbic acid (AA). The pH value of the homogenized pulp was measured by a pH meter (Renu & Chidanand, 2013). TSS was determined with Erma hand refractometer (0–32° Brix) and total acidity was estimated by titrating against 0.1N sodium hydroxide using phenolphthalein as indicator and expressed as mg of malic acid per g (Bayogan *et al*., 2017). AA content was determined by using 2, 6-Dichlorophenolindophenol dye method (Renu & Chidanand, 2013). Sample (2.5 g) was ground with about 25 ml of 4% oxalic acid and filter through Whatman filter paper. The filtrate was collected in a 50 ml volumetric flask and the volume was made up with 4% oxalic acid and titrated against the standard dye to a pink point. The amount of ascorbic acid was calculated and expressed as mg/ 100 g.

Data analysis

Experimental values were expressed as means $\pm$ SEM. Comparison of means values between the environmental conditions, treatments and their interaction were done by two way-analysis of variance (two way ANOVA) significant means were separated using Duncan Multiple Range Test (DMRT) at p≤0.01.

RESULTS AND DISCUSSION

Temperature and Relative humidity:

The refrigerator had the lowest temperature followed by evaporative cooling system throughout the storage period with an average of 12.22 °C and 23.8 °C respectively. At Day 20, highest percentage relative humidity was observed in evaporative cooling system (Table 1). The average temperature observed in this study was very close to 10 °C recommended by Hardenburg *et al*. (1986) for pepper storage as the fruits are very sensitive to chilling injury. Workneh & Woldetsadik (2004) also reported that the evaporative cooling chamber maintained the range of temperature varying from 17°C to 26°C and relative humidity between 43% to 98%, which were consistent with the values of temperature and relative humidity of ECS in this study.

Effects of packaging materials and storage on the weight loss of pepper

Refrigerator proved to be more efficient in preventing weight loss of pepper fruits than ambient condition and evaporative cooling system and no significant difference ($p > 0.01$) was observed among all the three packaging materials. Banana leaves promoted highest weight loss in both evaporative cooling system and ambient condition but samples stored in polythene bags recorded the lowest. In refrigerator, polythene bag was observed to the best packaging material for pepper to minimize weight loss (Table 2). This observation can be explained by the fact that the polyethylene material served as a barrier to moisture loss resulting in the quality of the sweet pepper fruits and the low percentage shriveled fruits (Meir *et al*., 1995). Water loss in ripe fruits is expedited by the change in permeability of cell membranes (Antoniali *et al*., 2007). However, in fruits and vegetable, water loss is one of the major factors that influence storability and also affects the availability of other compounds (Lownds *et al*., 1994).

Effects of packaging materials and storage on the percentage decay of pepper

Fruits wrapped with banana leaf and polythene bag showed the highest and lowest percentage decay in ambient condition and evaporative cooling system respectively. Although no significant difference was observed among all the packaging materials in the refrigerator, the lowest percentage decay was observed in the fruits packed in jute sac (Table 3). Refrigerator was able to minimize postharvest deterioration of the fruits and this agreed with the work of (Tsegay *et al*., 2013) who reported that tomato fruit, which is in the same family with pepper, had a high potential of storability under cold condition. This condition reduces spoilage of fruits and extends the storage period as it slows down fruit metabolism that will speed up rate of deterioration (Shen *et al*., 2013). Besides, stage of harvest has a significant effect on the rate of decay. Ciccarese *et al*. (2013) reported that fruits that are harvested at completely ripe stage are more prone and vulnerable to deterioration than fruits harvesting at intermediate stages and stored for less time. This finding supported the results in this work especially in the storage conditions where high percentage decay was recorded. Percentage decay seems to be high in a condition with high relative humidity and water condensation that support pathogenic activities (Coates *et al*., 1995).

Effects of packaging materials and storage on the physicochemical properties of stored pepper

The results of physicochemical properties of the stored pepper fruits were summarized in Table 4. The pH of all the fruits stored in refrigerator ranged from 5.60 to 8.15. There was no significant difference ($p \geq 0.01$) in the pH of all the fruits in refrigerator irrespective of the packaging materials. Pepper fruits packed with polythene bag were slightly alkaline after 14 days of storage, while those stored in banana leaf and jute bag remained acidic at ambient condition and in evaporative cooling system. The decreasing and increasing pattern in pH of *Capsicum* as storage period was advancing is in agreement with the previous findings by Camara *et al*. (1993) and Wills & Widjanarko (1995).

Titrable soluble solid of all pepper fruits in evaporative cooling system was reducing as storage period increasing. At ambient condition, similar reduction trend was observed in APB and AJB. The TSS of APB was significantly different ($p \geq 0.01$) from that of AJB and ABL 14 days after storage. FCL and FPB had lowest and highest TSS in refrigerator condition with no significant difference. The increase in TSS in pepper fruits is connected to disassociation of some molecules and structural enzymes in soluble compounds which influence the quantity of TSS (Tsegay *et al*., 2013). The decline of TSS of the fruits at ambient condition and ECS may likely be due to the use of the soluble sugars as respiration substrate that is promoted by higher temperature (Irtwange, 2006).

TTA values of all the pepper fruits in refrigerator were increased at Day 21 compared to the values recorded at Day 7 except in FPB that was decreased by 50%. The TTA of fruits stored at ambient condition as well as in evaporative cooling system ranged from 0.01 to 0.05 with no significant difference. Generally, TTA of *Capsicum* fruits showed a trend of an initial increase followed by a decrease and later increased. The decrease may be due to its utilization by the cells as a respiration substrate and decrease could be caused by temperature changes (Getenit *et al*., 2008). Lower TTA in fruits at high relative humidity and in the package during periods of storage may be due to reduced rate of acid production from carbohydrates as a result of slow respiration rate (Wills *et al.,* 1989).

The highest value for AA was recorded at Day 14 in FBL. It was also observed from the results that the refrigerator influenced increase in ascorbic acid in the fruits more than counterparts regardless of packaging materials except jute bag. At Day 20, the AA contents of all the fruits in the refrigerator showed no significant difference. Renu & Chidanand (2013) concluded in their study that AA did not change significantly in peppers stored in cold storage condition. As a general trend, AA content of sweet pepper fruits increased with ripening under both AC and ECS and showed a decline there after. Previous studies similarly reported that the AA content increased with stage of ripening and decreased once the fruits reached full ripe stage (Wills & Widjanarko, 1995; Bron & Jacomino, 2006).

Effect of packaging materials and storage on the colour attributes of stored pepper

L*, a* and b* are chromatic describing the colour character and are important index of international standard. The higher the L*, a* and a*/b* values of pepper products, the more acceptable the colour (Li *et al*., 2018). The increase of redness and decrease of greenness were associated with the increment in a* value and holds an evidence that there is increased breakdown of chlorophyll and synthesis of β-carotene and lycopene pigments (Edusei, 2011). The results revealed that At Day 21, no significant difference was observed for L* in all pepper fruits irrespective of storage methods and packaging materials at p>0.01. The increase in L* is attributed to an increase in bright pigment concentrations (Schweiggert *et al*., 2005). The a* values of all treated samples in the refrigerator were negative except FBL in Day 21. The temperature in the refrigerator was the lowest and low temperature retards colour development in pepper. In this study, the highest value of a* was recorded in APB indicating that polythene bag at ambient condition promoted redness of pepper fruits more than any other treatment used in this study. This could be due to the higher temperature recorded in that condition and such condition favours ripening and increase in capsaicin, dihydrocapsaicin, and total capsaicinoid contents (Oh and Koh, 2019). As no significant difference was observed in b* values of the treated fruits, highly significant difference was noticed in the interaction among the storage methods. Generally, the redness of the fruit was increasing along with storage period. The results also revealed that packaging materials have no influence on colour change. This assertion can be substantiated by the report of Sharma *et al*. (2018) who reported that packaging materials have no significant effect on colour development of pepper.

Conclusion

This study investigated the effects of three different packaging materials and storage methods on the physicochemical properties and deterioration of sweet pepper. Both the type of packaging materials and storage methods influenced the quality of the peppers. Generally, it appears that packaging materials negatively affected the weight loss and resulted in more decay than samples without packaging (control), but the degree of decay and weight loss was highly dependent on the storage conditions. This suggests greater influence of storage conditions on the quality of the pepper samples. Evaporative cooling system used alongside a polythene bag seems a better storage method than refrigeration and ambient storage combined with jute bag or banana leaves. The reason remains unclear and warrants future studies

Table 1: Temperature and relative humidity conditions of the storage

	DAY 4		DAY 8		DAY 12		DAY 16		DAY 20	
	TEMP (ºC)	RH (%)	TEMP (ºC)	RH (%)	TEMP (ºC)	RH (%)	TEMP (ºC)	RH (%)	TEMP (ºC)	RH (%)
REFRIGERATOR	12.3	57	12.3	55	12.2	58	12.3	60	12	65
AMBIENT	26.3	52	26.6	67	24.8	42	26.5	55	27.3	60
ECS	21.5	89	22	93	23.8	61	23.9	75	24.2	80

Table 2: Effects of packaging materials and storage methods on the percentage weight loss (%) of *Capsicum annuum* fruit.

STORAGE METHODS	PACKAGING MATERIAL	8	12	16
REFRIGERATOR	POLYETHYLENE	18.17± 9.36ª	23.92± 10.42ª	37.48± 14.08ª
	BANANA LEAF	13.48± 5.99ª	23.84± 7.79ª	30.43± 8.65ª
	JUTE SAC	7.98± 3.23ª	12.11± 3.63ª	13.68± 4.11ª
	CONTROL	6.23± 0.01ª	10.98± 0.02ª	13.65± 0.01ª
	Pvalue	NS	NS	NS
AMBIENT	POLYETHYLENE	4.08± 1.32ᵇ	21.43± 2.25ᶜ	35.83± 6.61ᶜ
	BANANA LEAF	34.49±11.57ª	55.69± 6.18ª	75.37± 4.08ª
	JUTE SAC	21.77± 4.24ᵃᵇ	42.63± 6.56ᵃᵇ	64.36± 6.35ᵃᵇ
	CONTROL	24.78± 0.02ᵃᵇ	39.65± 0.01ᵇ	51.89± 0.02ᶜ
	Pvalue	NS	***	**
EVAPORATIVE COOLER	POLYETHYLENE	0.82 ±0.19ᶜ	7.44± 5.87ᵇ	15.59±6.05ᶜ
	BANANA LEAF	46.89 ± 3.10ª	64.41± 18.04ª	95.00±0.00ª
	JUTE SAC	23.16± 9.23ᵇ	34.54±4.06ᵃᵇ	48.22±6.02ᵇ
	CONTROL	8.12±0.02ᵇᶜ	23.53±0.01ᵇ	47.06±0.02ᵇ
	Pvalue	**	NS	**
STORAGE METHODS (A)	Pvalue	NS	**	**
PACKAGING MATERIAL (B)	Pvalue	**	**	**
INTERACTION(A*B)	Pvalue	**	NS	**

NS = Not significant, ** = Significant at P < 0.01 *** = Highly significant at P ≤ 0.01; Means followed by the same letter(s) in the same columns are not significantly different

Table 3: Effects of packaging materials and storage methods on the percentage decay (%) of *Capsicum annuum* fruit.

STORAGE METHOD	PACKAGING MATERIAL	4	8	12	16
REFRIGERATOR	POLYETHYLENE	2.72±0.35^{a}	5.17±9.36^{a}	23.91±10.42^{a}	37.48±14.08^{a}
	BANANA LEAF	7.33±5.38^{a}	13.48±5.99^{a}	23.83±7.79^{a}	30.43±8.65^{a}
	JUTE SAC	6.12±2.32^{a}	7.98±3.23^{a}	12.11±3.63^{a}	13.68±4.11^{a}
	CONTROL	2.08±0.00^{a}	6.23±0.00^{a}	10.98±0.00^{a}	23.81±0.00^{a}
	Pvalue	NS	NS	NS	NS
AMBIENT	POLYETHYLENE	0.91±0.26^{a}	4.08±1.32^{b}	21.43±2.27^{c}	35.84±6.61^{c}
	BANANA LEAF	25.71±8.82^{a}	34.49±11.57^{a}	55.69±6.18^{a}	75.37±4.01^{a}
	JUTE SAC	12.33±3.77^{a}	21.77±4.24^{a}	42.63±6.56^{ab}	64.36±6.35^{ab}
	CONTROL	15.45±0.00^{a}	24.78±0.00^{a}	39.65±0.00^{b}	51.89±0.00^{ab}
	Pvalue	NS	NS	NS	NS
ECS	POLYETHYLENE	0.24± 0.13^{a}	0.81± 0.19^{c}	7.44± 5.87^{b}	15.59± 5.05^{c}
	BANANA LEAF	14.76± 4.02^{a}	46.89± 3.10^{a}	64.41±18.04^{a}	100.00± 0.00^{a}
	JUTE SAC	10.61± 6.46^{ab}	23.16± 9.23^{b}	34.54±4.06^{ab}	48.22±6.01^{b}
	CONTROL	7.56± 0.00^{ab}	8.12± 0.00^{ab}	23.53± 0.00^{b}	47.06± 0.00^{b}
	Pvalue	NS	**	NS	**
STORAGE METHODS (A)	Pvalue	**	**	**	**
PACKAGING MATERIAL (B)	Pvalue	**	**	***	***
INTERACTION(A *B)	Pvalue	**	**	**	**

NS = Not significant, ** = Significant at P < 0.01 *** = Highly significant at P $\leq$ 0.01; Means followed by the same letter(s) in the same columns are not significantly different

Table 4: Effects of packaging materials and storage environment on the Physicochemical attributes of *Capsicum annum* fruit during 21 days of storage

	pH			TSS			TTA			VIT C		
PM	7	14	21	7	14	21	7	14	21	7	14	21
FPB	5.95±0.25^{a}	4.50±0.40^{a}	7.65±0.05^{a}	0.38±0.28^{a}	0.52±0.04^{a}	0.70±0.30^{a}	0.06±0.02^{a}	0.03±0.00^{a}	0.03±0.01^{a}	2.78±0.74^{a}	6.92±0.00^{c}	6.18±0.19^{a}
FBL	5.60±0.10^{a}	3.40±0.00^{a}	8.10±0.00^{a}	0.13±0.01^{a}	0.51±0.21^{a}	0.40±0.20^{a}	0.04±0.01^{a}	0.02±0.00^{a}	0.08±0.04^{a}	1.03±0.19^{ab}	8.32±0.01^{a}	6.76±0.37^{a}
FJB	5.75±0.05^{a}	4.55±0.35^{a}	7.70±0.40^{a}	0.26±0.18^{a}	0.31±0.07^{a}	0.60±0.00^{a}	0.02±0.01^{a}	0.01±0.00^{a}	0.07±0.01^{a}	0.39±0.01^{b}	6.40±0.05^{d}	6.06±0.06^{a}
FCL	5.75±0.05^{a}	4.20±0.60^{a}	8.15±0.05^{a}	0.55±0.15^{a}	0.26±0.01^{a}	0.35±0.15^{a}	0.01±0.00^{a}	0.02±0.01^{a}	0.05±0.01^{a}	1.04±0.65^{ab}	7.79±0.05^{b}	6.62±0.50^{a}
P.val	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS
APB	9.70±0.00^{a}	9.80±0.30^{a}	NA	5.75±0.45^{a}	1.80±0.60a	NA	0.04±0.01^{a}	0.02±0.01^{b}	NA	5.79±1.51^{a}	2.06±0.16^{d}	NA
ABL	5.45±0.15^{b}	6.05±0.55^{b}	NA	0.07±0.01^{b}	0.25±0.03b	NA	0.02±0.01^{a}	0.01±0.00^{b}	NA	3.48±0.68^{ab}	3.69±0.01^{c}	NA
AJB	5.60±0.00^{b}	4.85±0.35^{ab}	8.15±0.05^{b}	0.21±0.17^{b}	0.14±0.00^{b}	0.30±0.10^{a}	0.02±0.01^{a}	0.03±0.00^{b}	0.60±0.02^{a}	3.51±0.61^{ab}	7.81±0.12^{a}	6.41±1.35^{b}
ACL	5.60±0.00^{b}	3.55±0.05^{c}	8.40±0.00^{a}	0.37±0.00^{b}	0.61±0.01^{b}	0.20±0.00^{ab}	0.01±0.00^{a}	0.05±0.00^{a}	0.03±0.00^{ab}	0.63±0.01^{b}	6.89±0.01^{b}	11.97±0.00^{a}
Pval	**	***	**	**	NS	NS	NS	**	NS	NS	**	**
EPB	8.75±0.55^{a}	9.60±0.00^{a}	NA	3.50±0.50^{a}	1.60±0.20^{a}	NA	0.03±0.01^{a}	0.01±0.00^{a}	NA	4.06±0.58^{a}	2.27±0.12^{c}	NA
EBL	5.25±0.05^{b}	4.25±0.35^{c}	NA	2.86±1.98^{a}	0.38±0..00^{b}	NA	0.03±0.00^{ab}	0.23±0.00^{a}	NA	1.16±0.16^{b}	7.67±0.70^{a}	NA
EJB	5.45±0.15^{b}	5.80±0.70^{b}	NA	1.94±0.58^{a}	0.19±0.11^{b}	NA	0.03±0.00^{ab}	0.23±0.01^{a}	NA	1.93±0.26^{b}	6.97±0.03^{a}	NA
ECL	5.75±0.05^{b}	3.70±0.00^{c}	NA	0.58±0.01^{a}	0.06±0.00^{b}	NA	0.01±0.00^{b}	0.02±0.00^{a}	NA	1.81±0.02^{b}	3.87±0.04^{b}	NA
Pval	**	**	NA	NS	**	NA	NS	NS	NA	***	**	NA
SM	**	**	**	**	NS	**	NS	NS	**	**	**	**
PM	**	**	**	**	**	NS	***	NS	NS	**	**	**
INT	**	**	**	***	NS	NS	NS	**	NS	NS	**	**

PM= Packaging material, SM= Storage method, NA= Not available, NS = Not significant, ** = Significant at P < 0.01 *** = Highly significant at P $\leq$ 0.01; Means followed by the same letter(s) in the same columns are not significantly different. .FPB (Refrigerator + Polyethylene bag), FJB (Refrigerator + Jute sac bag), FBL (Refrigerator + banana leaf), FCL (Refrigerator + control), EPB (Evaporative cooler + Polyethylene bag), EJB (Evaporative cooler + jute sac bag), ,EBL (Evaporative cooler + banana leaf), ECL (Evaporative cooler + control), APB (Ambient + Polyethylene bag), AJB (Ambient + jute sac bag), ABL (Ambient + banana leaf), ACL(Ambient + control)

Table 5: Effects of packaging materials and storage environment on the colour attributes of *Capsicum annum* fruit.

	L*			a*			b*		
PM	7	14	21	7	14	21	7	14	21
FPB	49.55± 1.79ᵃ	48.58±2.59ᵃ	53.54±0.62ᵃ	-2.19±0.04ᵃ	-1.56±0.23ᵃ	-0.19±0.78ᵇ	23.15±1.35ᵃ	19.57±1.67ᵃ	17.02± 0.41ᵃ
FBL	48.15±1.59ᵃᵇ	48.27±1.64ᵃ	50.66±2.61ᵃ	-1.95±0.25ᵃ	2.61±3.45ᵃ	6.62±2.93ᵃ	21.45±1.25ᵃ	20.52±1.06ᵃ	16.13±2.53ᵃ
FJB	50.15±1.29ᵃ	49.31±0.79ᵃ	53.92±0.82ᵃ	-2.28±0.72ᵃ	-2.61±0.22ᵃ	-1.74±0.43ᵇ	23.29±0.37ᵃ	21.86±0.11ᵃ	19.84±0.87ᵃ
FCL	44.86±0.43ᵇ	49.69±0.43ᵃ	50.35±0.64ᵃ	-1.36±0.06ᵃ	-1.29±0.04ᵃ	-0.38±0.06ᵇ	22.36±0.22ᵃ	21.58±0.38ᵃ	16.90±0.02ᵃ
Pvalue	NS	NS	NS	NS	NS	NS	NS	NS	NS
APB	54.02±1.26ᵃ	50.83±0.58ᵃ	50.52±0.37ᵃ	-2.59±0.60ᵇ	12.95±0.25ᵃ	11.88±0.54ᵃ	22.17±0.42ᵃ	18.14±1.17ᵃ	14.59±0.32ᵃ
ABL	47.65±1.14ᵇ	44.38±0.87ᵇ	48.60±0.70ᵃᵇ	-1.87±0.52ᵇ	4.92±2.22ᵇ	6.57±2.23ᵇ	22.27±1.36ᵃ	16.89±1.17ᵃ	13.93±0.69ᵃ
AJB	47.33±0.38ᵇ	45.09±1.46ᵇ	48.80±1.00ᵃᵇ	1.07±2.38ᵇ	4.69±1.47ᵇ	8.76±0.61ᵃᵇ	22.17±0.79ᵃ	18.11±1.52ᵃ	14.02±1.11ᵃ
ACL	45.78±0.31ᵇ	42.16±0.26ᵇ	47.45±0.24ᵇ	8.29±0.15ᵃ	7.17±0.15ᵇ	8.01±0.11ᵃᵇ	21.29±0.25ᵃ	14.95±0.16ᵃ	12.51±0.29ᵃ
Pvalue	***	***	NS	***	NS	NS	NS	NS	NS
EPB	46.69±1.82ᵃ	51.04±1.06ᵃ	NA	-1.68±0.25ᶜ	12.40±1.21ᵃ	NA	17.90±0.40ᶜ	18.53±0.79ᵃ	NA
EBL	47.65±0.52ᵃ	45.83±3.04ᵃᵇ	49.17±2.05ᵃ	-1.68±0.21ᶜ	6.85±2.49ᵇ	9.58±1.03ᵃ	22.05±0.64ᵃ	19.23±2.84ᵃ	15.50±2.81ᵃ
EJB	45.79±2.40ᵃ	46.89±1.96ᵃᵇ	48.19±1.94ᵃ	8.93±1.55ᵃ	0.98±0.50ᶜ	2.78±0.75ᵇ	19.37±0.22ᵇ	19.20±1.44ᵃ	12.09±0.74ᵃ
ECL	40.17±0.91ᵇ	44.21±0.19ᵇ	48.19±0.22ᵃ	1.25±0.06ᵇ	10.46±0.32ᵃᵇ	10.16±0.27ᵃ	22.44±0.18ᵃ	18.13±0.23ᵃ	14.93±0.57ᵃ
Pvalue	NS	NS	NS	**	NS	NS	**	NS	NS
SM	**	NS	NS	**	**	NS	**	**	***
PM	**	**	NS	**	**	NS	NS	NS	NS
INTR	NS	NS	NS	**	**	NS	**	NS	NS

PM= Packaging material, SM= Storage method, NS = Not significant, ** = Significant at P < 0.01 *** = Highly significant at P ≤ 0.01; For each factor, means followed by the same letter(s) in columns are not significantly different by Duncan Multiple Range Test (DMRT) at P > 0.01.FPB (Refrigerator + Polyethylene bag), FJB (Refrigerator + Jute sac bag), FBL (Refrigerator + banana leaf), FCL (Refrigerator + control), EPB (Evaporative cooler + Polyethylene bag), EJB (Evaporative cooler + jute sac bag), EBL (Evaporative cooler + banana leaf), ECL (Evaporative cooler + control), APB (Ambient + Polyethylene bag), AJB (Ambient + jute sac bag), ABL (Ambient + banana leaf), ACL(Ambient + control)

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