

EFFECT OF SALICYLIC ACID AND POTASSIUM METABISULFITE ON POSTHARVEST QUALITY OF PLUM CV. QADRI

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ABSTRACT

The study was conducted on Qadri cultivar plum fruits taken randomly at maturity stage from 14 year old trees planted at Barzinja, Sulaimani-Iraqi Kurdistan region on 10 September, 2014. Homogeneous fruits were selected and divided into three equal parts. The aim of the study was to investigate the effect of (0, 3, and 6 mmols.l⁻¹) salicylic acid and (0, 0.5, 1, 1.5, and 2 %) potassium metabisulfite on some fruit properties stored in a cold room at 2 ±1°C and 90 % relative humidity for 60 days. A factorial experiment within Completely Randomized Design was used with three replicates. The results indicate that 6 mmols.l⁻¹ salicylic acid increased significantly titratable acidity, hardness, and moisture content, while water loss, anthocyanin, and total phenols were reduced. On the other hand, 2% potassium metabisulfite caused increases in total soluble solids, titratable acidity, hardness, water loss, and total phenol, whereas moisture content and anthocyanin were decreased in fruits.

Keywords: plum fruits, salicylic acid, potassium metabisulfite, postharvest fruit quality

تأثير حامض الساليسيليك والبوتاسيوم ميتايبيسولفيت على الجودة مابعد الحصاد لثمار الاجاص صنف القادري

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المخلص

أجريت هذه الدراسة على ثمار الاجاص صنف القادري والتي حصدت عشوائيا عند مرحلة النضج الفسلجي من أشجار عمرها 14 سنة مزرعة ديما في ناحية البرزنجة، السليمانية - إقليم كردستان العراق في 10 سبتمبر 2014. تم اختيار الثمار المتجانسة وقسمت الثمار إلى ثلاثة أقسام متساوية. تهدف الدراسة إلى معرفة تأثير التغطيس بحامض الساليسيليك (0، 3، 6) مليمول/لتر و (0، 0.5، 1، 1.5، 2٪) البوتاسيوم ميتايبيسولفيت على بعض خصائص الثمار المخزنة في غرفة باردة عند 2 ±1°م و 90٪ الرطوبة النسبية لمدة 60 يوما. استخدمت تجربة

عاملية وفق التصميم العشوائي الكامل وبثلاثة مكررات. وتشير النتائج إلى أن 6 مليمول/لتر من حامض الساليسليك سبب في زيادة معنوية للحموضة القابلة للتسحيح وصلابة ومحتوى الرطوبة في الثمار، في حين قلل فقدان الرطوبة وصبغة الأنثوسيانين والفينولات الكلية في الثمار. من ناحية أخرى تسبب 2٪ البوتاسيوم ميتابيسلفيت في زيادة المواد الصلبة الذائبة الكلية والحموضة القابلة للتسحيح والصلابة وفقدان الرطوبة والفينولات الكلية في الثمار، في حين انخفض محتوى الرطوبة والانتوسيانين في الثمار.

كلمات مفتاحية: ثمار الاجاص، حامض الساليسليك، البوتاسيوم ميتابيسلفيت، نوعية الثمار مابعد الحصاد.

INTRODUCTION

Plum belongs to Rosaceae family and considered the most important stone fruit [1]. Plums have numerous varieties and hybrids which are suitable for many soils and sites [2]. Fruits are consumed fresh, dry, canned, frozen, and used in the production of jams and jellies. They are rich in vitamins, minerals, fibers, polyphenols, anthocyanins, and flavonoids as antioxidants which are very important in preventing human body from risky diseases. The main factor limiting the extension of storage life of many fresh fruits is postharvest decay. The Plum fruits are climacteric so they must be kept in cold storage for 2–6 weeks in order to extend postharvest market life [3–5].

Salicylic acid (SA) is endogenous growth regulator belongs to the phenolic group [6], it has an important role in physiological and biochemical process such as ion uptake, membrane permeability, enzymes activity [7]. SA can maintain the fruit quality under low temperatures for longer periods [8,9] as it delays ripening process and reduces the quality deterioration in some fruits such as peach [10] and plum fruits [11]. Application of exogenous SA at non-

toxic concentrations caused delay of the ripening softening of banana and kiwifruit and increase host resistance to postharvest diseases of sweet cherry [12],[13] and [14]. Through reduction fungal decay as a result of it is induction of the defense resistance system [15]. Also SA affect positively on reducing fruit respiration, ethylene biosynthesis, weight loss, decay and softening rate during storage.

Potassium metabisulfite (KMS) also known as E224 used as a food additive in which it forms sulfur dioxide gas (SO_2). KMS acts as an antifungal agent, and an effective antioxidant [16]. Application of KMS at 250 ppm to rambutans fruit, and stored under controlled atmosphere (CA) (13.5°C), controlled the diseases, color and maintained eating quality of the fruits for up to 21 days. it is very helpful in improving quality and shelf life of ginger puree [17], and used as chemicals for preservation, of the freshly harvested fruits of pointed gourd [18]. Qadri plum cultivar is widely planted in rainfed orchards in Iraqi Kurdistan region. It is fruit can be consumed fresh because of better quality and somewhat firm at maturity. Fruit undergoes various physiological

and biochemical changes during fruit ripening. Such changes continue to occur even after harvesting which leads to lowering of fruit quality and high post-harvest losses. Storage in a fresh condition for longer period with no loss in quality is thus a very important process for maintaining fruits in good condition.

SA and KMS treatments are used to maintain better fruit and the shelf life of harvested fruit. Little information is available about the use of the two chemicals for this purpose. Therefore, the objective of this study is to investigate the effect of the postharvest soaking of salicylic acid and potassium metabisulfite on Qadri plum fruit cultivar, especially changes in quality properties during storage.

2. MATERIALS AND METHODS

The 'Qadri' plum cultivars harvested manually at commercial maturity stage on 10 September 2014 from 14 year-old trees at Barzinja (Sulaimani province, Kurdistan region-Iraq). Average of temperature, total rainfall and relative humidity in the growing season (November to October) of 2014 were 15.6°C, 540 mm and 43%, respectively. Soil texture was clay-loam, EC=0.3(dS.m⁻¹) and soil pH=7.80. The trees were spaced at (3x4) m between and along the rows under rain-fed cultivation and routine cultural practices suitable for fruit production were carried out.

Fruits were transported to the laboratory soon after harvest at early morning. Plums with defects (sunburns, cracks, cuts and bruises in peel) were discarded afterward and fruits were selected in accordance with their colour and weight. The homogeneous fruits were randomly divided into 3 groups (each replicate contained 50 fruits). 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 at 0.05 level [19].

Fruits were soaked for 2 minutes in different concentrations of two chemicals including; salicylic acid (0, 3, and 6 mmols.l⁻¹) and potassium metabisulfite (0, 0.5, 1, 1.5, and 2 %), then fruits were left to dry at room temperature, after 30 minutes they were packed in polyethylene bags and stored at 2 ±1°C and 90 % relative humidity (RH) in a room for 60 days.

After the storage, the following parameters were measured:

1- Weight loss of fruit (WL %):

Determined with the method described by [20] according to the formula below:

$$\text{Weight loss (\%)} = [(A-B)/A] \times 100$$

A: initial fruit weight. B: fruit weight after storage period.

2- Moisture content:

The moisture content was determined according to standard

methods [20] as follows: Fruits were dried in an oven at 67 °C and the weight loss was measured after 48 hours. The moisture content was calculated as follows:

% moisture = (initial weight - final weight) × 100 / initial weight.

3- Hardness (kg.cm⁻³):

Hardness was determined by Texture Analyzer as described in [20] using 6 mm spindle diameter and 5 kg load cell which is moving at a speed (2 mm.sec⁻¹) with the depth of 5 mm.

4- Total soluble solids (TSS %):

TSS were determined by a hand refractometer as described in [20].

5-Total titratable acidity (TA %):

The same method mentioned for TSS was also used for determining TA%. The samples were titrated with NaOH using phenolphthalein index and the acidity was determined as Malic acid content (g.100 ml⁻¹ juice).

$$\text{Titratable acidity} = \frac{\text{Vol. NaOH ml} \times \text{N.} \times \text{Milli.eq. Of Acid (0.067)}}{\text{Weight of Sample (g)}} \times 100$$

6- Anthocyanins (mg.100 g⁻¹ fresh weight):

The method used for anthocyanins determination was described by [21].

7- Total phenol (mg.100 g⁻¹ fresh weight):

Total phenol was determined according to [21].

3. RESULTS AND DISCUSSION

3.1 Effect of salicylic acid and potassium metabisulfite and their interactions on (Qadri) plum fruit weight loss%:

As shown in Fig. (1), 3 mmol.l⁻¹ of salicylic acid significantly decreased weight loss compared to other treatments. It was previously found that the weight loss of apple fruit was significantly reduced when treated with salicylic acid in comparison to the control during storage [8]. [22] found that the weight loss of fruit over storage period could be due to the water exchange between the fruit and the atmosphere, the transpiration rate being hurried by cellular breakdown. Likewise, [23] showed that salicylic acid caused a decrease in the rate of respiration and weight loss of fruit by closing stomata. With regard to the results, the fruits treated with salicylic acid showed significantly reduction in weight loss during storage, which may be due to one of the following processes: metabolic activity, respiration and or transpiration. Salicylic acid as an electron donor produces free radical which blocks normal respiration, salicylic acid can also decrease respiration rate and fruit weight loss by stomata closing [23, 24].

Moreover, [25] showed that strawberry fruits immersed in salicylic acid solution had a low weight loss compared with control treatment. Concerning with the potassium metabisulfite, increasing concentrations led to increase the weight loss at the end of the storage period. The reason of slight increase in dehydration may come back to sulfur dioxide that caused some changes in the cells and reduced

the capacity of the cells to retain moisture [26]. Minimum weight loss occurred in the combination of 6 mmols.l⁻¹ salicylic acid + 0.5% potassium metabisulfite that reached 2.911%, that was superior to other interactions except the interaction between 3 mmols.l⁻¹ of salicylic acid + 0.5% potassium metabisulfite, While the maximum weight loss (5.365%) was recorded in control (Table 1).

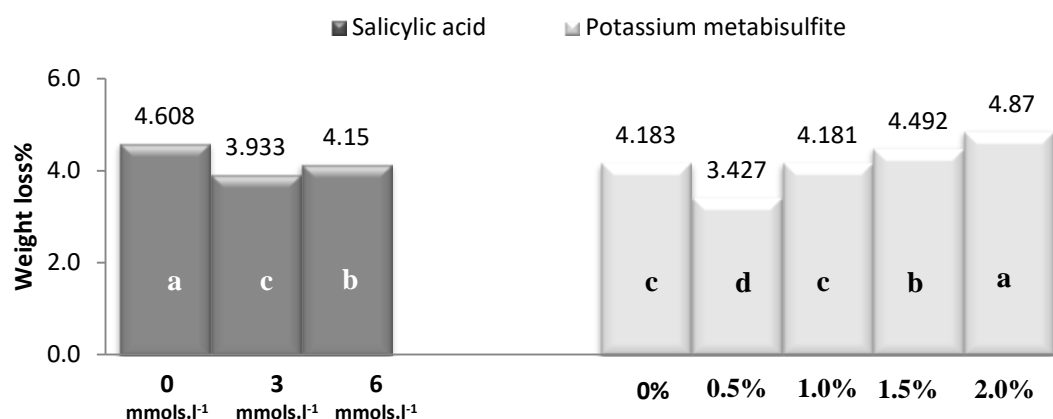


Fig. 1 Effect of salicylic acid and potassium metabisulfite on (Qadri) plum fruit weight loss%

Table (1): Effect of salicylic acid and potassium metabisulfite interactions on weight loss%, moisture% and hardness (kg.cm-3) of plum fruit

Salicylic acid mmols.l ⁻¹	Potassium metabisulfite%	Weight loss%	Moisture%	Hardness (kg.cm- 3)
0	0	5.365 a	80.053 bc	3.099 d
	0.5	4.094 cd	82.830 a	2.889 def
	1.0	4.464 bc	78.800 cd	2.993 def
	1.5	4.223 cd	79.350 bcd	2.337 gh
	2.0	4.892 ab	79.373 bcd	4.343 a
3	0	3.440 e	81.270 abc	1.990 h
	0.5	3.276 ef	80.660 abc	2.688 efg
	1.0	4.132 cd	78.743 cd	2.638 fg
	1.5	3.932 d	77.407 d	3.668 c
	2.0	4.888 ab	78.853 cd	3.055 de
6	0	3.743 de	81.400 abc	2.426 g
	0.5	2.911 f	81.443 abc	4.155 ab
	1.0	3.945 d	81.997 ab	2.428 g
	1.5	5.322 a	81.193 abc	3.147 d
	2.0	4.831 b	79.433 bcd	3.886 bc

3.2 Effect of salicylic acid and potassium metabisulfite and their interactions on (Qadri) plum fruit moisture%:

Highest moisture content found in 6 mmols.l⁻¹ of salicylic acid and 0.5% potassium metabisulfite which 81.093% and 81.644% respectively. However lowest moisture 79.387% and 79.22% was observed in 3 mmols.l⁻¹ of salicylic acid and 2% potassium metabisulfite

respectively (**Figure 2**). The reason of this may be due to the same reasons that mentioned before in water loss. Fruits treated with the combination of 0 mmols.l⁻¹ of salicylic acid + 0.5% potassium metabisulfite gave the highest significant moisture content compared with most other interactions. While the lowest moisture contains was found in fruits treated with 3 mmols.l⁻¹ salicylic acid and 1.5% potassium metabisulfite (**Table 1**).

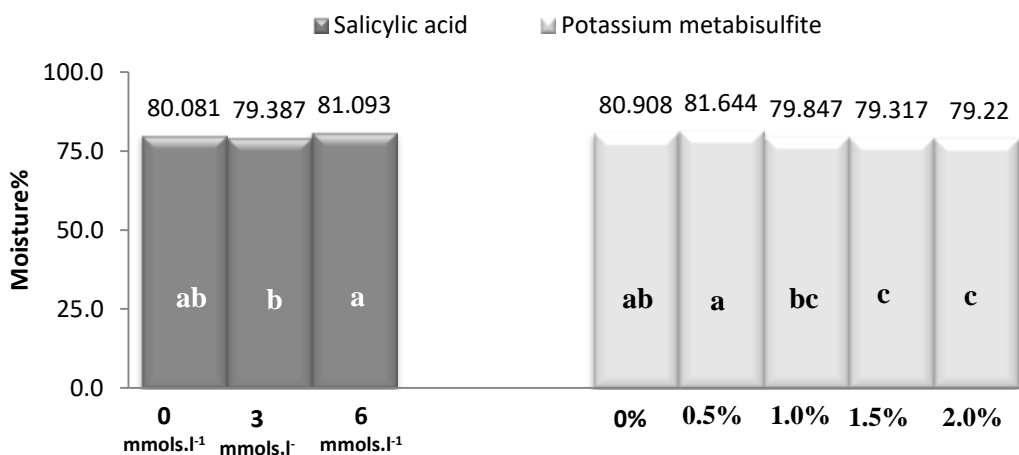


Fig. 2 Effect of salicylic acid and potassium metabisulfite on (Qadri) plum fruit moisture%

3.3 Effect of salicylic acid and potassium metabisulfite and their interactions on (Qadri) plum fruit hardness (kg.cm-3):

Data in **Figure (3)** showed that, the lowest fruit softening rate was recorded in 6 mmols.l⁻¹ salicylic acid (3.208 kg.cm-3) which was not different significantly from control, while the highest fruit softening rate was noted in 3 mmols.l⁻¹ salicylic acid (2.808 kg.cm-3). They found that quick softening of fruits during ripening

occurred at the same time with a fast decrease in the endogenous salicylic acid of fruits. Salicylic acid affects cell swelling which leads to highest hardness of fruits[23,25]. [27] noticed that the impact of salicylic acid on the decrease of fruit softening may be due to ACO (1-aminocyclopropane-1-carboxylic acid oxidase) activity inhibitory, and thus on ACC (1-aminocyclopropane-1-carboxylic acid) conversion to ethylene, or higher hardness in treated fruits can be attributed to the reduced hydrolysis of

soluble starch. Delayed ripening process in salicylic acid treated fruits was concentration dependent. The fruit hardness was significantly maintained high by increasing the concentration of potassium metabisulfite during storage period in all treatments compared to the control, and the highest occurred in 2.0% potassium metabisulfite (3.761 kg.cm^{-3}) while the least was recorded in control (2.505 kg.cm^{-3}) (Fig. 3).

Data in **Table (1)** refer to, the interaction between 0 mmols.l^{-1} salicylic acid and 2.0% potassium metabisulfite significantly preserved high fruits hardness (4.343 kg.cm^{-3}) in comparison with all other interactions, whilst, the least fruits hardness (1.990 kg.cm^{-3}) was recorded in the interaction treatment between 3 mmols.l^{-1} salicylic acid and 0% potassium metabisulfite.

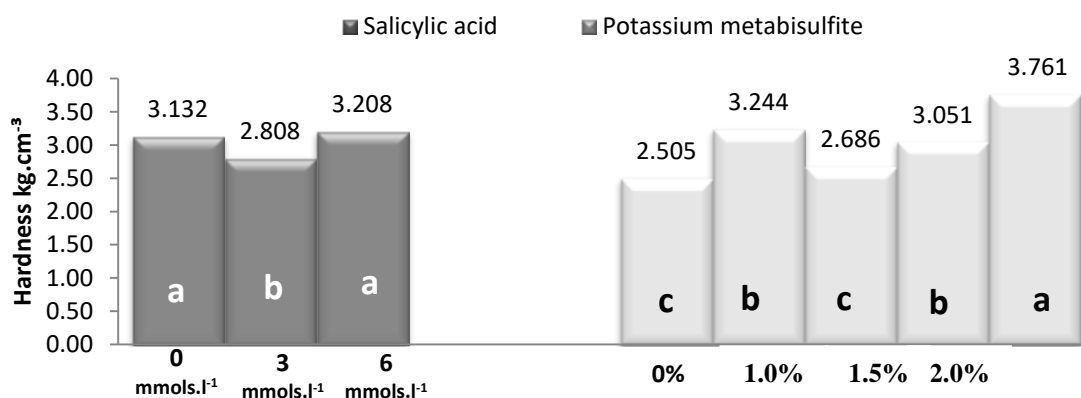


Fig. 3 Effect of salicylic acid and potassium metabisulfite (Qadri) plum fruit hardness (kg.cm^{-3})

3.4 Effect of salicylic acid and potassium metabisulfite and their interactions on (Qadri) plum fruit Total soluble solids (TSS %):

The results in **Figure (4)** indicated that increasing salicylic acid concentrations decrease the total soluble solids compared with the control treatment during the storage period. On contrary, 2.0% potassium metabisulfite application, recorded the highest

(17.883%) TSS compared with other treatments. However, the obtained results indicated that all application rates did not differ significantly in respect to TSS%. Maximum percentage of total soluble solids noticed in the interaction between the highest level of each salicylic acid and potassium metabisulfite (18.85%), Whereas, the lowest percentage (15.36% TSS) was recorded in the interaction between 6 mmols.l^{-1} of salicylic acid and 0% potassium metabisulfite (**Table 2**).

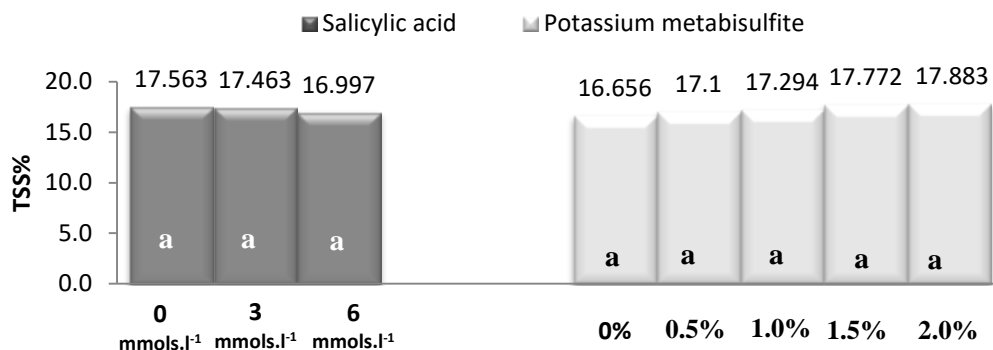


Fig. 4 Effect of salicylic acid and potassium metabisulfite on (Qadri) plum fruit total soluble solids (TSS %)

Table (2): Effect of salicylic acid and potassium metabisulfite interactions on TSS%, TA%, Anthocyanin and Total phenol of plum fruit

Salicylic acid mmols.l ⁻¹	Potassium metabisulfite%	TSS%		TA%		Anthocyanin		Total phenol	
0	0	17.633	abc	0.458	h	21.096	h	240.156	h
	0.5	16.550	abc	0.536	g	22.284	g	251.025	fg
	1.0	18.133	abc	0.593	fg	29.837	c	245.112	gh
	1.5	18.300	ab	0.616	f	25.509	e	265.530	c
	2.0	17.200	abc	0.682	e	25.102	e	302.359	a
3	0	16.967	abc	0.759	d	31.422	b	261.779	cde
	0.5	17.550	abc	0.882	bc	40.078	a	260.964	cde
	1.0	18.250	ab	0.892	bc	30.855	b	263.187	cd
	1.5	16.950	abc	0.927	b	22.030	g	254.124	ef
	2.0	17.600	abc	0.847	c	31.093	b	259.403	cde
6	0	15.367	c	0.899	bc	22.454	g	241.191	h
	0.5	17.200	abc	1.052	a	27.665	d	256.704	def
	1.0	15.500	bc	0.997	a	21.300	h	255.940	def
	1.5	18.067	abc	1.057	a	24.983	ef	275.577	b
	2.0	18.850	a	1.036	a	24.355	f	264.681	c

3.5 Effect of salicylic acid and potassium metabisulfite and their interactions on (Qadri) plum fruit titratable acidity (%):

The treated fruits with salicylic acid and potassium metabisulfite had a significantly influence on the titratable acidity content. At the end of storage period at 2°C, the highest level of titratable acidity was detected for each 6 mmols.l⁻¹ salicylic acid and 1.5% potassium metabisulfite treatments,

while the lowest content was observed in control treatment fruit (**Fig.5**). [27] proposed that the maximum titratable acidity was observed in 3 mmols.l⁻¹ salicylic acid and the minimum titratable acidity were recorded in control apple fruit during storage, This increase might be due to the breakdown of pectin in to pectenic acid[28].

However, the interaction between 6 mmols.l⁻¹ salicylic acid and all concentrations of potassium

metabisulfite significantly increased the total acidity compared with other interactions, while the lowest

percentage was recorded in control (0.458%) (**Table2**).

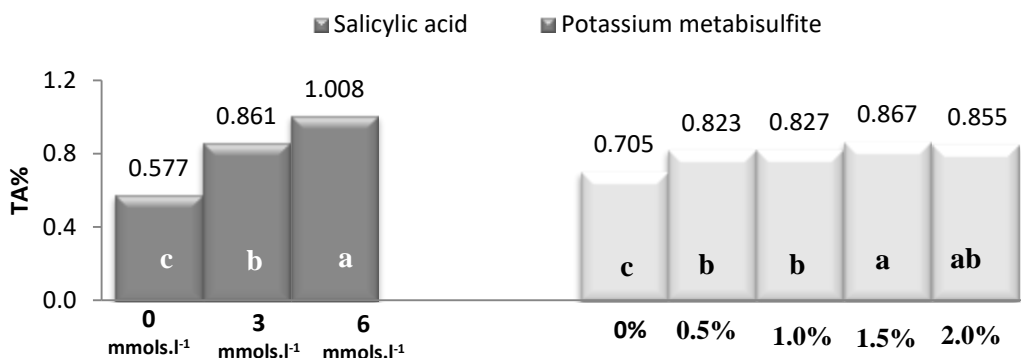


Fig. 5 Effect of salicylic acid and potassium metabisulfite on (Qadri) plum fruit titratable acidity (%)

3.6 Effect of salicylic acid and potassium metabisulfite and their interactions on (Qadri) plum fruit Anthocyanin (mg.100g⁻¹):

The lowest value of anthocyanin found in fruits treated with 6 mmols.l⁻¹ of salicylic acid (24.151 mg.100g⁻¹). [25] reported that addendum salicylic acid to the nutrient solution was not efficient on fruit color in comparison with control treatment; postharvest applications were not efficient on lightness while the effect of salicylic acid may be due to lower respiration which delays fruit senescence during

storage. Whilst, immersing in 0.5% potassium metabisulfite leads to increment the value of anthocyanin content in fruits, whereas, the lowest value was recorded in 1.5% potassium metabisulfite 24.174 mg.100g⁻¹ (**Fig. 6**). This increase of anthocyanin may be attributed to meta-bisulphate that acts both as an enzymic browning inhibitor and preservative [26]. The results in **Table (2)** indicated that fruits treated with 3 mmols.l⁻¹ of salicylic acid and 0.5% potassium metabisulfite was superior significantly to other interaction, while the lowest value was observed in control.

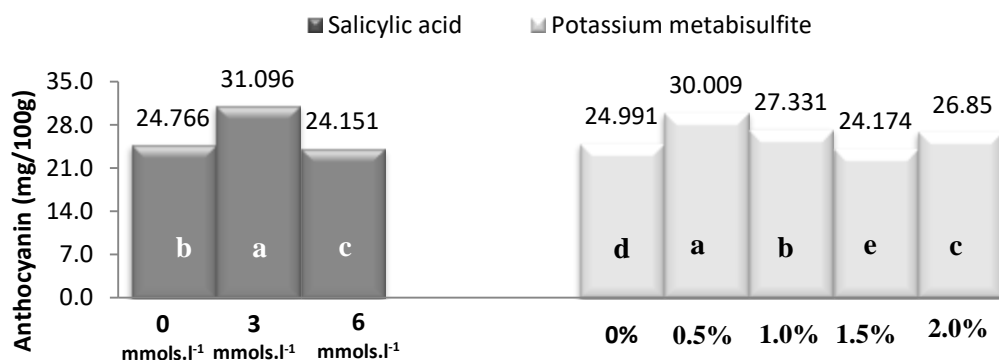


Fig. 6 Effect of salicylic acid and potassium metabisulfite on (Qadri) plum fruit Anthocyanin (mg.100g⁻¹)

3.7 Effect of salicylic acid and potassium metabisulfite and their interactions on (Qadri) plum fruit Total Phenol (mg.100g^{-1}):

Data in **Figure (7)** showed there was no significant difference among fruits immersed in salicylic acid with regard to total phenol. However, immersing in all concentrations of potassium metabisulfite caused significant increase in the value of total phenol. This increase may be due to sulfite

which prevent enzymatic browning by directly inhibiting polyphenol oxidase and also releasing sulfite ions which inhibit the formation of brown melanin pigments by combining with ortho-quinone [29]. The interaction between 0 mmols.l^{-1} salicylic acid and 2.0% potassium metabisulfite was superior significantly to other interaction treatments that maintained the highest value of total phenol in fruits at the end of the storage period (**Table2**).

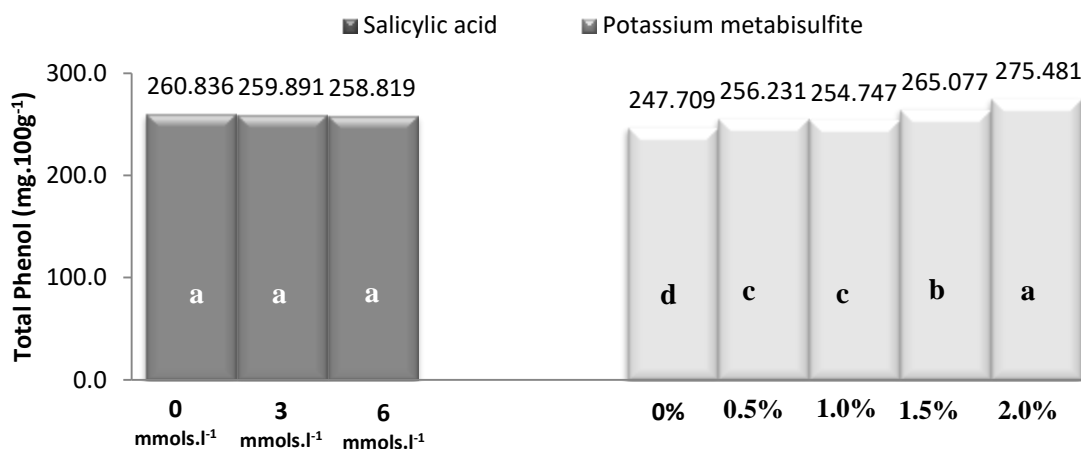


Fig. 7 Effect of salicylic acid and potassium metabisulfite (Qadri) plum fruit total phenol (mg.100g^{-1})

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