ZIBELINE INTERNATIONAL™ PUBLISHING
ISSN: 2735-0312 (Online)
CODEN: RFAEAW

Reviews In Food And Agriculture (RFNA)

DOI: http://doi.org/10.26480/rfna.02.2022.87.91

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RESEARCH ARTICLE

EFFECT OF DIFFERENT PACKAGING MATERIALS ON POST-HARVEST LIFE OF MANDARIN (*Citrus reticulata* Blanco)

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ARTICLE DETAILS

Article History:

Received 22 June 2022
Accepted 25 July 2022
Available online 02 August 2022

ABSTRACT

Mandarin (*Citrus reticulata* Blanco) is a major fruit crop of Nepal and faces huge post-harvest loss due to inconvenient and unscientific practices in post-harvest. To identify better practices, seven treatments viz no packaging materials (T1), cardboard packaging (T2), newspaper wrapping (T3), plastic packaging without any perforation (T4), plastic packaging with three perforations (T5), plastic packaging with six perforations (T6) and rice straw packaging (T7) replicated three times. The research was evaluated on the color, physiological weight loss, juice content, total soluble solids, pH, and total acidity on the 5th, 10th, and 15th days. The physiological weight loss and juice recovery percentage were only affected whereas other parameters remained unaffected by packaging materials. Plastic packaged with six perforations mandarin accounts lowest weight loss i.e., 8.56%, and the highest juice recovery i.e. 41.07%. To summarize, plastic (20 microns) packaged with six perforations is the best way to enhance the post-harvest life of mandarin among used treatments.

KEYWORDS

Citrus, Physiological weight loss, Handling, Packaging, Plastic.

1. INTRODUCTION

Mandarin (*Citrus reticulata* Blanco) is a most promising fruit crop that stands in the first position in the entire fruit industry in Nepal. It is cultivated in fifty-nine districts of the tropical and sub-tropical region from east to west. In Nepal, mandarin occupies 63.76%, and 14.63% of total citrus production and total fruit production respectively (MOALD, 2022). The country exports mandarin to India, China, Bangladesh, Bhutan, Pakistan, and other countries about 600 tonnes annually (TEPC, 2013). The very long time during transportation and storage is detrimental to mandarin as it is a non-climacteric and perishable fruit. Shelf-life of mandarin fruit is very much short up to 1 to 2 weeks. A huge amount of loss is incurred right after the harvest and gets increases by many folds during the other postharvest steps. Worldwide postharvest loss in fruits and vegetables is as high as 30% - 40% and even much higher in developing countries like Nepal (Bhattarai and Mishra, 2013).

Improper postharvest handling practices lead to inferior fruit quality and fetch a poor market price. In mandarin, a loss of 20% - 25% has been reported during transportation from field to market (PHLRD, 2005). The methods of harvesting, injury to fruit during harvesting, and weather conditions during harvest greatly determine the extent of decay losses during subsequent handling and storage (Ladhaniya, 2008). Losses of mandarin fruits during the harvesting, handling, and marketing are 25% - 30% (Singh, 2001). Generally, mandarin fruits after harvest show great losses and become non-accepted by the consumer in the market. Loss is greatly influenced by improper harvesting, handling, packaging, and transportation. Qualitative loss of quality values, such as caloric and nutritional values, loss of consumer acceptance, and loss of edibility, are more difficult to quantify than the quantitative loss of fresh fruit (Kader, 2005).

In addition to non-adherence to scientific harvesting, handling, transportation, storage, and antimicrobial treatment; poor plant protection practices, and increased pathogen inoculation orchards lead to heavy post-harvest fruit losses (Sonkar et al., 2009). Various viable technologies like the use of fungicides, cold storage, controlled atmosphere storage, anti-transpirants, wax coating, growth retardants, irradiation, and different types of packaging materials, etc. have been used to increase the shelf life of harvested fruits in past decades (Yadav et al., 2010). Postharvest treatments play a significant role in extending the shelf-life of the fruit (Deka et al., 2006). Nepal faces a huge loss of mandarins every year due to the lack of harvesting, transportation, and storage. Hence, to minimize these postharvest losses and to maximize the quantitative and qualitative parameters along with prolongation of storage capacity, postharvest treatments with wax and other safe fungicides are urgent for the effective marketing of mandarin in the country.

2. METHODOLOGY

The experiment was carried out in Jan 2022 at Banke, Nepal to determine the effect of different packaging materials of mandarin on post-harvest status. Mandarin was brought to the laboratory from the retailer's shop in Nepalgunj and checking and rejecting abnormal, diseased, and damaged fruits were done with a kind of sorting and grading manual practices. The mandarins were graded in three categories to ensure each treatment gets the alike types of mandarins. There were a total of seven treatments replicated three times in Completely Randomized Design (CRD). Treatments were no packaging materials (T1), cardboard packaging (T2), newspaper wrapping (T3), plastic packaging without any perforation (T4), plastic packaging with three perforations (T5), plastic packaging with six perforations (T6), and rice straw packaging (T7). Mandarins were

Quick Response Code	Access this article online	
	Website: www.rfna.com.my	**DOI:** 10.26480/rfna.02.2022.87.91

Cite The Article: Bibek Dabargainya, Bikram Acharya, Pooja Acharya (2022). Effect of Different Packaging Materials on Post-Harvest Life of Mandarin (*Citrus Reticulata* Blanco). *Reviews In Food and Agriculture, 3(2): 87-91.*

kept in a room maintained at ambient temperature (18-25°C), and relative humidity (50-85%) for the post-harvest analysis. The temperature and relative humidity of the observation was measured with the help of a thermo-hygrometer. Qualities were observed at 6 days intervals in the observation room (Color, Physiological Weight Loss, Juice Content) and TSS, TA, and pH in the lab.

3. Parameters

3.1 Colors

The color of fruits is based on the sensory evaluation of consumers referred to as Hedonic. A scale of 1- 5 was used to evaluate the color of mandarin.

3.2 Physiological Weight Loss

Weight loss was measured by using the weighing machine. Weights of the undisturbed sample were taken from the first day till the samples were rejected at the interval of 6 days. The weight loss was calculated in percentage using the standard procedure mentioned (AOAC, 2005).

$$Physiological\ Weight\ Loss\ (\%) = \frac{Weight\ of\ the\ first\ interval - Weight\ of\ the\ second\ interval}{Weight\ of\ the\ first\ interval} * 100\%$$

3.3 Juice Content

Juice content of mandarin measured as total juice percentage of individual fruits from disturbing sample measured from cutting fruits horizontally in between. Squeezed with hand or extractor to extract all juice and calculate juice content.

$$Juice\ Percentage(\%) = \frac{Juice\ weight\ per\ fruit}{Individual\ fruit\ weight} * 100\%$$

3.4 Total Soluble Solid (TSS)

The disturbed sample after extracting juice from fruit the juice drop placed in *Refractometer* and presence of sunlight the Brix value noted ranges with 0-32^{0}B, 28-62^{0}B, 56-92^{0}B readings.

3.5 pH

The extracted juice pH was calibrated with the help of a *Digital pH Meter* by dipping it in juice for 30-40 seconds and the readings were noted.

3.6 Total Acidity (TA)

The juice extracted should be enough as 50 ml at least for titration in place of insufficiency water added and noted. 6ml of juice mixed with 44ml of water to make a final volume of 50 ml. The titration of acidic juice with a popular 0.1 N sodium hydroxide (NaOH) base (4gm NaOH in 1 liter of water) till the pH becomes 8.2. The pH meter, phenolphthalein indicator gives typically pinkish used for titration endpoint determination.

$$Acid\ Percentage = \frac{Ml\ of\ NaOH\ used\ *\ 0.1\ N\ NaOH\ *\ Milliequivalent\ factor}{Grams\ of\ sample} * 100\%$$

Milliequivalent factor For Citrus = 0.064

4. Results and Discussions

4.1 Physiological Weight Loss

The treatments showed a significant effect on physiological weight loss in different periods of storage. Treatments with rice straw packaging showed significantly higher physiological weight loss during the entire period of storage. i.e 8.42% on the 5th day, 13.49 % on the 10th day, and 19.78 on the 15th day respectively. Similarly, control treatment (i.e no use of packaging materials) showed significantly lower physiological weight loss during the entire period of storage which was at par with the plastic packaging with six perforations (Rokaya et al., 2020; Bhattarai and Shah, 2017). Physiological weight loss is due to the loss of water by evapotranspiration through stomatal openings (Uddin et al., 2014).

4.2 Hedonic Ranking

None of the treatments had any significant effect on the color of fruits during the entire storage period. Hedonic on color basis value was 4.62 on the 5th day to 2.67 on the 15th day. The maximum value is shown by T6 from 4.667 to 3.667. The minimum value showed by T4 is from 5 to 2. The hedonic value ranged from 5 to 4.33 on the 5th day and 3.667 to 2 on the 15th day. The color appearance on different treatments seems very similar on different dates. Similar results were observed (Bhattaria and Shah, 2017).

4.3 Juice Recovery Percentage

Juice percent about the method of packaging was non-significant on the 5th day and immediately significant appears on15th day; similar observation as found on Pabitra, et al. 2019. The range of juice recovery percent was 34.3 to 31.7% from the 5th to 15th day. The maximum juice percent was recorded with T6 (41.07) and minimum in T1 (24.43) on the 15th day. The value was recorded from 45.67 to 27.6 % on the 5th day and 41.07 to 24.43 % on the 15th day. The decreasing trend of juice recovery percentage during storage might be due to transpiration and respiration processes under ambient conditions (Bhusal, 2002).

4.4 pH of The Juice

None of the treatments had any significant effect on the pH of fruits. The pH ranged from 3.633 to 3.35 on the 5th day and 4.22 to 3.947 on the 15th day. The maximum pH value was shown by T7 i.e. 3.633 to 4.22. The pH value of mandarin fruits was increased gradually with an increase in the time of storage under all treatment. It may be due to the conversion and utilization of different acids in the respiration process (Rokaya, 2017). The minimum pH value was shown by T5 i.e. 3.357 to 3.947 which might be due to the slower process of respiration and utilization of organic acid due to passive Modified Atmosphere Packaging (MAP) (Joshi et al., 2019).

Table 1: Effect of Treatments on Physiological Weight Loss

Particulars	Physiological Weight Loss (%)		
	5DAS	10DAS	15DAS
T1	2.58^d	4.03^c	8.36^e
T2	5.78^c	7.81^b	11.67^d
T3	7.34^{ab}	11.84^a	16.93^b
T4	6.39^{bc}	8.99^b	13.03^c
T5	6.17^{bc}	8.69^b	12.74^c
T6	3.53^d	5.01^c	8.56^e
T7	8.42^a	13.49^a	19.78^a
Grand Mean	5.74	8.55	13.01
SEM (±)	0.42	0.62	0.31
LSD	1.30	1.91	0.95
F- test	***	***	***
CV (%)	12.7	12.6	4.1

Table 2: Effect of Treatment on Organoleptic Properties

Particulars	Hedonic Ranking		
	5DAS	10DAS	15DAS
T1	4.33	3.333	2.333
T2	4.667	3.333	3
T3	4.333	4	2.333
T4	5	4	2
T5	4.667	3	2.667
T6	4.667	4	3.667
T7	4.667	4	2.667
Grand Mean	4.62	3.67	2.67
SEM (±)	0.329	0.337	0.686
LSD	1.015	1.039	2.114
F- test	NS	NS	NS
CV (%)	12.3	15.9	44.6

Table 3: Effect of Treatments on Juice Recovery Percentage

Particulars	Juice Recovery (%)		
	5DAS	10DAS	15DAS
T1	35.43	23.83	24.43^{cd}
T2	39.83	26	24.53^{d}
T3	29.1	27.57	30.9abcd
T4	31.9	30.6	27.6^{bcd}
T5	27.6	28.23	38ab
T6	45.67	34.77	41.07^{a}
T7	30.57	29.3	35.6^{abc}
Grand Mean	34.3	28.6	31.7
SEM (±)	7.35	5.27	3.32
LSD	22.64	16.24	10.22
F- test	NS	NS	*
CV (%)	37.1	31.9	18.1

Table 4: Effect of Treatments on pH of the Juice

Particulars	pH		
	5DAS	10DAS	15DAS
T1	3.603	3.743	4.097
T2	3.503	3.99	4.017
T3	3.35	3.875	3.983
T4	3.503	3.85	4.007
T5	3.357	4.077	3.947
T6	3.603	3.997	3.993
T7	3.633	3.75	4.22
Grand Mean	3.508	3.895	4.038
SEM (±)	0.1522	0.1496	0.1857
LSD	0.4691	0.4609	0.5720
F- test	NS	NS	NS
CV (%)	7.5	6.7	8

4.5 TSS Content

TSS content increased with the storage period in all treatments. TSS was observed from 11.56 to 12.02^{0} Brix value during the storage period. TSS ranges from 11.17^{o} Brix value to 12.5^{o} Brix value on the 5th day and increased from 13.07 to 13.37^{o} Brix value on the 15th day. The increase in TSS content was rapid in T7 which might be due to the untreated rice straw microbial stress accelerating the respiration process (Rokaya et al., 2020). The increased TSS may be attributed to the conversion of starch and other insoluble carbohydrates into soluble solids (Purbiati and Supriyanto, 2013).

4.6 Tritable Acidity (TA)

TA of different treatments was not significant all around the storage period. The percentage of TA declined with time in the storage in all treatments from 0.6823 to 0.6484. The pH was observed from 0.6259 to 0.7403 on the 5th day and 0.602 to 0.6947 on the 15th day. The decline was much higher in treatment in T4. However, maximum TA percent was found in T4. It may be due to the utilization of acid in the tri-carboxylic acid cycle in the respiration process (Rokaya, 2017).

Table 5: Effect of Treatments on TSS Content

Particulars	TSS		
	5DAS	**10DAS**	**15DAS**
T1	11.63	12.67	13.23
T2	11.2	12.13	12.53
T3	11.4	12.67	13.23
T4	11.67	12.73	13.2
T5	12.5	12.83	13.37
T6	11.33	12.93	12.53
T7	11.17	12.57	13.07
Grand Mean	11.56	12.50	12.02
SEM (±)	0.555	0.335	0.292
LSD	1.711	1.033	0.898
F- test	NS	NS	NS
CV (%)	8.3	4.6	3.9

Table 6: Effect of Treatments on TA

Particulars	TA		
	5DAS	**10DAS**	**15DAS**
T1	0.6756	0.6521	0.6277
Cardboard Package	0.7017	0.6803	0.6633
Newspaper Wrapping	0.6259	0.615	0.602
Plastic Package with No Perforation	0.7403	0.7249	0.6947
Plastic Package with Three Perforation	0.6791	0.6631	0.632
Plastic Package with Six Perforation	0.6757	0.6541	0.6373
Rice Straw Package	0.6779	0.6709	0.6505
Grand Mean	0.6823	0.6629	0.6468
SEM (±)	0.02016	0.02094	0.03118
LSD	0.06213	0.06454	0.05672
F- test	NS	NS	NS
CV (%)	5.1	5.5	4.83

5. Conclusion

The physiological weight loss and juice recovery percentage at the last were influenced by various packaging materials whereas other parameters remained unaffected. Among the various packaging materials, control and plastic packaging with six perforations are best for reducing physiological weight loss and maintaining juice recovery percentage. Rice straw packaging resulted worst in reducing physiological weight loss. The color appearance was better in plastic packaging with six perforations during the entire storage period. The maximum pH value of juice was observed in rice straw packaging on the 15th day. TSS during the entire storage period in all treatments increased. TA during the entire storage period in all treatments decreased. To summarize plastic packaging with six perforations is the best way of enhancing the post-harvest life of mandarin.

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