Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(1): 886-890
Received: 14-11-2017
Accepted: 15-12-2017

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Effect of active packaging on physico-chemical characteristics of stored peach fruits

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Abstract
Peaches are climacteric fruits with short post harvest life due to its high moisture content and relatively high metabolic activity during post harvest phase. Therefore, the present study was carried out to find out the effect of active packaging and different levels of ventilation on quality of peach fruits under refrigerated storage conditions. Peach (*Prunus persica* L. Batch) fruits of cultivar "Shan-e- Punjab" were harvested at colour break stage and packed in thermocol trays wrapped with polypropylene (PP) bags comprising the following treatments: T_1 (control), T_2 (ethylene absorber + 0 perforation), T_3 (ethylene absorber + 4 perforations), T_4 (ethylene absorber + 8 perforations), T_5 (oxygen absorber + 0 perforation), T_6 (oxygen absorber + 4 perforations), T_7 (oxygen absorber + 8 perforations), respectively. The packed fruits were stored under refrigerated conditions and analysed at regular interval of 7 days to ascertain the changes occurring in physical, chemical, and sensory quality parameters. Minimum mean physiological loss in weight of 3.04 percent, decay percentage of 1.83 per cent, specific gravity of 0.959 and TSS of 10.41 ^{0}B were observed in T_3 (ethylene absorber + 4 perforations). However, T_1 (control) recorded the lowest mean ascorbic acid content of 9.16 mg per 100g, total phenol content of 60.15 mg per 100g and antioxidant activity of 16.98 per cent and antioxidant activity of 16.98 and 16.87 per cent.. Sensory evaluation of actively packaged peach fruits revealed that T_3 (ethylene absorber + 4 perforations) recorded the highest mean score for overall acceptability (7.65). Overall, T_3 (ethylene absorber + 4 perforations) was best suited active packaging to retain quality as well as reduce the spoilage of peach fruits during storage under refrigerated conditions.

Keywords: peach, ethylene absorber, oxygen absorber, antioxidants, phenol, sensory parameters

1. Introduction
Peach (*Prunus persica* L. Batsch) is one of the most important fruits grown in the temperate zones of the world. In India, it is grown in the mid hill zone of the Himalayas in the states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand and in North Eastern region. Peach is a delicious but highly perishable fruit and has a short shelf life under ambient conditions. Shan-e-Punjab is a low chilling cultivar of peach that grows well under subtropical conditions and attains physiological maturity in the months of May–June, when the atmospheric temperature is high, which leads to fruit softening, shrinkage, decay and heavy post harvest losses. Immediately after harvest, the nutritional and organoleptic quality of fresh produce start to decline as a result of altered plant metabolism. This quality deterioration is the result of produce transpiration, senescence, ripening associated processes and development of postharvest disorders (Kader, 2001) [1].

Active packaging is an innovative concept that can be defined as a mode of packaging in which the package, the product and the environment interact to prolong shelf life or enhance safety or sensory properties, while maintaining the quality of the product. Active packaging involves placing absorbers inside the package (Guynot *et al*., 2003) [2] and includes concepts such as oxygen and carbon dioxide scavenging and generation and moisture regulation systems (Suppakul *et al*., 2003) [3]. Potential techniques used in active packaging are the use of oxygen scavenging/carbon dioxide, ethylene and moisture absorbing systems by placing sachets, incorporation of antimicrobial agents into polymer surface coatings or in plastics films, sheets or on materials and into the pads for fresh produce (John, 2008) [4].

Ethylene is a plant hormone responsible for the ripening of fruit. During storage, ascending concentration of ethylene could result in significant quality loss. Therefore, ethylene inhibition or its removal should be used to maintain post-harvest quality. One tool for ethylene removal is the absorber sachet, which contains a zeolite compound. Several studies have shown that $KMnO_4$ applications delay fruit softening and increase postharvest life (Correa *et al.*, 2005) [5]. Sholihati (2004) [6] stated that application of $KMnO_4$ as ethylene absorber significantly inhibited banana yellowing, maintained flavour by upto 15 days under ambient temperature (28^{o}C) and prolonged the shelf life of the fruit by upto 45 days at 13^{o}C.

The $KMnO_4$ treatment in combination with polyethylene packaging was also found to be better than polyethylene packaging alone in maintaining the quality of fruits stored under ambient conditions.

On the other hand, the presence of oxygen in a packaged food is also often a key factor that limits the shelf life of a product. Oxygen can cause changes in colour, flavour and odour (Suppakul, 2003) [3] and encourages growth of aerobic bacteria and moulds (Guynot *et al*., 2003) [2]. Therefore, the removal of oxygen from the package headspace has long been a target of the food packaging scientists. The deterioration in quality of O_2 sensitive products can be minimised by recourse to O_2 scavengers that removes the residual O_2 after packing. Hence, O_2 scavengers are used to minimize quality changes and prevent deterioration due to oxidation and growth of microorganisms (Charles *et al*., 2005) [7]. The present studies were, therefore, undertaken to investigate the effect of active packaging in enhancing the post harvest life of peach.

2. Material and method

The peach fruits of cultivar Shan-e-Punjab were harvested at physiologically mature, i.e. colour break stage from the Research orchards of Division of Fruit Science, Faculty of Agriculture, SKUAST – J, Udheywalla campus. The bruised and diseased fruits were sorted out and only healthy and uniform sized fruits were selected for the study. The selected fruits were washed by treating with chlorine solution (200 ppm) for 10 minutes and were then air dried for further use. The air dried peach fruits were divided into seven lots containing 40 fruits with three replications each. The desired numbers of fruits were placed on thermocol trays and were wrapped with polypropylene (PP) bags. Inside each tray a sachet of ethylene absorber (Freppe ^{TN}) and oxygen absorber (O- buster ^{TN}) were kept and control with no sachets. For ventilation, on the basis of area of packaging material, 4 and 8 pin hole perforations (diameter 0.3mm) each were made which were equally distributed on the film surface. The packaged samples were stored under refrigerated conditions (4-7^0C) for 28 days and observations for various physico - chemical parameters were recorded at an interval of 7 days. The recorded data were subjected to statistical analysis by adopting factorial CRD.

2.1 Physical characteristics

The physiological loss in weight (PLW) after each interval of storage was calculated by subtracting final weight from the initial weight of the fruits and expressed in per cent. The decay or rotting of the stored tomato fruits were determined by their visual observations. The specific gravity of fruits was measured by the water displacement method. Volume of the fruit was measured by dipping fruit in a known volume of water in a cylinder and specific gravity worked out by dividing the weight of fruit by its volume. The colour of the fruits was measured with colour difference meter (Mini Scan XE Plus, Hunter Lab, USA) and expressed as L, a, b Hunter colour values.

2.2 Chemical characteristics

The total soluble solids (TSS) of the fruit juice were determined using a hand refractometer and expressed as per cent TSS after making the temperature correction at 20°C. The titratable acidity was estimated as per standard procedures by treating against sodium hydroxide solution (Ranganna, 2008) [8]. Ascorbic acid content was determined by the procedure of Sadasivam and Manicham (2008) [9] using 2, 6-dichlorophenol indophenol dye.

Total phenols were determined as per McDonald *et al*. (2001) [10], using Folin Ciocalteu reagent. 1 g of peach was extracted with 10 ml of methanol: water (50:50, *v/v*). 0.5 ml of the diluted (1:10) extract or the standard phenolic compound (Gallic acid) was mixed with 5 ml of Folin Ciocalteu reagent (1:10 diluted with distilled water) and 4 ml of aqueous Na_2CO_3 (1M). The mixture was allowed to stand for 15 min and optical density of the mixture was determined against the blank at 765 nm with the help of UV-Vis spectrophotometer (Labtronics, Model No: 2800). The standard curve was prepared using gallic acid. Total phenol values were expressed in terms of the standard reference compound as gallic acid equivalent (mg/100 g).

Free radical scavenging activity was determined by DPPH (Di Phenyl Picryl Hydrazyl) method (Koga *et al*., 2007) [11]. The overall organoleptic rating of the fruits was done by a panel of ten judges on the basis of colour, flavour (taste + aroma), texture and overall quality rating was calculated making use of a nine point Hedonic scale (Amerine *et al*., 1965) [12].The data were analyzed statistically in completely randomized design.

3. Results and discussion

3.1 Physical characteristics of packaged peach

The highest mean PLW of 5.54 per cent was observed in T_1 (control) in polypropylene. However, minimum mean PLW of 3.04 per cent (Fig. 1a) was observed in treatment T_3 (ethylene absorber + 4 perforations). The lower weight loss in fruits placed in packaging bags with perforation compared to those in non perforated ones could be due to removal of ethylene that has a catalytic role in increasing respiration (Jobling, 2000) [13] while also increasing relative humidity in package thus reducing water loss. The removal of ethylene or inhibition of its effect in storage environment is fundamental to maintaining post harvest quality of climacteric produce (Salteveit, 1999) [14]. The PLW increased with the advancement of storage period from 3.21 to 4.49 per cent in polypropylene bags. The increase in PLW with storage might be due to continuous loss of moisture because of transpiration from fruits and respiration (Nath *et al*., 2011) [15].

Initially no decay was observed up to seven days of storage (Fig. 1b). However, after 14 days of storage the maximum decay percentage of 6.83 per cent was observed in T_1 (control). T_3 (ethylene absorber + 4 perforations), T_4 (ethylene absorber + 8 perforations), T_6 (oxygen absorber + 4 perforation) and T_7 (oxygen absorber + 8 perforations) remained unaffected upto 14 days of storage. The highest mean decay percentage of 9.59 per cent in polypropylene was observed in T_1 (control). Among treatments, the decay percentage was observed to be higher in fruits packed in non perforated films as compared to fruits packed in perforated films. This might be due to condensation of water in surface of fruits, anaerobic conditions and breakdown of enzymes during storage which encourages the multiplication of microflora (Kaur *et al*., 2014) [16]. The decay percentage increased as the storage period advanced irrespective of treatments from 1.86 to 11.52 per cent. The increase in decay percentage with storage might be due to the continuous process of transpiration and respiration which results in cellular disintegration due to reduced synthesis of protein and nucleic acid which enhances senescence and spoilage of fruits.

The highest mean specific gravity of 0.979 and 0.973 were observed in T_1 (control) in both polypropylene and low density polyethylene, respectively (Fig. 1c) whereas, T_3 (ethylene absorber + 4 perforations) recorded lowest mean specific gravity of 0.959 in polypropylene. Similar results have been reported by Bakshi (2004) [17] in peach fruits stored under refrigerated and ordinary conditions. During 28 days of storage period the specific gravity decreased significantly from initial value of 1.025 to 0.959 which might be due to loss of moisture.

Changes in external colour of peach were analysed by measuring L^* (lightness), a* (redness) and b^* (yellowness) values during storage (Fig. 1d, e, f). The highest mean L^* value of 57.34, a* value of 6.03 and b* value of 28.82 were observed in T_3 (ethylene absorber + 4 perforations). The less colour development in fruits packed in non-perforated bags has also been reported by Nath *et al*. (2011) [15] in pear fruits packed using different packaging materials. Storage period significantly influenced the L^* value and showed an increasing trend. The L^* value increased from 54.18 at 0 day to 57.14 after 28 days The improvement in colour during storage might be due to the degradation of chlorophyll pigment of the fruit and increased synthesis of carotenoids and anthocyanin pigment (Wankier, 1970) [18].

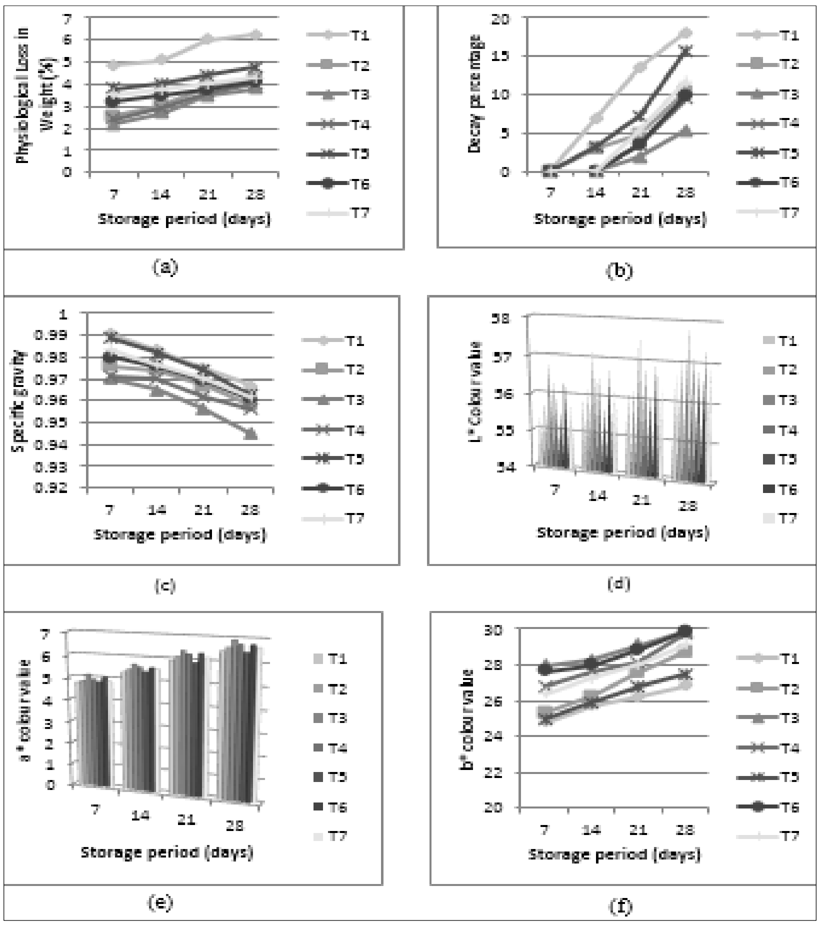

Fig 1: Physical characteristics of actively packaged peach during storage

3.2 Chemical characteristics of packaged peach

Among treatments, the minimum mean TSS content of 10.41 ^{0}B was observed in treatment T_3 (ethylene absorber + 4 perforations). However T_1 (control) recorded the highest mean TSS 10.81 ^{0}B (Fig. 2a). Lower TSS content in T_3 (ethylene absorber + 4 perforations) might be due to slow down of ripening by ventilation through the perforation. Higher TSS was observed in oxygen absorbers than ethylene absorbers which might be related to an intense reduction of respiration due to lower content of oxygen such reduction in respiration could also support the accumulation of free hexoses (Thompson, 1998) [19]. The TSS of peach fruits increased in the beginning of storage and then decreased gradually after 21 days of storage. An increase in TSS content was observed up to 21 days from 9.86 to 11.18 ^{0}B and thereafter TSS content decreased to 10.64 ^{0}B. The increase in TSS content during storage might be due to moisture loss, hydrolysis of polysaccharides and conversion of juice as a result of degradation. The decline in TSS can be attributed to the fact that on complete hydrolysis of starch, no further increase in TSS occur and consequently a decline in TSS is predictable as they are the primary substrates for respiration (Wills *et al*., 1980) [20].

Highest mean titratable acidity of 0.80 per cent was observed in treatment T_3 (ethylene absorber + 4 perforations) whereas, the lowest mean titratable acidity of 0.73 per cent was observed in treatment T_1 (control) (Fig. 2b). Polypropylene non perforated packed fruits could maintain high level of acidity which might be due to reduced respiration rate during storage as affected by film permeability to atmospheric gases (Nath *et al*., 2011) [15]. The higher retention of acidity in T_3 (ethylene absorber + 4 perforations) might be due to the effect of packaging film in delaying the respiration and ripening process. The progressive reduction in acidity was observed with the advancement of storage period from 0.79 to 0.73 per cent. The decrease in acidity during storage might be due to the increasing catabolism of organic acids present in fruits through the process of respiration. The decrease in titratable acidity during storage may also be attributed to utilization of organic acids in pyruvate decarboxylation reaction occurring during the ripening process in fruits (Kaur *et al*., 2014) [16].

Initial value of ascorbic acid was recorded as 10.10 mg per 100 g in fresh peach. Effect of treatments on ascorbic acid (Fig. 2c) showed that T_3 (ethylene absorber + 4 perforations) recorded highest ascorbic acid content of 9.88 mg per 100 g followed by T_6 (oxygen absorber + 4 perforations) with ascorbic acid content of 9.83 mg per 100 g after 7 days of storage. However, after 28 days of storage the highest ascorbic acid of 9.64 mg per 100 g was recorded in T_3 (ethylene absorber + 4 perforations) followed by T_6 (oxygen absorber + 4 perforations) having value of 9.55 mg per 100 g. Variation in ascorbic acid retention in different treatments might be due to different levels of oxidation as affected by film permeability to atmospheric oxygen (Nath *et al*., 2011) [15]. The higher retention of ascorbic acid in fruits packed in polypropylene bags with treatment T_3 (ethylene absorber + 4 perforation) might be due to the balance created by amount of escaped gases via perforated layer as well as gases entering the film (Singh *et al*., 2014) [21].

The phenol has antimicrobial effect which helps in reduction of microbial load (Dixon and Paiva, 1995) [22]. Among treatments, T_3 (ethylene absorber + 4 perforations) recorded maximum total phenols of 61.52 mg/100 g (Fig. 2d) whereas, T_1 (control) recorded the minimum mean total phenol as 60.15 mg/100 g. Both perforated and non perforated treatments recorded higher total phenol than control which might be due to an increase in activity of phenyl propanoid pathway under stressful conditions as evident from synthesis and accumulation of phenolic compounds (Kang and Saltveit, 2002) [23]. The total phenol content decreased gradually with progression of storage period from 62.55 to 59.17 mg per 100 g. This reduction in total phenols was explained through research that phenols might have been used as substrate for polyphenol oxidase enzyme (Janovitz- Klapp *et al*., 1990) [24]. The reduction in total phenols could also be explained by the conversion between free and bound phenolic substances (Ferrante *et al.*, 2007) [25].

T_1 (control) recorded minimum mean antioxidant activity of 16.98. However, T_3 (ethylene absorber + 4 perforations) recorded highest antioxidant activity of 17.77 per cent (Fig. 2e). The antioxidant activity decreased slightly for non-perforated samples which might be due to the higher level of head space CO_2 observed in these packages which might have prevented the action of antioxidant (Rai *et al*., 2011) [26]. During storage the antioxidant activity decreased significantly from 17.71 to 16.85 per cent. The decrease in content of antioxidants during storage was also reported by Serea *et al*. (2014) [27]. The antioxidant activity analysed for different treatments of peach stored at refrigerated conditions could be the result of synergetic influence of overall phenolic composition and it decreased simultaneously with total phenol content (Serea *et al*., 2014) [27].

The overall acceptability scores were observed to be maximum in T_3 (ethylene absorber + 4 perforation) having value of 7.65 in polypropylene and 7.50 in low density polyethylene (Fig. 2f) whereas, T_1 (control) recorded minimum overall acceptability score of 7.18 in polypropylene and 6.98 in low density polyethylene. The overall acceptability scores increased upto 21 days of storage and then decreased in both polypropylene and low density polyethylene. These results are in agreement with the findings of Sohail *et al*. (2015) [28] who also observed similar trend in overall acceptability during storage.

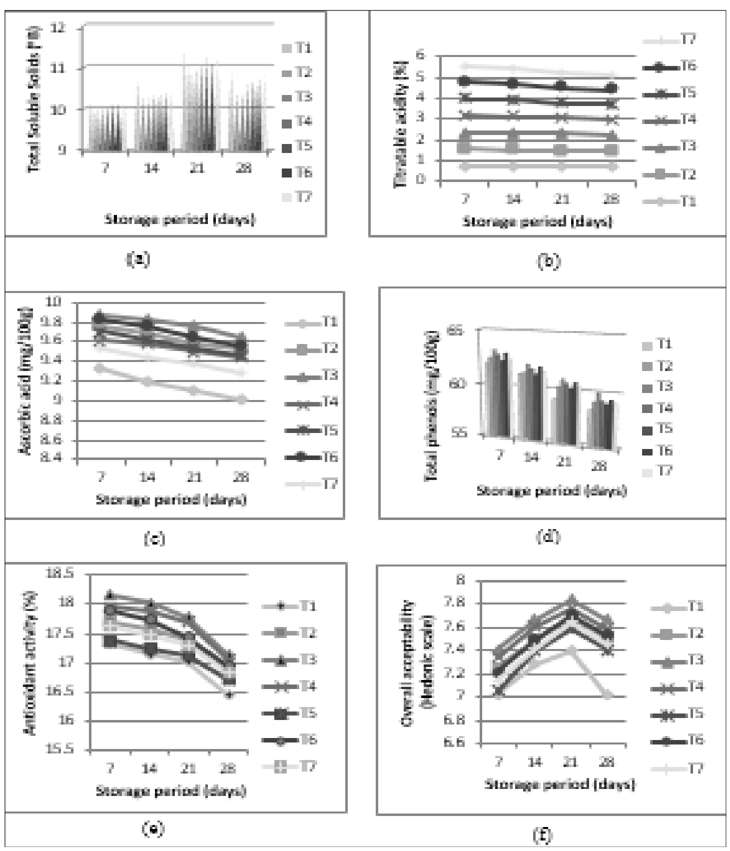

Fig 2: Relative effect of treatments and storage on chemical characteristics of peach

4. Conclusion

From the present studies it is thus concluded, that the use of active packaging to extend the shelf life of peach fruit can be considered as an economical and alternative method of packaging fresh peach fruits stored under refrigerated conditions. Active packaging has shown that besides reducing PLW and decay in peach fruits, they also retained ascorbic acid, total phenols, antioxidants and colour of fruits during storage. Among the various treatments, fruits packed in polypropylene bags with treatment T_3 (ethylene absorber + 4 perforations) was rated best by maintaining the quality parameters of peach fruits. Thus this technology can be helpful in minimizing the post harvest losses of peach fruits.

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