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Effect of foliar spraying of some materials on protecting Murcott mandarin fruits from sunburn injuries

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ABSTRACT

Sunburn in mandarin fruits costs growers a lot of economic losses annually due to high temperatures and low relative humidity during the summer in Egypt. This investigation was carried out during seasons (2017 /2018 and 2018/2019) to study the effect of spraying trees with different treatments on reducing sunburn injuries on Murcott mandarin (*Citrus reticulata*) budded on Volkamer lemon (*Citrus volkameriana* L.). The experiment included nine treatments as follows: Foliar spray of Calcium carbonate ($CaCO_3$) and Kaolin, at 4% and 6% either individually or with Cupper in chelating form (2.5cm^3/ L), in addition to control which was only sprayed with water. Trees were treated by all treatments at the first and mid-June in both seasons. Results indicated that, kaolin at 4% with Cupper was the best treatment in reducing the percentage of sunburned fruits (8.2%) followed by kaolin at 6% with Cupper (9.5%) and $CaCO_3$ at 6 % with Cupper (11%) as compared with (24.5%) in control treatment (no application of protective materials) . Kaolin at 4% plus Cupper achieved the best significant results for fruit quality (the heaviest fruit weight, biggest fruit dimensions, thicker fruit peel and maximum values for juice weight percentage and T.S.S / acid (ratio). Moreover, all reflective materials increased fruit peel Ca, Si and Cu content. Anatomical study of healthy and sunburned fruits was presented. According to the economic study it could be recommended to use Kaolin at 4% plus chelating Cupper at 2.5cm^3/ L which cost (690 L.E/ fed.) and resulted in the highest rate of marketable fruits (91.8%) to protect Murcott mandarin fruits from sunburn injuries , reducing economic losses and thus increasing the income for growers.

Keywords: Calcium carbonate, Kaolin, Murcott mandarin, Sunburn and Anatomical study

Introduction

Mandarin fruits stand as the second variety for exportation after orange fruits in Egypt. Murcott (*Citrus reticulata*) is one of common mandarin. The trees are vigorous, bushy in shape and have willowy branches, fruits are mainly borne terminally where they are vulnerable to wind, sunburn and frost damage (James, 1990). Sunburn injury is common on fruits due to high solar radiation levels and air temperatures and low relative humidity. Excess absorbed energy is the greatest contributor to cell death and sunburn. The incidence and severity of sunburn depends upon climatic factor, cultivars, hormonal, nutritional and soil moisture (Schrader *et al.,* 2003). The damage caused due to sun burning ranges from 0.9-19.13% in different varieties (Singh *et al.,* 2012). Some plant pathogens such as *Alternaria tenuis* can infect the fruit through the injured epidermal tissue, making it unmarketable (Leeuwen *et al.,* 2002). The quality of the fruits is affected by sunburn (Racskó *et al.,* 2005). Therefore, sunburn can cause serious economic losses in many crops with heavy losses in apple (Warner 1997; Schrader *et al.,* 2001). Sunburn can be prevented only by shutting off direct sunlight, or by wrapping the fruit with paper, or by other means, but these methods are not practical because of high labor costs, and they have not come into widespread use (Sadamatsu, 1981).

The nature of particles generally comprises minerals of high reflectivity, among them Calcium carbonate and kaolin are alternatives of relative low cost, safe use, low erosion, reduced particle size and water diffusion ability (Glenn, *et al*., 2003). Calcium carbonate or crystalline limestone is marketed as a liquid that is mixed with water and sprayed onto crop foliage and fruit to form a thin crystalline layer that reflects some sunlight. In this respect, Glenn *et al.* (2002) reported that crimson Seedless grapevines treated with plant protection as $CaCO_3$ were less prone to sunburn damage than untreated ones and this is due to reducing both fruit temperature and exposure to ultraviolet (UV)

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radiation. Moreover, Curry *et al.* (2004) reported that anti sunburn compounds effectively reduced solar radiation injury of apple trees. In addition, Ahmed *et al.* (2011) found that $CaCo_3$ and Pureshade stimulated plant metabolism through enhancing photosynthesis and formation of plant pigments in favour of enhancing quality of the berries.

Kaolin is a naturally occurring mineral (a clay), main constituent is kaolinite, with the formula $Al_4Si_4O_{10}$ $(OH)_8$ with the following theoretical composition SiO_2 = 46.5%, Al_2O_3 = 39.5% and H_2O = 14% (Obaje *et al.,* 2013). Kaolin used in clay-based sun protection products has been refined and modified to produce awe table powder which can be mixed with water and sprayed onto foliage and fruit to create a white film that will reflect some sunlight and reduce fruit surface temperatures by up to 5 to 10ºC, (Glenn and Puterka 2005). Kaolin reduces fruit surface temperature by increasing the reflection of visible and ultraviolet light (Wunsche *et al.,* 2004). The effectiveness of Kaolin in reducing sunburn in most cultivars and regions may be more strongly ascribed to the reduction in harmful radiation reaching the fruit surface than to the reductions in surface temperature, Gindaba and Wand, (2005), although the latter would lower the threshold for radiation damage. The same results were found by Schupp *et al.* (2002) on apple. Also, Melgarejo *et al.* (2004) found that, sunburn damage of pomegranate fruits was minimized from 21.9% in untreated control to 9.4% in the kaolin treated fruits.

The aim of this study is to evaluate the impact of foliar spraying of some materials on protecting Murcott mandarin fruits from sunburn injuries.

Materials and Methods

This study was conducted at a private orchard at El- Giza Governorate during seasons 2017/2018 and 2018/ 2019 seasons, on Murcott mandarin (*Citrus reticulata*) trees budded on Volkamer lemon rootstock (*Citrus volkameriana* L.) to examine the effect of spraying trees with different treatments which were: Calcium carbonate ($CaCO_3$), Kaolin ($Al_4Si_4O_{10}$ $(OH)_8$) and Cupper in chelating form on reducing sunburn injuries in. The trees were 5 years old, planted at 3x6 m apart in sandy soil under drip irrigation system, received the same horticultural managements and chosen in a completely randomized block design, each treatment was applied into three replicates, and each replicate represented two trees.

Trees were sprayed with nine treatments as follows:

1- Control
2- $CaCO_3$ at 4%
3- $CaCO_3$ at 6%
4- $CaCO_3$ at 4% + Chelating Cupper at 2.5cm^3/ L
5- $CaCO_3$ at 6% + Chelating Cupper at 2.5cm^3/ L
6- Kaolin at 4%
7- Kaolin at 6%
8- Kaolin at 4% + Chelating Cupper at 2.5cm^3/ L
9- Kaolin at 6% + Chelating Cupper at 2.5cm^3/ L

Trees were treated by all treatments at first and mid-June in both seasons. Each tree received 5L. of the spray solution till runoff with Triton B at 0.1 % as a wetting agent by using a backpack spray apparatus, in addition to control which was only sprayed with water.

The following parameters were measured.

Symptoms of sunburn injury on fruit. Observations on sunburned fruits were recorded during the two seasons.

Climate data. The daily maximum and minimum temperatures (˚C) as well as the hours of possible sunshine duration and the relative humidity (%) were collected at El- Giza Governorate according to the Central Laboratory for Climate - Ministry of Agriculture and then the monthly averages of all data collection were calculated.

Sunburn fruits percentage. At harvest time (mid-February) in both seasons, normal and sunburned fruits from all treatments were counted .Thereafter; the percentage of sunburned fruits was calculated.

Fruit quality. Samples of sunburned and healthy fruits from control trees and from all treatments were randomly taken in both seasons for each replicate and the following determinations were carried out: Average of fruit weight (g), fruit diameter and length (mm), Juice weight percentage, total soluble solids (T.S.S %) , total acidity (%) and T.S.S / acid (ratio) were determined according to (A.O.A.C, 1995).

Fruit peel mineral content. Calcium and Cupper were determined in 0.1g of dried fruit peel using atomic absorption spectra-photometer according to Brandfield and Spincer, (1965). Silicon content was analyzed using a spectrophotometric method at a wave length of 660 nm according to Elliot and Snyder, (1991).

Anatomical study. Samples of normal and sunburn of mandarin fruits were taken and fixed in formalin acetic acid, ethyl alcohol (FAA) solution. Transverse sections were taken from the pericarp of several fruits from each sample and were embedded in paraffin wax (56-58^{o}C M.P.), sectioned at 8-10 micron thickness were cut using the rotary microtome, and mounted in Canada balsam according to Nassar and El-Sahhar, (1998). The reported sections were microscopically examined and photographed.

Statistical analysis. The obtained data were statistically analyzed according to Clarke and Kempson (1997) and comparison among means were made using Duncan Multiple Range Test (Duncan, 1955).

Results and Discussion

Symptoms of sunburn injury on fruit. Fruits of Murcott mandarin are mainly borne terminally on the trees as shown in (Fig. 1B) where they are vulnerable to sunburn. Sunburn injury appeared as a somewhat circular, dark- brown spots on the side of the fruit exposed to direct sunlight (Fig. 1A, B) the injury started to occur in mid June when the fruits were young. With continued exposure to direct sunlight and with increase in age the injury appeared as a dark dry area and the juice vesicles were dry under the sunburned side. Similar observations were found by Myhob *et al*., (1996) on Balady mandarin fruits, and Nasr *et al*., (1971) in Balady mandarin, Balady sweet orange and Sangtra mandarin.

Fig. 1 A: Healthy (normal) fruits in the left and sunburned fruits in the right (Photo taken July 10, 2017).

Fig. 1 B: Sunburned fruits in the tree (Photo taken December 25, 2017).

Climate data. Averages of daily maximum and minimum temperatures (^{0}C) during the months of season (2017) were shown in Fig. (2). Data indicated that, there were increasing in averages of maximum temperatures during the months from May to August (after fruit set in April) and the maximum averages were recorded in July (38.2^{o}C) , then the temperatures started to decrease from August to December. Concerning the averages of minimum temperatures, data revealed that, July and August recorded the highest values (24.5, 24.6) as compared with other months. Moreover, data in Fig

.(3) showed the monthly averages of relative humidity (%) and indicated that, the lowest daily averages was recorded in Jun (23.3%)than the other months . As for the daily averages of sunshine hours duration during the months of the year, data in Fig. (4) showed that, the period from May to August scored the longest daily hours of sunshine duration (13.4, 13.9 , 13.8 and 13.1 hours), respectively, as compared with other months. From the above climate data it is noticed that, June month recorded (36.7 °C) and (16.0 °C) for averages of maximum and minimum temperatures, respectively with the lowest values of relative humidity (23.3%) and was exposed to the longest period of sunshine (13.9 hours), so application of high reflectivity materials like Calcium carbonate and kaolin at this month is the most suitable time to protect Murcott mandarin fruits from sunburn injuries according to available climatic data. In this respect, Syvertsen and Albrigo, (1980) indicated that, citrus fruits, at high ambient temperatures, are particularly vulnerable to heat stress, because the temperature of the tree canopy can easily exceed ambient temperatures up to 9 °C. In addition, Syvertsen and Lloyd, (1994) revealed that, when citrus are grown in warm subtropical areas, the average summer air temperature is above 31°C, and leaf temperature can reach 39 °C to 41 °C (8 ° to 10 ° C) above the air temperature . Similar findings in a study of 'Wase Satsuma' mandarin showed that when the average temperature of the orchard was at least 30° C, the peel temperature reached 46.8 ° C, resulting in sunburn symptoms. (Chikaizumi, 2007).

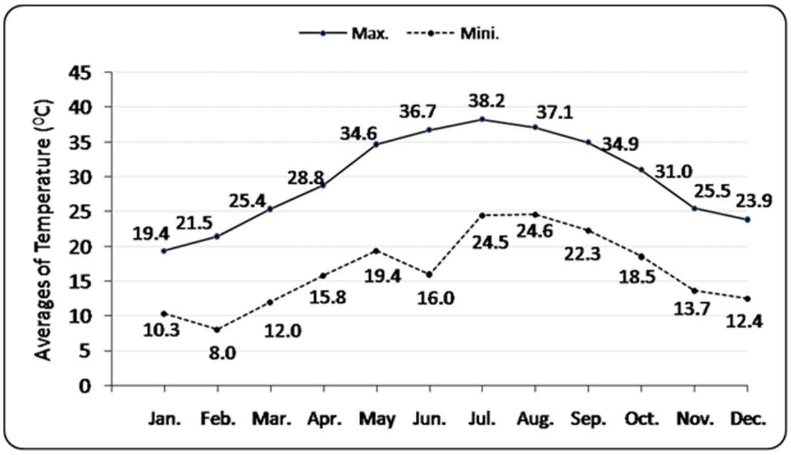

Fig. 2: Averages of daily maximum and minimum temperatures (^{0}C) during the months of season, 2017.

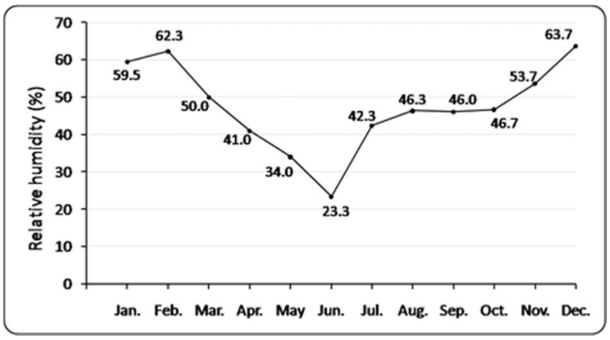

Fig. 3: Averages of daily relative humidity (%) during the months of season, 2017.

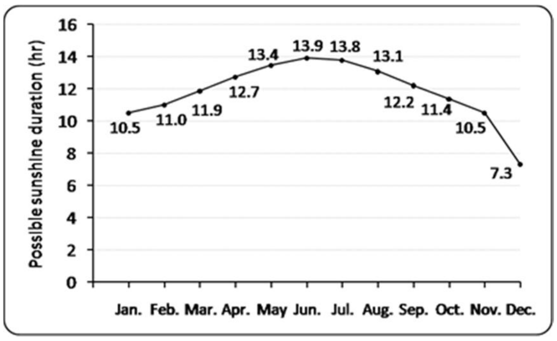

Fig. 4: Averages of daily hour's sunshine duration during the months of season, 2017.

Sunburn fruits percentage. Data in Table (1) and Figure (5) clearly showed that percentages of sunburned fruits of Murcott mandarin was significantly reduced by using $CaCO_3$ or Kaolin at different concentrations especially with chelating Cupper comparing with the control. In more details, (Fig. 5) indicated that, The minimum averages percentage of sunburned fruits was found by application of kaolin at 4% with Cupper (8.2%) followed by kaolin at 6% with Cupper (9.5%) , $CaCO_3$ at 6 % with Cupper (11%) and $CaCO_3$ at 4 % with Cupper (12.3%) as compared with untreated trees which resulted in the maximum averages values of sunburned fruits (24.5%) , while the other treatments scored the intermediate averages during the two seasons of the study (2017/ 2018 and 2018/ 2019).

These results revealed that, application of kaolin with Cupper treatments surpassed the use of $CaCO_3$ treatments in reducing sunburned fruits and therefore, increased the percentage of marketable fruits. These results are in harmony with those obtained by Glenn *et al*., (2002) who mentioned that, kaolin and $CaCO_3$ seemed to reflect some of the solar radiation, especially ultraviolet wavelengths from the fruit surface, thereby lowering fruit surface temperature and reducing sunburn. Also, Jifon and Syvertsen, (2003) on citrus concluded that kaolin applications on grapefruit reduced midday leaf temperatures by 3°C, increased midday stomatal conductance and net CO_2 assimilation of leaves and increased photosynthesis processes. In this respect, Melgarejo *et al*., (2004) found that sunburn damage of pomegranate fruits was decreased from 21.9% in untreated control to 9.4% in the kaolin treated fruits due to its positive role in reducing fruit and leaf surface temperatures. The same results were reported by Curry *et al*., (2004) on apple trees.

The role of Cupper for reducing the proportion of sunburned fruits may be attributed to its effect on increasing the flexibility, expansion and the moisture content of fruit peel; therefore, the fruit becomes more resistant, (Walter *et al*., 1968) .These results are in agreement with those obtained by Sadamatsu, (1981) who found that, Satsuma mandarin trees treated with Cufram Z produced a marked effect on reducing sunburned fruit, since this chemical contains inorganic elements such as Zn, Mn, and Cu.

Table 1: Effect of foliar sprays of Calcium carbonate and Kaolin on sunburned fruits percentage of Murcott mandarin.

Treatments	Sunburned fruits (%)	
	1st season	2nd season
Control	25.2 a	23.8 a
$CaCO_3$ at 4%	19.6 b	14.4 b
$CaCO_3$ at 6%	18.4 c	13.6 b
$CaCO_3$ at 4% + Cu	13.8 e	10.7 c
$CaCO_3$ at 6% + Cu	11.7 f	10.3 c
Kaolin at 4%	14.1 e	13.6 b
Kaolin at 6%	15.6 d	12.9 b
Kaolin at 4% + Cu	9.50 g	6.80 e
Kaolin at 6% + Cu	10.3 g	8.70 d

Mean separation within columns by Duncan's multiple range test, 5% level.
Values that don't share the same letter are significantly different.

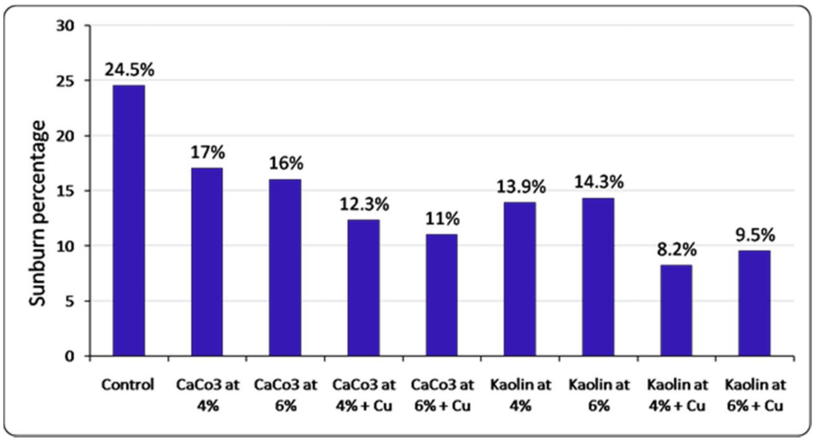

Fig. 5: Averages of sunburned fruits percentage of Murcott mandarin during the two seasons (2017/18and 2018/19).

Fruit quality. Data in (Tables 2 & 3) showed the effect of tested foliar materials on fruit characteristics of Murcott mandarin. Results indicated that, all treatments improved fruit quality. Trees treated by Kaolin at 4% plus Cupper as foliar spray was superior for achieving the best significant results, in terms of producing the heaviest fruits (gm), biggest fruit diameter and length (mm), thicker fruit peel (mm) and maximum values for juice weight percentage and TSS / acid (ratio), followed by $CaCO_3$ at 6% plus Cupper as compared with control treatment for two seasons (2018 & 2019).

Table 2: Effect of foliar sprays of Calcium carbonate and Kaolin on some characteristics of fruit quality on Murcott mandarin.

Treatments	Fruit weight (g)	Fruit diameter (mm)	Fruit length (mm)	Peel thickness (mm)	Juice weight (%)
			1st season		
Control	137 c	66.9 d	53.2d	2.0 c	57.9 c
$CaCO_3$ at 4%	160 b	70.4 c	57.0bc	3.0 a	60.7 b
$CaCO_3$ at 6%	177ab	72.7bc	59.0ab	2.9 a	59.7bc
$CaCO_3$ at 4% + Cu	178ab	72.5bc	59.5 a	2.5ab	61.1ab
$CaCO_3$ at 6% + Cu	187 a	73.9ab	59.0ab	2.3bc	63.0 a
Kaolin at 4%	177ab	73.6 b	56.5 c	2.5ab	60.0 b
Kaolin at 6%	183 a	76.5 a	59.6 a	2.7ab	59.9bc
Kaolin at 4% + Cu	192 a	76.6 a	61.2 a	2.3bc	62.8 a
Kaolin at 6% + Cu	183 a	74.0ab	59.1ab	2.9 a	61.3ab
Sunburned (Injured)	**103**	**54.3**	**47.6**	**1.8**	**39.1**
			2nd season		
Control	145 f	70.2 b	56.5 d	2.5 g	58.3 d
$CaCO_3$ at 4%	170 e	74.2ab	58.5bc	2.9cd	59.2 d
$CaCO_3$ at 6%	180 d	71.7ab	59.4 b	2.8de	61.6 c
$CaCO_3$ at 4% + Cu	188 c	74.0ab	62.3 a	3.1ab	63.2bc
$CaCO_3$ at 6% + Cu	197ab	74.4ab	61.7 a	2.6fg	63.6ab
Kaolin at 4%	180 d	74.5 a	58.4bc	3.0ab	62.7bc
Kaolin at 6%	192bc	73.5ab	59.3 b	2.7ef	64.1ab
Kaolin at 4% + Cu	202 a	74.6 a	62.5 a	2.9cd	65.4 a
Kaolin at 6% + Cu	200 a	72.4ab	57.6 c	3.2 a	63.7ab
Sunburned (Injured)	**110**	**56.1**	**46.1**	**2.2**	**36.3**

Mean separation within columns by Duncan's multiple range test, 5% level.
Values that don't share the same letter are significantly different.

Table 3: Effect of foliar sprays of Calcium carbonate and Kaolin on some characteristics of fruit quality on Murcott mandarin

Treatments	T.S.S (%)	Acidity (%)	TSS/ acid (ratio)
		1st season	
Control	10.7cd	1.02ab	10.3 c
$CaCO_3$ at 4%	10.2 d	0.99ab	10.3 c
$CaCO_3$ at 6%	10.3cd	0.98ab	10.5 c
$CaCO_3$ at 4% + Cu	10.7cd	0.99ab	10.8 b
$CaCO_3$ at 6% + Cu	11.5ab	1.01ab	11.4 a
Kaolin at 4%	10.2 d	0.98ab	10.4 c
Kaolin at 6%	11.0bc	0.96 b	11.5 a
Kaolin at 4% + Cu	11.7 a	1.03 a	11.4 a
Kaolin at 6% + Cu	10.7cd	0.96 b	11.1 a
Sunburned (Injured)	**13.1**	**1.09**	**12.02**
		2nd season	
Control	10.2 d	1.01 a	10.1 e
$CaCO_3$ at 4%	10.6cd	0.99 a	10.7 d
$CaCO_3$ at 6%	10.7cd	1.00 a	10.7 d
$CaCO_3$ at 4% + Cu	10.7cd	0.99 a	10.8cd
$CaCO_3$ at 6% + Cu	11.5 a	1.00 a	11.5ab
Kaolin at 4%	10.4 d	1.02 a	10.2 e
Kaolin at 6%	11.3ab	0.98 a	11.5ab
Kaolin at 4% + Cu	11.5 a	0.98 a	11.7 a
Kaolin at 6% + Cu	11.0bc	0.96 b	11.5ab
Sunburned (Injured)	**13.5**	**1.09**	**12.4**

Mean separation within columns by Duncan's multiple range test, 5% level.
Values that don't share the same letter are significantly different.

On the other hand, injured fruit scored the lowest values for all characteristics of fruit quality, while it has the biggest values for TSS / acid (ratio) compared with other treatments. In general, injured fruits seemed to be unmarketable fruits as a result of sunburn as well as it had bad fruit quality.

The high temperatures of leaves and fruit usually cause water shortages and reduce growth, net photosynthesis, fruit yield and quality (Goldschmidt, 1999). This conclusion is consistent with Myhob *et al*., (1996) and Tsai *et al*., (2013). Also Ketchie and Ballard (1968) reported that the fruit grown under full exposure to sunlight was smaller in weight than the fruit grown in the shade. This increase in fruit weight may be due to increasing of photosynthesis rates. In this concern, Jifon and Syvertsen, (2003) reported that grapefruit treated with kaolin film particles caused increased gas exchange in leaves, CO_2 absorption rates and water efficiency. On the other hand, the Silicon (Si) is considered as the one of Kaolin ($Al_4Si_4O_{10}$ $(OH)_8$) components and it has a positive effect on fruit quality. In this concern Hoda *et al*., (2013) revealed that, Diatoms as a source of silicon improved fruit peel quality, where, (the peel thickness and firmness increased, fruit peel was more lightness and had high good color quality), so it seems more attractive, also, silicon could being about earlier the harvest date by increasing fruit TSS/ acid (ratio) and Vitamin C contents on Valencia orange trees.

Peel mineral content. Results in Table (4) showed that, Calcium (Ca), Silicon (Si) and Cupper (Cu) contents in fruit peel of Murcott mandarin were affected by application of reflectivity materials under study. As for Calcium (%) content, data indicated that, all Calcium carbonate ($CaCO_3$) treatments either singly or in combination with Cupper increased fruit peel Ca content as compared with other treatments.

Table 4: Fruit peel mineral content of Murcott mandarin as affected by foliar sprays of some high reflective materials.

Treatments	Ca (%)	Si (%)	Cu (ppm)
		1st season	
Control	3.13 f	0.33 e	6.70 c
$CaCO_3$ at 4%	3.66 b	0.41 d	6.81bc
$CaCO_3$ at 6%	3.58cd	0.47bc	7.11 b
$CaCO_3$ at 4% + Cu	3.63bc	0.46bc	7.51 a
$CaCO_3$ at 6% + Cu	3.81 a	0.43cd	7.49 a
Kaolin at 4%	3.53 d	0.48ab	7.08 b
Kaolin at 6%	3.44 e	0.52ab	6.92bc
Kaolin at 4% + Cu	3.42 e	0.48ab	7.52 a
Kaolin at 6% + Cu	3.41 e	0.53 a	7.48 a
Sunburned (Injured)	**2.21**	**0.21**	**4.33**
		2nd season	
Control	3.32 g	0.31 d	6.53 g
$CaCO_3$ at 4%	3.54cd	0.39 c	7.05 d
$CaCO_3$ at 6%	3.60 b	0.44bc	6.78 f
$CaCO_3$at 4% + Cu	3.56bc	0.46 b	7.54 a
$CaCO_3$ at 6% + Cu	3.79 a	0.46 b	7.47 b
Kaolin at 4%	3.49de	0.49ab	6.91 e
Kaolin at 6%	3.41 f	0.53 a	7.23 c
Kaolin at 4% + Cu	3.48 e	0.49ab	7.49ab
Kaolin at 6% + Cu	3.39 f	0.50ab	7.51ab
Sunburned (Injured)	**2.53**	**0.24**	**3.98**

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Application of $CaCO_3$ at 6% plus Cupper scored the maximum values (3.81 & 3.79%) compared with control treatment (3.13 & 3.32%). On the other hand, sunburned (injured) fruits recorded the lowest percentages (2.21 & 2.53%) during the two seasons (2017/18 and 2018/19), respectively. Concerning fruit peel silicon (%) content data showed that, Kaolin treatments application increased peel Si and the best treatment was Kaolin at 6% plus Cupper (0.53%) in the first season and Kaolin at 6% (0.53%) in the second season comparing with control treatment (0.33 & 0.31 %), on the other side, sunburned fruits scored the lowest values (0.21 & 0.24%) in the first and second seasons, respectively. It is also cleared that, peel Cupper (ppm) content increased with the trees treated by all treatments plus Cupper, while sunburned fruits had the lowest values in this regard. However the differences between different treatments were high to be significant in both the experimental seasons.

Spraying Murccot trees with these materials, which protect it from the harmful effects of the sunburn, may have a positive effect on increasing the efficiency of these trees to uptake different nutrients and thus carry out the metabolism processes significantly. In this respect, Jifon and Syvertsen, (2003) on citrus concluded that kaolin applications on grapefruit reduced midday leaf temperatures by 3°C, increased midday stomatal conductance and net CO_2 assimilation of leaves and thus increased the photosynthesis processes.

Anatomical study: The results obtained showed that, in the sunburned part of the rind, the cells were smaller in size, dead and impregnated with many precipitates, probably lignins and suberins. The affected areas extended to include the epicarb, hypoderm and a few cells of the outer mesocarp (Fig.7).On the other hand, no such alteration were observed in healthy fruit rind (Fig.6). In this respect, Nasr *et al*., (1971) reported that, in sunburned area of fruit rind in Balady mandarin about 9 peripheral corky layers were observed in the epiderm, hypoderm and outer mesocarp. They also reported that, no anatomical differences were found associated with sunburn in the Balady sweet orange, Sangtra mandarin and Clementine tangerine. The same results were reported by Nasr, *et al*., (1987) on local orange variety.

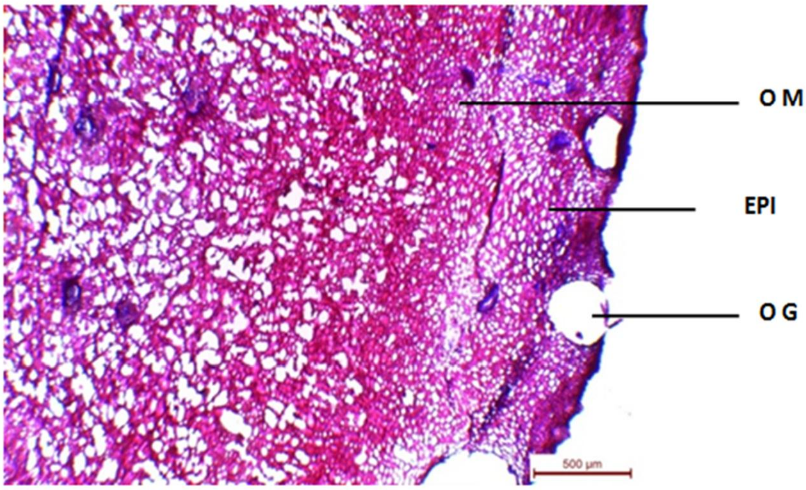

Fig. 6: Cross-section in a normal (healthy) fruit peel of Murcott mandarin. O M: Outer mesocarp; EPI: Epicarp cells and O G: oil gland.

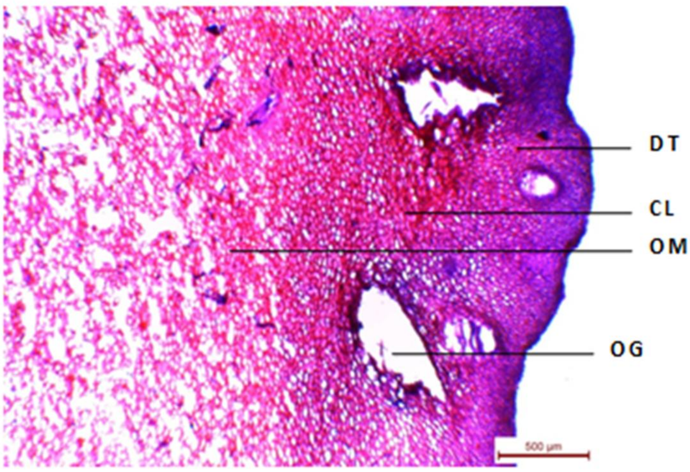

Fig. 7: Cross-section in a sunburned fruit peel of Murcott mandarin. DT: Dead Tissue; CL: Corky Layers; OM: Outer Mesocarp and OG: Oil gland. Not the thick layer of the dead tissue, and the formation of the corky layers

Economic study. In economic study the main economic criteria were cost of each substance (Calcium carbonate, Kaolin and Cupper in chelating form) that used under study (L.E / fed.), averages of sunburned fruits (%) and averages of marketable fruits (%) for each treatment. Results are given in Table (5). Other expenses such as the costs of supervision and royalties were not taken into consideration in this study. In more details unite price of Calcium carbonate was (10 L.E / k.gm.), Kaolin was (5 L.E / k.gm.) and unite price of chelating Cupper was (40 L.E / Liter) taking into account of all treatments were sprayed at two times under study.

Table 5: The economic study of the cost per feddan for each substance used under study (L.E / fed.) of Murcott mandarin.

Treatments	Quantity of each treat./tree	Quantity of each treat / fed.	Unit price of each treat.(L.E)	Cost of each treat./ Fed. /(L.E) * 2time	Averages of sunburned fruits (%)	Averages of Marketable fruits (%)
Control	……	……	……	……	**24.5**	**75.5**
$CaCO_3$ at 4%	200 gm	46 kg	10	**920**	**17**	**83**
$CaCO_3$ at 6%	300 gm	69 kg	10	**1380**	**16**	**84**
$CaCO_3$ at 4% + Cu	200 gm	46 kg	10	**1150**	**12.3**	**87.7**
	+12.5cm^3	+ 2.875 L	+40			
$CaCO_3$ at 6% + Cu	300 gm	69 kg	10	**1610**	**11**	**89**
	+12.5cm^3	+ 2.875 L	+40			
Kaolin at 4%	200 gm	46 kg	5	**460**	**13.9**	**86.1**
Kaolin at 6%	300 gm	69 kg	5	**690**	**14.3**	**85.7**
Kaolin at 4% + Cu	200 gm	46 kg	5	**690**	**8.2**	**91.8**
	+12.5cm^3	+ 2.875 L	+40			
Kaolin at 6% + Cu	300 gm	69 kg	5	**920**	**9.5**	**90.5**
	+12.5cm^3	+ 2.875 L	+40			

Where: *2 times refer to all treatments were applied at two times (first and mid-June).

From this economic study it could be noticed that, application of Kaolin at 4% + Cu with cost (690 L.E/ fed.) was the best combination for giving the highest rate of marketable fruits (91.8%) followed in descending order by using of Kaolin at 6% + Cu which cost (920 L.E/ fed.) and the marketable fruits was (90.5%) then , $CaCO_3$ at 6% + Cu with cost (1610 L.E/ fed.) and the marketable fruits was (89%) and so on as shown in Table (5),while the lowest rate of marketable fruits (75.5%) was obtained by control treatment as a result of no using of protective materials of sunburn injuries of Murcoot mandarin.

Conclusion. It is evident from these foregoing results that, Murcoot mandarin fruits are subjected to fruit sunburn and that, quality of such fruits is greatly impaired. Foliar sprays of some high reflective materials are very important to protect fruits from injuries. kaolin at 4% with chelating Cupper at 2.5cm^3/L at the first and mid June achieved the lowest percentage of sunburned fruits (8.2%) as compared with (24.5%) in control treatment .So, marketable fruits percentage increased as a result of decreasing fruit sunburn percentages and thus reducing economic losses for growers.

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