



Effect of potassium metabisulphite and clove oil dipping on some quality properties of pomegranate fruits cv. Salakhani during cold storage

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Article info	Abstract
Original: 28/12/2017 Revised: 25/01/2018 Accepted: 06/02/2018 Published online:	The experiment was performed using potassium metabisulphite (KMS) at (0, 2 and 4) % and clove oil (CLV) at (0, 1 and 2) % into which the fruits have been dipped for 2 min to study their effect on some quality properties of pomegranate fruits cv. Salakhani under cold storage conditions ($5 \pm 1^{\circ}\text{C}$ and 80-90 % RH) for 4 months, according to the factorial trial based on completely randomized design with three replicates.
Key Words: pomegranate fruits, potassium metabisulfite, clove oil, postharvest fruit quality	The obtained results showed that decay% of treated fruits was significantly decreased by 4% KMS when comparing with the control, as the concentration of both 2% and 4% KMS decreased the juice% compared to the control. In this respect, KMS treatments at all used rates had no effect on weight loss%, peel thickness (mm), peel%, arils% and TA% compared to the control. On the other hand, 4% KMS gave the maximum values of TSS, total sugars and anthocyanins contents. Whereas, statistically no significant differences were observed with clove oil treatments in all measured parameters except 2% CLV which was found effective in anthocyanins content against 1% and control. Application of 4% KMS+2% CLV showed the highest values of TSS, total sugars and anthocyanins contents, however, the lowest values of decay% and ascorbic acid in the same treatments were observed.

Introduction

Pomegranate (*Punica granatum* L.) belonging to the family Punicaceae is one of the most favorable fruits of tropical and subtropical regions, especially in the moderate climate of the Mediterranean region [1]. Pomegranate fruit is non-climacteric and thus cannot continue the ripening process after detachment from the parent plant [2], [3] and [4]. Fruit with non detectable levels of ethylene produced during storage and the fruit are generally harvested fully ripe [5]. It is one of the most important commercial fruits eaten fresh and also processed for jams, jellies, syrups, pomegranate juice products and is used for medical purposes [6], [7] and [8], although they are produced in various countries for the food and beverage industry as flavoring and coloring agents, so they are important for human health because of high antioxidant capacity and a high content of polyphenols and anthocyanins [9].

During postharvest storage of pomegranate, the important quality losses occur due to several physiological and enzymatic disorders, such as desiccation or weight loss, browning symptoms in both peel and arils, and losses of firmness, aril color, vitamin C and acidity, decay development and appearance blemishes on skin, leading to reduction of acceptability in terms of freshness, juiciness and taste [2]. Pomegranate fruit undergoes various physiological and biochemical changes during fruit storage and these changes continue to occur after harvesting that leads to lowering of fruit quality and high post-harvest losses. Therefore, the development and use of alternative postharvest control options, involving biological agents or natural plant extracts, have become important since it is perceived as being environmentally safer and more

acceptable to the general public health [10]. It has been mentioned that, weight loss continuously increased during fruit storage [11] and [12]. recently, Application of antioxidants and essential oils methods used as fungicidal alternatives for controlling postharvest diseases of fruits, such as, potassium metabisulfite and clove oil. Potassium metabisulfite (KMS) also known as E224 used as a food additive in which it forms sulfur dioxide gas (SO₂). KMS acts as an antifungal agent, and an effective antioxidant, therefore it use to prevent most microorganisms from growing, and protecting both the color and delicate flavors of wine [13]. It is an inhibitor of the polyphenol oxidase enzyme [14]; it is used as a preservative in fruits and fruit products. Therefore, the application of KMS at 250 ppm to rambutan fruit, and storage under CA (13.5°C), effectively controlled the diseases, color and maintained eating quality of the fruits for up to 21 days. Furthermore commonly used chemicals for preservation, the freshly harvested tender fruit of pointed gourd [15], and Potassium metabisulfite have been used as protective for fruits after postharvest [16]. Other approaches have been tried to identify the effective natural chemicals (such as, those present in plant extracts), which may be more acceptable to consumers than those produced synthetically [17]. Use of natural components such as natural extract is one of the healthiest and safest methods to control postharvest diseases; essential oils include extensive secondary metabolites, which in most cases have antimicrobial, fungicidal and bio-regulating properties [18]. Low concentrations of essential oils were used against banana rot disease and their fungal pathogens; they were also used to maintain quality during storage [19], [20], [21], [22], [23] and [24]. Recent experiments show that some essential oils are effective in reducing decay, quality maintenance and essential improvement post-harvest life of many fruits reported by [25] on clove oil [26] on thyme and clove oils. Thyme and Clove oils had significant effects on fungal growth on apricot [27]. In Iraq and Kurdistan region, pomegranate is one of the most important commercial fruits; 'Salakhani' cultivar pomegranate is widely planted in orchards in Kurdistan region for fresh consumption by farmers because of better fruit quality, color and size. It's fruit size is large and seems to be somewhat firm at maturity, so it is the most important cultivar for export to other countries [28] and [29]. Prolonging storability of pomegranate fruits by reducing postharvest decay, regulating marketing to avoid price fluctuations and the yield supply, in order to fulfill such purpose, therefore, the objective of this study is to investigate the effects of the postharvest application of KMS and clove oil in pomegranate cultivar 'Salakhani', especially changes in quality properties during storage.

Materials and methods

Pomegranates fruits cv. 'Salakhani' were obtained from a private orchard (Sitak) in (Sulaimani province, Kurdistan region-Iraq). Fruits were harvested manually at optimal time in the last week of October 2016 from 10 years-old tree in the full ripe and full color stage. The trees were spaced at (2.50x3.00) m between and along the rows under irrigated system cultivation and routine cultural practices suitable for fruit production were carried out.

The fruits were delivered on the same day to the laboratory soon after harvest at early morning. Non-defective 'Salakhani' pomegranates (those with defects such as sunburns, cracks, cuts and bruises in peel were discarded) were selected in accordance with their color and weight. The homogeneous fruits were randomly divided into 3 replicates (each replicate contained 9 fruits), and used in the postharvest treatments. A factorial experiment with the completely randomized design was used with three replicates, the treatment means were then compared according to Duncan's multiple range test ($P \leq 0.05$) [30].

Fruits were soaked in different concentrations of two chemicals including; potassium metabisulfite (0, 2 and 4) % and clove oil (0, 1 and 2) % for 2 minutes, then fruits were left to dry at room temperature and were packed in paper bags and stored at $5 \pm 1^\circ\text{C}$ and 80-90 % relative humidity (RH) in a cold room for 4 months. At the end of storage, the following parameters were measured:

Weight loss %:

The difference between the initial weight of the fruits and its final weight was translated as weight loss percentage and calculated as follows:

$$\text{Weight loss\%} = \frac{\text{Weight loss in (g)}}{\text{The initial weight of the fruits at the beginning of storage (g)}} \times 100$$

Decay%:

Fruits affected with either pathological or physiological disorders were weighted the defects were calculated as follows:

$$\text{Decay\%} = \frac{\text{No. of decayed fruits}}{\text{No. of fruits at the beginning of storage}} \times 100$$

Peel thickness (mm):

The peel thickness of the fruits was measured with a digital Vernier caliper.

Peels%:

Peel of fruits was hand-separated and calculated as follows:

$$\text{Peel \%} = \frac{\text{Weight of peels}}{\text{Weight of whole fruit}} \times 100$$

Arils%:

Fruits were carefully opened to avoid damaging arils. Arils of fruits were hand-separated and calculated as follows:

$$\text{Arils \%} = \frac{\text{Weight of arils}}{\text{Weight of whole fruit}} \times 100$$

Juice%:

Juice percentage was determined by extracting the juice of five fruits for each treatment representing three replicates was squeezed by handy squeezer and then (w/w).

Total soluble solids (TSS %):

TSS was determined by hand refractometer as described in [31].

Total titratable acidity (TA %):

The same reference mentioned for TSS was also used for determining TA%. The samples were titrated with NaOH using phenolphthalein index and the acidity was determined as citric acid content (g/100 ml juice).

$$\text{Titratable acidity} = \frac{\text{Vol. NaOH ml} \times \text{N.} \times \text{Milli.eq. Of acid (0.064)}}{\text{Weight of sample (g)}} \times 100$$

Total sugars (mg/g F.W.):

Total sugars were estimated by Lane and Eynon (1923) as described in [32].

Vitamin C (mg/ 100 g. F. W.):

It was measured using 2, 5-6 dichlorophenol indophenols' method described by [31].

Anthocyanin content (mg. /100 g. F.W.):

Anthocyanin content was determined according to the method described by [33].

Results

The data represented in table 1 regarding weight loss%, peel thickness (mm), peel% and arils% of the pomegranate fruit cv. 'Salakhani' stored at 5±1°C and 90% RH for 4 months showed statistically non-significant differences by dipping of potassium metabisulfite, Whereas, the decay% and Juice% were influenced by various potassium metabisulfite concentrations, where minimum value of decay% was recorded by dipping 4% KMS (4.317%) over other KMS concentrations. With respect to decay% and Juice% the maximum values were recorded by dipping 0% KMS (6.544 and 54.222%) respectively.

Table-1: Effect of potassium metabisulfite on weight loss%, decay%, peel thickness (mm), peel%, arils% and juice% in pomegranate fruits cv. 'Salakhani' stored at 5±1°C and 90% RH for 4 months.

KMS	Weight loss%	Decay%	Peel thickness (mm)	Peel%	Arils%	Juice%
0%	9.104 a	6.544 a	2.296 a	30.362 a	69.554 a	54.222 a
2%	9.096 a	4.994 ab	2.587 a	31.511 a	68.467 a	50.279 b
4%	8.279 a	4.317 b	2.410 a	31.707 a	68.254 a	50.530 b

It is clear from table (2) that the highest TSS%, total sugars (mg/g F.W.) and anthocyanins (mg/ 100 g. F.W.) were recorded from the 4% KMS (15.985, 12.930 and 14.122), respectively. Whereas, the lowest values (15.444, 11.144 and 8.881) were observed from the 0% KMS, respectively. On the other hand, no significant differences were found between treated and untreated pomegranate fruits in TA (%). Also 0% and 2% KMS treatments in fruit was significantly superior to the 4% KMS in ascorbic acid (mg/ 100 g. F. W.) contents, besides, no significant differences were found between 0% and 2% KMS treatments.

Table-2: Effect of potassium metabisulfite on TSS%, TA%, total sugars (mg/g F.W.), ascorbic acid (mg/ 100 g. F. W.) and anthocyanins (mg/ 100 g. F. W.) in pomegranate fruits cv. 'Salakhani' stored at 5±1°C and 90% RH for 4 months.

KMS	TSS%	TA%	Total sugars (mg/g F.W.)	Ascorbic acid (mg/ 100 g. F. W.)	Anthocyanins (mg/ 100 g. F. W.)
0%	15.444 b	0.714 a	11.144 c	11.211 a	8.881 c
2%	15.496 b	0.759 a	11.774 b	10.800 a	12.189 b
4%	15.985 a	0.808 a	12.930 a	8.389 b	14.122 a

It is evident from the data presented in table 3 regarding the weight loss%, decay%, peel thickness (mm), peel%, arils% and juice% of the pomegranate fruit showed statistically non-significant differences due to dipping in clove oil.

Table-3: Effect of clove oil on weight loss%, decay%, peel thickness (mm), peel%, arils% and juice% in pomegranate fruits cv. 'Salakhani' stored at 5±1°C and 90% RH for 4 months.

clove oil	Weight loss%	Decay%	Peel thickness (mm)	Peel %	Arils %	Juice %
0%	8.873 a	4.606 a	2.644 a	30.580 a	69.371 a	52.073 a
1%	8.892 a	6.239 a	2.334 a	31.949 a	67.985 a	49.920 a
2%	8.715 a	5.011 a	2.314 a	31.050 a	68.919 a	53.038 a

According to the data shown in table 4, there were no significant influence of 1 and 2% clove oil dip on fruit TSS%, TA%, total sugars (mg/g F.W.) and ascorbic acid (mg/100 g. F. W.) as compared with untreated fruit. On the other hand, fruit dipped in 2% clove oil has significantly increased fruit anthocyanins contents compared to other treatments, besides, no significant differences were found between 0% and 1% clove oil treatments.

Table-4: Effect of clove oil on TSS%, TA%, total sugars (mg/g F.W.), ascorbic acid (mg/100 g. F. W.) and anthocyanins (mg/100 g. F. W.) in pomegranate fruits cv. 'Salakhani' stored at 5±1°C and 90% RH for 4 months.

Clove Oil	TSS%	TA%	Total sugars (mg/g F.W.)	Ascorbic acid (mg/100 g. F. W.)	Anthocyanins (mg/100 g. F. W.)
0%	15.842 a	0.723 a	11.909 a	10.478 a	10.837 b
1%	15.591 a	0.766 a	11.891 a	10.078 a	11.511 b
2%	15.493 a	0.781 a	12.048 a	9.844 a	12.844 a

It is obvious from table (5) that weight loss%, peel% and arils% values gave no significant differences between all interaction treatments, whereas the highest value of decay% was recorded from 0% KMS and 1% CLV (8.317), while 2% KMS and 0% CLV gave the lowest value (3.567). The same table depicted that the highest peel thickness (mm) was noticed from the interaction between 2% KMS and 0% CLV, whereas the least values was observed from the 0% KMS and 2% CLV. On other hand, 0% KMS and 2% CLV

recorded the highest value for Juice% (56.249) in contrast to 2% KMS and 1% CLV which gave the lowest value (48.046).

Results shown in table (6) indicate that the highest value of TSS% was obtained from the interaction between 0% KMS and 0% CLV, while the lowest value was noticed from 0% KMS and 1% CLV. The same table shows that there were no significant differences between all interaction treatments on TA%. With respect to total sugars (mg/g F.W.) and anthocyanins (mg/100 g. F. W.), the highest value was found from the interaction between 4% KMS and 2% CLV (13.122) and (15.000), respectively, after storage for 120 days, whereas, the lowest values obtained from the interactions between 0% KMS and 1% CLV (10.761 and 8.233 respectively).

Pomegranate fruit dipped in the solutions of the interaction between 0% KMS and 0% CLV resulted in the highest value (11.633) of ascorbic acid (mg/ 100 g. F. W.), while the lowest value (7.633) was recorded from the 4% KMS and 2% CLV interaction.

Table-5: Interaction effects of potassium metabisulfite and clove oil on weight loss%, decay%, peel thickness (mm), peel%, arils% and juice% in pomegranate fruits cv. 'Salakhani' stored at 5±1°C and 90% RH for 4 months.

Treatment combinations	Weight loss%	Decay%	Peel thickness (mm)	Peel%	Arils%	Juice%
0% KMS *0% CLV	9.848 a	6.500 ab	2.745 a	30.820 a	69.074 a	53.914 ab
0% KMS *1% CLV	8.011 a	8.317 a	2.424 ab	31.973 a	67.923 a	52.502 ab
0% KMS *2% CLV	9.453 a	4.817 ab	1.718 b	28.293 a	71.663 a	56.249 a
2% KMS *0% CLV	8.733 a	3.567 b	2.867 a	30.058 a	69.915 a	51.358 ab
2% KMS *2% CLV	9.058 a	5.650 ab	2.659 ab	32.732 a	67.252 a	51.433 ab
2% KMS *1% CLV	9.499 a	5.767 ab	2.235 ab	31.741 a	68.234 a	48.046 b
4% KMS *0% CLV	8.039 a	3.750 b	2.320 ab	30.863 a	69.125 a	50.945 ab
4% KMS *1% CLV	9.165 a	4.633 b	2.342 ab	32.132 a	67.797 a	49.211 b
4% KMS *2% CLV	7.634 a	4.567 b	2.567 ab	32.126 a	67.841 a	51.433 ab

Table-6: Interaction effects of potassium metabisulfite and clove oil on TSS%, TA%, total sugars (mg/g F.W.), ascorbic acid (mg/100 g. F. W.) and anthocyanins (mg/100 g. F. W.) in pomegranate fruits cv. 'Salakhani' stored at 5±1°C and 90% RH for 4 months.

Treatment combinations	TSS%	TA%	Total sugars (mg/g F.W.)	Ascorbic acid (mg/100 g. F. W.)	Anthocyanins (mg/100 g. F. W.)
0% KMS *0% CLV	16.039 a	0.683 a	11.439 cd	11.633 a	8.443 de
0% KMS *1% CLV	14.994 c	0.712 a	10.761 d	11.433 a	8.233 e
0% KMS *2% CLV	15.300 abc	0.748 a	11.234 cd	10.567 a	9.967 de
2% KMS *0% CLV	15.556 abc	0.670 a	11.556 cd	10.700 a	10.533 cd
2% KMS *1% CLV	15.778 abc	0.858 a	11.978 bc	10.367 a	12.467 bc
2% KMS *2% CLV	15.156 bc	0.750 a	11.789 c	11.333 a	13.567 ab
4% KMS *0% CLV	15.933 ab	0.816 a	12.733 ab	9.100 b	13.533 ab
4% KMS *1% CLV	16.000 ab	0.728 a	12.934 a	8.433 bc	13.833 ab
4% KMS *2% CLV	16.022 a	0.846 a	13.122 a	7.633 c	15.000 a

Discussion And Conclusions

Pomegranates are non-climacteric fruit and shows very low respiration rates. Therefore; there is low consumption of sugar for respiration during postharvest life. Furthermore, fruit decay% decreased, this might be interpreted that pomegranates peel were hardened with long storage periods, so insects and fungi could not easily attacked, also peel hardened could be decrease gas exchanging between fruit and external atmosphere which finally decrease respiration, ripening metabolism and fruit deterioration [34].

The reason of the significant increase in fruit TSS (%) with prolonged storage periods, could be due to the alteration in cell wall structure and increasing the breakdown of complex carbohydrates into simple sugars, or might be due to increased juice concentration as a result of water loss (dehydration) from the fruit through transpiration or evaporation which occurred in fruit during storage period [35].

The breakdown of polysaccharides into water soluble sugar might be a reason for an increase in the sugar content. After harvest and during storage the fruits content in reducing sugars was increased in parallel with the TSS content. Results are consistent with those reported by [36].

Ascorbic acid is an important nutrient quality parameter, which is very sensitive to degradation due to its oxidation compared to other nutrients during storage [37]. However, information on ascorbic acid stability is limited when treated with KMS or Clove oils; According to [38] the decrease of ascorbic acid during storage could be due to the conversion of dehydroascorbic to diketogulonic acid by oxidation.

Anthocyanins are the pigments responsible for red color in pomegranates, unstable during storage of fruits. The browning of fruits was generally thought to be a rapid degradation of anthocyanins caused by polyphenol oxidase (PPO) and peroxidase (POD), producing the browning-colored by-products [39]. Other studies have shown the antioxidant activity and total phenolic and anthocyanin contents in blueberries which showed no significant decrease but slight increase depending on cultivar during marketable cold storage period (3–5 weeks) [40].

Metabisulphite and derivatives sulphites are oxidizing agents that act as preservatives color stabilizers in some products; furthermore the sodium metabisulphite treatment had a more effective control on the development of molds at 5°C [41]. These results were found to be similar to those of our results with decay percentage.

[42] reported in contrast with our results, they showed the loss of moisture in the skin, but statistically it was not significant, low of juice percentage in high concentration of KMS on the other hand gave high percentage with untreated fruits may be returning for this reason.

Increase of anthocyanin content may be due to meta-bisulphate (sulfite) which acts gradually on the effectiveness of the enzyme, preservative and also as a reducing factor [41]. [43] Found out that potassium metabisulphite treatment showed better color than the other samples. These results on color are also in consistent with those reported by [44], [42], [45] and [46].

It is therefore evident from our results, that the application of essential oils had no effect on the weight loss, decay, peel thickness, peel, arils, juice, TSS, TA, total sugars and ascorbic acid except anthocyanins in pomegranate fruits cv. 'Salakhani' stored at 5±1°C and 90% RH for 4 months. [47] Reported that clove oil treatment had no effect on the physicochemical attributes of banana fruits. These results were found to be similar to those of [27]. In contrast with our results, [47] reported that clove oil treatment on apricot fruits showed a significant effect on fruit quality retention as evaluated with weight loss, fruit firmness, TSS, TA and sensory parameters.

Clove oil caused no significant differences on most characteristics may be contributed to the low concentration of the oil used in this study, also the result could be related to the period time (2 minutes) into which the fruits were dipped. Another aspect for interpretation of this non-effectiveness may be the thickness of pomegranate peel in comparison to the fruits used in other studies.

The interaction between KMS and CLV on decay, TSS, total sugars and anthocyanins may create the best condition to increase these values. In contrast with ascorbic acid content, all these results of the interactions effects between the factors owed could be attributed to the positive reciprocal effects of these factors.

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