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S Usha
P.G, Scholar, Department of Postharvest Management, Dr. Y.S.R Horticultural University, College of Horticulture, Anantharajupeta, Annamayya, Andhra Pradesh, India

M Siva Prasad
Professor, Department of Postharvest Management, Dr. Y.S.R Horticultural University, College of Horticulture, Anantharajupeta, Annamayya, Andhra Pradesh, India

K Swarajya Lakshmi
Professor, Department of Postharvest Management, Dr. Y.S.R Horticultural University, College of Horticulture, Anantharajupeta, Annamayya, Andhra Pradesh, India

VV Padmaja
Associate Professor, Department of Plant Physiology, Dr. Y.S.R Horticultural University, College of Horticulture, Anantharajupeta, Annamayya, Andhra Pradesh, India

K Arunodhayam
Assistant Professor, Department of Plant Pathology, Dr. Y.S.R Horticultural University, College of Horticulture, Anantharajupeta, Annamayya, Andhra Pradesh, India

Corresponding Author:
S Usha
P.G, Scholar, Department of Postharvest Management, Dr. Y.S.R Horticultural University, College of Horticulture, Anantharajupeta, Annamayya, Andhra Pradesh, India

Effect of storage temperature and packaging material in mitigating oleocellosis in acid lime

S Usha, M Siva Prasad, K Swarajya Lakshmi, VV Padmaja and K Arunodhayam

Abstract
In order to learn effective methods for oleocellosis control in Acid lime variety Balaji Pulusu Nimma fruits by different storage temperatures and packing material was investigated in this study. As observed in the result, fruits stored at 4 °C in LDPE and HDPE packing material had a significant effect on controlling oleocellosis during storage compared to fruits stored at ambient temperature without packing material, maximum rind thickness and fruit firmness was maintained fruits stored at 4 °C in LDPE and maximum weight of the fruit and juice percentage was observed in fruits stored at 4 °C and absence of rind collapse index and discoloration index of the rind was observed in both packing material. Moreover, fruits stored in 4 °C in LDPE and HDPE had a rapid decrease in rind thickness, fruit firmness, weight of the fruit and juice percentage from 3 to 12 days of storage and rind collapse index and discoloration index of the rind gradually increased fruits stored at ambient temperature without packing material. Thus, low storage temperatures and LDPE, HDPE packing material control the oleocellosis during storage.

Keywords: Balaji Pulusu Nimma, storage temperatures, packing material, oleocellosis

Introduction
Citrus fruits are non-climacteric fruits belonging to the family Rutaceae originated in South East Asia. Citrus is the major fruit crop grown and traded worldwide. In India citrus fruits covers an area of 10,97,000 hectares with an annual production of 1,42,45,000 MT (NHB, 2021) [7]. Citrus industry around the globe has been facing deterioration in fruit surface quality and increased farmgate rejections, mainly due to high incidence of rind blemishes. Rind blemishes are caused by various biotic and abiotic factors at various stages of fruit development (Malik *et al*., 2021) [5].

Acid lime is one of the important fruit crops grown in tropical and sub-tropical regions of the world (Abobatta, 2019) [1]. Acid lime (*Citrus aurantifolia*) is a non-climacteric fruit originated in India, and belongs to the family Rutaceae with chromosome no. 2n=18 (Mandloi *et al*., 2021) [6] is an important citrus crop.

Oleocellosis is one of the rind disorders, affecting the commercial cultivars of acid lime in Andhra Pradesh. This is a physiological rind disorder caused by the action of phytotoxic rind oil. This oil is released from glands located in the rind (River-Cabera *et al*., 2010) [14]. It is one of the common rind disorders in citrus peel, appearing mainly during the storage period (Liu *et al*., 2012) [3], which results in unattractive blemishes (Liu *et al*., 2013) [4]. It is characterized by the sunken areas on the flavedo and collapsed oil glands, which starts between the damaged epidermis and the collapsed layers of flavedo, eventually spread and affect oil glands, followed by brown spot with different size and shape on the citrus peel, which is caused by climate, mechanical injury or storage conditions (Liu *et al*., 2012) [3].

Material and Methods
The study was conducted Postharvest management laboratory at Dr. YSRHU - College of Horticulture, Anantharajupeta, Annamayya district, Andhra Pradesh in the year 2023. The research encompassed the assessment of oleocellosis in acid lime variety Balaji Pulusu Nimma during after 3 to 12 days of storage. Fruits packed in different packaging material and stored for 3 days at different temperatures. After 3 days of packing and storage treatment, acid lime fruits were subjected to oleocellosis by inducing with lime rind oil for 24 hours.

Oil induction: Modified method of Wild (1998) was followed for oil induction.

Absorbent tissue paper measuring 10 mm^2 was placed on 20 mm wide transparent adhesive tape and 15 µl lime rind oil was pipetted on it. This tissue paper absorbed with lime rind oil, placed on the adhesive tape was adhered to the fruit under test for a period of 24 hours, under ambient conditions for inducing oleocellosis.

After 24 hours, adhesive tapes were removed and the fruits were evaluated for oleocellosis by storing them in respective packaging and storage temperature up to 12 days for evaluation of oleocellosis. Fruit without packing served as control under various temperatures.

Treatment details

No. of treatments :18
Number of replications: 2
Number of fruits per replication: 4
Number of fruits per treatment: 8
Design of the experiment: Factorial CRD

Factor 1: Storage temperature

S_1: Storage at 4 ºC
S_2: Storage at 15 ºC
S_3: Storage at ambient temperature

Factor 2: Packaging

P_1: LDPE
P_2: HDPE
P_3: Brown Paper
P_4: Paper Shreds
P_5: Paddy Straw
P_6: No packaging

Treatment Combinations

T_1	:	S_1P_1 – Storage at 4 ºC + LDPE
T_2	:	S_1P_2 – Storage at 4 ºC + HDPE
T_3	:	S_1P_3 – Storage at 4 ºC + Brown Paper
T_4	:	S_1P_4 – Storage at 4 ºC + Paper Shreds
T_5	:	S_1P_5 – Storage at 4 ºC + Paddy Straw
T_6	:	S_1P_6 – Storage at 4 ºC + No packaging
T_7	:	S_2P_1 – Storage at 15 ºC + LDPE
T_8	:	S_2P_2 – Storage at 15 ºC + HDPE
T_9	:	S_2P_3 – Storage at 15 ºC + Brown Paper
T_{10}	:	S_2P_4 – Storage at 15 ºC + Paper Shreds
T_{11}	:	S_2P_5 – Storage at 15 ºC + Paddy Straw
T_{12}	:	S_2P_6 – Storage at 15 ºC + No packaging
T_{13}	:	S_3P_1 – Storage at ambient temperature + LDPE
T_{14}	:	S_3P_2 – Storage at ambient temperature + HDPE
T_{15}	:	S_3P_3 – Storage at ambient temperature +Brown Paper
T_{16}	:	S_3P_4 – Storage at ambient temperature +Paper Shreds
T_{17}	:	S_3P_5 – Storage at ambient temperature +Paddy Straw
T_{18}	:	S_3P_6 – Storage at ambient temperature +No packaging

Observations were made on various attributes, including rind thickness, fruit firmness, weight of the fruit, juice percentage, rind collapse index and discoloration index of the rind after every 3, 6, 9 and 12 days during storage period after inducing oleocellosis.

Rind thickness (mm)

Rind thickness of the fruit was measured by digital vernier callipers after cutting the whole fruit longitudinally into two halves and expressed in millimetres.

Weight of the fruit (g)

Weight of each treatment fruit was weighed to get the fruit weight and expressed in grams.

Juice percentage (%)

Juice percentage is measured by weighing the fruit and extracting and straining the juice through 1-2 mm mesh. Juice percentage of fruits was calculated by using the following formula:

$$\text{Juice percentage} = \frac{\text{Weight of the extracted juice}}{\text{Weight of the fruits taken}} \times 100$$

Fruit firmness (N)

Firmness was measured according to the method described by with some modification. Force of penetration was measured by using penetrometer. Analysis was used to measure the force required for a 3 mm diameter probe to penetrate the acid lime fruits to a depth of 20 mm at a rate of 50 mm/min using 0.05 Kg load cell. Samples were placed so that the rod penetrated their geometric centers. Firmness of the fruit expressed as pressure of dynamometer in Newtons required to penetrate given fruit surface area.

Rind collapse index

Rind collapse index evaluated as suggested by Knight *et al.* (2002) [9] with the following score:

Score	Rind collapse index
0	Nil
1	Very slight
2	Slight
3	Medium
4	High

Discolouration index of the rind

Discolouration index of the rind evaluated as suggested by Knight *et al*. (2002) [9] with the following score:

Score	Rind collapse index
0	Nil
1	Very slight
2	Slight
3	Medium
4	High
5	Extreme

Results and Discussion

As depicted in Table 1, Table 2, Table 3, Table 4, Table 5 and Table 6, significant differences were observed among all the treatments.

Effect of storage temperature and packaging material in oleocellosis induced fruits of acid lime variety during storage on certain physical parameters *viz*., rind thickness (mm), weight of the fruit (g), Juice percentage (%), Fruit firmness (N), rind collapse index, discolouration index of the rind is presented in the Table 4.1 to 4.6.

Effect of storage temperature and packing material on rind thickness (mm) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage

The data on rind thickness (mm) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma as influenced by

various storage temperatures and packaging material has been presented in Table 1.

Maximum rind thickness of 2.435 mm was recorded in fruits stored at 4 °C in low density polyethylene (LDPE) (S_1P_1) which is on par with fruits stored at same temperature in high density polyethylene (HDPE) (S_1P_2), at 15 °C in LDPE (S_2P_1) and brown paper (S_2P_3) recorded 2.31 mm, 2.235 mm and 2.235 mm respectively after 3 days of storage. Minimum rind thickness of 0.885 mm was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 3 days of storage.

Maximum rind thickness of 2.315 mm was recorded in fruits stored at 4 °C in LDPE (S_1P_1) followed by fruits stored in the same temperature in HDPE (S_1P_2) recorded 2.185 mm after 6 days of storage. Minimum rind thickness of 0.775 mm was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 6 days of storage.

Maximum rind thickness of 2.185 mm was recorded in fruits stored at 4 °C in LDPE (S_1P_1) followed by fruits stored in the same temperature in HDPE (S_1P_2) recorded 2.075 mm after 9 days of storage. Minimum rind thickness of 0.655 mm was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 9 days of storage.

Maximum rind thickness of 2.075 mm was recorded in fruits stored at 4 °C in LDPE (S_1P_1) after 12 days of storage. Minimum rind thickness of 0.54 mm was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 12 days of storage.

Significant differences in the rind thickness were observed among the storage temperatures and packing materials and interaction after 3 to 12 days of storage period.

Maximum rind thickness has been observed in fruits stored at 4 °C in LDPE, HDPE and at 15°C stored in brown paper and minimum rind thickness have been observed in fruits stored at ambient temperature without packing material. Rind thickness gradually decreased in all treatment from 3 to 12 days of storage. Similar results were reported by Sohi *et al*. (2016) [15] in Kinnow fruits. They reported that, better peel thickness of Kinnow fruits packed with LDPE and HDPE films was maintained during storage period.

Effect of storage temperature and packing material on weight of the fruit (g) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage

The data on weight of the fruit (g) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma as influenced by various storage temperatures and packaging material has been presented in Table 2.

Maximum fruit weight of 46.975 g was recorded in fruits stored at 4°C in HDPE (S_1P_2) followed by the fruits stored at the same temperature in LDPE (S_1P_1) recorded 46.375 g after 3 days of storage. Minimum fruit weight of 37.145 g was recorded in fruits stored at ambient temperature in paddy straw (S_3P_5) after 3 days of storage.

Maximum fruit weight of 46.86 g was recorded in fruits stored at 4°C in HDPE (S_1P_2) followed by the fruits stored in same temperature in LDPE (S_1P_1) recorded 46.14 g after 6 days of storage. Minimum fruit weight of 28.125 g was recorded in storage at ambient without packing material (S_3P_6) after 6 days of storage.

Maximum fruit weight of 45.155 g was recorded in fruits stored at 4°C in LDPE (S_1P_1) followed by the fruits stored in same temperature in HDPE (S_1P_2) recorded 43.755 g after 9 days of storage. Minimum fruit weight of 21.565 g was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 9 days of storage.

Maximum fruit weight of 42.725 g was recorded in fruits stored at 4 °C in HDPE (S_1P_2) followed by fruits stored in the same temperature in LDPE (S_1P_1) recorded 40.025 g after 12 days of storage. Minimum fruit weight of 14.765 g was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 12 days of storage.

Significant differences in the weight of the fruit were observed among the storage temperatures and packing materials and interaction after 3 to 12 days of storage period.

Highest fruit weight was observed in fruits stored at 4 °C in LDPE and HDPE packing material. There was a progressive decrease in fruit weight was observed in all treatments after 3 to 12 days of storage. Similar results were observed by Reddy *et al*. (2008) [13] and Ramin and Khoshbakhat (2008) [11].

Reddy *et al*. (2008) [13] found that LDPE and HDPE packing material are most effective in preventing the loss in weight packing acid lime fruits. Ramin and Khoshbakhat (2008) [11] also reported that, low temperature storage of acid lime fruits at 20 °C and 10 °C in HDPE and LDPE caused minimum weight loss.

The pulp and peel of citrus fruits both have a lot of moisture. After harvest, moisture is lost through evaporation and respiration. A significant amount of moisture is lost from the peel tissue, which causes shrivelling, shrinkage, softening and deformation, which affects the appearance of the fruits. Kassim *et al*. (2020) [10] studied about the common citrus postharvest disorders and various pre-packaging treatments and it was also observed that individually wrapping oranges and grapefruit with high density polyethylene films caused minimum weight loss.

Effect of storage temperature and packing material on juice percentage (%) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage

The data on juice percentage (%) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma as influenced by various storage temperatures and packaging material has been presented in Table 3.

Maximum juice percentage of 46.72% was recorded in fruits stored at 4°C in HDPE (S_1P_2) followed by fruits stored in the same temperature in LDPE (S_1P_1) and at 15 °C in HDPE (S_2P_2) recorded 45.365% and 44.22% respectively after 3 days of storage. Minimum juice percentage of 31.825% was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 3 days of storage.

Maximum juice percentage of 43.745% was recorded in fruits stored at 4 °C in HDPE (S_1P_2) followed by the fruits stored at 14 °C without packing material (S_2P_6) and at the same temperature in paper shreds (S_2P_4) recorded 42.935% and 42.545% respectively after 6 days of storage. Minimum juice percentage of 22.465% was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 6 days of storage.

Maximum juice percentage of 41.665% was recorded in fruits stored at 4°C in HDPE (S_1P_2) followed by the fruits stored at the same temperature in LDPE (S_1P_1) recorded 40.555% after 9 days of storage. Minimum juice percentage of 19.655% was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 9 days of storage.

Maximum juice percentage of 38.675% was recorded in fruits stored at 4 °C in HDPE (S_1P_2) followed by the fruits stored at same temperature in LDPE (S_1P_1) and at 15 °C in paper shreds (S_2P_4) recorded 38.315% and 38.275% respectively after 12 days. Minimum juice percentage of 15.235% was recorded in fruits stored at ambient temperature without

packing material (S_3P_6) after 12 days of storage.
Significant differences in the juice percentage were observed among the storage temperatures and packing materials and interaction after 3 to 12 days of storage period.
Higher juice percentage was recorded in fruits stored at 4 °C in LDPE and HDPE, and at 15 °C in paper shreds compared to control. There was decreased trend in juice percentage was noticed from 3 to 12 days of storage. Similar results were reported by Sohi *et al*. (2016) [15].
According to Randhawa *et al*. (1999) [12] citrus fruits with HDPE film wrapping had higher juice percentages than control fruits.
Sohi *et al*. (2016) [15] reported a linear decline in juice percentage with an increase in storage time for Kinnow fruits packed in different films. The respiration process to required a minimum percentage of oxygen because appropriate aeration may eliminate the minor amounts of alcohol and ethylene produced during anaerobic respiration, delayed the decline in juice percentage. Lime and lemon, have higher juice contents maintained in packed fruits compared control fruits.

Effect of storage temperature and packing material on fruit firmness (N) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage
The data on fruit firmness (N) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma as influenced by various storage temperatures and packaging material has been presented in Table 4.
Maximum fruit firmness of 56.75 N was recorded in fruits stored at 4 °C in LDPE (S_1P_1) followed by the fruits stored at 15 °C in HDPE (S_2P_2) recorded 55.36 N after 3 days of storage. Minimum fruit firmness of 35.15 N was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 3 days of storage.
Maximum fruit firmness of 56.575 N was recorded in fruits stored at 4°C LDPE (S_1P_1) followed by the fruits stored at temperature at 15°C in HDPE (S_2P_2) recorded 54.575 N after 6 days of storage. Minimum fruit firmness of 31.255 N was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 6 days of storage.
Maximum fruit firmness of 55.45 N was recorded in fruits stored at 4 °C LDPE (S_1P_1) followed by fruits stored at 15 °C in HDPE (S_2P_2) recorded 54.455 N after 9 days of storage. Minimum fruit firmness of 28.975 N was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 9 days of storage.
Maximum fruit firmness of 53.755 N was recorded in fruits stored at 4 °C in LDPE (S_1P_1) followed by fruits stored at 15 °C in HDPE (S_2P_2) recorded 53.345 N after 12 days of storage. Minimum fruit firmness of 26.875 N was recorded in fruits stored at ambient temperature without packing material (S_3P_6) after 12 days of storage.
Significant differences in the fruit firmness were observed among the storage temperatures and packing materials and interaction after 3 to 12 days of storage period.
Higher fruit firmness was observed in fruits stored at 4 °C in LDPE and at 1 5°C in HDPE compared to control and other packing material. Fruit firmness gradually decreased from 3 to 12 days of storage.
Ramin *et al*. (2008) [11] also reported similar results with "Key" acid lime fruits stored 20 °C and 10 °C in HDPE exhibited higher fruit firmness compared to the control.
Azene *et al*. (2014) [2] concluded similar results in papaya during storage with different packing material. They reported that, the firmness of the fruit decreased irrespective of packing material and storage environments during storage period. Both HDPE and LDPE bags, showed higher fruit firmness compared to other packaging materials, ultimately, firmness gradually decreased during 9 days of storage period. Decrease in fruit firmness is as a result of softening, as the storage progressed, which could be due to texture modification through degradation of polysaccharides such as pectins, cellulose and hemicellulose that occur during ripening. It has been well established that texture changes in fruits were consequences of modifications by component of polysaccharides that give rise to disassembly of primary cell wall and middle lamella structures due to enzyme activity on carbohydrate polymers (Manrique and Lajolo, 2004) [8]. The rapid loss in firmness of fruits during ripening at ambient temperature is associated closely with increase in activity of polygalacturonase, pectinmethyl esterase and β-galactosidase as well as with depolymerisation of cell wall pectins.

Effect of storage temperature and packing material on rind collapse index in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage
The data on rind collapse index in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma as influenced by various storage temperatures and packaging material has been presented in Table 5.
Maximum rind collapse index of 2.575, 3.865, 3.905, 3.96 were recorded storage at ambient temperature without packing material (S_3P_6) after 3, 6, 9,12 days of storage respectively. Fruits stored at ambient temperature without packing material exhibited progressive increase in rind collapse index during storage. Whereas, other treatments irrespective of the storage temperature, all the fruits packed in different packing material did not exhibit any signs of rind collapse index. Similar results were reported by Zhou *et al*. (2017) [17].
Zhou *et al*. (2017) [17] conducted an experiment on navel oranges (*Citrus sinensis* L. Osbeck) were treated with pure orange oil to simulate the natural cause of oleocellosis at the end of the storage period, the rate of rind collapse was higher in effected fruits.

Effect of storage temperature and packing material on discolouration index of the rind in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage
The data on discolouration index of the rind in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma as influenced by various storage temperatures and packaging material has been presented in Table 6
Maximum discoloration index of the rind 2.52, 3.66, 3.825, 3.97 were recorded fruits stored at ambient temperature without packing material (S_3P_6) after 3, 6, 9,12 days of storage respectively. Fruit stored at ambient temperature without packing material exhibited progressive increase in discoloration index of the rind during storage. Whereas, other treatments irrespective of the storage temperature, all the fruits packed in different packing material did not exhibit any signs of discolouration index.
Zhou *et al*. (2017) [17] conducted an experiment on navel oranges (*Citrus sinensis* L. Osbeck) were treated with pure orange oil to simulate the natural cause of oleocellosis at the end of the storage period, the rate of discolouration score was higher in effected fruits.

Table 1: Effect of storage temperature and packing material on rind thickness (mm) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage.

	Days after storage															
	3				6				9				12			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
P_1	2.435	2.235	1.935	2.202	2.315	2.115	1.815	2.082	2.185	1.985	1.685	1.952	2.075	1.875	1.575	1.842
P_2	2.31	2.065	1.985	2.12	2.185	1.945	1.865	1.998	2.075	1.825	1.745	1.882	1.955	1.715	1.625	1.765
P_3	1.445	2.235	1.585	1.755	1.325	2.115	1.075	1.505	1.23	1.985	0.955	1.39	1.12	1.875	0.835	1.277
P_4	1.335	2.085	1.135	1.518	1.215	1.975	1.015	1.402	1.085	1.855	0.885	1.275	0.975	1.735	0.775	1.162
P_5	2.165	1.835	1.045	1.682	2.045	1.715	0.925	1.562	1.925	1.585	0.825	1.445	1.815	1.475	0.715	1.335
P_6	1.035	1.155	0.885	1.025	0.915	1.035	0.775	0.908	0.785	0.915	0.655	0.785	0.675	0.785	0.54	0.667
Mean	1.788	1.935	1.428		1.667	1.817	1.245		1.548	1.692	1.125		1.436	1.577	1.011	
Factor	SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)	
S	0.038		0.114		0.002		0.006		0.003		0.007		0.002		0.007	
P	0.054		0.161		0.003		0.009		0.004		0.009		0.003		0.010	
SXP	0.093		0.279		0.005		0.015		0.008		0.016		0.005		0.017	

Table 2: Effect of storage temperature and packing material on weight of the fruit (g) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage.

	Days after storage															
	3				6				9				12			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
P_1	2.435	2.235	1.935	2.202	2.315	2.115	1.815	2.082	2.185	1.985	1.685	1.952	2.075	1.875	1.575	1.842
P_2	2.31	2.065	1.985	2.12	2.185	1.945	1.865	1.998	2.075	1.825	1.745	1.882	1.955	1.715	1.625	1.765
P_3	1.445	2.235	1.585	1.755	1.325	2.115	1.075	1.505	1.23	1.985	0.955	1.39	1.12	1.875	0.835	1.277
P_4	1.335	2.085	1.135	1.518	1.215	1.975	1.015	1.402	1.085	1.855	0.885	1.275	0.975	1.735	0.775	1.162
P_5	2.165	1.835	1.045	1.682	2.045	1.715	0.925	1.562	1.925	1.585	0.825	1.445	1.815	1.475	0.715	1.335
P_6	1.035	1.155	0.885	1.025	0.915	1.035	0.775	0.908	0.785	0.915	0.655	0.785	0.675	0.785	0.54	0.667
Mean	1.788	1.935	1.428		1.667	1.817	1.245		1.548	1.692	1.125		1.436	1.577	1.011	
Factor	SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)	
S	0.038		0.114		0.002		0.006		0.003		0.007		0.002		0.007	
P	0.054		0.161		0.003		0.009		0.004		0.009		0.003		0.010	
SXP	0.093		0.279		0.005		0.015		0.008		0.016		0.005		0.017	

Table 3: Effect of storage temperature and packing material on juice percentage (%) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage.

	Days after storage															
	3				6				9				12			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
P_1	45.365	35.825	38.325	39.838	42.425	32.155	31.235	35.272	40.555	30.125	29.085	33.255	38.315	27.885	24.575	30.258
P_2	46.72	44.22	40.075	43.672	43.745	41.355	35.065	40.055	41.665	39.22	32.915	37.933	38.675	37.075	28.415	34.722
P_3	34.525	41.185	34.085	36.598	32.515	39.175	29.885	33.858	30.365	37.025	27.745	31.712	28.245	34.915	23.245	28.802
P_4	37.885	43.355	33.765	38.335	36.285	42.545	25.675	34.835	33.635	40.385	23.525	32.515	31.515	38.275	19.015	29.602
P_5	37.315	39.615	32.885	36.605	34.455	34.525	26.815	31.932	31.32	32.375	24.665	29.453	29.185	30.255	20.155	26.532
P_6	42.415	43.475	31.825	39.238	42.025	42.935	22.465	35.808	39.375	40.14	19.655	33.057	37.255	35.625	15.235	29.372
Mean	40.704	41.279	35.16		38.575	38.782	28.523		36.153	36.545	26.265		33.865	34.005	21.773	
Factor	SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)	
S	0.002		0.005		0.134		0.402		0.002		0.007		0.001		0.004	
P	0.002		0.007		0.190		0.569		0.003		0.009		0.002		0.006	
SXP	0.004		0.011		0.329		0.985		0.005		0.016		0.004		0.011	

Table 4: Effect of storage temperature and packing material on fruit firmness (N) in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage.

	Days after storage															
	3				6				9				12			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
P_1	56.75	46.855	43.13	48.912	56.575	45.785	42.575	48.312	55.45	45.665	41.35	47.488	53.755	44.555	39.545	45.952
P_2	52.66	55.36	44.545	50.855	51.485	54.575	43.865	49.975	51.37	54.455	42.585	49.47	50.255	53.345	39.785	47.795
P_3	47.13	48.855	42.725	46.237	46.745	47.755	41.635	45.378	46.625	47.64	40.365	44.877	45.515	46.525	37.355	43.132
P_4	48.915	52.125	40.12	47.053	47.885	51.235	39.545	46.222	47.565	51.115	38.245	45.642	46.555	50.215	35.235	44.002
P_5	52.745	52.245	41.83	48.94	51.565	51.545	40.575	47.895	51.245	51.43	39.33	47.335	50.335	50.315	36.335	45.662
P_6	48.27	50.355	35.15	44.592	47.125	49.245	31.255	42.542	46.24	49.125	28.975	41.447	45.125	48.015	26.875	40.005
Mean	51.078	50.966	41.25		50.23	50.023	39.908		49.749	49.905	38.475		48.59	48.828	35.855	
Factor	SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)	
S	0.003		0.008		0.001		0.004		0.003		0.008		0.010		0.031	

P	0.004	0.011	0.002	0.006	0.004	0.012	0.015	0.044
SXP	0.006	0.019	0.003	0.010	0.007	0.020	0.026	0.077

Table 5: Effect of storage temperature and packing material on rind collapse index in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage.

	Days after storage															
	3				**6**				**9**				**12**			
	S_1	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**
P_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_6	0	0	2.57	0.857	0	0	3.865	1.288	0	0	3.905	1.302	0	0	3.96	1.32
Mean	0	0	0.428		0	0	0.644		0	0	0.651		0	0	0.66	
Factor	SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)	
S	0.001		0.003		0.001		0.004		0.001		0.004		0.001		0.003	
P	0.001		0.004		0.002		0.006		0.002		0.006		0.001		0.004	
SXP	0.002		0.007		0.004		0.011		0.004		0.011		0.002		0.007	

Table 6: Effect of storage temperature and packing material on discoloration index of rind in oleocellosis induced fruits of acid lime variety Balaji Pulusu Nimma during storage.

	Days after storage															
	3				6				9				12			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
P_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_6	0	0	2.52	0.84	0	0	3.66	1.22	0	0	3.825	1.275	0	0	3.97	1.323
Mean	0	0	0.42		0	0	0.61		0	0	0.638		0	0	0.662	
Factor	SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)		SE(m) ±		CD (5%)	
S	0.001		0.003		0.001		0.003		0.001		0.004		0.001		0.003	
P	0.001		0.004		0.001		0.004		0.002		0.006		0.001		0.004	
SXP	0.002		0.007		0.002		0.007		0.004		0.011		0.002		0.007	

Conclusions

Balaji Pulusu Nimma fruits stored at 4 °C (S_1) packed in LDPE (P_1) and HDPE was found to have highest tolerance to induced oleocellosis with maximum rind thickness, fruit firmness, weight of the fruit, juice percentage and absence of rind collapse and discoloration index of the rind.

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