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EFFECT OF WASHING METHOD AND STORAGE TEMPERATURE ON QUALITY AND SHELF LIFE OF WINTER SQUASH

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Abstract

An experiment was conducted at the Postharvest Technology Division Laboratory, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh, during 10 January 2020 to 10 March 2020 to find out the suitable storage temperature for winter squash (*Cucurbita pepo*) and extend its shelf life. The experiment comprised two sets of treatments *viz.,* washing methods consisting of tap water washing (W_1) and chlorinated water washing (W_2), and four storage temperature composed of control room temperature; 25±2 ºC (T_1); 8±0.5 ºC (T_2); 12±0.5 ºC (T_3) and 16±0.5 ºC (T_4). The experiment was carried out in a Completely Randomized Design with three replications. For chlorinated water wash (120 ppm chlorine) was used which was prepared from sodium hypochlorite. The variety 'BARI Squash-1' was used in this experiment. The results showed that squash fruit stored in 8±0.5 ºC with chlorinated water wash had the highest firmness and vitamin C during the storage period (10-50 days at 10 days interval). However, squash fruits stored at 12±0.5 ºC with chlorinated water wash showed the maximum total soluble solid (TSS) during the storage. Shelf life was recorded maximum (57.33 days) from the combination of squash fruits stored in 8±0.5 ºC and chlorinated water wash which was statistically similar to the combination of squash fruits stored in 12±0.5 ºC and chlorinated water wash (55.33 days). It is concluded that chlorinated water wash using 120 ppm chlorine and storage temperature at 8 to 12 °C are suitable for storing squash fruits.

Keywords: Squash (*Cucurbita pepo*), washing method, storage temperature, quality and shelf life.

Introduction

Squash (*Cucurbita pepo* L.) is one of the important vegetables belonging to the family Cucurbitaceae. It is grown worldwide in both temperate and tropical climatic zones. In Italy, France, South America, Saudi Arabia it is called 'Zucchini', 'Courgette', 'Summer squash' and 'Kusa', respectively. Both the

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words ‘Zucchini’and ‘Courgette’ mean ‘small gourd’ or ‘small squash’. The squash fruits are harvested at edible stage and are consumed cooked when young and tender.

Squash has various health benefits to human as well as medicinal potentials (Mohammad *et al.,* 2011). It contains a variety of vitamins (ß-carotene, vitamin A, vitamin C, vitamin B_2, α-tocopherol and vitamin E), minerals, amino acids, carbohydrates, and minerals, especially potassium, as well as phenolics and flavonoids. Fresh squash is a good source of fiber, relatively low in calories (around 16-20 kcal/100g FW).

Storage of vegetable produces is an important means for improving shelf life, avoiding market surplus and ensuring supply through the year as well as increasing profit to the producers (Magray *et al*., 2017). Temperature both- high or low plays a vital role in the determination of postharvest quality and shelf life of tropical fruits and vegetables. Different levels of temperature subjected to different postharvest deterioration (Kader, 1993). Squash gets affected when it is stored below sub optimal temperature but above the freezing point (Sevillano *et al*., 2009). Chilling injury symptoms may persist after transfer of fruit from 4 to 20 °C. Megias *et al*. (2014) reported that over the first week of storage, squash fruits los only 5–7% of their initial weight, irrespective of the storage temperature but, after the second week of storage period, fruits stored at both 12 °C and 20 °C lost more weight than those fruit stored at 4 °C.

Cleaning and washing are very important practices in order to improve the hygiene, which can help extend shelf life of squash. Proper sanitation of the washing water is essential to maintain to prevent spread of diseases and inoculums build up in the wash water. The most commonly used sanitizer to wash fruits and vegetables is chlorine (100-150 ppm) solution (Anon., 2019; Gunathilake and Tiwari, 2017).

Squashe is a quick growing, short duration vegetable (40-60 days from transplanting 16-days-old seedlings) which had made it a popular vegetable crop in Bangladesh. As it is a newly introduced crop in Bangladesh and there is little research information on this crop regarding its shelf life. The present investigation was carried out to develop a suitable washing method and optimum starage temperature for storage of squash.

Materials and Methods

Research Location

The experiment was conducted at the Postharvest Technology Division Laboratory of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, during 10 January 2020 to 10 March 2020: 60 days.

Treatment setting

The experiment consisted of two factors, Factor A: two washing methods- Tap water washing (W_1) and chlorinated water washing (Sodium hypochlorite 120 ppm) (W_2) and Factor B: four storage temperature- Control (room temperature: 25±2 ºC) (T_1); 8±0.5 ºC (T_2); 12±0.5 ºC (T_3) and 16±0.5 ºC (T_4). Therefore, treatment combinations were 8 comprising Factor A and Factor B. The experiment was laidout in Completely Randomized Design (CRD) with three replications. The variety 'BARI Squash-1' producing elongated, dark green colourd fruit was used in this experiment.

Plant materials and storage conditions:

Freshly harvested squash fruits of 'BARI Squash-1' were collected from the vegetable research field of HRC, BARI. Eighteen-day-old uniform seedlings were transplanted in the Vegetable Research Field on 01 November 2019. First female flowering occurred in plants 35 days after transplanting of seedlings. Squash fruits were harvested on 10 January 2020 in the morning at proper edible stage when the fruits were young and tender (green coloured, smooth, bright shiny fruits and the nails entered the fruits easily after pressing them with nails). The harvested fruits were carried to the Postharvest Technology Division Laboratory of BARI keeping fruits in plastic crates with perforated polythene cover spread over the fruits. 240 fruits were used in this study and fruits were selected on the basis of uniformity in size (800-900 g). No physical injuries or infections were considered.

At first all the selected fruits ($8 \times 10 \times 3 = 240$) were divided into two groups. According to washing treatments, the selected fruits of 1st group (120 fruits) were soaked into tap water and washed, and the 2nd group fruits (120 fruits) were soaked into 120 ppm chlorinated water for 5 min. and washed. Tap water washed ten fruits weighing approximately 8.5 kg (packed in 1% perforated Polyethylene bags) were selected for each storage temperature treatment or 40 tap water washed fruits (4 perforated Polyethylene bags with 10 fruits per bag) were used for each replication. In the same way, 120 ppm chlorinated washed ten fruits weighing approximately 8.5 kg (packed in 1% perforated Polyethylene bags) were selected for each storage temperature treatment or 40 chlorinated water washed fruits (4 perforated Polyethylene bags with 10 fruits per bag) were used for each replication. Nine perforated polyethylene bags containing 10 tap water washed fruits per bag and 9 perforated polyethylene bags with 10 chlorinated washed fruits per bag totaling 180 fruits ($10 \times 3 \times 3 + 10 \times 3 \times 3$) were kept in constant temperature and humidity chambers (Model: VS-111H-350, Korea) for 10 days maintaining temperature 8 ºC, 12 ºC and 16 ºC. Eighteen bags containing 180 squash fruits (9 bags with 90 tap water washed fruits and 9 bags with 90 chlorinated washed fruits) at the rate of 10 fruits per bag were kept in different chambers with fixed temperature (8, 12 and

16 ºC) according to temperature treatment. Three bags (10 fruits per bag) containg 30 tap water washed fruits and three bags (10 fruits per bag) containg 30 chlorinated washed fruits were kept in room condition (temperature (25±2 ºC) and 70±5 % RH). In all chambers the relative humidity (HR) was adjusted to 70±5%, squash fruits kept in room temperature conditions (25±2 ºC and 70±5% RH) were used as control. One squash fruit was collected (from each polythene bag) for data collection of TSS and Vitamin C at 10 days intervals and it was continued up to 50 days of storage. Five fruits were used to record data of weight loss and firmness.

Parameters studies and their data collection procedure:

Total Soluble Solid:

Total soluble solids (TSS) content was determined by a hand-held refractometer (model: ATAGO PAL-1 made in Japan and TSS measuring range 0-53 °Brix) by placing drop of homogenized pulp juice on its prism. TSS was obtained from direct reading of the refractometer. At first the middle size of the fruit (about 5 cm length) was cut from the whole fruit, and the portion was peeled out and this portion was cut ito several thin pieces by sharf knife. Pulp juice was then collected from these thin pieces after hand pressing.

Vitamin-C content: (Ranganna, 1986).

The reagent used for the estimation vitamin C were as follows

a) Metaphoporic acid solution (3%)

b) Standard ascorbic solution

c) Dye solution

The estimate procedure of vitamin C was as follows:

Five ml of standard ascorbic solution was taken in conical flask and 5 ml metaphoporic acid (HPO_3) was added to it and shaken.

A micro burette was filled with dye solution then the mixed solution was titrated with dye using phenolphthalein as indicator solution to a pinked coloured end point, which persisted at least for 15 seconds. The dye factor was calculated using the following formula-

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of sample

10 g of fresh fresh sample was taken and transferred to 250 ml volumetric flask and the volume was made up to the mark with metaphosphoric acid.

Titration

Five ml of metaphosphoric acid extracted sample was taken in an aliquot and titrated with standard dye solution, using phenolphthalein as indicator to a pink-coloured end point which persisted for at least for 15 seconds.

Vitamin C content was calculated using the following formula-

$$\text{Vitamin C content (mg/100 g fresh sample)} = \frac{T \times D \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titre

D= Dye factor

V_1= Volume made up

V_2= Volume of extract taken for estimation

W= Weight of sample taken for estimation

Firmness:

Fruit firmness of squash fruit was measured (Rahman *et al*., 2014) using a Digital Firmness Tester (DFT 14, Agro-Technologie, France) equipped with 5 mm diameter stainless probe. The tester was checked before use. The plunger of the tester was moved in and out about 10 times to ensure that it was running smoothly. Firmness was reported in kilogram-force cm^{-2} (kg-f-cm^{-2}). Measurements were taken at three different places of each fruit and mean was calculated.

Weight loss of fruits: Squash (10 fruits) were weighed at the beginning of the experiment at fresh condition and there after weighing was continued up to 50^{th} day at every 10 days. Weight loss was calculated and expressed as the percentage weight loss of initial total weight according to the formula used by Moniruzzaman *et al*. (2015).

$$\text{Total weight loss (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Shelf life: Shelf life of squash as influenced by different postharvest treatments was estimated by counting the days from the harvest of squash-fruits up to its last edible stage.

Statistical analysis:

The recorded quantitative data were analyzed statistically by using MSTAT-C computer- based program. Treatment means were compared by Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results and Discussion

Effect of washing methods

Total soluble solids content (TSS), vitamin C content, weight loss (%) and firmness of squash were not affected significantly due to washing method of squash (Table 1). TSS and vitamin C content were decreased gradually with the increase of storage duration as compared to initial stage, while weight loss (%) and firmness were increased gradually with the increase of storage duration as compared to at initial stage (Table 1).

Table 1. Changes in percent TSS, vitamn C content, weight loss and firmness of stored squash as influenced by different washing method.

Washing methods	Days after storage (DAS)					
	Initial	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS
Total soluble solids (TSS)						
W_1	5.78	5.20	4.40	3.90	3.15	2.48
W_2	5.81	5.26	4.55	4.03	3.20	2.51
CV (%)	3.10	3.17	3.69	2.46	3.68	6.08
Vitamin C content (mg/100 g Fresh Weight)						
W_1	12.15	11.04	10.00	8.96	8.10	7.40
W_2	12.20	11.16	10.05	9.21	8.24	7.50
CV (%)	1.9	1.59	1.51	1.54	1.95	1.36
Weight loss (%)						
W_1	0	2.38	4.21	5.34	6.54	8.60
W_2	0	2.24	3.96	4.89	6.06	7.78
CV (%)	-	6.17	7.17	7.91	6.3	7.04
Firmness (kg-f-cm^{-2})						
W_1	1.74	1.98	2.21	2.38	2.58	2.80
W_2	1.75	2.05	2.26	2.44	2.63	2.83
CV (%)	1.86	4.21	6.19	5.92	5.4	3.9

W_1 = Tap water wash, W_2 = 120 ppm Chlorinated water wash DAS = Days after storage

There was a significant variation on shelf life of squash influenced by different washing methods (Fig. 1). Results revealed that the maximum shelf life (43.42 days) was recorded from the treatment W_2 (chlorinated water wash) whereas control treatment W_1 (tap water wash) showed minimum shelf life (37.25 days) of squash (Fig. 1). Arah *et al*. (2016) reported that different washing methods techniques before storage helped to minimize the postharvest losses and extend the shelf life of fruits which was also supported by the findings of Tolasa *et al*. (2021) and Nyamende *et al*. (2021).

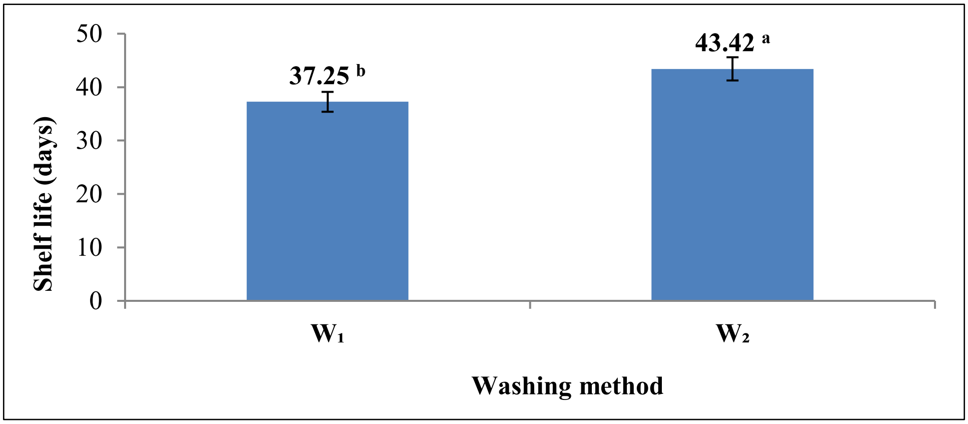

Fig. 1. Shelf life of stored squash fruits as influenced by different washing methods.

Vertical Bars indicates mean±SE of three replicates. Means having different letter (s) are significantly different at 5% level of probability by DMRT; W_1 = Tap water wash, W_2 = 120 ppm Chlorinated water wash

Effect of storage temperature

Total soluble solid (TSS) was gradually decreased with the advancesment of storage (DAS) in all storage temperature treatments (Table 2). At the beginning (0.0 DAS), TSS and vitamin C content did not differ significantly by storage temperature. At 10 DAS and 50 DAS, TSS content of squash fruits was found nonsignificant but at 20, 30 and 40 DAS, significant variation was observed recorded due to different storage temperature (Table 2). At 20, 30 and 40 DAS, the strage temperature 12±0.5 °C (T_3) gave the highest TSS content (4.80, 4.15 and 3.50%, respectively) followed by the storage temperature 16±0.5 °C (T_4) (4.40, 4.00 and 3.20%, respectively and 8±0.5 °C (T_2) (4.45, 3.95 and 3.15%, respectively) at 20, 30 and 40 DAS with no significant difference between T_4 and T_3 treatments while control temperature treatment T_1 (room temperature) showed the lowest TSS content (4.25, 3.75 and 2.85%, respectively).Vitamin C content of squash fruits decreased gradually with the increase of storage duration (Table 2). At 10 and 20 DAS, significant variation was observed in vitamin C conntent but at initial (0.00 DAS), 30, 40 and 50 DAS vitamin C content was not differed significanty due to storage temperature. Results revealed that at 10 and 20 DAS, the maximum vitamin C content (11.40 and 10.20 mg/100g FW, respectively) was recorded from the temperature 8±0.5°C (T_2) which was statistically identical with temperature 12±0.5°C (T_3) and 16±0.5°C (T_4), whereas control temperature (room temperature) (T_1) showed the lowest vitamin C content (10.55 and 9.83 mg/100g FW, respectively). (Table 2). Similar findings were also found by Sharma *et al*.

(2002) who reported that the decline in vitamin C in plum squash might be due to its degradation into dehydro-ascorbic acid at room temperature.

Table 2. Changes in percent TSS and vitamn C content, weight loss (%) and firmness of stored squash as influenced by different storage temperatures

Storage temperature	Days After Storage (DAS)					
	Initial	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS
Total soluble solids (% TSS)						
T_1	5.78	5.13	4.25 c	3.75 c	2.85 c	2.43
T_2	5.80	5.19	4.45 b	3.95 b	3.15 b	2.48
T_3	5.80	5.35	4.80 a	4.15 a	3.50 a	2.58
T_4	5.80	5.24	4.40 b	4.00 b	3.20 b	2.49
CV (%)	3.10	3.17	3.69	2.46	3.68	6.08
Vitamin C content (mg/100 g FW)						
T_1	12.13	10.55 b	9.83 b	8.95	8.03	7.40
T_2	12.18	11.40 a	10.20 a	9.23	8.25	7.50
T_3	12.18	11.28 a	10.08 a	9.08	8.23	7.45
T_4	12.23	11.18 a	10.00 a	9.10	8.18	7.45
CV (%)	1.9	1.59	1.51	1.54	1.95	1.36

In a column means having similar letter (s) are not statistically significant and those having dissimilar letter (s) differ significant at 5% level of probability by DMRT. T_1 = Control (room temperature, 25±2 °C), T_2 = 8±0.5°C, T_3 = 12±0.5°C, T_4 = 16±0.5°C. DAS = Days after storage.

Significant variation was found for weight loss of squash fruits at different days after storage (DAS) due to different storage temperatures (Table 3). At 10, 20, 30, 40 and 50 DAS, the highest weight loss (3.88, 7.58, 9.68, 11.88 and 16.10%, respectively) was recorded from the control temperature (room temperature) (T_1) which differed significantly to other treatments, whereas the lowest weight loss (1.25, 2.13, 2.60, 3.35 and 4.60%, respectively) was recorded from the 8±0.5 °C (T_2) closely followed by 12±0.5 °C (T_3) (1.73, 2.70, 3.33, 4.43 and 5.38%, respectively) (Table 3). There were no significant difference among the T_2 (8±0.5 °C), T_3 (12±0.5 °C) and T_4 (16±0.5 °C). This result was in conformity with the findings of Jany *et al*. (2008) who reported that the rate of weight loss increased with time progress of the storage period in all conditions.Firmness of squash fruits was significantly influenced by different days after storage (DAS) due to different storage temperatures except iniating day (Table 3). Fruit firmness increased gradually with the increasing storage duration (Table 3). At 10, 20, 30, 40 and 50 DAS, the maximum firmness (2.10, 2.28, 2.48, 2.68 and 2.88 kg-f-cm^{-2}, respectively) was recorded from the temperature 8±0.5 °C (T_2) followed by the temperature 12±0.5 °C (T_3) (2.05, 2.26, 2.43, 2.63 and 2.83 kg-f-cm^{-2}), whereas the lowest firmness (1.93, 2.18, 2.35, 2.52 and 2.77 kg-f-cm^{-2}, respectively) was recorded from the control (room temperature (T_1). Tano *et al*. (2007) also observed similar results.

Table 3. Changes in weight loss (%) and firmness of stored squash fruits as influenced by different storage temperatures.

Storage temperature	Days After Storage					
	Initial	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS
Weight loss (%)						
T_1	0	3.88 a	7.58 a	9.68 a	11.88 a	16.10 a
T_2	0	1.25 b	2.13 b	2.60 b	3.35 b	4.60 b
T_3	0	1.73 b	2.70 b	3.33 b	4.43 b	5.38 b
T_4	0	2.40 b	3.95 b	4.85 b	5.55 b	6.68 b
CV (%)	-	6.17	7.17	7.91	6.3	7.04
Firmness (kg-f-cm^{-2})						
T_1	1.74	1.93 c	2.18 c	2.35 c	2.52 d	2.77 c
T_2	1.76	2.10 a	2.28 a	2.48 a	2.68 a	2.88 a
T_3	1.73	2.05 b	2.26 a	2.43 b	2.63 b	2.83 b
T_4	1.74	1.98 c	2.23 b	2.38 c	2.58 c	2.79 c
CV (%)	1.86	4.21	6.19	5.92	5.4	3.9

In a column means having dissimilar letter (s) are not statistically significant at 5% level of probability by DMRT. T_1 = Control (room temperature) (25±2 °C), T_2 = 8±0.5°C, T_3 = 12±0.5°C, T_4 = 16±0.5°C. DAS = Days after storage.

Significant variation was observed on shelf life of squash as influenced by different temperature treatments.

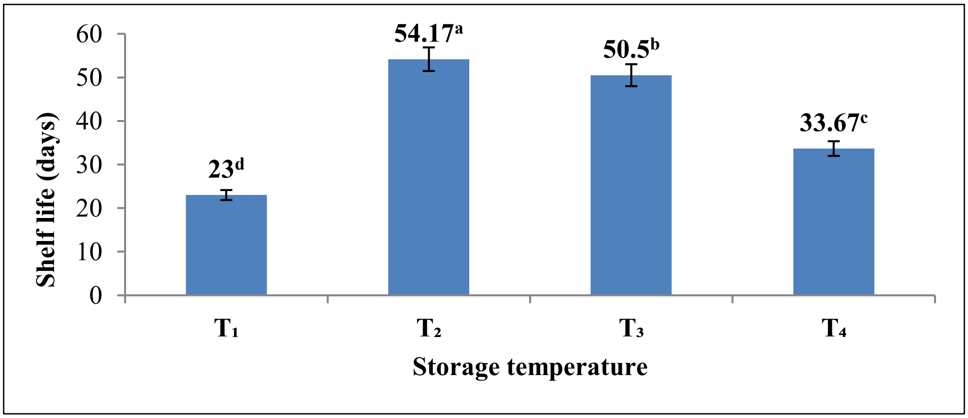

Fig. 2. Shelf life of stored squash fruits as influenced by different storage temperature.

Vertical Bar indicates mean±SE of three replicates. Means having different letter (s) are not significantly different at 5% level of probability by DMRT.

T_1 = Control (room temperature) (25±2 °C), T_2 = 8±0.5°C, T_3 = 12±0.5°C, T_4 = 16±0.5°C.

Significant variation was observed on shelf life of squash fruits as influenced by different temperature treatments (Fig. 2). Results revealed that the maximum shelf life (54.17 days) was recorded from the temperature 8±0.5 °C (T_2) which was significantly different to other temperature treatments followed by temperature 12±0.5 °C (T_3) (50.5 days), whereas control temperature (room temperature) (T_1) showed the lowest shelf life (23.0 days) (Fig. 2). This result suggested that a higher shelf life was achieved with lower temperature. Han *et al*. (2007) reported that the spoiling rate of squash fruits was affected more by the storage temperature. Above critical threshold level of temperature, lower temperature showed reduced respiration rate which resulted higher shelf life (Posmyk *et al*., 2005).

Interaction effect of washing methods and storage temperature

Different washing methods of squash fruits in combination with different storage temperatures showed significant variation in TSS content at 20, 30 and 40 DAS, but interaction of washing method and storage temperature had no significant effect on TSS content at initial stage (before storage), 10 and 50 days after storage (Table 4). In interaction treatments, it is seen that TSS content was decreased gradually with the advancement of storage duration. At 20, 30 and 40 DAS, the highest TSS content (4.90, 4.40 and 3.60%, respectively) was recorded from W_2T_3 combination which was statistically similar to the combinations W_1T_2 (3.40%) and W_1T_3 (3.40%) at 40 DAS, whereas the lowest TSS content (4.20, 3.70 and 2.70%, respectively) was obtained from W_1T_1 combination that was significantly similar to the W_2T_1 combination at 20 and 30 DAS. Numerically at 50 DAS, the maximum TSS content (2.60%) was noticed in W_2T_3 combination and the minimum TSS (2.40%) was recorded from W_1T_1 combination. Different storage temperatures in combination with two washing methods of squash fruits showed significant variation on vitamin C content at 10, 20, 30 and 40 DAS except initial stage and 50 DAS (Table 4). In all combinations, vitamin C content of squash fruits decreased gradually with the advancement of storage duration. At 10 DAS, the maximum vitamin C content (11.45 mg/100 g FW) was recorded from the treatment combination of W_2T_2 which was statistically similar to W_2T_3 (11.15 mg/100 g FW), W_2T_4 (11.25 mg/100 g FW), W_1T_2 (11.35 mg/100 g FW) and W_1T_3 (11.40 mg/100 g FW), whereas W_1T_1 gave the minimum vitamin C content (10.30 mg/100 g FW). Similarly, at 20 DAS, the maximum vitamin C content (10.30 mg/100 g FW) was found from the combination W_2T_2 which was statistically similar to W_1T_2 (10.10 mg/100 g FW), W_1T_3 (10.20 mg/100 g FW) and W_2T_4 (10.10 mg/100 g FW), and the minimum vitamin C was recorded from the combination W_1T_1 (9.80 mg/100 g FW). At 30 DAS, the treatment combination of W_2T_2 gave the maximum vitamin C content (9.35 mg/100 g FW) which was identical with W_2T_3 (9.25 mg/100 g FW) and W_2T_4 (9.20 mg/100 g FW). The minimum vitamin C was recorded from W_1T_1 combination (8.85 mg/100 g FW). At 40 DAS, the maximum vitamin C content was also recorded from the combination W_2T_2 (8.30 mg/100 g FW) closely followed by the combinations W_2T_3 (8.25 mg/100 g FW), W_2T_4 (8.25 mg/100 g FW), W_1T_2 (8.20 mg/100 g FW), W_1T_3 (8.20 mg/100 g FW) and W_1T_4 (8.10 mg/100 g FW) whereas the minimum vitamin C was found in combination W_1T_1 (7.90 mg/100 g FW).

Table 4. Changes in TSS and vitamin C content of stored squash fruits as influenced by the interaction of different washing methods and storage temperature

Washing methods x Storage temperature	Days After Storage					
	Initial	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS
Total soluble solids (TSS)						
W_1T_1	5.75	5.10	4.20 d	3.70 c	2.70 e	2.40
W_1T_2	5.80	5.20	4.30 d	4.00 b	3.40 ab	2.45
W_1T_3	5.80	5.30	4.70 b	3.90 b	3.40 ab	2.55
W_1T_4	5.75	5.18	4.40 cd	4.00 b	3.10 cd	2.50
W_2T_1	5.80	5.15	4.30 d	3.80 c	3.00 cd	2.45
W_2T_2	5.80	5.17	4.60 bc	3.90 b	2.90 d	2.50
W_2T_3	5.80	5.40	4.90 a	4.40 a	3.60 a	2.60
W_2T_4	5.85	5.30	4.40 cd	4.00 b	3.30 bc	2.48
CV (%)	3.10	3.17	3.69	2.46	3.68	6.08
Vitamin C content (mg/100 g FW)						
W_1T_1	12.10	10.30 d	9.80 c	8.85 d	7.90 b	7.35
W_1T_2	12.15	11.35 ab	10.10 abc	9.10 bcd	8.20 a	7.45
W_1T_3	12.10	11.40 ab	10.20 ab	8.90 d	8.20 a	7.40
W_1T_4	12.25	11.10 bc	9.90 c	9.00 cd	8.10 ab	7.40
W_2T_1	12.15	10.80 c	9.85 c	9.05 bcd	8.15 ab	7.45
W_2T_2	12.20	11.45 a	10.30 a	9.35 a	8.30 a	7.55
W_2T_3	12.25	11.15 ab	9.95 bc	9.25 ab	8.25 a	7.50
W_2T_4	12.20	11.25 ab	10.10 abc	9.20 abc	8.25 a	7.50
CV (%)	1.9	1.59	1.51	1.54	1.95	1.36

In a column, figures having similar letter (s) are not significantly different at 1% or 5% probability level by DMRT. DAS = Days after storage.

Interaction of four storage temperature and two washing methods of squash fruits had significant effect on weight loss (Table 5). It was observed that at all storage duration, % weight loss was decreased gradually with the advancement of storage duration (from 10 to 50 DAS). The combination W_1T_1 gave the highest weight loss (3.95, 7.65, 9.80, 12.05 and 16.70% at 10, 20, 30, 40 and 50 DAS, respectively) which was statistically similar to W_2T_1 (Chlorinated water wash with storage in room temperature) (3.80, 7.50, 9.55, 11.70 and 15.5%, respectively), whereas the combination W_2T_2 recorded the weight loss of squash fruits (1.15, 1.95, 2.25, 3.05

and 4.25% at 10, 20, 30, 40 and 50 DAS, respectively) which was statistically similar to W_1T_2, W_1T_3 and W_2T_3 (Table 5).

Table 5. Changes in percent weight loss (%) and firmness of stored squash fruits as influenced by the interaction of different washing methods and storage temperature

Washing methods x Storage temperature	Days After Storage					
	Initial	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS
Weight loss (%)						
W_1T_1	0	3.95 a	7.65 a	9.80 a	12.05 a	16.70 a
W_1T_2	0	1.35 c	2.30 bc	2.95 bc	3.65 bc	4.95 bc
W_1T_3	0	1.80 c	2.85 bc	3.55 bc	4.60 bc	5.80 bc
W_1T_4	0	2.45 bc	4.05 b	5.05 b	5.85 b	6.95 b
W_2T_1	0	3.80 ab	7.50 a	9.55 a	11.70 a	15.5 a
W_2T_2	0	1.15 c	1.95 c	2.25 c	3.05 c	4.25 c
W_2T_3	0	1.65 c	2.55 bc	3.10 bc	4.25 bc	4.95 bc
W_2T_4	0	2.35 c	3.85 b	4.65 b	5.25 bc	6.40 b
CV (%)	-	6.17	7.17	7.91	6.3	7.04
Firmness (kg-f-cm^{-2})						
W_1T_1	1.74	1.90 f	2.15 d	2.30 e	2.50 e	2.75 d
W_1T_2	1.75	2.05 c	2.25 ab	2.45 b	2.65 b	2.85 b
W_1T_3	1.70	2.00 d	2.25 ab	2.40 c	2.60 c	2.80 c
W_1T_4	1.75	1.95 e	2.20 c	2.35 d	2.55 d	2.78 cd
W_2T_1	1.74	1.95 e	2.20 c	2.40 c	2.55 d	2.78 cd
W_2T_2	1.77	2.15 a	2.30 a	2.50 a	2.72 a	2.89 a
W_2T_3	1.75	2.10 b	2.27 a	2.45 b	2.65 b	2.85 b
W_2T_4	1.72	2.00 d	2.25 ab	2.40 c	2.60 c	2.80 cd
CV(%)	1.86	4.21	6.19	5.92	5.4	3.9

In a column means having dissimilar letter (s) are not statistically different at 5% level of probability by DMRT. DAS = Days after storage

Four storage temperature incombination with two washing methods of squash fruits put significant effect on firmness at various storage duration except intial stage (Table 5). In all interaction treatments, firmness of squash fruits was gradually increased with the advancement of storage duration (10 to 50 DAS), the combination W_2T_2 showed the maximum firmness of squash fruits whereas W_1T_1 showed the minimum firmness of squash fruits with significant difference but at initial stage it was found that farmness was 1.77 and 1.74 kg-f-cm^{-2} in the combinations W_2T_2 and W_1T_1 respectively with non-significant difference between these two combinations. The The results indicated that, at 10, 20, 30, 40 and 50

DAS, the highest firmness (2.15, 2.30, 2.50, 2.72 and 2.89 kg-f-cm^{-2}, respectively) was recorded from the combination W_2T_2 which was significantly different from the other combinations and followed by W_2T_3 (2.10, 2.27, 2.45, 2.65 and 2.85 kg-f-cm^{-2} at 10, 20, 30, 40 and 50 DAS, respectively) and W_1T_2 (2.05, 2.25, 2.45, 2.65 and 2.85 kg-f-cm^{-2} 10, 20, 30, 40 and 50 DAS, respectively), whereas W_1T_1 combination gave the lowest firmness (1.90, 2.15, 2.30, 2.50 and 2.75 kg-f-cm^{-2} at 10, 20, 30, 40 and 50 DAS, respectively) (Table 5). Shelf life of squash fruits was significantly influenced by the interaction of different storage temperature and different washing methods of squash fruits (Fig. 3). It was observed that the maximum shelf life was recorded from the combination W_2T_2 (57.33 days) which was statistically similar to W_2T_3 combination (55.33 days), whereas the combination W_1T_1 gave the minimum shelf life (21.33 days) (Fig. 3).

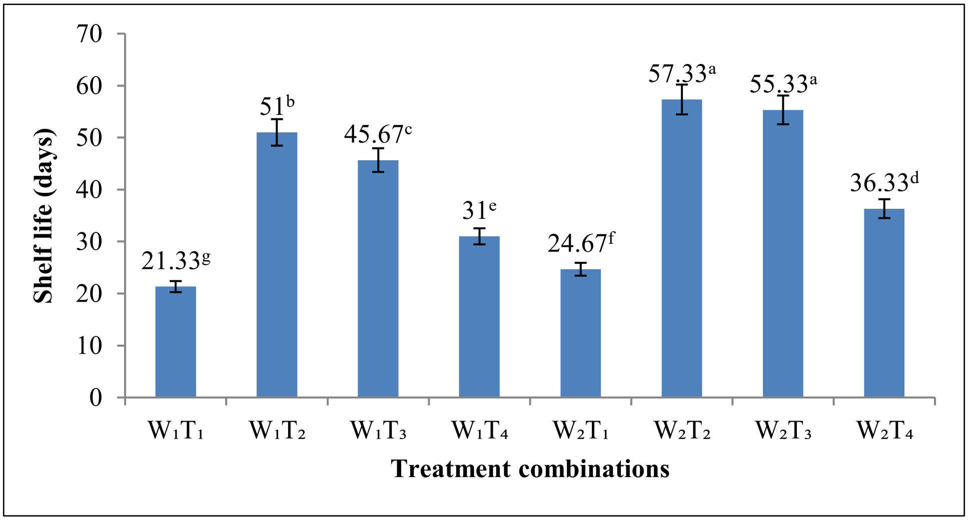

Fig. 3. Shelf life of stored squash fruits as influenced by different treatment combinations of washing methods and storage temperature

Vertical bars indicate mean±SE of three replicates. Means having different letter (s) are not significantly different at 5% level of probability by LSD.

W_1 = Tap water wash, W_2 = 120 ppm Chlorinated water wash.

T_1 = Control (room temperature 25±2 °C), T_2 = 8±0.5°C, T_3 = 12±0.5°C, T_4 = 16±0.5°C.

Conclusion

From the study, it may be concluded that, total soluble solids and vitamin C content of squash fruits were gradually decreased but weight loss and firmness increased with the advancement of storage duration from 10 to 50 days after storage at 10 days interval. TSS, vitamin C and fruit firmness were found maximum from the combination of chlorinated water washing using 120 ppm sodium hypochlorite solution and the storage temperature of 12±0.5 °C. Minimum weight loss was also recorded from this combination. The maximum shelf life (57.33 days) was recorded from the combination chlorinated water washing and the storage temperature of 8±0.5 °C which was statistically similar to chlorinated water washing with storage temperature of 12±0.5 °C (55.33 days). Chlorinated water washed squash fruits using (120 ppm sodium hypochlorite solution) and storage temperature of 8 to 12 °C are suitable for the storage of squash fruits.

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