International Journal of Economic Plants

https://ojs.pphouse.org/index.php/IJEP

Crossref

IJEP November 2024, 11(4): 441-451

Article IJEP5619b

Full Research

Doi: HTTPS://DOI.ORG/10.23910/2/2024.5619b

Effectiveness of Different Packaging Materials on Storage Ability of Lime (*Citrus aurantiifolia* Swingle)

P. Manoj Reddy[1], Alok Kumar[1*], Ng. Piloo[1], Ng. Joykumar[2], N. Gopimohon Singh[3] and Malay Marut Sharma[4]

[1]Dept of Horticulture, [2]Dept of Agricultural Engineering, [3]Dept of Basic Sciences, College of Agriculture, CAU, Imphal, Manipur (795 004), India
[4]Dept of Horticulture, Rajiv Gandhi University, Itanagar, Arunachal Pradesh (791 112), India

Corresponding Author

Alok Kumar
e-mail: alokkr581996@gmail.com

Article History

Received on 19th July, 2024
Received in revised form on 14th October, 2024
Accepted in final form on 05th November, 2024

Abstract

The present study was undertaken at the Department of Horticulture, College of Agriculture, Iroisemba, Central Agricultural University, Imphal during 2021–2022 with the objectives to study the effectiveness of different packaging materials on shelf life of lime and their impact on quality of fruit during storage. Acid lime is one of the important commercial cultivar in India. The genus is significant economically because many of its species are grown for their fruit, which is consumed raw or pressed to extract juice that is then preserved to make pickles and marmalades. Experimental design was followed in Randomised Block Design (RBD) constituting eight treatments combinations as follows: T_1: Low density polyethylene (LDPE) bags without ventilation, T_2: Low density polyethylene (LDPE) bags with 1% ventilation, T_3: Low density polyethylene (LDPE) bags with 3% ventilation, T_4: Low density polyethylene (LDPE) bags with 5% ventilation, T_5: Tray overwrapping with cling film, T_6: Vacuum packging, T_7: Plastic punnet, T_8: No Packaging (control). Physiological loss in weight (%), decay percentage (%), specific gravity (g cm^{-3}), TSS (ºBrix), titrable acidity (%), TSS acid ratio, ascorbic acid (mg 100 ml^{-1}) and sensory quality of the fruits were recorded at fixed interval of time period. From the obtained result, it can be concluded that vacuum packaging was found to be best treatment for extending shelf life of lime up to 36–38 days maintaining a low physiological loss in weight, good sensory, minimum spoilage and other physio-chemical characters at the same time under ambient condition of storage.

Keywords: Acid lime, packaging, post-harvest, shelf life, quality

1. Introduction

Citrus is a significant genus within the Rutaceae family (Velasco and Concetta, 2014) and the widely grown citrus cultivar known as acid lime (*Citrus aurantifolia*) is notable in the global citrus market (Ladaniya et al., 2020). Citrus fruits are known for their characteristic harsh taste because they are high in citric acid and the juice contains other organic acids (Duarte et al., 2010). Lime stands out among citrus fruits as a great source of naturally occurring bioactive chemicals known for their health-promoting qualities (Suri et al., 2022). It is native to India and South Eastern China and widely distributed in tropical and subtropical zones of India. It is one of the important commercial cultivars in India and also known as Kagzi lime. Acid lime fruit is round to oval, greenish-yellow with thin skin, and has a solid core when mature. The flesh is greenish-white, and the juice is highly acidic, with irregular maturity throughout the year (Ghosh, 1990). Kagzi lime, known for its thin, papery skin and high vitamin C content, is widely cultivated in India and other tropical countries (Mandloi et al., 2021). The soap and cosmetic industries use lime peel oil and peel powder extensively (Debaje et al., 2011). Their storage life is limited to only 6–9 days due to this inherent susceptibility (Samaradiwakara et al., 2019). In addition, the peel's chlorophyll deterioration causes a loss of greenness, which exacerbates the fruit's shorter shelf life (Champa et al., 2020).

In Manipur during peak season, fruit grower fetch lower price in the market and the post-harvest losses are as high as 30%. It is, therefore, necessary to find out ways to increase post- harvest life of fruits. In Manipur, farmers do not give any post-harvest treatments like packaging to the fresh produce, so the crops suffer heavy post-harvest loss. If suitable protocol for post-harvest treatment is developed, these losses can be reduced to a great extent. The only way to meet market demand both during and after off-season is to extend the shelf life of fruits. Kagzi limes are perishable in nature, just like other fruits. After harvest, improper post-harvest management and microbial invasion cause about 25–40% of the fruits to be destroyed before they can be consumed (Mahajan and Singh, 2008). Shelf life of lime can be regulated by adopting various post-harvest practices like packaging during the desired season.Post-harvest losses can be reduced by extending the shelf life by monitoring respiration and transpiration rates, microbial infections, and membrane disorganisation prevention (Bisen and Pandey, 2008).

According to Packaging Institute International (1998), packaging is defined as "the enclosure of items, products, or packages in a wrapped pocket, envelope, jar, cup, tray, can, tube, bottle, or other type of container to perform such functions". Generally, the functions of good packaging for exporting horticultural crops are containment provision, mechanical and physical damage prevention, temperature control and other physical factors (e.g. relative humidity) to provide a beneficial environment, prevention of moisture loss in fresh oranges, protection of commodities from fungal infection, promoting hygiene and cleanliness of goods, service advertising and merchandise sales (Robertson, 2006). Packaging is crucial to extending the shelf life of fresh fruits in locations without access to refrigeration or storage facilities (Gidagiri et al., 2020). Studies have shown that pre packing of fresh produce in polythene bags helps to extend the shelf life by reducing shrinkage, weight loss and occurrence of various blemishes. The films used are partially permeable to gases and water vapour and can modify fruit's micro atmosphere and hence, delayed the deterioration of fruits at room temperature.

2. Materials and Methods

The present experiment was undertaken at the Laboratory of the Department of Horticulture, College of Agriculture, Iroisemba, Central Agricultural University, Imphal, India during 2021–2022. It is situated at latitude 24° 45′ N and longitude 93° 56′ E with an elevation of 790 meter above the mean sea level. The experiment was conducted in RBD with three replications. The fruits of lime harvested on same day at green mature stage were collected from local market of Imphal. The bruised and diseased fruits were sorted out and healthy uniform fruits washed with water and surface dried followed by giving different packaging treatments namely; T_1: Low density polyethylene (LDPE) bags without ventilation , T_2: Low density polyethylene (LDPE) bags with 1% ventilation,T_3: Low density polyethylene (LDPE) bags with 3% ventilation,T_4: Low density polyethylene (LDPE) bags with 5% ventilation, T_5: Tray overwrapping with cling film, T_6: Vacuum packaging , T_7: Plastic punnet, T_8: No Packaging (control).

During the experiment the mean temperature and relative humidity of the laboratory were recorded as 26.46°C (max: 29.1°C, min: 25.6°C) and 63.23% (max: 80%, min: 30%) respectively.

2.1. Physiological parameters

2.1.1. Physiological loss in weight

The physiological loss in weight of the fruits was expressed in percentage and calculated on initial weight basis by following formula

P.L.W (%)=(Initial weight-Final weight/Initial weight)×100

2.1.2. Spoilage (%)

The percent spoilage (%) of lime was calculated on the number basis by counting number of fruits spoiled and total fruits at 7 days interval days.

Spoilage (%)=(Number of spoiled fruits/(Total number of fruits)×100

2.1.3. Specific gravity (g cm^{-1})

Specific gravity of lime was determined by water displaced method as described by Mazumdar and Majumder (2003). The following formula was used to compute it:

Specific gravity=(Weight of Lime fruit/Volume of water displaced)

2.2. Biochemical parameters

2.2.1. Total soluble solids (TSS)

Total soluble solids (TSS) were measured by using a hand refractometer (range 0–32%) (Ranganna, 1986).

2.2.2. Titratable acidity (%)

Acidity was determined by using the standard procedure for the titrable acidity as described by Ranganna (1986).

TA (%)=(Titre value×N of Alkali×Vol.made up×Eq.wt.of acid×100)/Vol.of sample taken for estimation×Wt.or Vol.of sample taken×1000)

2.2.3. Ascorbic acid

The ascorbic acid content of fresh and stored fruits was determined by diluting the known quantity of the fruit juice with 4% metaphosphoric acid and filtered through filter paper and titrating with 2, 6-dichlorophenol indophenol dye solution (Anonymous, 1960) until the stable faint pink colour was obtained.

2.2.4. TSS/ Acid ratio

T.S.S **(**Brix) to acid ratio was calculated by dividing the TSS i.e. brix with the titratable acidity.

2.3. Sensory quality

The organoleptic evaluation for assessing the colour, flavour and texture was worked out by judges using one to nine-point Hedonic scale as given below by Amerine et al., 1965:

9 - Like extremely, 8 - Like very much, 7 - Like moderately, 6 - Like slightly, 5 - Neither like not dislike 4- Dislike slightly, 3 - Dislike moderately, 2 - Dislike very much, 1 - Dislike extremely.

The final rating was calculated by averaging the score. A score of 5.5 and above was rated as acceptable and treatment showing score less than 5.5 was terminated.

3. Results and Discussion

3.1. Physiological parameters

3.1.1. Physiological loss in weight (PLW) (%)

Data presented in table 1 reveals that all plastic bags were effective in checking the physiological loss in weight in lime fruit on different days of storage. Fruits packed in vacuum packaging (T_6) had the minimum PLW on all periods of storage. On 36 days of storage, the minimum physiological loss in weight of 1.77% was recorded in fruits packed in vacuum packaging (T_6) followed by fruits packed in Low density polyethylene (LDPE) bags without ventilation (T_6) as 3.33% while the maximum physiological loss in weight of 38.76% was observed in fruits without packaging (T_8) fruits. On 42 days of storage, fruits packed in vacuum packaging (T_6) recorded minimum physiological loss in weight of 2.04 % followed by fruits with plastic punnet (T_6) of 4.15% while maximum weight loss of 4.21% recorded in fruits packed in Low density polyethylene (LDPE) bags without ventilation (T_1).

An increase in physiological loss in weight in all the treatments with increasing period of storage is obvious as the different physiological processes continue in the fruits even after harvest. Weight loss in fruits is mainly due to physiological processes like respiration and transpiration, which are constantly going on in fruits for respiration fruits use the various reserve food materials present inside the fruit. Transpiration process also continues from the surface of fruits even after their harvest. The results are confirmatory with the results of Srivastava et al. (1973) who have reported that PLW is mainly due to evaporation of water from the orange fruits, respiration and various degradation processes occurring during storage. The minimum physiological loss in weight observed in low density Polyethylene (LDPE) bags without ventilation (T_1) is (3.43%) might be due to characteristics feature of LDPE in reducing the rate of transpiration and respiration by restriction on diffusion of gases and feedback mechanism. These results are in agreement partially with the results of Kaufman et al. (1956) in oranges; Kohli and Bhambota (1966) in Kagzi lime; Sadasivam et al. (1972) in Sathgudi oranges; Srivastava et al. (1973) in orange; Chaudhari and Kumbhare (1979) in sweet orange; Jadhao et al. (2012) in Kagzi lime and Sujeetha et al. (2020) in pomegranate arils.

3.1.2. Spoilage (%)

There were significant differences among the storage intervals, treatments and interaction effects as indicated in Table 2. Spoilage of the fruits was observed from the 7th day of storage (19.56%) and increased up to the end of storage period (100.00%). On 42 days of storage, vacuum packaging (T_6) fruits recorded minimum spoilage (21.10%), low density polyethylene (LDPE) bags with 1% ventilation (T_2), low density

Table 1: Physiological loss in weight (PLW) (%) of lime as affected by packaging during different days of storage

Treat-ments	Days of storage							
	0	6	12	18	24	30	36	42
T_1	0.00 (0.71)	0.59 (1.04)	1.17 (1.29)	1.66 (1.47)	1.95 (1.57)	2.74 (1.80)	3.33 (1.96)	4.21 (2.17)
T_2	0.00 (0.71)	8.21 (2.95)	19.13 (4.43)	24.20 (4.97)	28.61 (5.39)	32.21 (5.71)	35.80 (6.02)	0.00 (0.71)
T_3	0.00 (0.71)	12.30 (3.57)	21.62 (4.70)	25.20 (5.07)	28.58 (5.39)	31.92 (5.69)	34.86 (5.95)	0.00 (0.71)
T_4	0.00 (0.71)	15.52 (4.00)	22.12 (4.75)	25.62 (5.11)	29.29 (5.46)	32.57 (5.75)	36.31 (6.06)	0.00 (0.71)
T_5	0.00 (0.71)	10.2 (3.27)	18.00 (4.30)	22.79 (4.82)	26.94 (5.23)	30.46 (5.55)	34.88 (5.93)	0.00 (0.71)
T_6	0.00 (0.71)	0.44 (0.97)	0.80 (1.14)	1.06 (1.25)	1.33 (1.35)	1.59 (1.44)	1.77 (1.51)	2.04 (1.59)
T_7	0.00 (0.71)	0.73 (1.10)	1.43 (1.39)	1.86 (1.53)	2.40 (1.70)	2.91 (1.84)	3.45 (1.98)	4.15 (2.14)
T_8	0.00 (0.71)	19.55 (4.47)	25.02 (5.04)	28.34 (5.36)	32.06 (5.70)	35.66 (6.00)	38.76 (6.26)	0.00 (0.71)
SEm±	0.00 (0)	6.49 (0.11)	10.35 (0.12)	12.33 (0.10)	14.26 (0.12)	16.06 (0.16)	17.89 (0.18)	1.05 (0.06)
CD (p=0.05)	0.00 (0)	19.68 (0.33)	31.38 (0.35)	37.39 (0.31)	43.25 (0.37)	48.71 (0.48)	54.25 (0.54)	3.20 (0.17)

Data in the parenthesis are square root transformed values

Table 2: Decay loss (%) of lime fruits as affected by packaging during different days of storage

Treat-ments	Days of storage						
	0	7	4	21	28	35	42
T_1	0.00 (0.71)	0.00 (0.71)	21.75 (4.71)	20.36 (4.57)	35.40 (5.98)	40.00 (6.22)	100.00 (10.02)
T_2	0.00 (0.71)	0.00 (0.71)	22.48 (4.79)	77.41 (8.82)	99.97 (10.02)	100.00 (10.02)	100.00 (10.02)
T_3	0.00 (0.71)	0.00 (0.71)	20.92 (4.62)	100.00 (10.02)	100.00 (10.02)	100.00 (10.02)	100.00 (10.02)
T_4	0.00 (0.71)	19.56 (4.48)	47.35 (6.92)	100.00 (10.02)	100.00 (10.02)	100.00 (10.02)	100.00 (10.02)
T_5	0.00 (0.71)	20.15 (4.54)	19.53 (4.48)	66.67 (8.18)	99.97 (10.02)	100.00 (10.02)	100.00 (10.02)
T_6	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	21.10 (4.65)
T_7	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	21.70 (4.71)
T_8	0.00 (0.71)	57.78 (7.63)	100.00 (10.02)	100.00 (10.02)	100.00 (10.02)	100.00 (10.02)	100.00 (10.02)
SEm±	0.00 (0.00)	0.57 (0.04)	0.93 (0.09)	2.64 (0.16)	1.02 (0.08)	4.08 (0.33)	1.64 (0.16)
CD (p=0.05)	0.00 (0.00)	1.72 (0.13)	2.82 (0.28)	8.01 (0.48)	3.10 (0.26)	12.38 (1.01)	4.97 (0.48)

Data in the parenthesis are square root transformed values

polyethylene (LDPE) bags with 3% ventilation (T_3), low density polyethylene (LDPE) bags with 5% ventilation (T_4), tray overwrapping with cling film (T_5) and no packaging (T_8) fruits recorded maximum spoilage (100.00%) and intermediate range fruits low density polyethylene (LDPE) bags without ventilation (T_1) (27.81%) and plastic punnet bags (T_7) (21.70%).

Spoilage of acid lime fruits increased with increase in storage period, irrespective of treatments, packaging materials, treatments and storage conditions. The spoilage was more in case of fruits stored at room temperature resulting in reduced shelf life. This spoilage was more due to shriveling and loss of colour than due to spoilage organisms. Acid lime fruits treated with vacuum packaging (T_6) showed least spoilage compared to all other treatments. The present study results are in confirmation with these reported by findings of Singh and Mandal (2006) in peach fruits; Gautam and Neeraja (2005) in Baganpalli mangoes; Prasad et al. (1999) in Khasi mandarin fruits; Dhatt et al. (1999) in kinnow mandarin; Venkatesha and Reddy (1994) in guava fruits; Joshua and Sathiamoorthy (1993) in sapota fruits.

3.1.3. Specific gravity

Data presented in Table 3 reveals that specific gravity in all the treatments goes on decreasing during the entire period of storage. On zero days of storage maximum specificgravity was recorded which ranged from 0.94 g cm^{-3} to 1.07 g cm^{-3}. On 42nd day of storage maximum specific gravity was found in fruits packed in low density polyethylene (LDPE) bags without ventilation (T_1) as 0.85 g cm^{-3} followed by fruits packed in vacuum packaging (T_6) as 0.83 g cm^{-3} while minimum specific gravity was found in fruits packed in plastic punnet (T_7) as 0.80 g cm^{-3}.

The decrease in specific gravity may be attributed to the reduction in weight and volume of the fruits because of increased transpiration and respiration (Pandey *et al.*,1974 ; Shukla, 1977). In the present study, a decreasing trend in specific gravity of lime fruits was observed with the advancement of maturity and ripening of fruits. These results are in confirmation with the findings of Shukla (1977), Sastry and Krishnamurthy (1975), Nandiniand Oommen (2002) in mango and Teotia et al. (1964) and Tripathi and Gangawar (1971) in guava.

3.2. Bio chemical parameters

3.2.1. Total soluble solids (TSS)

Effect of different plastic bags of different thickness on TSS of Lime on different days of storage is presented in Table 4**.** Fruits at the initial stage *i.e*. at zero day of storage had TSS of 6.86% to 7.57%. TSS content of the fruits during the initial period of storage increased in all the treatments while it decreased on prolonged storage. On 7th day of storage, maximum TSS of (7.73%) was retained in fruits packed in vacuum packaging (T_6).

Table 3: Specific gravity of lime as affected by packaging during different days of storage

Treatments	Days of storage						
	0	7	14	21	28	35	42
T_1	0.97 (1.21)	1.03 (1.24)	1.02 (1.23)	1.07 (1.25)	1.03 (1.24)	0.97 (1.21)	0.85 (1.16)
T_2	0.85 (1.16)	1.09 (1.26)	1.00 (1.22)	1.01 (1.23)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_3	1.08 (1.26)	1.13 (1.28)	1.09 (1.26)	0.97 (1.21)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_4	1.02 (1.23)	1.02 (1.23)	0.97 (1.21)	0.95 (1.20)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_5	1.07 (1.25)	1.16 (1.29)	0.96 (1.21)	1.16 (1.29)	1.09 (1.26)	0.94 (1.20)	0.00 (0.71)
T_6	1.01 (1.23)	1.03 (1.24)	1.04 (1.24)	1.00 (1.23)	1.05 (1.25)	0.99 (1.22)	0.83 (1.15)
T_7	0.94 (1.20)	0.96 (1.21)	0.98 (1.22)	0.98 (1.22)	1.00 (1.22)	0.97 (1.21)	0.80 (1.14)
T_8	1.05 (1.25)	1.06 (1.25)	0.96 (1.21)	0.86 (1.17)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
SEm±	0.03 (0.01)	0.04 (0.01)	0.02 (0.01)	0.04 (0.01)	0.04 (0.02)	0.03 (0.01)	0.02 (0.01)
CD (p=0.05)	0.09 (0.03)	0.12 (0.05)	0.07 (0.03)	0.11 (0.04)	0.12 (0.05)	0.08 (0.03)	0.05 (0.02)

Data in the parenthesis are square root transformed values

Table 4: Total Soluble Solids (TSS) of lime fruits as affected by packaging during different days of storage

Treatments	Days of storage						
	0	7	14	21	28	35	42
T_1	7.55 (2.84)	7.50 (2.83)	8.13 (2.94)	8.47 (2.99)	8.47 (2.99)	8.77 (3.04)	8.91 (3.07)
T_2	7.38 (2.81)	7.53 (2.83)	7.80 (2.88)	8.40 (2.98)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_3	6.99 (2.74)	7.17 (2.77)	7.43 (2.82)	7.60 (2.85)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_4	7.36 (2.80)	7.43 (2.82)	7.53 (2.83)	7.83 (2.89)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_5	6.95 (2.73)	7.03 (2.74)	7.20 (2.77)	7.50 (2.83)	7.50 (2.83)	8.00 (2.92)	0.00 (0.71)
T_6	7.57 (2.84)	7.73 (2.87)	7.93 (2.90)	8.13 (2.94)	8.37 (2.98)	8.43 (2.99)	8.50 (3.00)
T_7	6.86 (2.71)	7.00 (2.74)	7.20 (2.77)	7.40 (2.81)	7.63 (2.85)	7.90 (2.90)	8.03 (2.92)
T_8	6.88 (2.72)	7.03 (2.74)	7.13 (2.76)	7.37 (2.80)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
SEm±	0.12 (0.02)	0.09 (0.02)	0.11 (0.02)	0.11 (0.02)	0.07 (0.01)	0.11 (0.02)	0.10 (0.02)
CD (p=0.05)	0.36 (0.06)	0.28 (0.05)	0.32 (0.06)	0.32 (0.06)	0.21 (0.04)	0.33 (0.05)	0.30 (0.05)

Data in the parenthesis are square root transformed values

In low density polyethylene (LDPE) bags without ventilation (T_1) (8.47%) packed fruits TSS increased up to 21st day of storage while in all the other plastic bags packed fruits it increased up to 14th day of storage. On 42nd day of storage, the maximum TSS (8.91%) was found in (T_1) followed by fruits packed with vacuum packaging (T_6) while, the minimum TSS of 8.03 in fruits packed in plastic punnet (T_7).

The total soluble solids (TSS) of the fruits increased with the advancement of storage in all the treatments. This increase in TSS of fruits might be due to loss of water from the fruits and conversion of polysaccharides to monosaccharides. The present study findings are in agreement with the findings of Kakade (1982), Prasad (1989), Desai (1990) and Badiyala (1992). Reports on increased TSS due to hydrolysis of polysaccharides during storage have been reported in Acid lime by Dhoot*et al*. (1984), Singh et al. (1993), Sharma et al. (1994), Adsule and Tandon (1983), Venkatesha and Reddy (1994), in guava, Singh and Narayana (1995) in mango.

3.2.2. Titratable acidity (%)

Results of titratable acidity during storage in Lime as affected by different treatments have been presented in Table 5. There was a slight increase in titrable acidity on 7th day of storage in all the treatments then after it decreased. On 42th day of storage, maximum titrable acidity of 6.17% was recorded in fruits packed with vacuum packaging (T_6) followed by 5.80 % in fruits packed in plastic punnet (T_7) while minimum in fruits packed in low density Polyethylene (LDPE) bags without ventilation (T_1) as 5.70%.

More reduction in acidity of lime fruits is observed in no packaging fruits due to higher rate of respiration than the fruits sealed in LDPE bags without ventilation. A decrease in titratable acidity may be due to the use of sugar as a substrate in the metabolic process (Bhatia et al., 2013). This result was in agreement with Dhatt et al. (1991) in Kinnow mandarin and Dhatt and Randhawa (1994) in kinnow fruits. In the present study acidity in tray overwrapping cling film packed fruits decreased faster when stored at room temperature, which is in agreement with Gorini and Testoni (1988), Siddiqui and Gupta (1997), in guava; Singh et al. (1989), Tewari et al. (1992), and Angadi and Krishnamurthy (1992), Sonkar and Ladaniya (1998), Gupta et al. (1980), Singh et al. (1988) in Kinnow; Abbas et al. (1990), Baviskar et al. (1995) in ber; Chhattopadhyay and Ghosh (1994) in mango; Tandon and Kalra (1997) in sweet orange; Singh et al. (1987) in grapes; Singhrot et al. (1987), Sharma et al. (1989) in Baramasi lemon and Sujeetha et al. (2020) in pomegranate arils.

3.2.3. TSS/Acid ratio

The observations on TSS/ Acid ratio during storage in Lime as affected by different plastic bags of different thickness has been presented in Table 6 which indicates that the TSS/add

Table 5: Titratable acidity (%) of lime fruits as affected by packaging during different days of storage

Treatments	Days of storage						
	0	7	14	21	28	35	42
T_1	6.58 (2.66)	7.10 (2.76)	6.93 (2.73)	6.67 (2.68)	6.63 (2.67)	6.27 (2.60)	5.70 (2.49)
T_2	6.84 (2.71)	7.27 (2.79)	7.00 (2.74)	6.73 (2.69)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_3	6.79 (2.70)	6.97 (2.73)	6.77 (2.70)	6.53 (2.65)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_4	6.68 (2.68)	6.77 (2.70)	6.47 (2.64)	6.33 (2.61)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_5	7.03 (2.74)	7.17 (2.77)	6.93 (2.73)	6.63 (2.67)	6.53 (2.65)	6.33 (2.61)	0.00 (0.71)
T_6	7.23 (2.78)	7.30 (2.79)	7.17 (2.77)	6.90 (2.72)	6.60 (2.66)	6.37 (2.62)	6.17 (2.58)
T_7	7.10 (2.76)	7.17 (2.77)	6.97 (2.73)	6.67 (2.68)	6.47 (2.64)	6.13 (2.58)	5.80 (2.51)
T_8	6.72 (2.69)	6.80 (2.70)	6.47 (2.64)	6.00 (2.55)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
SEm±	0.13 (0.02)	0.10 (0.02)	0.10 (0.02)	0.10 (0.02)	0.07 (0.01)	0.06 (0.01)	0.05 (0.01)
CD (p=0.05)	0.40 (0.07)	0.30 (0.05)	0.30 (0.06)	0.31 (0.06)	0.21 (0.04)	0.19 (0.04)	0.16 (0.03)

Data in the parenthesis are square root transformed values

ratio increased during the early day of storage but decreases on prolonged storage.

On zero day of storage the ratio range was from 0.92 to 1.05 in all the treatments. On 42[th] days of storage, maximum TSS: acid ratio was observed in fruits packed in low density Polyethylene (LDPE) bags without ventilation (T_1) as 1.50 while minimum in fruits packed in fruits packed with vacuum packaging (T_6) as 1.38 which is statistically at par with fruits packed in plastic punnet (T_7).In the present study results are in confirmation with the findings of Bhushan et al. (2002) in kiwi fruits; Rao and Krishnamurthy (1983) and Chaudhari and Kumbhare (1979) in sweet oranges.

3.2.4. Ascorbic acid

On the 0[th] day of storage ascorbic acid ranged from 48.11 to 40.80 mg 100 ml^{-1}. The data presented in Table 7 indicates the effect of different packaging materials on different days of storage on ascorbic acid content of lime.

Table 6: TSS and acid ratio of lime fruits as affected by packaging during different days of storage

Treatments	Days of storage						
	0	7	14	21	28	35	42
T_1	0.94 (1.20)	1.06 (1.25)	1.17 (1.29)	1.27 (1.33)	1.28 (1.33)	1.24 (1.32)	1.50 (1.41)
T_2	1.01 (1.23)	1.04 (1.24)	1.12 (1.27)	1.25 (1.32)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_3	0.95 (1.20)	1.03 (1.24)	1.10 (1.26)	1.17 (1.29)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_4	1.05 (1.24)	1.10 (1.26)	1.17 (1.29)	1.24 (1.32)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_5	0.92 (1.19)	0.98 (1.22)	1.04 (1.24)	1.13 (1.28)	1.15 (1.28)	1.26 (1.33)	0.00 (0.71)
T_6	0.97 (1.21)	1.06 (1.25)	1.11 (1.27)	1.18 (1.30)	1.21 (1.31)	1.33 (1.35)	1.38 (1.37)
T_7	0.92 (1.19)	0.98 (1.22)	1.03 (1.24)	1.11 (1.27)	1.16 (1.29)	1.29 (1.34)	1.39 (1.37)
T_8	1.01 (1.23)	1.03 (1.24)	1.10 (1.27)	1.23 (1.31)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
SEm±	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.03 (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)
CD (p=0.05)	0.07 (0.03)	0.07 (0.03)	0.07 (0.03)	0.10 (0.04)	0.06 (0.02)	0.05 (0.02)	0.05 (0.02)

Data in the Parenthesis are square root transformed values

The ascorbic acid content of the juice decreased with the increase of storage period in different packaging materials except fruits packed in Low density polyethylene (LDPE) bags with 5% ventilation (T_4) and fruits with no packaging (T_8) in which it increased from 41.32 to 41.34 mg 100 ml^{-1} and 45.75 to 55.30 mg 100 ml^{-1} respectively on 7[th] day of storage then after it decreased. On 42[nd] days of storage, maximum ascorbic acid of 34.50 mg 100 ml^{-1} was found in (T_6) followed by fruits packed in plastic punnet as 32.73 mg 100 ml^{-1} (T_7) while minimum value of 31.26 mg 100 ml^{-1} in fruits packed in Low density polyethylene (LDPE) bags without ventilation (T_1).

Increase in ascorbic acid content during storage may be due to evapotranspirational losses. While the later decrease in ascorbic acid content was due to oxidation and irreversible conversion of L-ascorbic acid to dehydroascorbic acid in the presence of enzyme ascorbinase.

In the present study results are in confirmation with the results of Ahmad et al. (1980) in kinnow fruits; Srivastava et al. (1973) in oranges. On 21[st] day of storage maximum ascorbic acid content was maintained in low density polyethylene (LDPE) bags with 1% ventilation (T_2) and vacuum packaging (T_6) (38.45 - 38.50 mg 100ml^{-1}) packed fruits although all the packed fruits retained more ascorbic acid than the vacuum packaging (T_6) packed fruits.

3.3. Sensory quality

Sensory evaluation was carried out on the basis of external colour, appearance, firmness, odour and overall acceptability of lime fruits. The mean hedonic scores for various sensory parameters are presented in table 9. On 36 days of storage,

Table 7: Ascorbic acid (mg 100 ml^{-1}) of lime fruits as affected by packaging at different days of storage

Treatments	Days of storage						
	0	7	14	21	28	35	42
T_1	48.11 (6.97)	41.76 (6.50)	40.21 (6.38)	37.02 (6.13)	35.71 (6.02)	34.21 (5.89)	31.26 (5.63)
T_2	43.99 (6.67)	41.65 (6.49)	40.05 (6.37)	38.50 (6.24)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_3	42.62 (6.57)	41.93 (6.51)	39.28 (6.31)	36.52 (6.08)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_4	41.32 (6.47)	40.34 (6.39)	38.45 (6.24)	35.81 (6.03)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_5	40.80 (6.43)	40.32 (6.39)	39.17 (6.30)	37.04 (6.13)	34.62 (5.92)	33.61 (5.84)	0.00 (0.71)
T_6	42.19 (6.53)	41.75 (6.50)	41.14 (6.45)	38.45 (6.24)	36.41 (6.07)	35.17 (5.97)	34.50 (5.92)
T_7	42.20 (6.53)	41.80 (6.50)	40.06 (6.37)	38.19 (6.22)	34.98 (5.96)	34.57 (5.92)	32.73 (5.76)
T_8	45.75 (6.80)	55.30 (7.47)	37.26 (6.14)	34.84 (5.94)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
SEm±	0.68 (0.05)	0.60 (0.05)	0.49 (0.04)	0.64 (0.05)	0.56 (0.05)	0.62 (0.05)	0.43 (0.04)
CD (p=0.05)	2.06 (0.15)	1.82 (0.14)	1.47 (0.12)	1.96 (0.16)	1.70 (0.14)	1.89 (0.16)	1.29 (0.11)

Data in the parenthesis are square root transformed values

maximum score for the sensory quality of fruit was recorded in fruits with vacuum packaging (T_6) as 7.20 followed by plastic punnet (T_7) as 5.40 while in rest of the treatments it was disliked (Table 8).

The present study results revealed that vacuum packaging (T_6) and plastic punnet (T_7) lime fruits recorded significantly higher scores in terms of external colour, appearance, firmness, odour and overall acceptability as compared to tray overwrapping with cling film (T_5) lime fruits on both the days of evaluation. In the present study, results are in confirmation with the findings by Jones et al. (1955) and Peryam and Pilgrim (1957) in lime fruits; Srivastava et al. (1973) in orange fruits; Khedkar et al. (1982) and Venkatesha and Reddy (1994) in guava fruits.

Table 8: Sensory quality of lime fruits as affected by packaging at different days of storage

Treat-ments	Days of storage							
	0	6	12	18	24	30	36	42
T_1	9.27 (3.13)	7.87 (2.89)	7.20 (2.77)	6.87 (2.7)	6.73 (2.68)	5.13 (2.37)	3.07 (1.86)	1.41 (1.36)
T_2	8.87 (3.06)	6.60 (2.66)	4.73 (2.28)	1.93 (1.55)	0.13 (0.79)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_3	9.40 (3.15)	5.93 (2.54)	3.60 (2.02)	0.53 (1.00)	0.13 (0.79)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_4	9.13 (3.10)	6.27 (2.60)	2.20 (1.62)	0.33 (0.88)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_5	9.20 (3.11)	7.13 (2.76)	5.80 (2.49)	2.53 (1.72)	0.40 (0.9)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_6	9.20 (3.11)	8.53 (3.00)	8.47 (2.99)	8.47 (2.99)	8.47 (2.99)	8.13 (2.94)	7.20 (2.77)	6.92 (2.72)
T_7	9.40 (3.15)	8.00 (2.92)	7.60 (2.84)	7.53 (2.83)	7.40 (2.80)	6.93 (2.72)	5.40 (2.42)	1.73 (1.49)
T_8	8.80 (3.5)	2.80 (1.80)	1.33 (1.35)	0.33 (0.90)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
SEm±	0.11 (0.02)	0.41 (0.09)	0.55 (0.13)	0.44 (0.12)	0.40 (0.09)	0.32 (0.06)	0.41 (0.09)	0.25 (0.07)
CD (p=0.05)	0.32 (0.05)	1.24 (0.26)	1.68 (0.39)	1.33 (0.35)	1.21 (0.29)	0.97 (0.19)	1.23 (0.28)	0.76 (0.22)

9: Like extremely; 8: Like very much; 7: Like moderately; 6: Like slightly; 5: Neither like not dislike; 4: Dislike slightly; 3: Dislike moderately; 2: Dislike very much; 1: Dislike extremely) Data in the Parenthesis are square root transformed values

4. Conclusion

Acid lime fruit with vacuum packaging was found to be superior in maintaining the quality of fruit with a shelf life of 36–38 days. Vacuum packaging, low density polyethylene (LDPE), bags without ventilation and plastic punnet bags were found to be effective in controlling the physiological loss in weight as well as other physio- chemical parameters, thereby maintaining the quality and extending the shelf life of lime.

5. Acknowledgement

I would want to sincerely thank Dr. Ng. Piloo ma'am, my adviser, for all of her help and support during my research project.

6. References

Anonymous, 1960. Official Methods of Analysis. Association of the Official Analytical Chemists, Washington,D.C.8thEdn. https://archive.org/details/gov.law.aoac.methods.1980/page/n3/mode/2up.

Abbas, M.F., Al-Niami, J.H., Asker, M.A., 1990. The effect of temperature on certain chemical constituents and storage behavior of jujube fruits (*Zizyphusspina-christi* (L) Willd) cv. Zaytoni. Haryana Journal of Horticultural Sciences 19 (3-4), 263–267.

Adsule, P.G., Tandon, D.K., 1983. Assessment of LDPE bags for enhancing shelf life of guava. Indian Food. Packer 37(3), 82–87.

Ahmad, M., Khalid, Z.M., Farooqui, W.A., 1980. Effect of waxing and lining materials on storage life of some citrus fruits [Mandarins]. Proceedings of Florida State Horticultural Society 92, 237–240.

Amerine, M.S., Pangbore, R.M., Rossler, E.A., 1965. Principles of sensory evaluation of food academic Press. New York and London, 235–241,

Angadi, S.G., Krishnamurthy, S., I992. Effect of temperature on storage of coorg mandarins (*Citrus reticulata Blanco*). Punjab Horticultural Journal 32(1–4), 25–33.

Badiyala, S. D., Bargava, J.N., Lakhanpal, S.C., 1992. Variability studies in acid lime (*Citrus aurantifolia Swingle*) strains of Paonta Valley of H.P. Punjab Horticultural Journal 32(1-4), 5–9.

Baviskar, M.R., Waskar, D.P., Kaulgud, S.N., 1995. Effect of various post-harvest treatments on shelf life and quality of ber fruit. Indian Journal of Horticulture 52(1), 37–45.

Bhatia, K., Asrey, R., Jha, S.K., Singh, S., Kannaujia, P.K., 2013. Influence of packaging material on quality characteristics of minimally processed Mridula pomegranate (*Punica granatum*) arils during cold storage. Indian Journal of Agricultural Sciences 83(8), 872–876

Bhushan, S.S., Tripathi, N., Thakur, N.K., 2002. Effect of different modified atmosphere packaging on the quality of kiwi fruit stored at room temperature. Journal of Food Science and Technology 39(3), 279–283.

Bisen, A., Pandey, S.K., 2008. Effect of post harvest treatments on biochemical and organoleptic constitutes of Kagzi lime fruits during storage. Journal of Food Science and Technology 3, 53–56.

Champa, W., Gunasekera, N., Wilson, W.S., Hewajulige, I., Weerasinghe, W., Kumara, B., 2020. Postharvest treatment of cinnamon (*Cinnamomum zeylanicum*) bark oil and hexanal incorporated biowax maintains quality and extends marketable life of lime (*Citrus aurantifolia* Swingle). International Journal of Fruit Science 20, 76–88.

Chaudhari, K.G., Kumbhare, G.B., 1979. Post-harvest life of sweet oranges (*Citrus sinensis*) as influenced by various polythene film packs. Journal of Maharashtra Agricultural Universities 4(2), 228–229.

Chhattopadhyay, N., Ghosh, S.N., 1994. Studies on the storage life of some sweet orange cultivars. Haryana Journal of Horticultural Sciences 23(1), 9–16.

Debaje, P.P., Shinde, E.P., Ingale, H.V., 2011. Effect of plant growth regulators and nutrients on quality of acid lime (*Citrus aurantifolia* Swingle). Asian Journal of Horticulture 6(1), 253–255.

Desai, U.T., 1990. Final report of Ad-hoc scheme for improvement of Kagzi lime by selection. Department of Hort., MPKV, Rahuri submitted to ICAR, New Delhi.

Dhatt, A.S., Randhawa, J.S., Singh, S.N., 1991. Effect of individual seal packaging in high density polyethylene (HDPE) film on storage life and quality of kinnow. The Journal of Plant Science Research 7, 84–85.

Dhoot, L.R., Desai, U., Rane, D.A., 1984. Studies on the shelf life of guava fruits with polyethylene packaging and chemical treatments. Journal of Maharashtra Agricultural Universities 9, 185–188.

Duarte, A.M., Caixeirinho, D., Miguel, M.G., Sustelo, V., Nunes, C., Fernandes, M.M., Marreiros, A., 2010. Organic acids concentration in citrus juice from conventional versus organic farming. In XXVIII International Horticultural Congress on Science and Horticulture for People (IHC2010): International Symposium, pp. 601-606.

Gautam, B., Neeraja, G., 2005. Effect of polythene bag storage on shelf life and quality of Bagnapalli mangoes. The Orissa Journal of Horticulture 33(2), 89–92.

Ghosh, S.P., 1990. Citrus in fruits of India. Tropical and subtropical 2nd edition. Ed by Bose, T.K. Nayaprokash Publications, Calcutta., 162–218.

Gidagiri, P., Jhaleghar, J., Jagadeesh, M.D., Babu, S.L., Meti, S., Padashetti, B., 2020. Studies on Zeolite-LDPE composite bags to extend the shelf life of acid lime fruits stored at ambient conditions. International Journal of Current Microbiology and Applied Sciences 9(2), 2673–2682.

Gorini, F., Testoni, A., 1988. Trial on individual seal packaging of citrus fruits in Italy. *Citriculture* ,31, 1545–1554.

Gupta, O.P., Singh, J.P., Gupta, A.K., 1980. Use of fungicides in oil and wax emulsion to increase the storage life of kinnow fruits. Haryana Agricultural University Journal of Research 10(45), 445–496.

Jadhao, S.D., Waghmode, K.T., Hadole, S.S., Chaudhari, R.D., Gite, P.A., 2012. Studies on storability of kagzi lime as influenced by different gauges and ventilations of packaging material. PKV Research. Journal 36(2), 93–97.

Jones, L.V., Peryam, D.R., Thurstone, L.L., 1955. Development of a scale for measuring soldiers' food preferences. Journal of Food Science, 20(5), 512–520.

Joshua, P., Sathiamoorthy, S., 1993. Storage of sapota fruits in polythene bags. South Indian Horticulture 41, 368–369.

Kakade, N.R., 1982. Survey of superior acid lime (*Citrus* *aurantifolia Swingle*) selections from Nanded district. M.Sc. (Agri.) Thesis, MarathwadaAgril. Uni.,Parbhani, M.S., India. https://krishikosh.egranth.ac.in/items/acc94076-b893-4361-935a-c7c681ba62d2.

Kaufman, J.S., Hardenburg, R.E., Lutz, J.N., 1956. Weight losses and decay of florida and California oranges in open mesh and perforated polythene consumer bags. Proceedings of the American Society for Horticultural Science 67, 244–250.

Khedkar, D.M., Ansarwadkar, K.W. Dabahde, R.S., Ballal, A.L., 1982. Extension of storage life of guava var L-49. Indian Food Packer 36(1), 49–52.

Kohli, R.R., Bhambota, J.R., 1966. Storage of lime (*Citrus aurantifolia*Swingle). Indian Journal of Horticulture, 23(3-4), 240–246.

Ladaniya, M., Marathe, R., Das, A., Rao, C., Huchche, A., Shirgure, P., Murkute, A., 2020. High density planting studies in acid lime (*Citrus aurantifolia* Swingle). Scientia Horticulturae 261, 108935

Mahajan, B.V.C., Singh, G., 2008. Effect of 1-methylcyclopropene (1-MCP) on storage life and quality of winter guava fruits. Journal of Food Science and Technology 45, 537–539.

Mandloi, V., Gurjar, P., Vishvkarma, D., 2021. Flowering and fruiting pattern of acid lime as affected by different growth regulators and chemicals. The Pharma Innovation Journal 10(4), 661–665

Mazumdar, B.C., Majumder, K., 2003. Methods on physico-chemical analysis of fruits. Delhi: Daya publishing house, 93–139.

Nandini, F.P.V., Oommen, B.E., 2002. Quality parameters of selected mango cultivars. Journal of Food Science Technology, (India), 39(4), 379–383.

Peryam, D.R., Pilgrim, F.J., 1957. Hedonic scale method of measuring food preferences. Food Technology 11(9), 9–14.

Prasad, M.B.N.V., 1989. Clonal variability for physico-chemical characters in acid lime South Indian Horticulture 37(2), 71–74.

Prasad, M.S., Lakshmi Prasad, M.S., Singh, A.K., Sharma, Y.P., 1999. Effect of container and fungicidal application on the storage of khasi mandarin. Proc. IntemationalSymp. Citriculture, held at NRC for citrus, Nagpur on Nov., (23-27), 1123–1128.

Ranganna, S., 1986. Handbook of Analysis and Quality control for Fruits Vegetables (Second edition). Tata McGraw-Hill Publishing. Company, limited. New Delhi, 9–10.

Rao, K.P.G., Krishnamurthy, S., 1983. Studies on shelf life of Coorg mandarin (*Citrus reticulata Blanco*). South Indian Horticulturer 31(2-3), 55–61.

Robertson, G.L., 2006. Food packaging principles and practice second edition. Food Scence and Technology, New York-Marcel Dekker, *152*.

Samaradiwakara, S.W., Champa, J., 2019. Eeswara, Harvest maturity afects postharvest quality of lime fruits (*Citrus aurantifolia* Swingle). Tropical Agricultural Research 30, 125–131

Suri, S., Singh, A., Nema, P.K., 2022. Current applications of citrus fruit processing waste: a scientifc outlook. Applied Food Research 2(1), 100050.

Sadasivam, R., Subramanian, T.M., Raman, N.V., 1972. Polythene packages ensure better storage of Sathgudi fruits. Indian Farming 22(1), 32–37.

Sastry, M.V., Krishnamurthy, N., 1975. Studies on Indian Pickles Part IV Physicochemical variations of some important varieties of mangoes. Indian Food Packer 29(3), 55-61.

Sharma, R.K., Kumar, J., Singh, R., Kumar, S., 1994. Shelf life of Guava fruits (*Psidium guajava* L.) as affected by different cushioning materials. Haryana Journal of Horticultural Sciences 23, 114–114.

Sharma, R.K., Singh, R., Kumar, J., Sharma, S.S., 1989. Shelf life of Baramasi Lemon as affected by some chemicals. Res. Dev. Reporter 6(1), 78–82.

Shukla, H.K., 1977. Pre and post-harvest physiology of the mango fruit (*Mangifera indica L. cv* Dashehari). A Ph. D. Thesis, Kanpur University, India. https://shodhganga.inflibnet.ac.in/handle/10603/268827

Siddiqui, S., Gupta, O.P., 1997. Effect of individual fruit wrapping by different materials on the storage life of guava cv. Allahabad Safeda. Haryana Journal of Horticulture Science 26 (1-2), 101–104.

Singh, B.P., Narayana, C.K., 1995. Storage behaviour of 'Dashehari' mango in ventilated poly bags. *I*ndian Food Packer 49(1), 29–31.

Singh, D., Mandal, G., 2006. Post-harvest quality and spoilage of peach fruits stored in perforated polybags. Indian Journal of Horticulture 63(4), 390–392.

Singh, J.P., Singhrot, R.S., Sharma, R.K., Sandooja, J., 1987. A note on comparison of zero energy cool chambers versus room temperature in combination with antifungal fumigants for storage of grapes. Haryana Journal Horticulture 16 (1-2), 92–97.

Singh, K., Mann, S.S., Mohan, C., 1988. Effect of fungicides and wax emulsion on storage of kinnow mandarin at ambient temperature storage condition. Haryana Journal Horticulture 17(1-2), 14–19.

Singh, R., Sharma, R.K., Kumar, J., 1989. Effect of some chemicals on shelf life of kinnow mandarin. Research Developers 6(1), 87–91.

Singh, R.V., Tewari, T.D., Chauhan, B.B.S., 1993. Effect of wax coating and pre-packaging in polythene bag on the storage behaviour of guava *cv.* Allahabad Safeda. Haryana Journal of Horticultural Sciences 22(2), 126–130.

Singhrot, R.S., Sharma, R.K., Sandooja, J.K., Singh, J.P., 1987. Effect of some chemicals to enhance the shelf life of Baramasi Lemon. Haryana Journal of Horticultural Sciences 16(1-2), 25–30.

Sonkar, R.K., Ladaniya, M.S., 1998. Effect of tray-over wrapping by heat shrinkable and stretchable films on Nagpur Mandarin Fruits. Indian Food Packer 52, 22–26.

Srivastava, R.K., Ram, H.B., Singh, V.P., 1973. A note on the storage behaviour of Hill oranges in ventilated polythene bags. Progressive Horticulture 5(1), 66–72.

Sujeetha, A.P., Meenatchi, R., Patricia, P., Negi, A., 2020. Effect of vacuum packaging on quality of pomegranate arils during storage. Current Journal of Applied Science and Technology 39(38), 40–46.

Tandon, D.K., Kalra, S.K., 1997. Ripening of early harvested Dashehari mangoes with ethrel along with polyethylene packaging. Indian Food Packer 51, 11–14.

Teotia, S.S., Tripathi, R.S., Shan, S., 1964. Evaluation of indices for determination of maturity in guava. Horticultutre Advances 1, 99–107.

Tewari, J.D., Singh, R.V., Chauhan, B.B.S., 1992. Physiological study of the storage behaviour of Kinnow Orange as affected by growth regulators and fungicides. Progressive Horticulture 24(1-2), 102–108.

Tripathi, R.S., Gangawar, B.M., 1971. Biochemical changes as indices of maturity in guava. Progressive Horticulture 3(1), 17–23.

Velasco, R., Concetta, L.A., 2014. genealogy of the Citrus family. Nature Biotechnology 32, 640–642.

Venkatesha, M., Reddy, V.T., 1994. Use of polyethylene bags to extend the shelf life of guava (*Psidium guajava* L.) fruits. Indian Food Packer 48(5), 5–9.

