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Effect of Modified Atmosphere Packaging on Physico-Chemical Characteristics of Orange Segments

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ABSTRACT

Fresh and sorted orange fruits were sanitized, dried, peeled and segmented. The segments (150 g) were packed under 5% O_2 + 10% CO_2 + 85% N_2 gas composition in different packaging materials like Low Density Poly Ethylene (LDPE, 60 µm), Polypropylene (PP, 32 µm) and Poly Vinyl Chloride (PVC, 20 µm) and stored at 5°C. The physico-chemical characteristics were monitored at an interval of 4 days for a storage period of 20 days. The results showed that oxygen concentration gradually decreased but the carbon dioxide concentration gradually increased and reached a steady state concentration in all treatments during the storage. The TSS, titratable acidity, ascorbic acid and color (L* and a*/b* value) of orange segments packed in LDPE covers decreased during storage period of 20 days. Less change was observed in physiological loss in weight (PLW) of samples stored in LDPE covers. The increase in firmness and pH was less in samples stored in LDPE covers during storage period. Study revealed that the quality orange segments was good when packed in LDPE covers and stored at 5°C with a shelf life of 20 days where as the shelf life of control samples was only 4 days.

Key words : Modified atmosphere packaging, Orange segments, Packaging materials, Physico-chemical characteristics, Storage.

Orange (*Citrus sinensis*) belongs to *Rutaceae* family evolved in the South East Asia. Oranges have excellent nutritive, medicinal, food values may prevent and reduce the cardiovascular, neurological and cancer diseases due to their antioxidant activity.

The production level in India is over 2906.3 thousand metric tonnes and the total area under orange cultivation is around 311.2 thousand hectares, which accounts for 3.6% of total fruit production. Consumption of orange juice increases the vitamin C levels in plasma and reduces the markers of oxidative stress in humans and also daily ingestion of minimally processed orange fruit increases the levels of hesperetin in plasma. The consumption of vitamin C is very much essential for normal teeth and bone (Del Caro *et al*., 2004).

Minimal processing or ready to eat oranges are very relevant since the fresh market is often limited and also inconvenience of peeling, especially due to the release of essential oils (Groppo *et al*., 2009). The fact that oranges have specific physiological (non-climacteric), morphological (structure into wedges) characteristics and are chilling-tolerant make them suitable for minimally processed product. The oranges have ideal conditions for being prepared as RTU/RTE products, since their distribution in segments allows the sectioning of the fruit without modifying the integrity of the vesicular structure (Pretel *et al*., 1998).

Ready-to-eat/use products are a rapidly growing sector of the horticultural industry due to evidences of health-promoting properties of fruit and in the market because of increase in the standard of living of the population has implied a change in the eating habits by increasing the preference of consumers for natural products, without addition of preservatives, with a high quality, convenient and easy to prepare products. Mechanical damage to the cells during processing, however, is a major limitation to shelf life of minimally processed or ready to eat/ use fruits and vegetables. The damages enhance the process of deterioration by increased microbial activity, respiration and senescence. However, in addition to storage under a low temperature environment, an additional barrier in the form of modified atmosphere packaging (MAP) has been used extensively for increasing the shelf life of orangse segments (Dash *et al.,* 2013).

Chaves *et al.* (2013) studied the effect of sensory and physico-chemical characteristics of minimally processed pera oranges added citric acid and ascorbic acid both at a concentration of 2% stored at 5 & 10^0C. The use of antioxidants did not adversely affect the sensorial acceptance of minimally processed orange with the storage time and also increase the shelf life up to four days. pH, TSS and mass loss influenced by antioxidants.

Rapisarda *et al.* (2012) evaluated the shelf-life of two minimally processed tarocco (gallo and scire) genotypes were packaged under three different gas compositions of O_2, CO_2 and N_2 stored at 4^0C for 15 days. Results revealed that the low O_2 percentage in the atmosphere of trays caused a decrease in the oxidation process and also the increasing amount of CO_2 due to the respiration process did not lead to fermentation phenomena. The shelf-life of Tarocco Gallo slices is suggested as 12 days, whereas shelf life is limited to 5-6 days for Tarocco Scirè slices.

The objective of the present study was to investigate the physico-chemical properties of orange segments stored under modified atmosphere packaging using three different packaging materials i.e., Low density polyethylene (LDPE), poly propylene (PP) and poly vinyl chloride (PVC).

MATERIAL AND METHODS

Fresh and matured orange fruits (*Citrus sinensis*) used for the study were procured from fruit market at Vijayawada, Krishna District. The required packaging covers of size 15 cm × 20 cm and chemicals were procured.

Fresh and sorted orange fruits were sanitized with 200 ppm sodium hypochlorite solution (NaOCl) for 2 min, wiped surface adhering moisture and peeled manually. Peeled fruits were segmented carefully. The packaging materials like PVC, PP and LDPE pouches having thickness of 20, 32 and 60 µm were selected and the size of pouch was 15 cm × 20 cm. Packaging pouches were sanitized with 3% hydrogen peroxide. The undamaged segments were weighed as 150 g and packed in PP, PVC and LDPE covers under 5% O_2 + 10% CO_2 + 85% N_2 gas composition by advanced vacuum packaging machine (Model: QS 400 VM 3G XT). The oxygen and carbon dioxide inside the packages were measured using a head space gas analyzer (PBI Dansensor, Model: Checkmate II). Gas analysis was performed by inserting the needle attached to the gas analyzer through a silicon septum fixed on the packing cover. Then the packed and control samples were kept in refrigerator at a temperature of 5^0C. At an interval of 4 days, the samples were analyzed for changes in physico-chemical properties of the stored orange segments.

PHYSICO-CHEMICAL ANALYSIS

Physiological Loss in Weight

The initial weight of the sample was measured. For every four days the samples were taken and their final weight was measured on electronic digital weighing machine having an accuracy of 0.01 g. The weight loss was calculated by following equation.

$$\text{Weight loss (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

Firmness

Fruit flesh firmness was assessed by using a fruit pressure tester having a tip diameter of 10 mm. Firmness was expressed as maximum cutting force. The segments similar in thickness were selected for firmness measurement. Three segments per package were measured for each treatment on each sampling day. The readings were recorded in kg force.

Total soluble solids

Total soluble solids of orange segments were measured by placing a drop of the orange juice sample on the prism of the Hand refractometer (Erma refractometer) and results were expressed as % Brix. Correction at 20^0C was applied for the observed reading.

pH

The pH measurement was determined by using a Digital pH meter (Make: Systronics). The device having the glass electrode was placed inside the homogenized sample of orange juice and the value was registered once it had stabilized.

Colour

The colour of orange segment samples was measured using Hunter lab colour flex meter (M/s. Hunter lab, Reston, VA, USA; model CFLX-45). The surface colour was quantified in terms of L^*,

a^* and b^* values of CIELAB colour space. The instrument was standardized with white and black ceramic tiles before starting the measurement. The orange segments were placed over the port. Two measurements were made at opposite sides of each fruit segment and results represented the mean of the measurements taken from fruit segments of each bag.

Titratable acidity

Total acidity was determined by titrating the juice sample extracted in distilled water against 0.1N sodium hydroxide using phenolphthalein as indicator. Appearance of light pink colour denotes the end point. The acidity was calculated by using following equation and expressed in % citric acid. Where, D.F= Dilution factor

$$\text{Titratable acidity (\%)} = \frac{\text{Equivalent weight of acid} \times \text{Normality of NaoH} \times \text{Titre} \times 100}{\text{Weight of sample} \times 1000} \times \text{D.F}$$

Where, D.F= Dilution factor

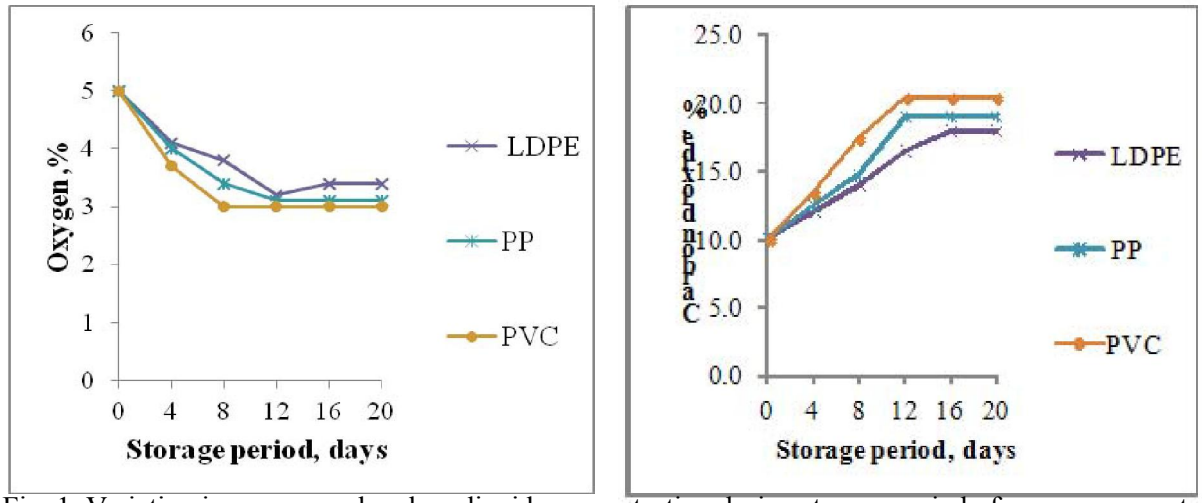

Fig. 1. Variation in oxygen and carbon dioxide concentration during storage period of orange segments packed in different packaging materials under MAP at 5^0C.

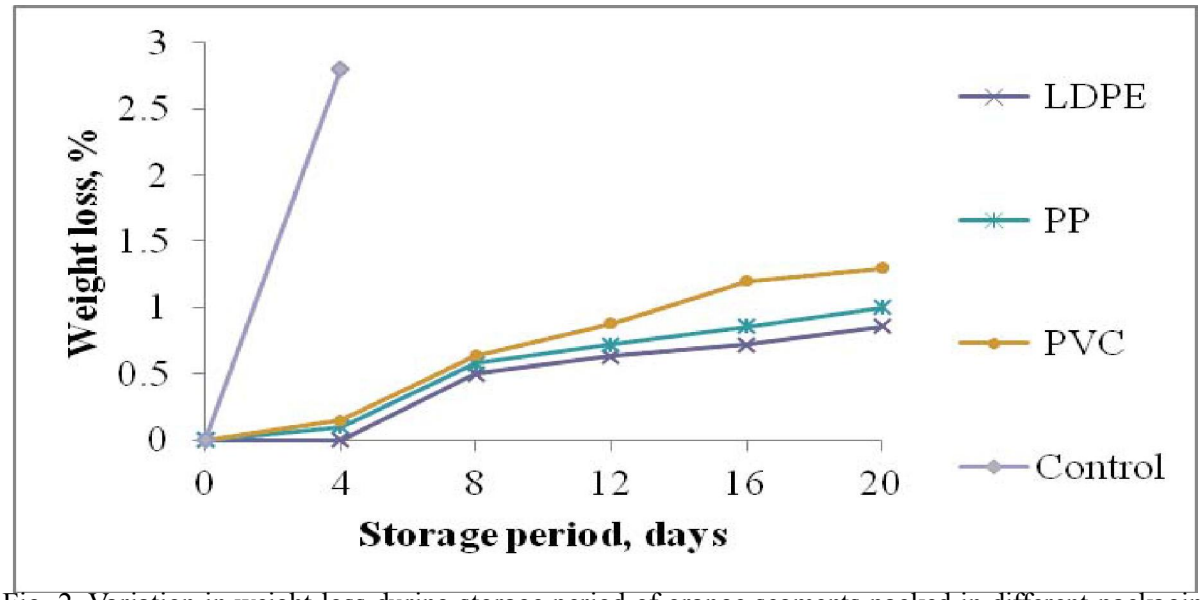

Fig. 2. Variation in weight loss during storage period of orange segments packed in different packaging materials under MAP at 5^0C.

Ascorbic acid (Vitamin C) content

Sample extract in oxalic acid was titrated against standard sodium 2, 6 dichlorophenol indophenol dye to a faint pink colour which persists for 5-10 seconds. The ascorbic acid was calculated by using following equation and expressed in mg/ 100g.

$$\text{Ascorbic acid, mg/100g} = \frac{0.5\,\text{mg}}{V_1} \times \frac{V_2}{5\text{ml}} \times \frac{\text{Volume made}}{\text{wt. of sample}} \times 100$$

RESULTS AND DISCUSSION

Effect on Oxygen and Carbon dioxide concentration under MAP during storage of packed orange segments

Preliminary packaging and storage experiments were done to understand the changes in O_2 & CO_2 concentrations on MAP.

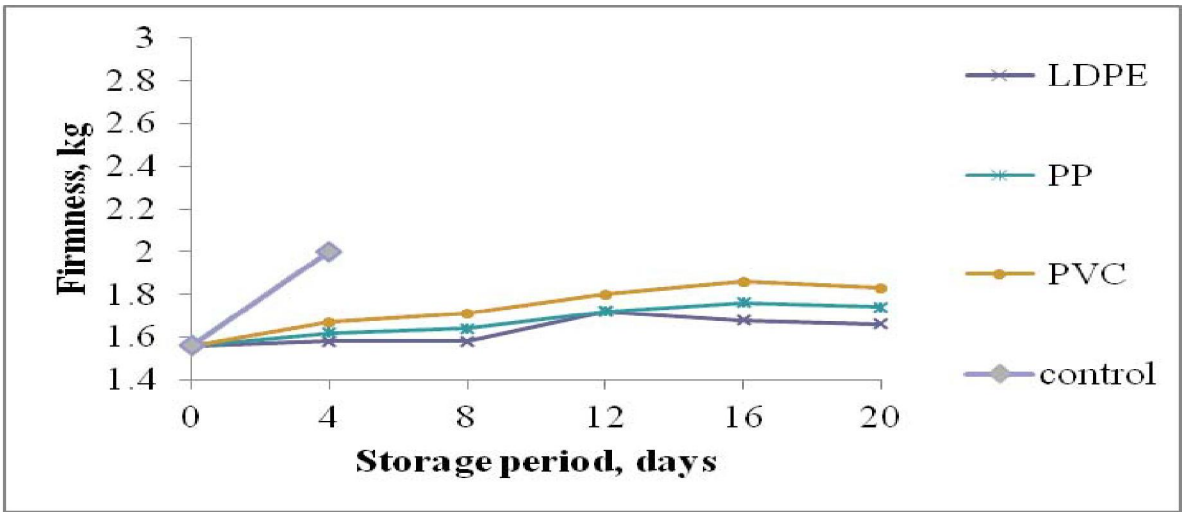

Fig. 3. Variation in firmness during storage period of orange segments packed in different packaging materials under MAP at 5^{0}C.

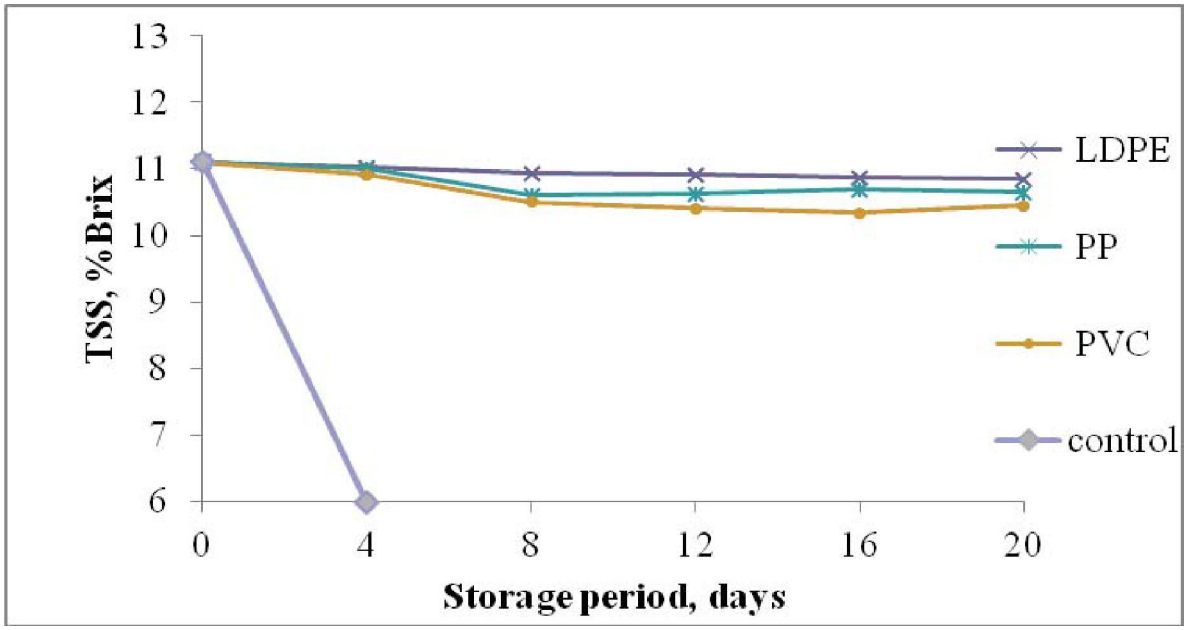

Fig. 4. Variation in TSS during storage period of orange segments packed in different packaging materials under MAP at 5^{0}C.

It was observed from the Fig. 1, the oxygen concentration gradually decreased from 5.0% to 3.4%, 3.1% and 3.0% and equilibrium atmosphere reached in LDPE covers after 16 days storage period whereas in PP and PVC covers after 12 & 8 days storage period respectively. Further it was also observed that the level of carbon dioxide concentrations increased from 10% to 18%, 19% and 20.5% and LDPE covers reached equilibrium after 16 days storage period whereas PP and PVC covers reached equilibrium after 12 days. The concentration of O_2 in packed orange segments decreased and carbon dioxide increased during the storage period and then steady equilibrium was reached between respiration of the produce and the diffusion of these gases was counter balanced by production and consumption during respiration of the orange segments (Kader *et al*., 1989).

Effect of Packaging Material and Gas composition on Physiological Loss in Weight

The physiological weight loss of orange segments packed in different packaging covers namely LDPE, PP and PVC covers stored at refrigerated temperature (5^0C) and control samples were determined.

It was observed from the Fig. 2, weight loss of orange segments was linearly increased with the storage period. The weight loss of orange segments in LDPE, PP and PVC covers were 0.86, 1.00 & 1.30% respectively during storage period of 20 days. For unpacked (control) orange segments stored at 5^0C, weight losses were higher i.e. about 2.80% during 4 days storage period. Lower respiration rate of the orange segmsents occurred with the higher CO_2 and lower O_2 levels inside these films. LDPE, PP had the lowest gas permeability and also the lowest weight loss.

Effect of Packaging Material on Firmness

The firmness of stored orange segments increases with increase in storage period with different packaging films under MAP was shown in Fig. 3.The firmness of packed orange segments in LDPE, PP and PVC covers were 1.66, 1.74 and 1.83 kg respectively during storage period of 20 days. For unpacked orange segments (control) stored at 5^0C, firmness increased from 1.56 kg to 2.0 kg during storage period of 4 days. The increase in firmness may be due to surface drying of the segments due to water loss by resspiration and transpiration as stated by Sanchez – Bel *et al*., 2013; Khazaei *et al.*, 2011.

Effect of Packaging Material on Total Soluble Solids

The TSS contents of orange segments decreased with increase in storage period as shown in Fig. 4. This decrease was probably associated with weak hydrolysis phenomena of the sugar and might be because of an intensive respiration activity in the period after peeling and cutting, during which the sugars would be used as substrate in the metabolic process. These findings are in agreement

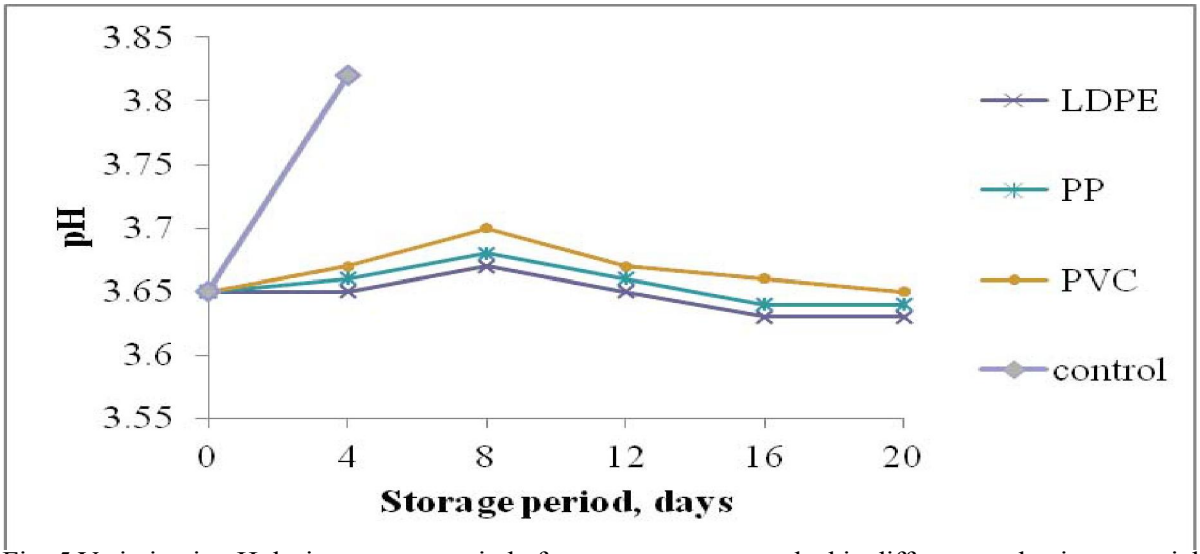

Fig. 5 Variation in pH during storage period of orange segments packed in different packaging materials under MAP at 5^0C.

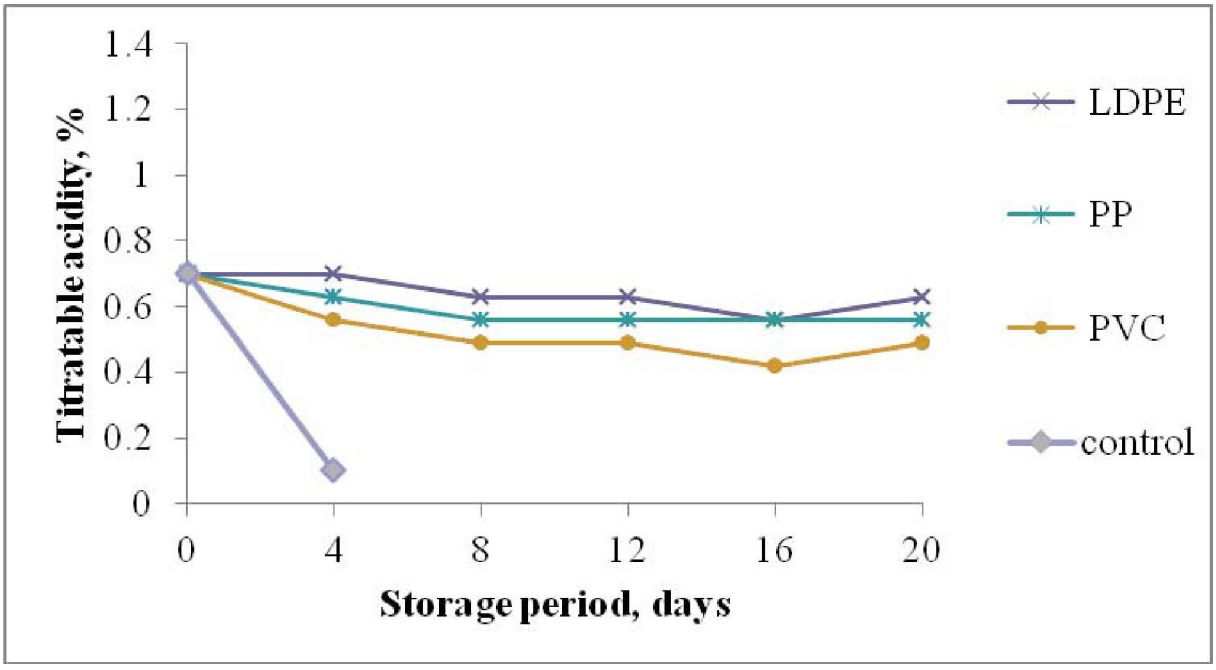

Fig. 6. Variation in TA during storage period of orange segments packed in different packaging materials under MAP at 5^{0}C.

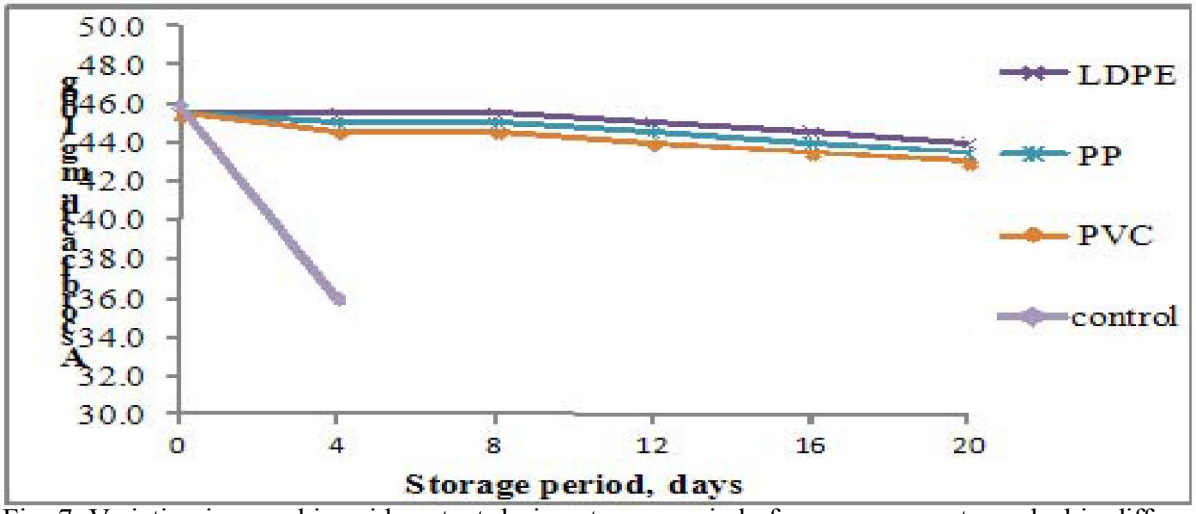

Fig. 7. Variation in ascorbic acid content during storage period of orange segments packed in different packaging materials under MAP at 5^{0}C.

with the findings of Rapisarda *et al.* 2012; Rocha *et al*., 1995. For unpacked (control) orange segments, TSS decreased from 11.1% to 6.0% during storage period of 4 days.

Effect of Packaging Material on pH

It was observed from the Fig. 5, the pH of packed orange segments was increased during initial storage period and there was a decreasing trend at the end of storage period.

The pH values were observed as 3.63, 3.64 & 3.65 in LDPE, PP and PVC covers at the end of storage period. The unpacked orange segments (control) had a pH of 3.82 at the end of 4 days of storage. The increase in pH could be a result of the fruit tissue undergoing oxidative browning reactions (Karacay and Ayhan, 2010). The decrease in pH values can be attributed to conversion of sugars into the acids by fermentation process of sugars.

Effect of Packaging Material on Titratable Acidity (TA)

It was observed from Fig. 6, there was a slight decrease of titratable acidity up to 8 days of storage period and then remained constant at the

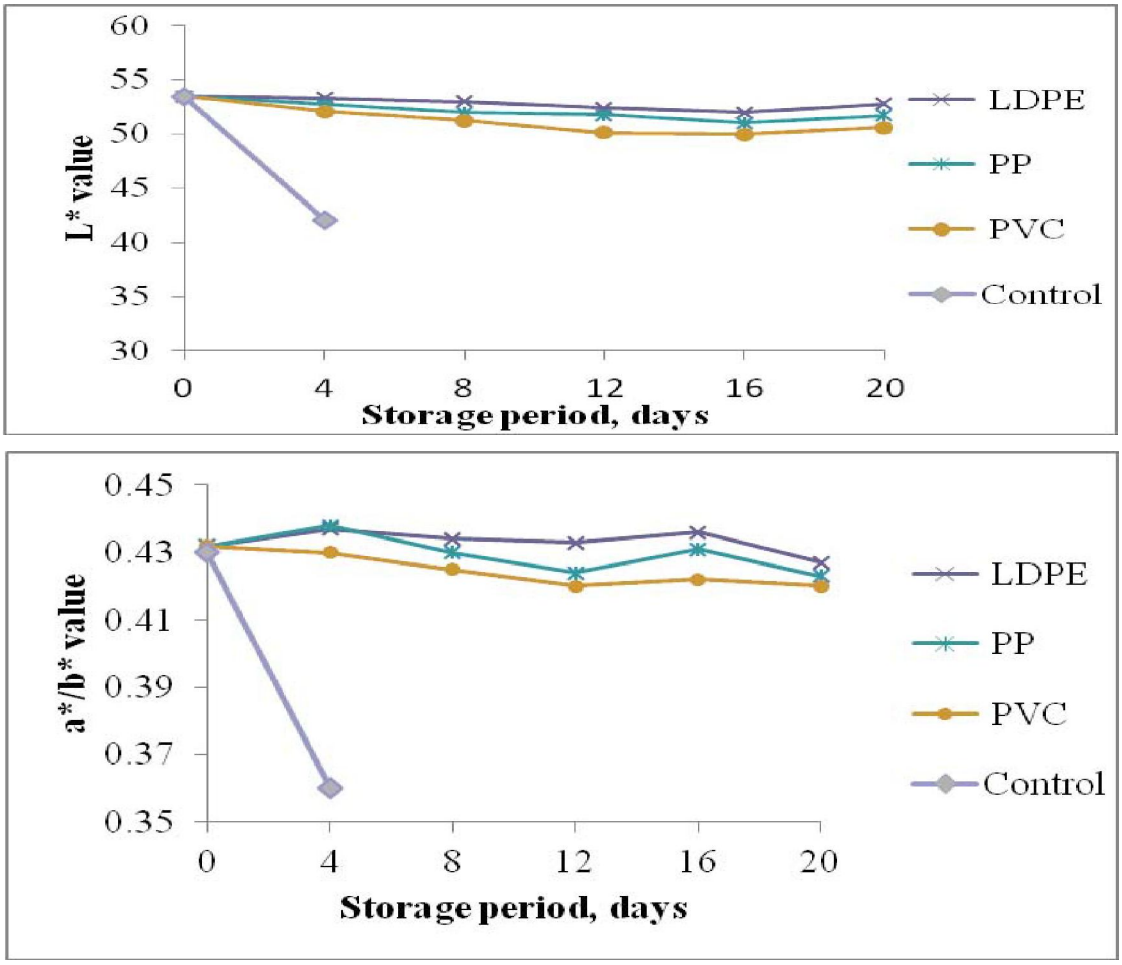

Fig. 8. Variation in L* and a*/b* value during storage period of orange segments packed in different packaging materials under MAP at 5^0C.

end of storage period while the unpacked orange segments (control) had titratable acidity of 0.1% at the end of 4 days storage period. The titratable acidity decreased during the postharvest life due to the oxidation of the acids. These findings are in agreement with the findings of Chaves *et al*., 2013.

Effect of Packaging Material on Vitamin C (Ascorbic Acid Content)

The highest retained ascorbic acid contents of 44.0, 43.5 & 43.0 mg/100 g were found in orange segments stored at 5^0C in LDPE, PP and PVC covers. Ascorbic acid content of 36 mg/100g was recorded in unpacked (control) orange segments stored at 5^0C during 4 days storage period. It was observed from the Fig. 7, decrease in ascorbic acid might be due to enzymatic oxidation of L- ascorbic acid to dehydro ascorbic acid (Singh *et al*., 2007).

Effect of Packaging Material on Colour (L* and a*/b*)

Fruit color is an important attribute in purchase decisions especially if the product is packaged and cannot be touched or smelled. L* indicates the lightness or darkness. The characteristic color of the segments is defined by a mixture of red (+a*) and yellow(+b*), so the a*/ b* coefficient gives an idea of the degree in which the red and yellow colors contribute to the orange color typical of these fruits due to the accumulation of different carotenoids (Sanchez – Bel *et al*., 2013).

It was observed from the Fig. 8, the L* values of packed orange segments during storage period decreased from 53.5 to 52.77, 51.70 & 50.60 in LDPE, PP and PVC covers respectively. It was observed that the L* value of unpacked (control)

orange segments increased from 53.5 to 42.00 stored at 5^0C during storage period of 4 days. Low a*/b* values observed in orange segments stored at 5^0C after 4 days of storage period was 0.36. Thesre were slight changes in colour during storage, therefore, high a*/b* value should indicate a more intense orange colour, while a low a*/b* value should indicate a loss of the characteristic colour.

Conclusions

Oxygen concentration gradually decreased but the carbon dioxide concentration gradually increased and reached a steady state concentration during the storage. The TSS, titratable acidity, and colour (L* and a*/b* value) of orange segments packed in LDPE covers decreased during storage period of 20 days. The highest retention (reduction in ascorbic acid content was low) of ascorbic acid content (44.5 mg/100 g) was observed in orange segments packed in LDPE covers. Less change was observed in physiological loss in weight (PLW) of samples stored in LDPE covers. The increase in firmness and pH was less in samples stored in LDPE covers during storage period. Modified atmosphere packaging of orange segments packed under LDPE covers stored at 5^0C gives a shelf life of 20 days where as the shelf life of control samples was only 4 days.

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