



Alleviation of enzymatic browning and maintenance of postharvest quality of litchi (*Litchi chinensis*) fruit with packaging films

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Received: 16 December 2018; Accepted: 04 July 2019

ABSTRACT

The present study was carried out during the years 2016–17 and 2017–18 to evaluate the effect of different packaging films for control of pericarp browning and maintenance of postharvest quality of litchi (*Litchi chinensis* Sonn.) fruits during cold storage. Litchi fruits of cultivar Dehradun were harvested at physiological mature stage and de-stalked. The fruits were packed in low density polyethylene film (LDPE, 25 μ), high density polyethylene film (HDPE, 10 μ) and heat shrinkable film (15 μ). The control fruits were packed with in gunny sack with litchi leaves as per traditional technique. The fruits were then stored in walk-in-cold store (2–3°C and 90–95% RH) for 4 weeks. The results revealed that LDPE packaging film proved to be the most effective in minimizing the pericarp browning of litchi fruits. LDPE film resulted in reducing the weight loss, browning index and maintained, organoleptic quality, TSS, acidity, ascorbic acid and gave the best browning inhibition during the storage by reducing the activities of polyphenol oxidase and maintained a higher level of total anthocyanin. The data revealed that litchi fruits packed in LDPE films can be stored successfully up to three weeks with acceptable marketable quality.

Key words: Browning, Cold storage, Litchi, Packaging films, Quality

Litchi (*Litchi chinensis* Sonn.) is a prominent fruit of India, occupies an area of 92 thousand ha with the production of 6 lakh MT and productivity of 6.2 MT/ha (Anonymous 2018). It is a good source of vitamins, minerals, dietary fibres, proanthocyanidins and polyphenolics which are responsible to boost the immune system (Deerasamee and Chaisawadi 2014). It is in high demand for its appealing natural red color, sweet taste and aroma. However, it is highly perishable in nature and rapid loss of red pericarp colour after harvest has been the major impediment for its trade. Several physical and chemical methods have been used to control browning and/or inactivate the activities of enzymes such as polyphenol oxidase (PPO) and peroxidase (POD) in litchi fruit. The pericarp browning results from oxidation and polymerization of phenolic compounds, including the red anthocyanins, caused by PPO and POD (Zhang *et al.* 2005). Currently, the use of a sulphitation plus acid dips is the most efficient chemical approach for control of litchi browning. However, the major limitation of the use

of HCl and sulfur dioxide are health concerns, since these chemicals are toxic to human. The alternate non-chemical approach is packaging of fruits in suitable films. Packaging films create modified atmospheric conditions around the produce inside the package allowing lower degree of control of gases and can interplay with physiological processes of commodity resulting in reduced rate of respiration, transpiration and other metabolic processes of fruits (Soltani *et al.* 2016). In this regard, the present investigation was conducted to study the effect of different packaging films on storage life and quality of litchi cv. Dehradun fruit under cold storage conditions.

MATERIALS AND METHODS

The present study was carried out during the years 2016–17 and 2017–18 at Punjab Agricultural University, Fruit Research Station Gangian situated at sub-montaneous zone of Punjab at 31° 48' N and 75° 38' E latitude and longitude, respectively. Fifteen plants of litchi cv. Dehradun having uniform age and vigour were selected. These plants were maintained under a recommended schedule of fertilizer, irrigation and phytosanitary treatments of insect pest control. The fruits were harvested at optimum maturity when fruits attained rosy red colour. The bruised and diseased fruits were sorted out and only fruits with uniform size and colour were selected for the study.

Three types of packaging films commercially available in the market, viz low density polyethylene film (LDPE, 25

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μ), high density polyethylene film (HDPE, 10 μ) and heat shrinkable film (15 μ) were used for packaging of fruits. The fruits were packed and sealed in different packaging films. However, the shrink film wrapped packs were passed through a shrink wrapping machine at 165°C for 10 sec. The control fruits were packed in gunny sacks with litchi leaves as per traditional technique for comparison of quality of litchi fruits. The fruits were stored in walk-in-cold room (2-3°C and 90–95% RH). There were three replications for each treatment and each replication comprised 2 kg of fruits. The various physiological and biochemical attributes of fruits were recorded at 7 days interval till 28 days.

The physiological loss in weight (PLW) of stored fruit was calculated by subtracting final weight from the initial weight of the fruits and expressed in per cent. Browning index of fruit was assessed in a 0–4 scale (Ramma 2003), where 0 is no browning (excellent quality), 1 is slight browning, 2 is $<1/4$ browning, 3 is $1/4$ to $1/2$ browning, 4 is $>1/2$ to $3/4$ browning (poor quality). The overall organoleptic rating of the fruits was done by a panel of ten judges on the basis of external appearance of fruits, texture, taste and flavour. The overall quality rating was calculated making use of a 9-point Hedonic scale (Lawless and Heymann 1998).

The total soluble solids (TSS) of the fruit juice were determined using a hand refractometer and expressed as °Brix. The titratable acidity and ascorbic acid were estimated as per standard procedures (Ranganna 1986). The anthocyanins in the pericarp were estimated as per method proposed by Zheng and Tian (2006) and expressed as expressed as ΔA per g FW.

Polyphenol oxidase assay was determined as per Zauberman *et al.* (1991) method. Fresh pericarp sample (0.1g) was homogenized in a pestle mortar using 2 ml of ice cold 0.05 M sodium phosphate buffer (pH 6.5) containing 1 % polyvinylpyrrolidone (PVP). Homogenized material was centrifuged at 10000 rpm at 4°C for 20 min and the resulting supernatant was used for the assay of PPO enzyme. To determine PPO enzyme activities, 3.5 ml of 0.05 M sodium phosphate buffer (pH 6.5) was taken in a cuvette to which 0.1 ml of enzyme extract was added. The reaction was initiated by the addition of 0.5 ml of 0.1 M Catechol. The absorbance was read at 410 nm for 3 min at the interval of 1 min against the buffer. The activity of polyphenol oxidase was expressed as unit/min/g of fresh weight.

The experiment consisted of 4 treatments and 4 storage intervals and laid out in completely randomized design with three replications for each treatment. The data for both the years were pooled and analyzed for variance by using the SAS (V 9.3, SAS Institute Inc., and Cary, NC, USA) package.

RESULTS AND DISCUSSION

Physiological loss in weight: The fruits packed in LDPE film registered the lowest average PLW (4.31 %) and ranged between 0.36 to 6.45 % from 7 to 28 days of storage as compared to control where PLW was found to be the highest (6.93%) and ranged between 4.69 to 8.61% (Table 1). The higher weight loss in unpacked fruit is generated by high

Table 1 Effect of different packaging materials on physical and organoleptic quality of litchi cultivar Dehradun stored at 2-3°C and 90-95% RH

Treatment	Storage interval (days)				
	7	14	21	28	Mean
<i>PLW (%)</i>					
T ₁ LDPE film 25 μ	0.36	4.60	5.82	6.45	4.31
T ₂ HDPE film 10 μ	2.37	5.62	6.43	7.49	5.48
T ₃ Shrink film (15 μ)	2.73	5.88	6.53	7.45	5.65
T ₄ Control	4.69	6.45	7.97	8.61	6.93
Mean	2.54	5.64	6.69	7.50	
LSD(P $\leq$ 0.05): Treatments (T) = 0.08; Storage (S) = 0.05; T $\times$ S = 0.17					
<i>Browning index (0-4 Scale)</i>					
T ₁ LDPE film 25 μ	1	2	3	4	
T ₂ HDPE film 10 μ	2	3	4	4	
T ₃ Shrink film (15 μ)	2	3	4	4	
T ₄ Control	3	4	4	4	
<i>Organoleptic quality (9 point Hedonic scale)</i>					
T ₁ LDPE film 25 μ	7.95	7.35	7.05	5.90	7.06
T ₂ HDPE film 10 μ	7.85	7.20	6.50	5.40	6.74
T ₃ Shrink film (15 μ)	7.55	6.85	5.50	5.15	6.26
T ₄ Control	7.30	5.70	5.20	4.95	5.79
Mean	7.66	6.78	6.06	5.35	
LSD(P $\leq$ 0.05): Treatments (T) = 0.25; Storage (S) = 0.16; T $\times$ S = 0.50					

metabolic activity, i.e. respiration and transpiration rates. The reduction in weight loss in film-packed fruits is attributed to lower moisture loss due to restricted respiratory process of fruits inside the packaging films (Faasema *et al.* 2011).

Browning Index : The fruits packed in LDPE film recorded browning score index 1 (slight browning) to 3 ($1/4^{\text{th}}$ to $1/2$ surface area brown) from 7th to 21st days of storage resulting in maintaining the acceptability of fruits for three weeks and thereafter the browning of pericarp aggravated rapidly (Table 1). The control fruits registered the acceptable BI score 3 ($1/4^{\text{th}}$ to $1/2$ surface area brown) on 7th day of storage and thereafter the pericarp browning increased at a faster rate and recorded BI score 4 ($> 1/2$ surface area brown) leading to rejection of fruit. The maintenance of acceptable browning index score in LDPE film for three weeks may be due to influence of LDPE film in slowing down the metabolic activity of fruits resulting in decelerating the degradation of anthocyanin content in the litchi pericarp (Jitareerat *et al.* 2013).

Organoleptic quality: Organoleptic quality score was found to be the highest in fruits packed in LDPE film (7.06 out of 9) and were highly acceptable up to 21 days of storage, thereafter that sudden decline in organoleptic quality was recorded (Table 1). On the other hand the control fruits were found acceptable only up to 7 days of storage and sudden decline in organoleptic quality score was

observed afterwards. The characteristic feature of LDPE film, maintaining a proper balance for the permeability of carbon dioxide and oxygen and relative humidity has been reported to preserve the better overall sensory quality in pomegranate fruits (Jena *et al.* 2018).

Total Soluble Solids: The TSS content in litchi fruits packed in LDPE film increased slowly and steadily up to 21 days of storage and after that a sharp decline was recorded up to 28 days of storage (Table 2). On the other hand, in control fruits, the TSS content of litchi fruits declined at sharp rate during storage, which indicates rapid metabolic activities of fruits. The maximum TSS content was observed in fruits packed in LDPE film (17.93°B), whereas the minimum TSS content was noticed in control fruits (16.68°B) respectively. The gradual increase and decrease in TSS in LDPE film wrapped fruits during storage may be possibly due to retarded ripening and senescence processes as a result of modified atmosphere created inside the packaging films, which simultaneously delayed the conversion of starch into sugars. The present results confirmed the findings of Dong *et al.* (2004) who have reported a delayed and sustained increase in the total soluble solids under modified atmospheric conditions (MAP) of fruits.

Table 2 Effect of different packaging materials on biochemical parameters of litchi cv. Dehradun stored at 2-3°C and 90-95% RH

Treatment	Storage interval (days)				
	7	14	21	28	Mean
<i>TSS (°B)</i>					
T ₁ LDPE film25 μ	18.10	18.40	18.65	16.55	17.93
T ₂ HDPE film 10 μ	18.20	18.15	17.49	16.50	17.59
T ₃ Shrink film (15 μ)	18.15	17.70	17.05	16.15	17.26
T ₄ Control	18.00	16.75	16.15	15.80	16.68
Mean	18.11	17.75	17.34	16.25	

LSD(P ≤ 0.05): Treatments (T) = 0.48; Storage (S) = 0.32; T × S = 0.96

Titrateable acidity (%)

T ₁ LDPE film 25 µ	0.27	0.25	0.22	0.19	0.23
T ₂ HDPE film 10 µ	0.26	0.24	0.20	0.18	0.22
T ₃ Shrink film (15 µ)	0.27	0.23	0.20	0.16	0.22
T ₄ Control	0.25	0.21	0.19	0.15	0.20
Mean	0.26	0.23	0.20	0.17	

LSD(P ≤ 0.05): Treatments (T) = 0.009; Storage (S) = 0.006; T × S = 0.02

Ascorbic acid (mg/100g)

T ₁ LDPE film 25 µ	36.40	34.15	28.48	25.25	31.07
T ₂ HDPE film 10 µ	33.95	31.85	27.00	22.79	28.90
T ₃ Shrink film (15 µ)	34.05	28.85	25.20	24.40	28.13
T ₄ Control	31.40	27.85	22.25	18.90	25.10
Mean	33.95	30.68	25.73	22.84	

LSD(P ≤ 0.05): Treatments (T) = 0.71; Storage (S) = 0.47; T × S = 1.41

Titrateable acidity (%): The acidity of litchi fruits experienced a linear decline as the storage period advanced (Table 2). However, the decreasing trend of acidity during storage was gradual in fruits packed in LDPE and HDPE films, whereas it declined at faster pace in case of control. The highest cumulative mean acidity at the end of storage was noticed in fruits packed in LDPE film (0.23 %), whereas lowest acidity was observed in control (0.20 %). The slower decline in acidity in packed fruits of litchi compared to control might be due to delayed senescence and lower respiration rate in the film packed fruits (Kore *et al.* 2017).

Ascorbic acid: The ascorbic acid showed a linear decline during storage in all treatments (Table 2). The LDPE film retained the highest ascorbic acid content (31.07 mg/100g) throughout the storage intervals. The minimum ascorbic acids content was noticed in control (25.10 mg/100g). The maintenance of higher ascorbic acid in mandarin fruits packed in packaging films has been reported by Mahajan *et al.* (2018).

Anthocyanins: The LDPE film showed decline in anthocyanins at very slower rate during the storage (0.34 to 0.18 ΔA/g FW) as compared to other treatments (Fig 1). However, in control fruits the decline of anthocyanin at faster rate was observed (0.31 to 0.19 ΔA/g FW). The maintenance of higher anthocyanin in litchi fruits packed in LDPE films might be due to restricted oxidation of PPO enzyme activity. Zhang *et al.* (2003) reported that anthocyanin content of strawberry decreased continuously during storage and packaging treatments can retard this decrease.

Polyphenol oxidase activity: The PPO activity showed a wide variation among all the treatments as it increased gradually in all treatments all over the storage periods (Fig 2). The maximum increase in PPO activity was observed in control throughout the stipulated storage period of four weeks (77.75 unit/min/g FW to 103.65 unit/min/g FW). On the other hand the lowest increase of PPO activity was found

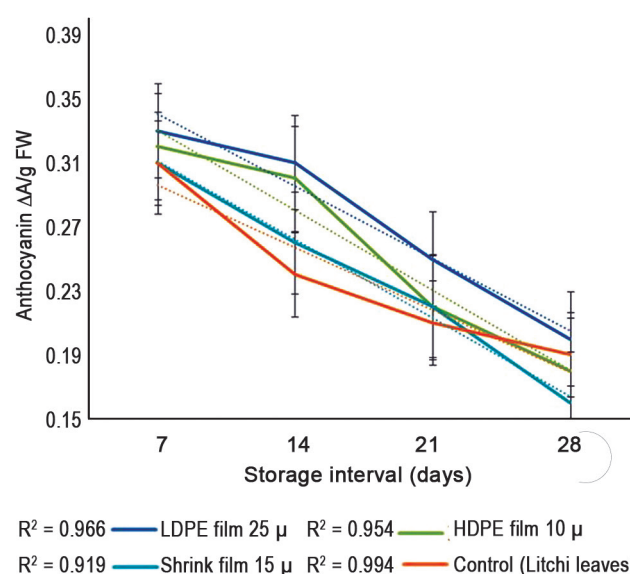


Fig 1 Effect of different packaging materials on anthocyanins of litchi cv. Dehradun stored at 2-3°C and 90-95% RH.

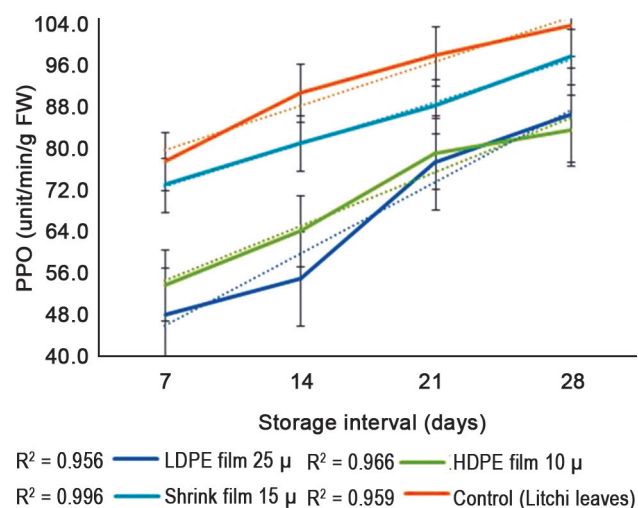


Fig 2 Effect of different packaging materials on polyphenol oxidase (PPO) enzyme activity of litchi cv. Dehradun stored at 2-3°C and 90-95% RH.

in LDPE film (48.25 unit/min/g FW to 86.65 unit/min/g FW). It has been seen that LDPE film markedly inhibited PPO activity and had higher content of anthocyanins, which could be due to role of packaging film in stabilization of the anthocyanin pigments by preventing the oxidation of PPO activity (Liang *et al.* 2013). Zhang *et al.* (2005) suggested that the browning of litchi pericarp may be a consequence of the anthocyanin-PPO reaction.

From the present study it can be concluded that litchi fruits packed in LDPE film can be successfully stored for three weeks in cold storage (2-3°C and 90-95% RH) with minimum pericarp browning acceptable quality. This technology can be helpful in minimizing the postharvest losses of litchi fruits during marketing.

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