Pak. J. Agri. Sci., Vol. 57(2), 361-369; 2020
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
DOI: 10.21162/PAKJAS/20.9232
http://www.pakjas.com.pk

COMPARISON OF PLANT EXTRACTS AND COMMERCIAL FUNGICIDE TO REDUCE THE FRUIT DECAY AND MAINTAIN THE QUALITY OF KINNOW FRUIT DURING COLD STORAGE

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The Kinnow is the extensively cultivated variety of citrus fruit and a common name of mandarin (*Citrus reticulate* L.) in Pakistan. Being a non-climacteric fruit, it keeps low storage life even in cold storage, because some physiochemical changes may lose its quality. The current study was planned to check the efficacy of plant extracts in comparison with commercial fungicide to enhance the storage life of Kinnow mandarin. Findings regarding the comparison of plant extracts and fungicide (Thiabendazole) indicated that 60% *Aloe vera* extract showed similar results as synthetic fungicide (TBZ) and controlled fruit decay up to 6.25%. The fruits of same treatment also showed better biochemical characteristics of fruit quality after storage of 90 days. The minimum changes in juice weight, TSS, titratable acidity and ascorbic acid were recorded in *Aloe vera* extract treated fruits. Fruits coated with 60% *Aloe vera* extract also maintained higher levels of total phenolic (225.7 mg GAE $100g^{-1}$), antioxidant (76.3%) and enzyme activities of catalase (19.1 mg^{-1} protein), peroxidase (0.80 mg^{-1} protein), and superoxide dismutase (130.4 mg^{-1} protein) during storage. It was evaluated that 60% *Aloe vera* extract proved valuable for long term storage of Kinnow mandarin and to minimize the rotting of fruit during storage and
its performance was almost at par to commercial fungicide and maintained the fruit quality related parameters. Hence it can be recommended to overcome the storage issues of Kinnow fruits.
Keywords: *Aloe vera*, fruit decay, storage life, total phenolic contents, kinnow.

INTRODUCTION

The Kinnow is the extensively cultivated variety of citrus fruit and a common name of mandarin (*Citrus reticulate* L.) in Pakistan. The Kinnow grown in this region is a result of cross between King *Citrus nobilis* Lour and *Citrus deliciosa* Tenora of Riverside California and is the principal citrus commercial cultivar. In Pakistan, Kinnow export increased tremendously in2017-18 and touched a record of 370,000 tons compared to the previous year (TDAP, 2018).

Currently 187 varieties of citrus are commercially available in Pakistan and Kinnow is one of the favorite among these citrus varieties. Based on nutritional value, Kinnow possesses enormous quantity of vitamin C, mono and disaccharide sugars, minerals, folate comprising of considerable amount of Calcium and Magnesium (Arowora *et al*., 2013; Singh *et al*., 2018) and also contains some phytochemicals like monoterpenes, flavonoids and hydroxycinnamic acid and antioxidant activity which is effective in lowering the risk of cardiovascular diseases, cancer and cataracts (Razzaghi-Asl *et al*., 2013). Kinnow is cultivated at approximately 60% of the total citrus area (Mustafa and Ahmad, 2006). Inadequate availability of suitable postharvest management approaches, Limited cold chain facilities, unsatisfactory packing houses, and conventionally passive marketing system are the triggering factors of post-harvest losses of Kinnow (Hand *et al*., 2005; Adetunji *et al*.,2013;). Among the various approaches applied to enhance the shelf life of fruits, utilization of edible coating (wax, oil, extracts) to fruit has attained a considerable attention worldwide in these days (Tietel *et al*., 2010; Khan *et al*., 2015). For the formulation of comestible films and coatings, different kinds of materials are practiced having very indispensable features (Sindhu and Singhrot, 2016). A number of plants have recognized and classified by Grainge *et al.* (1984) which possess fungicidal and growth regulating properties, as well as some plants such as neem (*Azadirachta indica*L.), lantana (*Lantana camara* L.) and melia (*Melia azedarach*L.). Commonly, neem based products are present in market because of its active substance "azadirachtin" which has insecticidal and fungicidal properties (Schmutters, 1990). Moreover, neem leaves, fruits and bark have enormous pharmacological properties like anti-ulcer, anti-fungal, anti-bacterial, and pesticide (Biswas *et al*., 2002). Leaf extract of neem was found to be effective to control the fruit rot control in tomato and maintained the postharvest shelf life and quality during storage (Zakki *et al*.,2017).

Aloe vera is a natural product having no taste which is safe and also environment friendly as the alternate for the synthetic preservative. It is used in numerous cases as prevention tool

to manage fruit decay as its gel based edible coatings used to avert the respiration rate, delay oxidative browning, moisture loss and firmness. Owing to presence of numerous complex ingredients (enzymes, amino acids, hormones, salicylic acid, phenolic compounds, glycoproteins and polysaccharides) it is considered as a beneficial plant (Serrano *et al*., 2006). These ingredients possess the antifungal properties (Nidiry *et al*., 2011). A number of authors have stated the application and benefits of *Aloe vera* gel for the sustainable storage of various fruits and vegetables (Valverde *et al*., 2005). Hence *Aloe vera* reduces the proliferation of various insects, pests and microorganisms in fruits and vegetables (Castillo *et al*., 2010).

In Pakistan the use of fungicide is very common to control postharvest diseases but unfortunately, the application of non-chemical techniques are being ignored which can prevent the harmful consequences for human health. The use of chemicals has been discouraged to control the losses of fruits worldwide as there is emergence of concepts regarding food safety in the postharvest supply chain. The import of food commodities with chemical residues has been banned by numerous countries (Khalid *et al*., 2012).

The National standards fixed maximum residual limit (MRL) on fruits' exports which exceeds this limit would be rejected by importers (Pesticide Action Network, 1998). Citrus industry is facing the challenge to maintain the quality of fruit with minimum chemical residues. The plant extract and organic nature mineral oil is the best alternate to control the pre and postharvest disease for the fruits across the world.

In view of contemporary scenario of high priced fungicide and to reduce postharvest losses, the current investigation was planned to ascertain the best local plant extract to sustain the quality and storage life of Kinnow fruits.

MATERIALS AND METHODS

The current study was planned to assess the effectiveness of plant extracts to increase the consumption period of Kinnow and all the experimentations were carried out at Postgraduate Pomology Laboratory (PPL) University of Agriculture, Faisalabad (UAF) during 2015-2016. Physiologically matured Kinnow fruits were picked from Experimental Fruit Orchard, located in UAF. The fruits were brought to PPL and were graded to get rid of unhealthy or bruised ones. The fruits were cleaned up in tap water and dried under fan. All treatments (coating materials and storage days intervals) were evaluated under CRD factorial. Different plant extracts were compared with commercial fungicide as Control, 60% *Aloe vera* extract, TBZ Commercial (Thiabendazole) Fungicide and 40% Neem extract. Twenty fruits of Kinnow mandarin were used and each treatment was replicated four times. Fruits were dipped in plant extracts and commercial fungicide (TBZ). Treated Kinnow fruits were placed in cold storage at 5˚C and 85% RH for the time period of 90 days and quality parameters were studied up to 3 months (by keeping equal intervals of 15 days).

***Preparation of Aloe vera and Neem Extract*:** *Aloe vera* gel was collected from its leaves by peeling it off and this colorless *hydro parenchyma* was blended in a blender. Collected fresh leaves of neem were dried in shade and then grinded in an electric blender. Grinded powdered was soaked in an equal quantity of water and kept for overnight.

***Physical and physiological characteristics*:** Fruits samples were weighed before storage with consecutive interval of 15 days until the end of whole storage. The fruit parameters were calculated by using following formula.

$$\text{Fruit Rot (\%)} = \frac{\text{Spoiled fruits}}{\text{Total fruits}} \times 100$$

Weight loss (%)

$$= \frac{\text{Initial weight of fruit-final weight of fruit}}{\text{Initial weight of fruit}} \times 100$$

Peel weight (g)

The fruits of Kinnow were manually peeled off and digital weight balance was used to weigh the peel. Weight of peel was measured in grams (g).

$$\text{Juice content (\%)} = \frac{\text{Average juice weight}}{\text{Average fruit weight}} \times 100$$

***Physiochemical characteristics of juice*:**

$$\text{TA \%} = \frac{\text{0.1 N NaOH} \times 0.0064 \times 100 \text{ ml juice used}}{\text{ml juice used}}$$

Ascorbic acid: Juice contents regarding ascorbic acid were found following the procedure as described by AOAC (2000). A known quantity of juice (10 ml) was poured into 100 ml volumetric flask and final volume was prepared by adding 0.4% oxalic acid solution. Five ml filtrated aliquot was taken from the volume, and titrated against 2, 6-dicholorophenolindophenol until the end point (light pink color). Ascorbic acid formula

$$\text{Ascorbic acid (mg 100 g}^{-1}) = \frac{1 \times R1 \times V \times 100}{R \times W \times V1}$$

***Total phenolic and total antioxidants*:** The results regarding total Phenolic (mg GAE $100g^{-1}$) were recorded using spectrophotometer at wavelength of 765 nm and 517 nm (Ainsworth and Gillespie, 2007).

***Enzymes assay*:** Frozen juice was used to estimate the enzymatic activities of POD, CAT an SOD after homogenization using phosphate buffer. The enzyme extracts were prepared and readings were recorded at spectrophotometer at 240 nm. The activity of enzyme was demonstrated as U mg^{-1} protein (Liu *et al*., 2008).

***Statistical analysis*:** The recorded data were subjected to statistical analysis of variance using two way ANOVA to examine the overall significant data, whereas the least significant difference test ($P \leq 0.05$) was performed for the comparison of means (treatments and storage periods) (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Physical and physiological characteristics

***Weight loss (%)*:** It was quite clear from the findings of the experiment that constant increased weight loss was assessed with storage time. Estimation of weight loss when computed during 90 days of storage depicted that about 1.82-folds lower weight loss was calculated in fruits treated with 60% *Aloe vera* extract in comparison with untreated fruits. Fig.1 showed that weight loss was less(1.87-fold) in 60% *Aloe vera* extract treated fruit when tested during 90 days of storage where weight loss was maximum3.36-fold during 90 days of storage period. Interaction indicated maximum weight loss (22.50%) in control treatment after 90 days as compared to TBZ (13.15%) and 60% *Aloe vera* extract (12.40%). From the interaction, minimum weight loss reduction was found in 60% *Aloe vera* extract treated fruit during 90 days of storage of fruits while untreated fruit showed high weight loss from 15-90 days storage period (Fig.1).

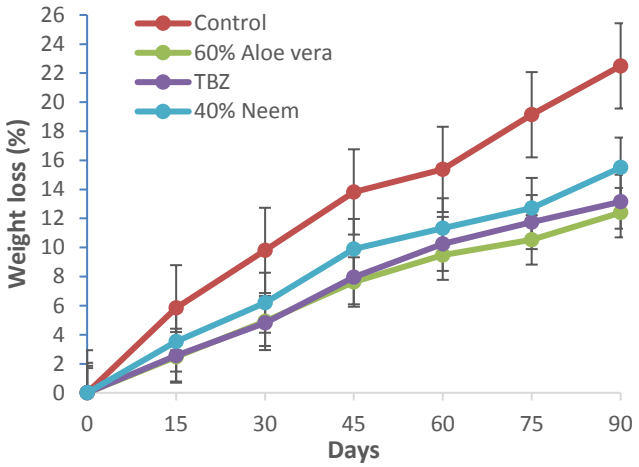

Figure 1. Effect of plant extracts and fungicide on weight loss (%) of 'Kinnow' fruits stored at 5ºC.

***Fruit rot (%)*:** The combined effect of corresponding treatments and storage duration exhibited substantially valid outcomes. The control fruit showed the maximum fruit rot (8.58%) as compared to Kinnow treated with TBZ having minimum (1.81%) and *Aloe vera* extract 60% (2.09%) during cold storage of 90 days. Interaction showed maximum fruit rot (17.50%) in control treatments after ninety days duration followed by the treatment of 40% neem extract coating (9.50), TBZ (5.50%) and *Aloe vera* extract 60% (6.25%). Control treatments had swift increase in fruit rot (%) after 45 days while *Aloe vera* extract coating treatment had maximum decay during 90 days. *Aloe vera* extract 60% indicated 0% decay when assessed at 30 days storage while control fruit showed 5.50% decay at the same period. Moreover 60% *Aloe vera* extract showed similar results as TBZ after 90 days storage (Fig.2).

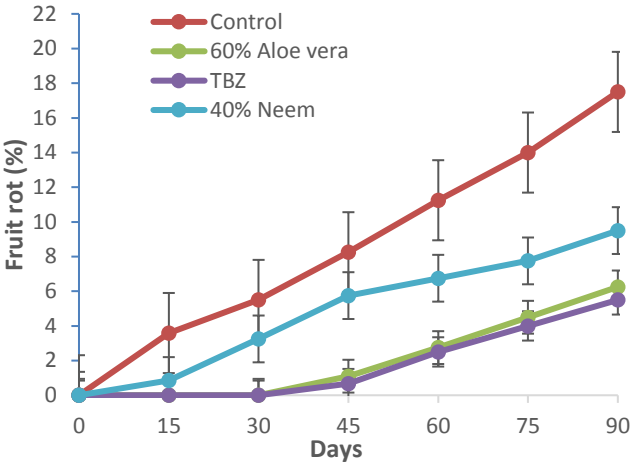

Figure 2. Effect of plant extracts and fungicide on fruit rot (%) of 'Kinnow' fruits stored at 5ºC.

***Peel weight (g)*:** The untreated fruit showed the minimum peel weight (41.46 g) as compared to the Kinnow treated with 60% *Aloe vera* extract having highest (48.41 g) peel weight followed by fruit treated with TBZ and 40% neem extract where peel weight was (48.37 g) and (47.38 g), respectively after 90 days storage. The peel weight was minimum (38.56 g) when Kinnow fruit were tested after 90 days whereas when fruits were examined at 15 days, peel weight was the maximum i.e. (50.63 g). Interaction of treatment and storage period showed that control fruit had a rapid decrease during 30-90 days of storage period while *Aloe vera* extract 60% exhibit gradual decrease till 90 days storage. Mean peel weight was about 1.53-folds higher in fruit treated with 60% *Aloe vera* extract than control after 90 days of storage (Table 1).

Table 1. Effect of plant extract and fungicide on peel weight (g) of 'Kinnow' fruits stored at 5ºC.

Treatments	Storage duration (Days)							
	0	15	30	45	60	75	90	Mean
Control	52.30 a	49.80de	47.28 h	42.50 l	37.75 n	32.48 o	28.13 p	41.46C
60% *Aloe vera* extract	52.30 a	51.00 b	50.70bc	49.00 f	47.85gh	45.05 j	43.00 l	48.41A
TBZ	52.30 a	51.13 b	50.20cd	49.10ef	47.90gh	45.13 j	42.85 l	48.37A
40% Neem extract	52.30 a	50.60bc	49.78de	48.50fg	46.33i	43.85 k	40.28 m	47.38B
Mean	52.30A	50.63B	49.49C	47.28D	44.96E	41.63F	38.56G	

LSD value ($p \leq 0.05$) for treatments = 0.28, storage days = 0.36 and interaction = 0.73

***Juice content (%)*:** Results revealed 1.21-folds higher juice weight in fruit treated with 60% *Aloe vera* extract treated fruits than untreated fruits. The juice weight was minimum (39.18 %) when Kinnow fruits were tested after 90 days of storage whereas juice weight was the highest (53.20 %) after storage of 15 days. Conjunctive impact of corresponding treatments and storage duration exhibited that during initial 45 days a minimum decline in Kinnow juice was found when Kinnow treated with *Aloe vera* extract, however a rapid and abrupt decrease in juice was seen during a duration of 60-90 days. The60% *Aloe vera* extract treated fruits showed maximum juice weight (43.78) followed by TBZ (43.48), 40% neem extract (42.23) and control treatments (27.23) after 90 days storage (Table 2).

Bio-chemical characteristics

***Total soluble solids (°Brix)*:** It was observed that 60% *Aloe vera* extract treated fruits showed 1.07-fold lower total soluble solid contents than control fruits. The soluble solid contents were maximum (11.96) when Kinnow tested on 90 days of storage whereas soluble solid contents were minimum i.e. (9.71) when Kinnow fruits were examined after 15 days of storage. Combined and interactive impact of various coating practices and storage duration demonstrated that untreated fruits had an immediate increase in TSS after 30 days of storage however; *Aloe vera* and other coatings showed maximum increase during 75-90 days of storage. Interaction showed maximum TSS (13.05) in control treatments followed by 40% neem extract (11.70), TBZ (11.60) and *Aloe vera* extract 60% (11.50) (Table 3).

***Titratable acidity (%)*:** The critical and statistical computation of data (P≤0.05) exhibited that titratable acidity (TA)was significantly affected with the interactive response of various treatments and storage duration. Results revealed that during storage period of 90 days 1.14-folds higher titratable acidity was found when fruits were treated with 60% *Aloe vera* extract than untreated fruits. The titratable acidity in Kinnow decreased with the storage period**.** An opposite relation was found between TA of fruit during storage. Interaction showed that 60% *Aloe vera* performed better and maintains maximum TA during storage in contrast to other treatments. Highest titratable acidity was observed in fruit treated with *Aloe vera* extract 60% (0.93) followed by the treatments of TBZ (0.92), 40% neem extract (0.89) and control treatment (0.70) after 90 days of storage (Fig.3).

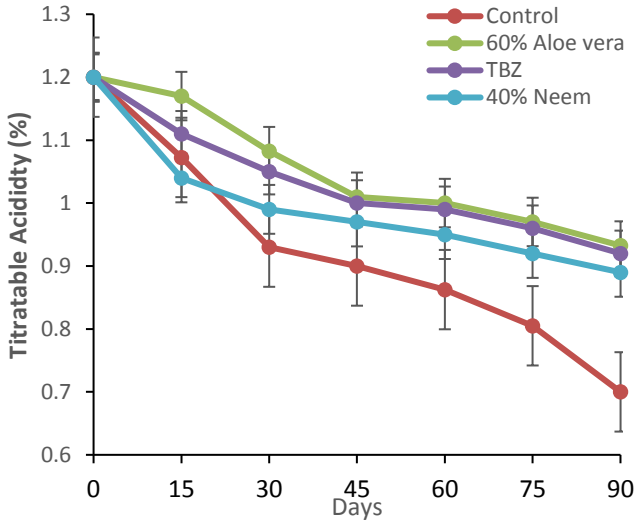

Figure 3. Effect of plant extracts and fungicide on titratable acidity (%) of 'Kinnow' fruits stored at 5ºC.

***Vitamin C (mg 100 g^{-1})*:** A glimpse of the Fig.4 depicted a substantial decreased Vitamin C content when various corresponding treatments and storage durations were

Table 2. Effect of different plant extracts and fungicide on juice content (%) of 'Kinnow' fruits stored at 5ºC.

Treatments	Storage duration (days)							
	0	15	30	45	60	75	90	Mean
Control	55.40 a	52.30de	47.85i	41.25 o	34.48 p	31.40 q	27.23 r	41.41C
60% *Aloe vera* extract	55.40 a	53.80 b	52.10 e	50.70 f	49.00gh	46.10 k	43.78 m	50.13A
TBZ	55.40 a	53.70bc	51.70 e	50.20 f	48.90gh	45.78 k	43.48 m	49.88A
40% Neem extract	55.40 a	53.00cd	49.40 g	48.28 hi	47.00 j	44.83 l	42.23 n	48.59B
Mean	55.40A	53.20B	50.26C	47.61D	44.84E	42.03F	39.18G	

LSD value ($p \leq 0.05$) for treatments = 0.28, storage days = 0.38 and interaction = 0.76

Table 3. Effect of plant extracts and fungicide on TSS (°Brix) of 'Kinnow' fruits stored at 5ºC.

Treatments	Storage duration (days)							
	0	15	30	45	60	75	90	Mean
Control	9.20 n	9.90jklm	10.63ghi	11.00efg	11.60 c	12.40 b	13.05 a	11.11A
60% *Aloe vera* extract	9.20 n	9.50mn	10.00jkl	10.30hij	10.60ghi	11.00efg	11.50cd	10.30C
TBZ	9.20 n	9.63lmn	10.20ijk	10.30hij	10.70fgh	11.10def	11.60 c	10.39C
40% Neem extract	9.20 n	9.80klm	10.23ijk	10.78fg	10.90fg	11.40cde	11.70 c	10.57B
Mean	9.20G	9.71F	10.26E	10.59D	10.95C	11.48B	11.96A	

LSD value ($p \leq 0.05$) for treatments = 0.17, storage days = 0.23 and interaction = 0.46

compared in contrast to each other during cold storage. It was found that Kinnow fruits coated with 60% *Aloe vera* extract exhibited about 1.16-foldshigher vitamin C as compare to control fruit. Interaction showed that vitamin C contents were reduced gradually from 45-90 days in fruit treated with 60% *Aloe vera* extract while rapid decrease was noted in untreated fruits with same storage duration. However, a gradual decreasing trend was noted after 15 days in control treatment while 60%*Aloe vera* extract treated fruit showed high reduction during 75-90 days. (Fig.4).

***Total phenolic contents (mg GAE 100 g^{-1})*:** The mean value of total phenolic content (TPC) was noted about 1.07-foldshigher in Kinnow mandarin fruits treated with 60% *Aloe vera* extract than control fruits during long term storage (Fig.7). However, 60% *Aloe vera* extract suppressed the change in TPC. *Aloe vera* extract 60% treated fruits showed maximum (215.68) total phenolic contents after 90 days storage period followed by the treatment of TBZ (215.28), 40% neem extract (211.0) and control treatment (171.95) respectively. The interaction exhibited that a significant increasing trend was noted in TPC in all treated fruits from 0-15 days. The 60% *Aloe vera* extract treated fruits showed 6.4-fold higher TPC as matched to untreated fruits after 30 days (Table 4).

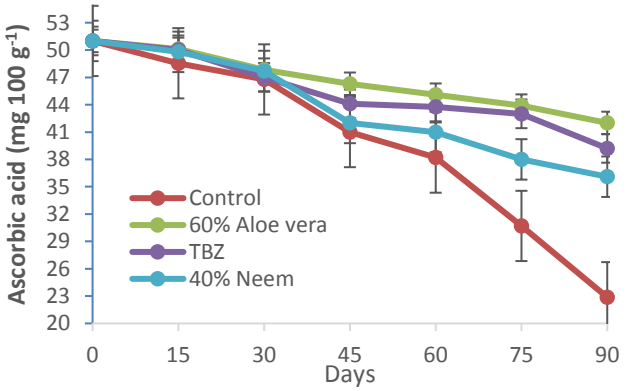

Figure 4. Effect of plant extracts and fungicide on Vitamin C (mg 100 g^{-1}) of Kinnow' fruits stored at 5ºC.

***Total antioxidants (%)*:** Among treatments 60% *Aloe vera* extract showed 1.06-folds higher mean antioxidant activity, as compare to untreated control fruits after 90 days. Interaction of treatment and storage days showed maximum antioxidant activity (68.88) in *Aloe vera* extract 60% followed by the treatment of TBZ (67.20), 40% neem extract (66.58%) and control treatment (62.40%) respectively after 90 days storage period. The 60% *Aloe vera* extract coated fruits had increase in antioxidant activity for the period of early 30 days then marginally decreased during 60-90 days. Furthermore; 60%*Aloe vera* extract was useful to maintain antioxidant activities till 90 days storage (Fig.5).

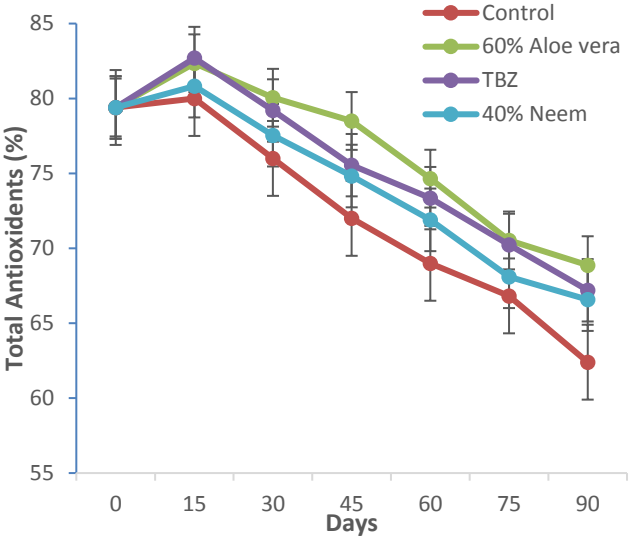

Figure 5. Effect of plant extracts and fungicide on total antioxidants (%) of 'Kinnow' mandarin stored at 5ºC.

Antioxidant enzyme activities

***Catalase (U mg^{-1} protein)*:** The critical and statistical computation of data exhibited that percentage of catalase activity(CAT)was significantly (P≤0.05) affected with the interactive response of various treatments and ninety days of storage. Application of 60% *Aloe vera* extract showed about 1.25-folds higher activity of CAT enzyme as compared to untreated fruits. Catalase enzyme activity drop with storage time and after 45-90 days depending upon the coating treatments. Interaction showed maximum catalase activity (21.40) in fruits treated with *Aloe vera* extract 60% after 30 days storage which was 2.7 folds higher in contrast to untreated fruits with minimum CAT activity (18.70). Interactive effect also showed substantial changes during

Table 4. Effect of plant extracts and fungicide on TPC (mg GAE 100 g^{-1}) of 'Kinnow' fruits stored at 5ºC.

Treatments	Storage duration (days)							
	0	15	30	45	60	75	90	Mean
Control	228.30f	228.65ef	224.40gh	217.13 k	206.93n	195.40o	171.95 p	210.39D
60% *Aloe vera* extract	228.30f	229.90bc	230.80 a	230.00abc	224.78g	220.50 j	215.68 l	225.71A
TBZ	228.30f	229.50cd	230.73 ab	229.33cde	223.93h	219.73 j	215.28 l	225.10B
40% Neem extract	228.30f	228.90def	229.30cde	228.53ef	222.00i	217.78k	211.00m	223.51C
Mean	228.30C	229.24A	228.81B	225.86D	219.41E	213.35F	203.48G	

LSD value ($p \leq 0.05$) for treatments = 0.11 storage days =0.2 and interaction = 0.34

storage and higher catalase activity was noted in 60% *Aloe vera* extract treated fruits after 30 days (Fig.6).

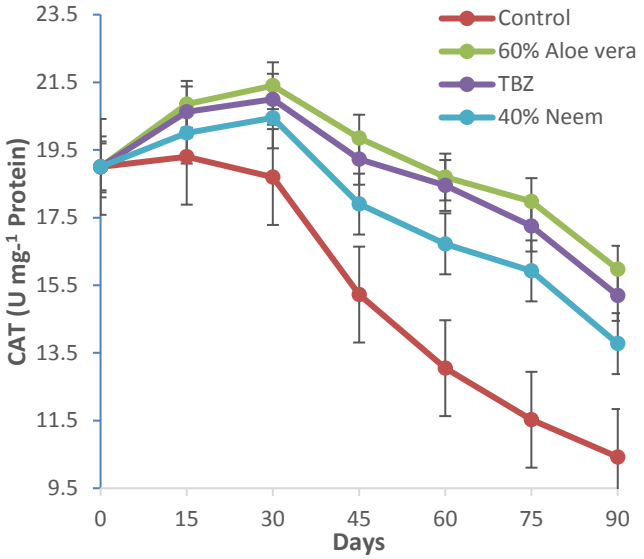

Figure 6. Effect of plant extracts and fungicide on catalase (U mg^{-1} protein) of 'Kinnow' fruits stored at 5ºC.

***Peroxidase (U mg^{-1} protein)*:** The statistically investigated data showed non-significant results ($p \leq 0.05$) concerning to peroxidase enzyme (POD)activity for interaction but coating treatments and storage days were significant after 90 days of storage period. The 60% *Aloe vera* extract revealed about 1.06-folds higher POD enzyme activity in Kinnow mandarin fruits in contrast to fruit which received no treatment. Maximum peroxidase enzyme activity during storage period was observed in 60% *Aloe vera* extract treated fruits (0.80) followed by the treatment of TBZ (0.79), 40% neem extract (0.78) and control treatment (0.75). Results showed that peroxidase enzyme activity in *Aloe vera* extract 60% coated fruits was maximum (0.84) after 15 days of storage while control treatment had minimum (0.65) when evaluated after 90 days (Fig.7)

***Superoxide dismutase (U mg^{-1} protein)*:**It was noted from the study, that there were significant changes in superoxide dismutase(SOD)enzyme activity due to storage effect nevertheless there was no substantial decrease in SOD activity from 0 day to 30 days in 60% *Aloe vera* treated fruit but, SOD activity declined significantly after the 30 days up to 90 days in untreated fruits. A significant increasing trend was found in SOD enzyme activity in 60% *Aloe vera* extract treated fruits with advanced storage period. This increase was more evident (1.06-folds) than control. Interaction of coating treatments and storage days regarding superoxide dismutase enzyme activity during storage period of 90 days was maximum in 60% *Aloe vera* extract treated fruits (124.40) followed by TBZ (124.0), 40% neem extract (121.75) and control treatments (110.63) after 90 days of storage (Fig.8).

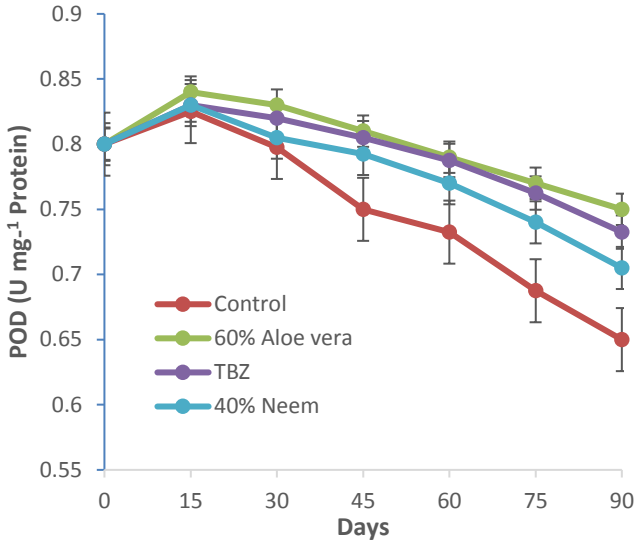

Figure 7. Effect of plant extracts and fungicide on peroxidase (U mg^{-1} protein) of Kinnow fruits stored at 5ºC.

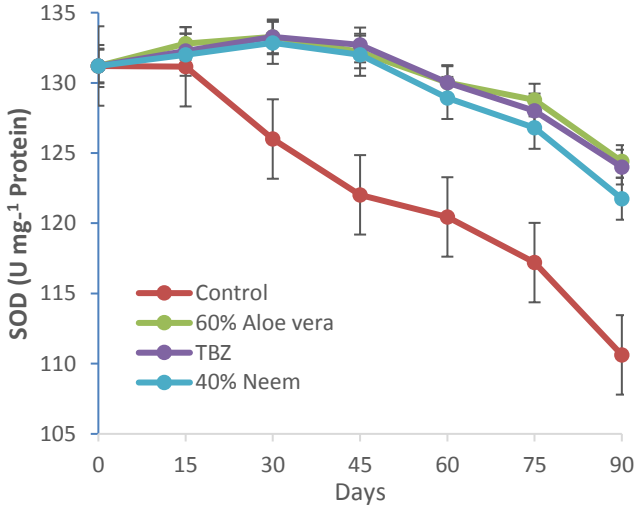

Figure 8. Effect of plant extracts and fungicide on superoxide dismutase (U mg^{-1} protein) of 'Kinnow' fruit stored at 5ºC.

Discussion: Among citrus Kinnow is one of the most promising fruit crops of Pakistan owing to its delicious taste and excellent aroma. Kinnow being a promising variety has a significant importance in the global market. Pakistan is facing a drastic reduction in quality of Kinnow mandarin due to improper postharvest management. In this context an experiment was needed to introduce an effective and residual free fruit rot control strategy which can improve the storage life of stored Kinnow fruits. So this study was planned to

resolve this issue and replace the unsafe synthetic costly fungicide with botanical extracts like *Aloe vera* and neem.

It is argued that the application of 60% of *Aloe vera* remarkably reduced the weight loss in Kinnow mandarin. The60% coating of *Aloe vera* extract developed a barrier which reduce the water loss of fruits and also demonstrated less loss in weight. *Aloe vera* gel was used as coating in different studies on different fruits like papaya, tomato and strawberry and it shows the similar results (Brishti *et al.,* 2013; Garcia *et al.,* 2013; Sharmin *et al*., 2015)

There was less fruit rot when the 60% coating of *Aloe vera* was applied on Kinnow mandarin. Anti-fungal properties have been found in *Aloe vera* extract (Brishti *et al*., 2013). It could be the main reason of less fruit rot. There was observation of similar results in papaya fruits which were treated with *Aloe vera* gel (Arowara *et al*., 2013). There was low fruit rot in raspberry, grapes and tomato fruits which were layered with *Aloe vera* gel (Garcia *et al.,* 2013; Chauhan *et al.,* 2014; Hassanpour, 2015).

It is argued that the higher peel weight is an indication of less water loss in fruit which caused the higher weight of Kinnow mandarin. There were similar conclusions shown in different studies where the orange fruits were coated with *Aloe vera* extract. The orange fruits coated with *Aloe vera* gel showed the higher preservation of weight as compare to control (Arowara *et al*., 2013). *Aloe vera* extracts treated Kinnow fruit exhibited greater juice weight as compare to control.

Likewise, *Aloe vera* gel treated grapes also indicated higher juice content, than fruits received no treatment (Asghari *et al*., 2013). During the storage period the complex sugars convert into simple sugar which increases the total soluble solid (TSS). There was rise in TSS in all kinds of treatments except 40% *Aloe vera* coated Kinnow where the increase was significantly low. The60% *Aloe vera* extract minimized the total soluble solids because of reduction in fruit senescence and metabolic activities. Different studies showed similar results i.e. *Aloe vera* extract applied on jujube, grapes, papaya and strawberry fruits (Vadhat *et al.,* 2010; Brishti *et al.,* 2013; Chauhan *et al.,* 2014; Sophia *et al.,* 2015; Sogvar *et al.,* 2016). Under storage conditions the respiration rate utilizes the acids which caused the reduction in ascorbic acid contents. There were reduced contents of ascorbic acid in all kinds of treatments except those Kinnow mandarin fruits which were treated with 60% *Aloe vera* extract. Decrease in contents of ascorbic acid remarkably reduced due to the *Aloe vera* extract. *Aloe vera* extract showed similar results in different fruits i.e. jujube, grapes, mango, papaya and strawberry (Vadhat *et al.,* 2010; Padmaja and Bosco, 2014; Chauhan *et al.,* 2014; Sophia *et al.,* 2015; Sogvar *et al.,* 2016).

Under storage conditions, normally the complex sugars are converted into simple sugars in fruits. All kinds of treatments including total sugars, non-reducing and reducing treatments showed the increase in sugar, though Kinnow mandarin which was treated with 60% *Aloe vera* gel showed significantly low increase. The similar finding was reported earlier (Chrysargyris *et al.,* 2016) who described that *Aloe vera* treated tomatoes maintained sugar content during storage as compared to untreated. In present study it was observed that fruits which were coated with *Aloe vera* gel exhibited less increase in sugar during storage. Under storage conditions, normally the complex sugars are converted into simple sugars in fruits. *Aloe vera* gel treated fruits showed the similar results in different kind of fruits including orange and papaya (Arowara *et al*., 2013; Brishti *et al*., 2013).

Higher phenolic contents were exhibited in the fruits which were coated with 60% *Aloe vera* extract. Phenolic contents were significantly maintained in treatments of *Aloe vera* coatings as compared to control. It was suggested that oxidation might have resulted in decrease phenolic contents of fruits (Ullah *et al*., 2013). In our experiment, higher phenolic contents might be due to decreased oxidation of *Aloe vera* extract application. During storage period of raspberry fruit which was layered with *Aloe vera* exhibited high rate of phenolic contents (Hassanpour, 2016).

Higher total antioxidants were exhibited in the fruits which were coated with 60% *Aloe vera* extract. Reduction of free radical was affected by the application of *Aloe vera* extract which cause high production of antioxidants in fruits. During storage of fruits usually total antioxidants decreases (Ullah *et al*., 2013). There is higher level of antioxidant in fruits which were coated with *Aloe vera* as compare to control. There were similar results reported in different studies, where the total antioxidants were on a higher level in strawberry and raspberry fruits which were coated with *Aloe vera* during storage (Hassanpour, 2015; Sogvar *et al*., 2016).

***Conclusion*:** It was concluded that 60% *Aloe vera* extract showed minimum fruit decay as compared to untreated fruits which was similar to synthetic fungicide (TBZ). The fruits of same treatment also showed better biochemical characteristics relating to fruit quality such as total soluble solids, titratable acidity, total phenolic contents, antioxidants, POD, CAT and SOD activities after 90 days storage. Therefore; *Aloe vera* gel can be used as an alternative to commercial fungicide to manage postharvest storage decay which is safe for human health having no residual effects.

***Acknowledgment*:** Authors are grateful to institute of Horticultural Sciences for providing us Kinnow fruit for experimental purposes. We also appreciate Post-Harvest Research Centre, Ayub Agriculture Research Institute and Dr. Shahid Mahmood, Biochemistry Department, UAF, Faisalabad, Pakistan for providing us technical support.

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[Received 01 July 2019: Accepted 03 Dec- 2019
Published 8 Feb.2020]