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MODIFIED ATMOSPHERIC PACKAGING OF GUAVA : EFFECT OF PACKAGING FILM AND STORAGE CONDITIONS ON PHYSICAL AND BIOCHEMICAL PROPERTIES

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Abstract

The effect of modified atmospheric packaging along with variation in storage temperature and thickness of low density polyethylene (LDPE) bags was evaluated for maintaining the quality of guava and to extend the shelf life of fruits. The fruits were packaged in low density polyethylene bags with varying thicknesses (200 and 180 gauge). Two types of LDPE bags filled with three types of gaseous concentrations (3% O_2 5% CO_2, 5% O_2 8% CO_2 and 8% O_2 10% CO_2) were stored at ambient conditions *i.e.* room (25±2°C) and refrigerated (5±2°C) temperature. Periodical observations were recorded on CO_2 & O_2 concentration, physiological loss in weight, color value, total soluble solid, titratable acidity, total sugar and ascorbic acid loss at different temperature and storage period. The findings showed that the vitamin C decreases from 251.35 to 120.54 mg/100, while the acidity was increases from 0.33 to 2.68 %during the storage at different storage condition and temperatures. It was found that the shelf life of guava increased up to 32 days at low temperature (5±2°C) and 16 days at high temperature (25±2°C) with gaseous concentration O_2:CO_2 5:8% which packed in LDPE 50 µm thickness bags and observed that this combination maintains desirable nutritional and physical properties.

***Key words**: Shelf life, LDPE, Titratable acidity, Total soluble solid, Ascorbic acid, Physiological loss in weight.*

Introduction

Guava (*Psidium guajava L.*) is cultivated in tropical and subtropical regions of the world. In India, it is grown all over India. Production of guava was 3648000 MT from area 262000 Ha which contributes 4.1% of total fruit production in 2016-17 provisional (NHB Database 2017). Guava is highly demanding fruit throughout the year for fresh and processing produce due to its tastiness and having health-promoting qualities such as ascorbic acid (260 mg/100g) (Pedapati *et al.*, 2014) and dietary fiber (63.94 g/100g) (Uchôa-thomaz *et al.*, 2014). It is also exported in the International market which was 1.43 thousand MT in 2016-17 (NHB Database 2017), this number can be increased if fruit handling is proper after the harvesting.

Guava is considered as perishable fruit due to higher respiration rate and has shorter storage life in ambient conditions. The post-harvest deterioration begins within a few days after harvesting. Post-harvest changes include loss in physiological weight (moisture loss), color change (chlorophyll senescence), texture change from crunchy to soft and loss of nutritional value. All these changes responsible for the reduction in the value of its marketability. Organoleptic and nutritional value declines expeditiously during storage of guava. It is more prone to chilling injury which limited its marketability at national and international level (Sahoo *et al.*, 2015). Due to high chilling sensitivity, guava is not stored at very low temperatures. Therefore, guava cannot be shipped to distant markets under normal circumstances. In the food industry, there are many packaging techniques available to extend the shelf life of fruits and vegetables for example modified atmosphere packaging (MAP), controlled atmosphere packaging (CAP), edible coating, shrink wrap packaging and vacuum packaging (Šèetar *et al.*, 2010; Sahoo *et al.*, 2015).

MAP has been widely used for the storage of guava fruits and this technique has emerged as the most meaningful technology for food preservation. This

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technique delayed fruit ripening through lowering the respiration rate by modification of gas concentration in the packet. Generally, oxygen, carbon dioxide and nitrogen gases are used in modified atmospheric packaging. Oxygen inhibits anaerobic respiration and prevents the growth of anaerobic microorganisms and carbon dioxide gives an anaerobic atmosphere and prevent aerobic microorganisms. Carbon dioxide intercepts ethylene production and delays ripening of guava. N_2 used as filler gas which prevents package collapse (Sandhya, 2010). Modified atmospheric packaging is done with various types of packaging materials like low density polyethylene (LDPE), polypropylene (PP), polyvinyl chloride (PVC) and biaxially oriented polypropylene Films (BOPP) (Berins, 1991; Abdel-Bary, 2003; Mangaraj *et al.,* 2009). Modified atmospheric packaging of guava in PVC polybag with 40 µm thickness were observed shelf life of guava extend up to 25 and 20 days at 5 and 10˚C (Mrmum & Mishra, 2017a). LDPE bags with 50 µm thickness increased storage life of guava up to 42 days at 10˚C without much change in sensory characteristics (Antala *et al.,* 2105). Modified atmospheric packaging (MAP) of guava in polypropylene (PP) with pin holes was observed that it could be store for 28 days at refrigerator temperature (Sahoo *et al.,* 2015). The above studies showed that thickness of packaging materials and storage temperature is an important factor for packaging of fruits and vegetables during modified atmospheric packaging.

This study aimed to investigate the most appropriate gaseous concentration, thickness of LDPE bag and temperature to enhance the storage life of guava and assessment of physicochemical quality during storage.

Materials and Methods

Materials and sampling

Safeda variety of guava (*Psidium guajava* L.) were procured in winter season (January to March) from Khusrobhag Horticulture garden, Prayagraj. Uniform and light green color skin of guava fruit was selected to run further experiments. Fruits were washed with 1% sodium hypochlorite and then further cleaned with tap water. Guava fruits were air dried. Control sample was stored at ambient condition (25±2˚C and RH 50-55%) without packaging.

Packaging films

2 types thickness of LDPE *i.e.* 45 and 50 µm, were used in the present research. All the packaging films were purchased from the Rama plastic, meerganj, Prayagraj.

Gas concentration and storage condition

2 types of packaging materials contain 3 types of gaseous concentration which is G1 (3% O_2 5% CO_2), G2 (5% O_2 8%CO_2) and G3 (8% O_2 10% CO_2). N_2 used as balance gas. The packed fruits were stored at 25±2 ˚C and 5±2 ˚C.

Details of treatments

Details of treatments given in table 1

Packaged guava was evaluated by various Physico-chemical properties, the methods are given below.

Headspace gas composition

Headspace analysis was done to know the concentration of O_2 and CO_2 in the packet. This test was carried by PBI Dansensor chackmat II. A needle of dansensor injected in to packet and the sensor converted signals to values of O_2 and CO_2 concentration, which are displayed on the digital display panel of the instrument (Tirkey *et al*., 2014).

Physiological loss in weight (PLW)

Physical loss in weight (PLW) was defined by weighing guava packages with top loading weighing balance on the first day of the packaging and end of the storage period. The difference between two values was considered as weight loss and expressed in percentage (Sahoo *et al*., 2015).

PLW(%) = Initial weight " Final weight/ initial weight × 100

Total soluble solids (TSS)

Total soluble solids of guava juice was measured by digital refractometer. The juice was extracted from a fine paste of guava and measured TSS˚B according to

Table 1: Treatment combination with LDPE 50µmand LDPE 45 µm packaging bag.

Treat-ment code	Gaseous concentration (O_2:CO_2)	Packaging material	Storage temper-ature
LDPE 50 µm			
$T1_{L50}$	G1 (3:5)	LDPE 50	25±2˚C
$T2_{L50}$	G2 (5:8)	LDPE 50	25±2˚C
$T3_{L50}$	G3 (8:10)	LDPE 50	25±2˚C
$T4_{L50}$	G1 (3:5)	LDPE 50	5±2˚C
$T5_{L50}$	G2 (5:8)	LDPE 50	5±2˚C
$T6_{L50}$	G3 (8:10)	LDPE 50	5±2˚C
LDPE 45µm			
$T1_{L45}$	G1 (3:5)	LDPE 45	25±2˚C
$T2_{L45}$	G2 (5:8)	LDPE 45	25±2˚C
$T3_{L45}$	G3 (8:10)	LDPE 45	25±2˚C
$T4_{L45}$	G1 (3:5)	LDPE 45	5±2˚C
$T5_{L45}$	G2 (5:8)	LDPE 45	5±2˚C
$T6_{L45}$	G3 (8:10)	LDPE 45	5±2˚C

Table 2: Effect of different LDPE bags and storage temperature on surface color of packed guava.

		Last day of storage		
Storage tempe-rature	**Treat-ment**	**L**	**±a**	**±b**
	Control (0 day)	51.15^{h}±1.80	-7.15^{f}±0.35	6.40^{a}±1.00
25±2 °C	$T1_{L50}$	28.40^{fg}±1.04	0.84^{a}±0.13	13.25^{c}±0.37
	$T2_{L50}$	27.49^{ef}±0.90	1.36^{abc}±0.23	16.7^{d}±0.42
	$T3_{L50}$	24.85^{d}±1.01	2.56^{d}±1.24	18.53^{e}±0.50
	$T1_{L45}$	15.24^{a}±0.32	3.42^{de}±0.93	12.38^{c}±0.65
	$T2_{L45}$	21.57c±0.95	2.67^{d}±0.41	10.14^{b}±0.80
	$T3_{L45}$	18.68^{b}±0.09	2.48^{cd}±0.95	13.94^{c}±1.44
5±2 °C	$T4_{L50}$	25.92d^{e}±1.18	-1.32^{abc}±0.20	21.53^{f}±1.20
	$T5_{L50}$	29.29^{g}±0.64	-2.68^{d}±0.92	17.64^{de}±0.74
	$T6_{L50}$	21.72^{c}±0.78	-3.94^{e}±0.34	16.29^{d}±0.95
	$T4_{L45}$	17.45^{b}±1.37	-1.23^{ab}±0.18	24.43^{g}±1.20
	$T5_{L45}$	18.57^{b}±0.54	-3.30^{de}±0.72	25.97^{g}±1.26
	$T6_{L45}$	15.71^{a}±0.85	-2.21^{bcd}±0.27	25.17^{g}±0.52

Mohammadi &Hanafi, (2014).

Titratable acidity

Titratable acidity of packed guava samples was measured by AOAC (2005) method by boiling the sample for 1 h in water and making up the volume up to 100 ml and then titrating it against 0.1 N sodium hydroxide solution.

% Titratable acidity =

$$\frac{Titre\ X\ Normality\ of\ alkali\ X\ volume\ made\ up\ X\ equivalent\ wt\ of\ acid\ X\ 100}{Volume\ of\ sample\ taken\ for\ estimation\ X\ Wt\ of\ sample\ taken\ X\ 100}$$

Total sugar

The total sugars of guava were determined by the Lane and Eynon method according to Rangana (2007). This method proposed that total sugars of fruit are the addition of reducing sugar and sucrose. In this way sucrose was determined by calculation manner and the formula was

Sucrose % = (Total invert sugars % - Reducing sugars %) × 0.95

Sample preparation for reducing sugar was done by following method in which 50 g of blended fruit pulp was mixed with 400 ml of water and neutralized with 1N NaOH, boiled this solution for 1h, cool and transferred the mixture in to 500 ml volumetric flask then make up the volume and filter the solution. 100 ml aliquot pipette out in to 500 ml volumetric flask from this solution andadd 2 ml of neutral lead acetate and 200 ml of water. Kept it for 10 min to precipitate the extra lead with potassium oxalate solution make up to mark and filter. This solution titrate the mixed Fehling solution (A & B) with methylene blue indicator. Titrate the Fehling solution in hot condition until the reduction is complete and give brick red color.

% Reducing sugars =

$$\frac{mg\ of\ invert\ sugar\ X\ dilution\ X\ 100}{titre\ X\ wt.of\ sample\ X\ 100}$$

Total invert sugars were estimated after the completion of inversion of above prepared clarified solution. Pipette 50 ml of the clarified solution in to 250 ml flask, add 5 gm of citric acid and 50 ml water. Gently boiled this solution for 10 min to complete the inversion of sucrose. Cool the solution and neutralized with 1N NaOH. Mixture of Fehling solutions (A & B) titrated with this solution until the brick red color appeared.

% Total invert sugars =

$$\frac{mg\ of\ invert\ sugar\ X\ dilution\ X\ 100}{titre\ X\ wt.of\ sample\ X\ 100}$$

Ascorbic acid

Ascorbic acid was estimated by 2, 6 dichlorophenol indophenol titration method. 10 g sample was prepared in 3% (w/v) metaphosphoric acid and the volume was made up to 100 ml with metaphosphoric acid. Filtered aliquot (5 ml) of sample was titrated against standard 2, 6dichlorophenol indophenol dye solution until the pink color developed completely (Rangana, 2007).

mg of Ascorbic acid/100 gm of sample =

$$\frac{Dye\,factor \times Volume\ made\,up \times titre\ value \times 100}{ml\ of\ aliquot\ taken\ for\ estimation \times 1000 \times wt.or\ vol.of\ sample\ taken}$$

Color value of peel

The surface color of guava was measured with X-rite (Grandville, MI, USA). The color attributes *i.e.* lightness (L^*), redness (a^*) and yellowness (b^*) were recorded of each sample.

Analysis of experimental data

The experimental data were analyzed by the variance of analysis (ANOVA) with the help of statistical software of IBM SPSS 16.0. The mean of data was obtained from a replicate reading of each experiment and mean differences were carried out by Duncan's multiple range tests at 95% level of confidence. The graph of obtained results were draw in sigma plot 10.0.

Result and Discussion

Headspace gas composition

The gaseous concentrations of $O_2$and CO_2 within the different thickness of LDPE bags with various treatment were shown in Figs. 1 which showed that for both the thickness of LDPE bags the concentration of O_2 within the packet gradually decreases as the storage period increases. The highest O_2 retention (80-89%) was found in 50 µm thick LDPE bag because it have low gas permeability. 5±2°C storage temperature maintain higher level of O_2 (80-98%) up to 32 days for the packaging bags, while at 25±2°CO_2 level maintain up to 80-95% for 16 days. At 25±2°C after 16 days of storage samples were spoiled so further analysis was not done for those samples. In treatment $T6_{L45}$ O_2 level reduced from 8-0.14% and from 5-0.98% in $T5_{L50}$ treatment. So result showed that O_2 retention rate is higher in $T5_{L50}$ treatment *i.e.* 80.4%. After some day of storage, O_2 availability was less within the packet which causes slows respiration rate of guava and it may help to increase the shelf life of guava (Nath *et al.,* 2012). The current finding were in consent with Nath *et al.,* (2012) for pear in different polyfilms and Sahoo *et al*., (2015) for guava.

The CO_2 concentration increases with the increase in storage period of packages. All three factors that is CO_2 concentration, the thickness of LDPE bags and storage temperature affect the CO_2 concentration within package during storage period. The increase rate in CO_2 concentration was found highest (59.13%) in 45µm thick LDPE bag, in which CO_2 increases from 5-11.8%. Gaseous concentration *i.e.* 5% $O_2$and 8% CO_2 showed minimum increase for both 45 and 50µm thick LDPE bags *i.e.* 52.4 and 48.39% at 5±2°C. Under 25±2°C and 5±2°C of storage same trend were found in which CO_2 concentration increases as storage days increase but at 5±2°C changes were more gradual. Treatment combination $T5_{L50}$ was showed slow increase rate (48.39%) for 32 days of storage. The increase in CO_2 concentration within the packet also reported by Antala *et al*., 2015, Mrumu & Mishra 2018.

Physiological loss in weight

A significant weight loss was observed in stored guava fruits for both the packaging bags that is LDPE 50 & 45µm. Guava fruits lose physiological weight due to reduction in moisture content of fruit (Chitravathi *et al.,* 2015). The physiological weight loss of stored guava fruit was increased gradually as storage days increased (Antala *et al.,* 2015). The thickness of packaging material affects the rate of physiological weight loss, LDPE 50µm showed a slow rate of weight loss in guava during storage period. Storage temperature and gaseous composition within the packet also affect the rate of PWL. The result shows that in room temperature guava fruits can be stored for only 16 days, while at low temperature *i.e.* 5±2°C it can be preserved for 32 days. The retention of weight at 5±2°C is due to low respiration and transpiration that take place at low temperatures (Edusei *et al.,* 2012). There is a loss in a carbon atom in the process of respiration that causes a decrease in the weight of fruits during

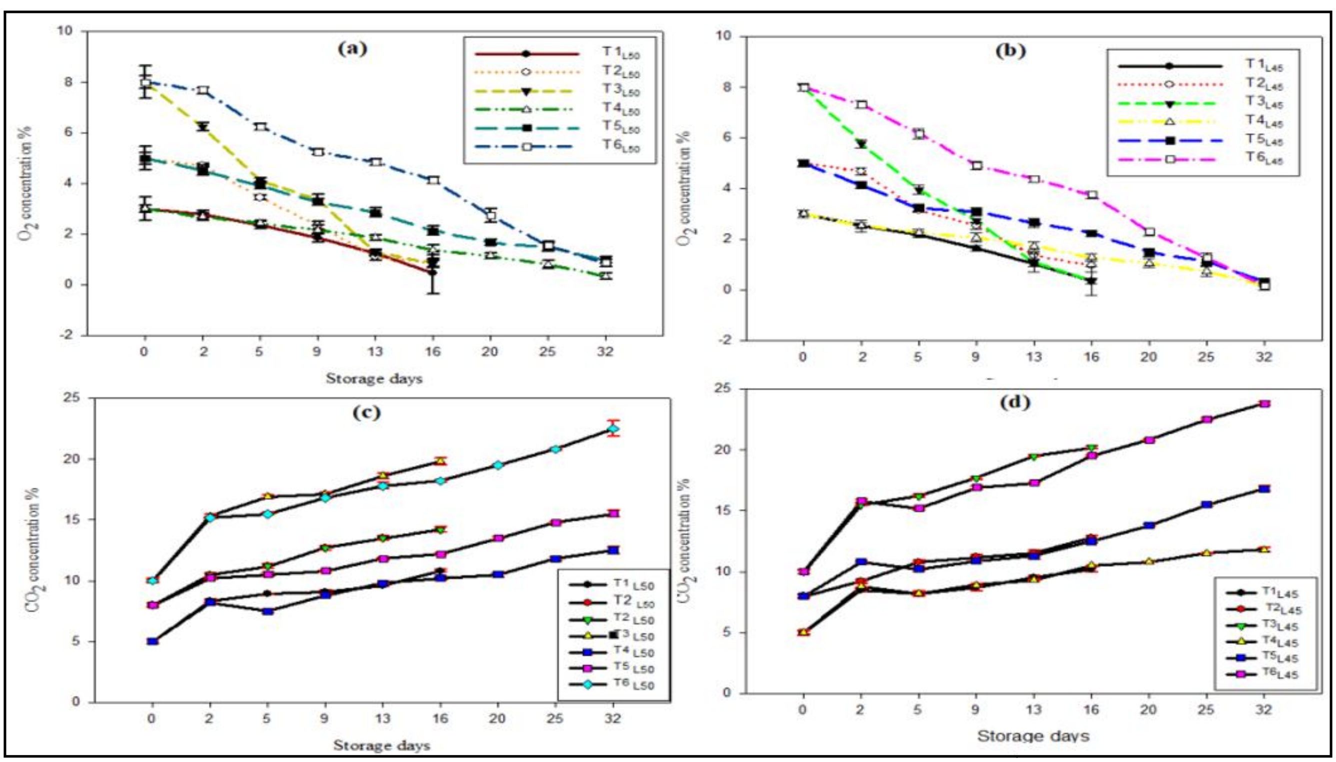

Fig. 1: Effect of different treatments and thickness of LDPE bags on headspace concentration of O_2 (a& b) and CO_2 (c & d).

preservation (Tano *et al.,* 2008). G2 gas composition *i.e.* 5% O_2 + 8% CO_2 exhibit more retention in physiological weight of guava during storage compared to the other two gas composition.

Total sugar and Total soluble solids

Fig. 2 describes changes in total sugar (%) during the storage period of guava. Total sugar increases gradually with the increase in storage days. Hydrolysis of polysaccharides releases sugar during the storage period due to this sugar increases with the increase in storage days (Antala *et al*., 2105), loss of water also contributed to enhanced sugar level (Mohammadi & Hanafi, 2014). This Fig. 3 reveals that the total sugar of stored guava increased with higher concentration of O_2, increased storage temperature and decreased LDPE bag thickness. The maximum total sugar content was observed in $T5_{L45}$ (15.54%) and minimum in $T5_{L50}$ (8.23%) on 32 days of storage. Antala *et al*., (2105) and Mohammadi & Hanafi, (2014) also reported the same result for total sugar of modified atmospheric packaged guava and strawberry respectively.

Total soluble solids are one of the important acceptable edible quality index for any fruits during storage (Park, 2002). Fig. 3 showed the change in TSS content (°Brix) of guava fruits during storage. TSS content increased constantly over the storage period in all treatments. However, the minimum increase in TSS was recorded in $T5_{L50}$ treatment packed fruits during storage. The maximum and minimum TSS of 13.97 °Brix and 9.12 °Brix were recorded in $T5_{L50}$ treatment on 2nd day and 32nd day of the storage period. Packaging material thickness and gas compositions were found to be non-significant, but storage temperature was found to play a significant role in increasing TSS of guava during the storage. An increase in TSS during storage influenced by the conversion of pectic substances and starch hydrolysis and may also be affected by dehydration of fruits (Goncalves *et al.,* 2000; Park 2002; Carrillo *et al.*, 2003). Similar results were found by Antala *et al.,* (2015) in guava fruits, Rao and Rao, (2009) in mango.

Ascorbic acid and Titratable acidity

Fig. 4 concluded that ascorbic acid decreases with increase of storage days underall the packaging treatments and storage environments. The rate of reduction in ascorbic acid increases with the decrease in thickness of packaging materials (*i.e.* LDPE 50 to LDPE 45 µm). The reduction in ascorbic acid content during storage of guava were significantly higher in case of ambient storage as compared to low temperature (5±2°C) storage conditions. The maximum retention of ascorbic acid was in treatment combination $T5_{L50}$ at low temperature on 32nd day of storage *i.e.* 120.54 mg/100g and at room temperature higher level of ascorbic acid maintain in treatment combination $T1_{L50}$ 152.63 mg/100g on 16th day of storage period. Ascorbic acid degrades during the storage of fruits by the oxidation. In this process, ascorbic acid converts into dehydroascorbic acid (Mapson, 1970; Singh *et al*., 2005). A process of oxidation occurs slowly at low temperature leading to a decrease in degradation of ascorbic acid (Sahoo *et al*., 2015). Similar was found by Sahoo *et al*., (2015) and Antala *et al*.,

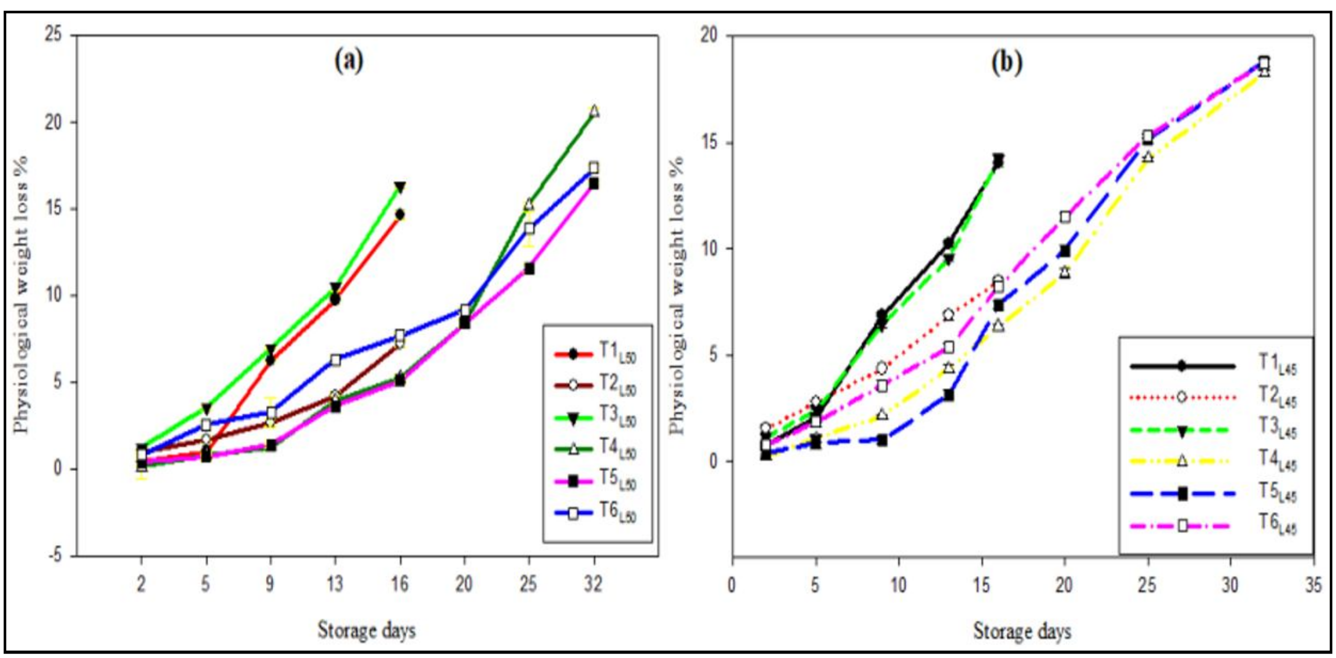

Fig. 2: Effect of different treatments and thickness of LDPE bags on physiological weight lossof packed guava (a & b).

(2105) for guava packed in different packaging materials with different gaseous condition.

The above figure also represents that titratable acidity of guava fruits decreased throughout the storage period. Titratable acidity decreased with increase of storage period. More thickly packaging material *i.e.* LDPE 50µm can maintain higher level of acidity. Temperature was found to be significant in maintaining higher level of titratable acidity. In low-temperature storage of fruits, respiration goes slow down which indicates that the rate of metabolic changes lessens up. The graph showed that maximum retention was found in $T5_{L50}$ and $T2_{L50}$ treatment *i.e.* 0.92 g/L and 0.33 g/L respectively. Fruits storage results in its acidity reduction and it happens due to the conversion of organic acids into sugars and their derivatives or because of their use during respiration (Zerbini 2002). These findings are agreement with Antala *et al.,* (2015) in guava fruits, Nath *et al.,* (2012) in pear fruits and Selcuk & Erkan, (2015) in pomegranate who reported that titratable acidity declines during storage of fruits.

Peel/surface color measurements

Peel color of guava denotes by Lab value, 'L' shows the degree of lightness from black (0) to white (100), 'a' from green (-) to red (+) and b from blue (-) to yellow (+). Table 1 shows Lab value of stored guava in different

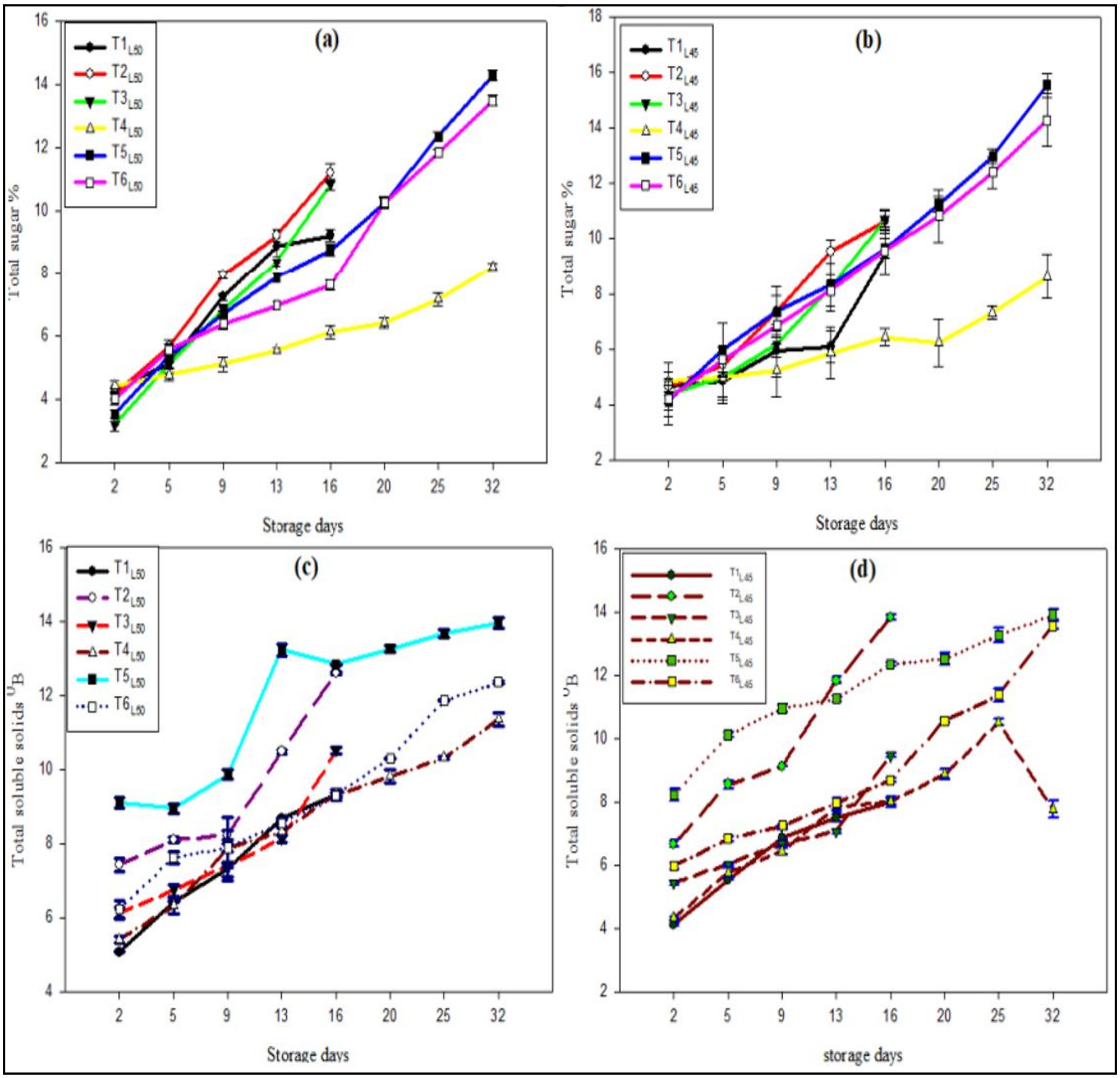

Fig. 3: Effect of different treatments and thickness of LDPE bags on total sugar (a & b) and TSS (c & d)of packed guava.

temperature and different thickness of LDPE bags. This table represents lab values of guava before given treatment and after maximum storage of guava at room temperature and refrigeration temperature. As the days of storage increase, so the lightness of guava becomes decreases, the green value of guava shifted towards red value and yellowness of stored guava increases. Storage temperature shows significant effect on Lab values of stored guava. Room temperature shows maximum decrease in lightness value than refrigeration temperature (5°C). Thickness of packaging materials and variation in gaseous composition also represents significant effect on color value of peel during storage period. Lesser yellow color was developed in gaseous concentration of 5 % O_2 + 8% CO_2 and 5°C storage temperature.

Conclusions

This study reveals that the use of modified atmospheric packaging for the preservation of guava is one of a better option to preserve it. Packaging of guava in MAP and stored at low temperature could be increased the shelf life of fruit up to 32 days. The thickness of LDPE bags and gaseous composition within the packet also affects the nutritional value and shelf life of guava. Gas concentration with 5% O_2 and 8 % CO_2 and packaging material LDPE with 50 µm thickness showed good maintenance of quality attributes during the storage period of guava. It also maintains the physical appearance

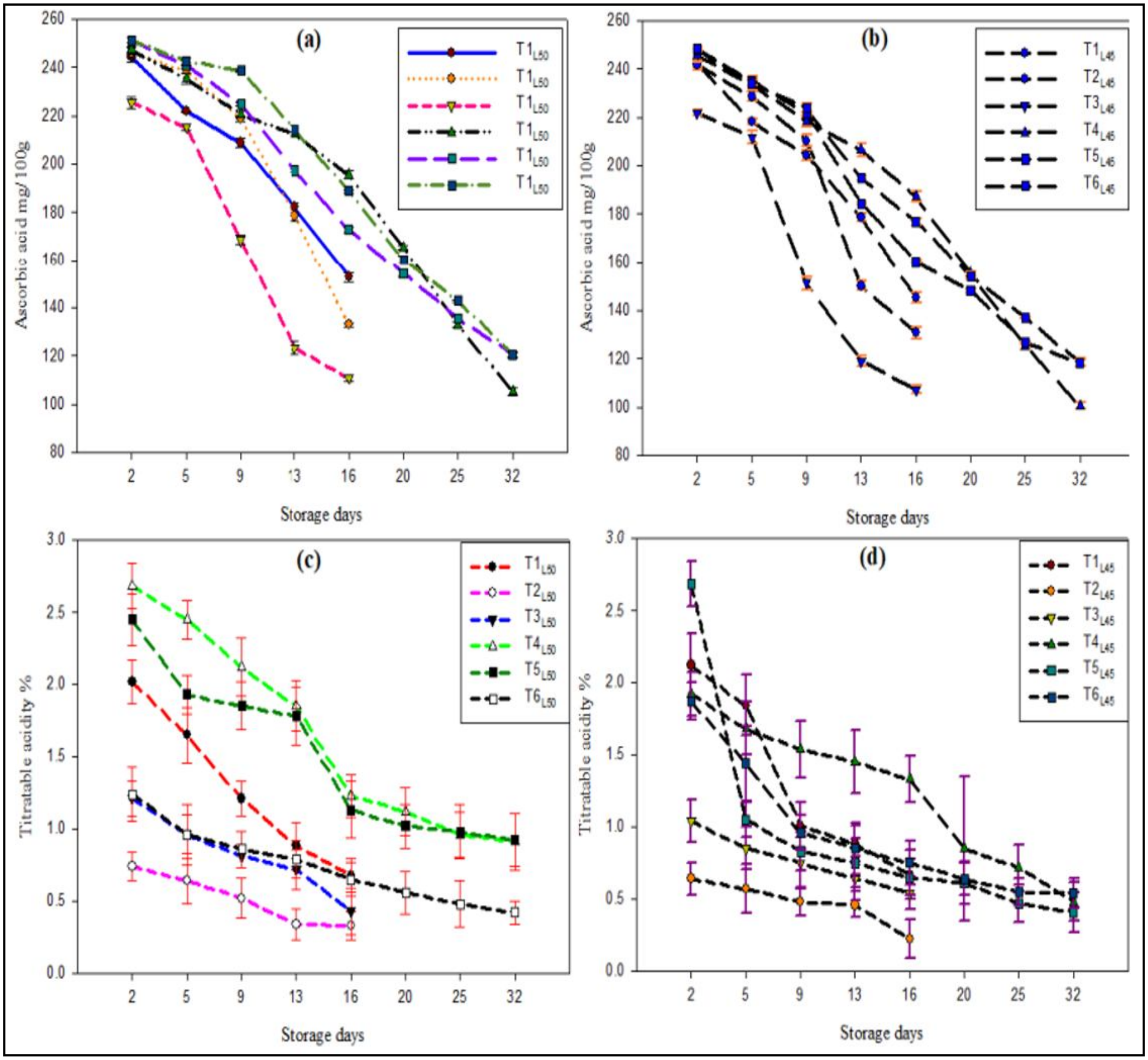

Fig. 4: Effect of different treatments and thickness of LDPE bags on ascorbic acid (a & b) and titratable acidity (c & d)of packed guava.

of fruits, which attracts the buyers to purchase it. Promotion of this type of packing may improve the marketability and utility of guava because it free from any kind of artificial preservatives which hazardous to health. When this technique of preservation combine with another preservation technique such as edible coatings, may it can give more potential result.

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