Effect of Post-Harvest Dipping and Various Packaging Materials on Quality Traits of Mandarin (Citrus Reticulata Blanco.)

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DOI: 10.2478/acmy-2019-0007

Abstract:

An experiment was carried out to study the effect of post-harvest dipping and various packaging materials on quality traits of mandarin at the laboratory of Project Implementation Unit (Citrus zone) Udayapur, Katari from January to February 2019. The parameters observed were physiological loss in weight, juice content, titrable acidity, total soluble solids, TSS/TA ratio and shelf life. The packaging materials include individual newspaper wrapping, perforated polyethene and corrugated box. Gibberellic acid with a concentration of 100 ppm was used as a dipping material. The experiment was laid out in Completely Randomized Design (CRD) with 8 treatment replicated 3 times. The result showed that among eight treatments combination, fruits treated with GA3 in combination with perforated polyethene recorded minimum physiological loss in weight (1.99%) and control (19.08%). High retention of juice content (40.30%), total soluble solids(12.83brix) and titrable acidity (0.60%) was recorded in fruits treated with GA3 in combination with perforated polyethene in 24 days of storage. Fruits treated with GA3 in combination with perforated polyethene attained shelf life of 48 days followed by perforated polyethene with a shelf life of 44 days. Finding of the experiment may prove to be helpful in rural area to store mandarin with minimum loss as markets are far from the village.

Keywords: Citrus, gibberellic acid, combination, attributes

1.0. Introduction:

Citrus fruits are grown in subtropics and tropics regions of the world. It is grown commercially in the subtropical region of Nepal. Citrus is widely grown throughout the mid- hills (900-1400 masl) from east to west across the country [1]. 146 countries in the world are producing 139.79 million mt of citrus from the 9.08-million-hectare area in the world [2]. China is the leading country with >24% of the world's total citrus production. In Nepal citrus is grown successfully in more than 55 districts and occupies 20th position in the world's mandarin production [3]. Mandarin alone covers 67% of the total productive area and 64% of the total production [4]. In subtropical regions, citrus fruits are produced distant from consumer markets and often must be stored for the market economy. According to a study conducted, the citrus fruits imported only from India are Mandarin (9,51,100 kg), lime (17,89,110 kg), sweet orange (2,64,095 kg) [5]. Due to the long duration between harvest and consumption, there is postharvest loss due to pathological and physiological diseases. Nearly 20-25% of mandarin fruits are wasted due to faulty postharvest management [6]. At room temperature, the postharvest shelf life of mandarin is 2-3 weeks and fruits sold at this condition leads to huge qualitative and quantitative losses [7]. The postharvest losses can be minimized with the help of the extension of shelf life through lowering and checking the rate of transpiration, respiration, microbial infection and protecting membranes from disorganization.

The application of various chemicals either alone or in combination with different packaging materials may be used for extending post-harvest shelf life of mandarin during storage [8]. Packaging of fruits can result in the creation of a modified atmosphere due to ineffective blockage of the pores within the fruits, reducing respiration rate and improving postharvest quality [9]. There are certain chemicals like PGR, botanical extract etc. which reduce the ethylene production (respiration rate) and growth of micro-organism so as to increase the shelf life of mandarin. Since use or packaging materials in farmers level and in other retail market are new in Udayapur districts. Plant growth regulators like 2-4 D, GA_3 are also used to decrease the fungus infestation. However, the role of these packaging alone or in combination with pre-storage treatment needed much focus on correlating the positive mode of applicability to mandarin. The main objective of this research was to enhance post-harvest life of mandarin by using different packaging materials and post-harvest dipping.

2.0. Materials and Methods

The present research was carried out at laboratory of Project Implementation Unit (Citrus zone) Udayapur, Katari from January to February 2019.

2.1. Selection and harvest of fruits

The fresh mandarin fruits of Khoku variety were selected and harvested by clipper keeping with small pedicel intact of fruit and collected in crates from the orchard.

2.2. Details of the experiment

The experiment was laid out in Completely Randomized Design (CRD). A total of 36 fruits per treatment were divided into equal lots for all three replication and each replication of treatment consists of 12 fruits. The treated fruits were kept for storage and observed at 3 days interval up to 24 days.

2.3. Packaging and dipping for fruits

The packaging materials used in this experiment were Corrugated boxes (27cm × 13cm × 10cm), perforated polyethylene 25-micron LDPE (30cm × 20cm) with a diameter of perforation 5mm (2 in each polyethene), newspaper (30cm×20cm). For the preparation of 100 ppm GA_3 solution, 1g of GA_3 with active ingredient 90% w/w were dissolved in 10 ml of solvent prepared from dissolving solvent crystals in distilled water. Thereafter, 9 liters of distilled water was added to it. Fruits were separately dipped for 5 minutes in GA_3 solution in a bucket. Dipped fruits were dried again under the shed over the newspaper.

Treatments details

T_1	Open	T_5	Individual Newspaper wrapping
T_2	GA3(100ppm)	T_6	GA3(100PPm) + Perforated Plastic Packaging
T_3	Perforated plastic packaging	T_7	GA3(100ppm) + Corrugated Box
T_4	Corrugated Box	T_8	GA3 (100 ppm) + Individual Newspaper wrapping

3.0. OBSERVATION

Observations were recorded in 3 days interval for 24 days. Physical and chemical quality attributes were taken in each three days interval.

3.1. Physical quality attributes

Physiological loss in weight (% loss in weight from the initial weight) and

Juice content (% of juice weight to fruits weight).

3.2. Chemical quality attributes

Total soluble solids (°Brix),

Titrable acidity (%)

TSS: acid ratio

On the basis of the procedure the observation was taken [10]. On the basis of marketable acceptability shelf life (days) was determined. The data pertaining to various parameters were collected at different stages and intervals and tabulated in an Excel sheet for analysis. All routine statistical analysis was carried out using Genstat software 15th Edition. Means were compared using Duncan's Multiple Range Test (DMRT) at 0.05 and 0.01 levels of significance [11].

3.3. Temperature & RH
Temperature and RH was recorded each day during the experimental period using thermo-hygrometer. (18.12 ± 0.97)°C mean temperature and (68.21 ± 1.56) % humidity.

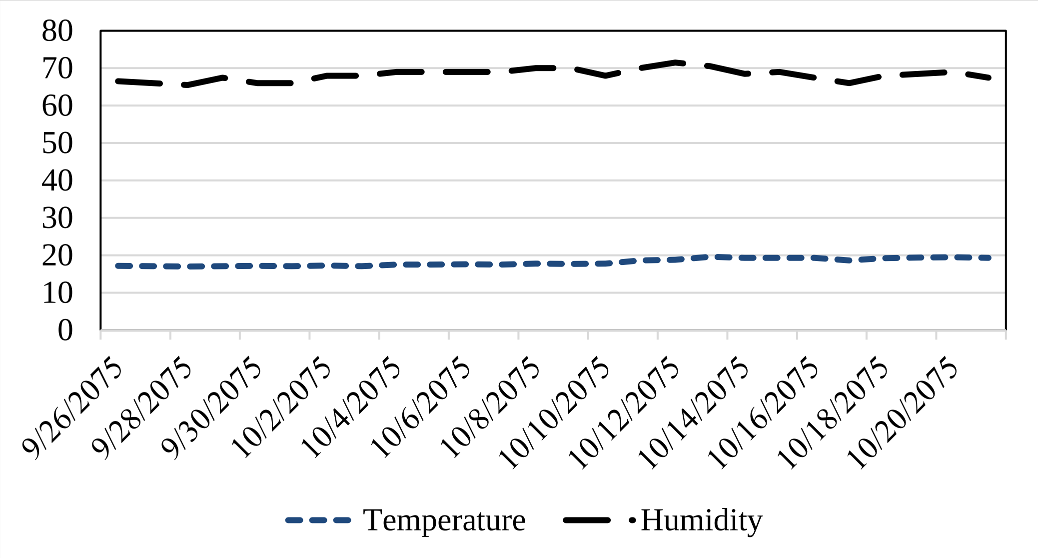

Figure 1: Climatic parameter of experimental lab

4.0. Results and Discussion

4.1. Physiological loss in weight (PLW)
Significant differences existed among different post-harvest treatments for physiological loss in weight with the advancement of the storage period. Fruit treated with GA_3 in combination with Perforated polyethene recorded minimum percentage of PLW during the whole storage period and the losses ranged from 0.24% in 3rd day to 1.99% in 24th day whereas maximum weight loss was recorded in the fruits with untreated as control (3.19% to 19.08%) which was followed by GA_3 treated (2.59% to 16.86%), followed by newspaper wrapping which was statistically at par with the finding of GA_3 in combination with newspaper wrapping is shown in Table 1.

Physiological loss in weight during period of storage is characterized by a reduction in fruit weight by the way of loss of moisture through evaporation and/or transpiration. Physiological loss in weight is the most important parameter because it governs the post-harvest quality of the fruits. Among different post-harvest treatments, GA_3 at 100 ppm in combination with perforated polyethene recorded the lowest PLW followed by perforated polyethene might be due to retardation of transpiration and respiration losses from fruits. A possible explanation for lower PLW in the mandarin fruits obtained in the present study could be that perforated polyethene and corrugated boxes provide better protective cover as compared to newspaper wrapping which perhaps helps in lower PLW of mandarin fruits. These packaging materials might have lowered the temperature surrounding the fruits thereby reducing evapotranspiration of the fruits.GA_3 treatment in combination with perforated polyethene and other packaging material is due to GA_3 reduces the incidence of fungus and thus retaining resistance of fruit to the decay pathogen [12-16].

Table 1: Effect of post-harvest dipping and packaging on physiological weight loss (%) of mandarin fruit during storage at ambient condition (18.12 ± 0.97)°C mean temperature and (68.21 ± 1.56) % RH, Udayapur, Nepal, (2019)

Treatments	The physiological loss in weight (%) on days indicated						
	3 DOS	6 DOS	9 DOS	12 DOS	15 DOS	18DOS	24DOS
Control	3.192^{a}	6.25^{a}	9.03^{a}	11.38^{a}	13.53^{a}	16.16^{a}	19.08^{a}
GA_3(100ppm)	2.592^{b}	5.42^{a}	7.97^{a}	10.29^{a}	12.05^{ab}	14.06^{b}	16.86^{b}
Perforated Polyethene	0.239^{e}	0.47^{d}	0.77^{d}	1.48^{d}	1.90^{e}	2.08^{f}	2.38^{f}
Corrugated Box	2.168^{bc}	4.16^{b}	5.82^{b}	7.13^{b}	8.62^{c}	9.66^{d}	10.69^{d}

Newspaper wrapping (individual)	1.982^{bc}	4.10^{b}	6.21^{b}	8.31^{b}	10.10^{bc}	12.10^{c}	13.76^{c}
GA_3(100ppm) + Perforated Polyethene	0.237^{e}	0.51^{d}	0.56^{d}	1.05^{d}	1.40^{e}	1.76^{f}	1.99^{f}
GA_3(100ppm) + Corrugated Box	1.298^{d}	2.49^{c}	3.51^{c}	4.54^{c}	5.46^{d}	7.15^{e}	8.51^{e}
GA_3(100ppm) + Newspaper wrapping Individual	1.929^{c}	4.31^{b}	6.49^{b}	8.41^{b}	10.24^{bc}	12.16^{c}	13.94^{c}
SEm (±)	0.1947	0.305	0.419	0.505	0.626	0.557	0.519
LSD (=0.05)	0.5837**	0.913**	1.255**	1.513**	1.876**	1.670**	1.556**
CV, %	19.8	15.2	14.4	13.3	13.7	10.3	8.2
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Grand mean	1.704	3.46	5.05	6.57	7.91	9.39	10.90

Means in column followed by common letters is not significantly different at 5% level of significance, Level of significance '**'0.01, '*'0.05, NS=non-significant DOS= Days of Storage, CV= co-efficient of variation, LSD= least significant difference, SEm= standard error of mean.

4.2. Juice content

Table 2 shows that the juice content percentage decreased with the time during the storage in all the treatments but was not significantly lower to 12 days of storage. At 24th days of storage, GA_3 (100 ppm) + Perforated polyethene treated fruits recorded the maximum juice content percentage (40.30%) which was statistically at par with the findings of perforated polyethene followed by GA_3 (100ppm) + newspaper wrapping which was statistically at par with the findings of GA_3 (100ppm) + corrugated box, corrugated box, newspaper wrapping whereas the minimum juice content percentage(32.63%) was observed in control fruits.

The trend of decrease in juice percentage during the storage was might be due to loss of moisture from the surface of the fruits. GA_3 treated fruits with perforated polyethene showed a low reduction in juice content during storage as compared to control or other treatments. This might be due to the fact that polyethene acted as a barrier which had checked the losses of the moisture from the fruit surface. A group researhcers reported higher juice recovery percentage in PE-packed fruits (T10) followed by the fruits with 100% Sta-Fresh 960 (T4) which might be due to less water loss in PE-packaging and waxing treatments as the combination acts as a barrier to moisture loss [17]. GA_3 treatment delay the degradation of starch and also maintain the freshness of peel which lowers the loss of moisture from the peel of citrus result in higher juice content in GA_3 treated fruits [18-20].

Table 2: Effect of post-harvest dipping and packaging on juice recovery (%) of mandarin fruit during storage at ambient condition (18.12 ± 0.97)°C mean temperature and (68.21 ± 1.56) % RH, Udayapur, Nepal, (2019)

Treatments	Juice recovery % of fruit on days indicated						
	3 DOS	6 DOS	9 DOS	12 DOS	15 DOS	18 DOS	24 DOS
Control	40.71	40.54	39.90	37.61	35.90^{c}	33.70^{e}	32.63^{d}
GA_3(100ppm)	39.57	40.91	41.49	38.81	36.65^{bc}	34.26^{e}	34.12^{cd}
Perforated Polyethene	45.05	43.88	42.17	41.02	40.98^{a}	40.40^{ab}	40.02^{a}
Corrugated Box	44.11	42.54	39.90	39.44	38.51^{abc}	37.37^{cd}	35.56^{bc}
Newspaper wrapping (individual)	39.54	40.84	38.92	37.18	37.06^{bc}	36.54^{d}	34.27^{bcd}
GA_3(100ppm) + Perforated Polyethene	44.61	42.29	41.65	41.34	40.90^{a}	40.86^{a}	40.30^{a}
GA_3(100ppm) + Corrugated Box	41.64	40.14	39.83	40.44	39.38^{ab}	38.61^{bc}	35.69^{bc}
GA_3(100ppm) + Newspaper wrapping Individual	40.67	41.75	39.36	38.36	38.37^{abc}	36.96^{cd}	36.67^{b}
SEm (±)	1.688	1.671	1.557	1.495	0.957	0.611	0.755
LSD (=0.05)	NS	NS	NS	NS	2.869*	1.832**	2..263**
CV, %	7.0	7.0	6.7	6.6	4.3	2.8	3.6
P-value	0.154	0.780	0.755	0.459	0.012	<0.001	<0.001
Grand mean	41.99	41.61	40.40	39.19	38.47	37.34	36.16

Means in column followed by common letters is not significantly different at 5% level of significance, Level of significance '**'0.01, '*'0.05, NS=non-significant DOS= Days of Storage, CV= co-efficient of variation, LSD= least significant difference, SEm= standard error of means

4.3. Total Soluble Solids (TSS)

Table 3. shows the increasing trend is higher in untreated (control), GA_3 treated and newspaper wrapping than the fruits with perforated polyethene packaging. Fruits which are untreated showed the maximum TSS content during the storage period and ranged from 11.60°brix during 3rd day to 14.20°brix during 24th day which was statistically at par with GA_3 treated fruits and minimum TSS content was recorded in the fruits treated with GA_3 in combination with perforated polyethene packaging. In control, TSS was increased at a faster pace, this might be due to faster metabolic activities through respiration and transpiration than in the other treatment's combination. The increase in TSS with the advancement of storage may be accounted to the moisture loss, hydrolysis of polysaccharides and concentration of juice as a result of dehydration [21].

Table 3: Effect of post-harvest dipping and packaging on total soluble solids (TSS) of mandarin fruit during storage at ambient condition (18.12 ± 0.97)°C mean temperature and (68.21 ± 1.56) % RH, Udayapur, Nepal, (2019)

Treatments	TSS of fruits on days indicated						
	3DOS	6DOS	9DOS	12DOS	15DOS	18DOS	24DOS
Control	11.60	11.93	12.27	12.93	13.07	13.70^{a}	14.20^{a}
GA_3(100ppm)	11.53	11.53	11.87	12.80	12.90	13.60^{a}	13.73^{ab}
Perforated Polyethene	11.13	11.60	12.10	12.07	12.40	12.67^{bc}	13.26^{bc}
Corrugated Box	11.33	11.80	11.90	12.30	12.57	13.40^{ab}	13.76^{ab}
Newspaper wrapping (individual)	11.43	11.33	12.03	12.73	12.53	13.07^{abc}	13.67^{ab}
GA_3(100ppm) + Perforated Polyethene	10.67	11.47	11.73	11.90	12.13	12.33^{c}	12.83^{c}
GA_3(100ppm) + Corrugated Box	11.67	11.63	11.83	12.80	12.87	12.93^{abc}	13.36^{bc}
GA_3(100ppm) + Newspaper wrapping (Individual)	11.53	12.10	12.00	12.73	12.80	12.87^{abc}	13.50^{abc}
SEm (±)	0.579	0.353	0.527	0.378	0.2333	0.267	0.233
LSD (=0.05)	NS	NS	NS	NS	NS	0.8018*	0.6977*
CV, %	8.8	5.2	7.6	5.2	3.2	3.5	3
P-value	0.934	0.809	0.997	0.46	0.175	0.029	0.032
Grand mean	11.36	11.68	11.97	12.50	12.658	13.071	13.542

Means in column followed by common letters is not significantly different at 5% level of significance, Level of significance '**'0.01, '*'0.05, NS=non-significant DOS= Days of Storage, CV= co-efficient of variation, LSD= least significant difference, SEm= standard error of means.

4.4. Titrable Acidity

As data presented in Table 4, the TA was significantly decreased from 18 days of storage. Higher acidity was recorded in the fruits treated with GA_3 in combination with perforated polyethene packaging which was 0.69 on 3rd day of storage and 0.60 on 24th day of storage period whereas there was a significant decrease in the titrable acidity content of the fruits left untreated which was 0.68 on 3rd days of storage and 0.52 on 24th day of storage period. The decreasing trend of titrable acidity during the storage period probably due to the utilization of acid in the tricarboxylic acid cycle in the respiration process. On 24th days of storage higher acidity was in the fruit treated with GA_3 in combination with perforated polyethene packaging which was significantly at par with the finding of perforated polyethene, GA_3 in combination with corrugated box [22,23].

Table 4: Effect of post-harvest dipping and packaging on titrable acidity (TA) of mandarin fruit during storage at ambient condition (18.12 ± 0.97)°C mean temperature and (68.21 ± 1.56) % RH, Udayapur, Nepal, (2019)

Treatments	Titrable acidity (%) on days indicated						
	3DOS	6DOS	9DOS	12DOS	15DOS	18DOS	24DOS
Control	0.68	0.64	0.60	0.57	0.57	0.55^{c}	0.52^{d}
GA_3(100ppm)	0.69	0.65	0.62	0.60	0.58	0.56^{bc}	0.54^{cd}
Perforated Polyethene	0.69	0.68	0.66	0.64	0.61	0.59^{a}	0.58^{abc}
Corrugated Box	0.70	0.66	0.61	0.61	0.59	0.58^{ab}	0.56^{bcd}
Newspaper wrapping (individual)	0.69	0.65	0.60	0.60	0.58	0.57^{abc}	0.55^{bcd}
GA_3(100ppm) + Perforated Polyethene	0.69	0.69	0.67	0.66	0.62	0.60^{a}	0.60^{a}
GA_3(100ppm) + Corrugated Box	0.69	0.66	0.61	0.62	0.59	0.58^{ab}	0.58^{ab}

GA_3(100ppm) + Newspaper wrapping Individual	0.70	0.66	0.61	0.61	0.58	0.58[ab]	0.57[abc]
SEm (±)	0.0179	0.013	0.0178	0.0209	0.01197	0.01037	0.0120
LSD (=0.05)	NS	NS	NS	NS	NS	0.03109*	0.0361*
CV, %	4.5	3.5	4.9	5.9	3.5	3.1	3.7
P-value	0.99	0.116	0.062	0.209	0.141	0.028	0.005
Grand mean	0.69	0.66	0.62	0.61	0.59	0.58	0.56

Means in column followed by common letters is not significantly different at 5% level of significance, Level of significance '**'0.01, '*'0.05, NS=non-significant DOS= Days of Storage, CV= co-efficient of variation, LSD= least significant difference, SEm= standard error of means

4.5. TSS: TA ratio

TSS: TA ratio of mandarin fruit as influenced by a different combination of treatments is depicted in Table 5. The effect of treatment was significant with respect to TSS: TA ratio. At the beginning of the storage period from 3rd day to 12th day no significant differences were observed among the treatments. From 12th to 24th day of storage significant differences among the treatments were observed. On the 24th day of storage, the significantly maximum ratio was observed with untreated fruits (27.20) while the minimum ratio was observed with GA_3 treated fruits in combination with perforated polyethene packaging (21.27).

Table 5: Effect of post-harvest dipping and packaging on TSS/TA ratio of mandarin fruit during storage at ambient condition (18.12 ± 0.97)°C mean temperature and (68.21 ± 1.56) % RH, Udayapur, Nepal, (2019)

Treatments	TSS/TA on days indicated						
	3DOS	6DOS	9DOS	12DOS	15DOS	18DOS	24DOS
Control	17.02	18.71	20.46	22.68[a]	23.14[a]	24.89[a]	27.20[a]
GA_3(100ppm)	16.44	17.85	19.30	21.24[ab]	22.17[ab]	24.42[ab]	25.37[ab]
Perforated Polyethene	16.10	16.93	18.31	18.82[bc]	20.05[cd]	20.91[de]	22.46[cd]
Corrugated Box	16.09	17.86	19.39	20.32[abc]	21.12[bcd]	23.09[bc]	24.55[bc]
Newspaper wrapping (individual)	16.60	17.31	19.94	21.08[ab]	21.13[bcd]	22.94[c]	25.07[b]
GA_3(100ppm) + Perforated Polyethene	15.40	16.53	17.42	18.05[c]	19.49[d]	20.29[e]	21.27[d]
GA_3(100ppm) + Corrugated Box	16.98	17.62	19.25	20.76[abc]	21.31[bc]	22.05[cd]	22.87[cd]
GA_3(100ppm) + Newspaper wrapping Individual	16.57	18.30	19.86	20.31[abc]	21.90[ab]	22.36[cd]	23.84[bc]
SEm (±)	0.798	0.623	0.862	0.876	0.536	0.465	0.674
LSD (=0.05)	NS	NS	NS	2.625*	1.606**	1.394**	2.021**
CV, %	8.4	6.1	7.8	7.4	4.4	3.6	4.8
P-value	0.861	0.313	0.330	0.047	0.005	<0.001	<0.001
Grand mean	16.40	17.64	19.24	20.41	21.29	22.62	24.08

Means in column followed by common letters is not significantly different at 5% level of significance, Level of significance '**'0.01, '*'0.05, NS=non-significant DOS= Days of Storage, CV= co-efficient of variation, LSD= least significant difference, SEm= standard error of means

4.6. Shelf life (no of days)

Treatments	**Storability (Days)**
Control	26
GA3(100ppm)	27
Perforated Polyethene	44
Corrugated Box	42
Newspaper wrapping (individual)	35
GA3(100ppm) + Perforated Polyethene	48
GA3(100ppm) + Corrugated Box	43
GA3(100ppm) + Newspaper wrapping Individual	37

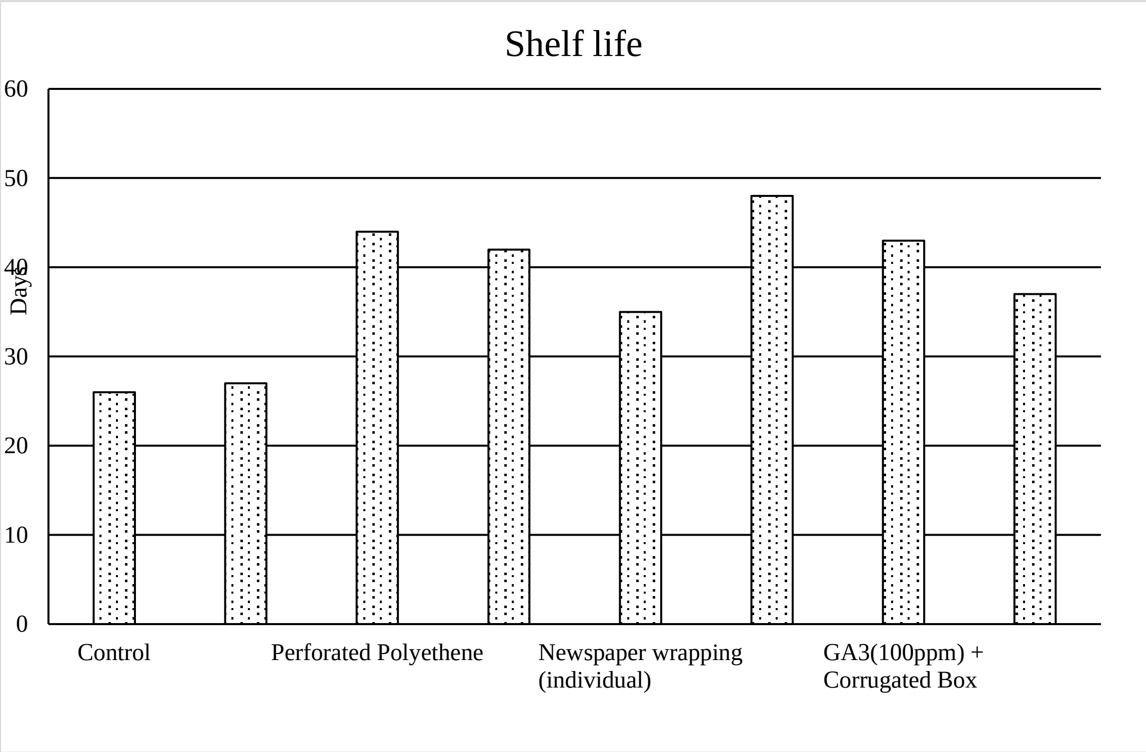

Figure 2: Shelf life of mandarin fruits as influence by different post-harvest treatment combination

5.0. Conclusion

Among the eight treatments combination, fruits treated with GA_3(100 ppm) in combination with perforated polyethene recorded minimum physiological loss in weight, high retention of Total soluble solids, titrable acidity and juice content. Fruits treated with GA_3(100 ppm) in combination with perforated polyethene attained shelf life of 48 days followed by perforated polyethene with a shelf life of 44 days. Hence fruits after harvest can be treated with GA_3 (100 ppm) and packed in perforated polyethene to control post-harvest loss and retain post-harvest attributes. In the light of experience gained during the course of investigation and results obtained, investigations are further needed with various dipping materials, plant growth regulators, botanical extracts and other commonly used packaging materials to enhance shelf life and retain quality traits.

6.0. Acknowledgements

The research was conducted as a part of Learning for Entrepreneurial experience supported by Prime Minister Agriculture Modernization Project. The author is thankful to all supervising committee, Project Implementation Unit (Citrus Zone), Udayapur and Agriculture and Forestry University, Rampur, Chitwan.

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