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Research Article

Application of colored nets to prevent sunburn and increase pomegranate fruit quality

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ABSTRACT- A prevalent problem in pomegranate (*Punica granatum* L.) fruit is sunburn which reduces fruit quality. This study aimed to reduce the severity of sunburn during the fruit development of pomegranate by covering them with colored netted bags. Kaolin (5%) as a traditional treatment to reduce sunburn was used to compare the efficiency of noble and traditional techniques. The netted bags used were either white, green, yellow, gray or blue. This study was carried out on a commercial cultivar (Rabab-e-Neyriz) over a period of two successive years. The color of the netted bags affected the anthocyanin content of arils at harvest besides minimizing the levels of sunburn. Fruit of the control group were damaged notably (32.26%) by sunburn, compared to those covered with blue and white netted bags (0%). The highest amount of ascorbic acid and the minimum amount of anthocyanin were recorded in the fruit covered with blue netted bags. The lowest degree of aril whitening (discoloration of arils) was observed when fruit were covered with white bags. Covering the fruit with gray netted bags caused the highest antioxidant activity and the highest total phenolic content in the arils. Overall, covering fruit with netted bags is recommended to prevent sunburn and to enhance fruit quality.

INTRODUCTION

Pomegranate (*Punica granatum* L.) is one of the well-known fruit (Taki et al., 2014). Pomegranates are widely cultivated in the warmest areas of the Mediterranean basin and southern Asia. It is well acclimatized to marginal lands and arid soils (Dandachi et al., 2017). With a total production of ca. 1000,000 tons per year, Iran is ranked among the largest producers of pomegranate in the world (Ramezanian and Erkan., 2017). The southern part of Iran is characterized by hot and dry summers. There are more pomegranate trees than any other parts of the country.

Despite the fact that pomegranate trees can partially adapt to marginal soils, various qualities of water and unfavorable climates, researchers cannot ignore the damages caused by these mentioned variables (Shakeri et al., 2006). For instance, the exposure of fruit to extreme sunlight can cause sunburn which appears as large black spots on the fruit skin, and reduce the marketability of fruit (Melgarejo et al., 2004). Pomegranate is a terminal-bearing fruit crop susceptible to sunburn. During the course of fruit development, the thin branches of terminal-bearing trees mostly bend downward, and the fruit are inevitably exposed to the sunlight throughout the summer. Under adverse conditions, sunburn can damage more than 30% of the harvested fruit (Melgarejo et al., 2004).

Several methods have been used to limit the occurrence of sunburn. Protecting fruit from direct sunlight can involve methods such as the appropriate application of fertilizers and irrigation regimes (Almutairi et al., 2021). An adequate degree of vegetative development can also decrease the prevalence of sunburn. Alternatively, shades or screens could be erected to shelter trees and fruit from direct exposure to sunlight (Kittas et al., 2009). Furthermore, the available literature refers to various other methods for the prevention of sunburn. These are included combinations of shading and reflective material such as kaolin (Melgarejo et al., 2004; Ehteshami et al., 2011), evaporative cooling at high temperatures (Parchomchuk and Meheriuk, 1996) and fruit covering with paper bags (Fallik et al., 2008).

Colored netting is an emerging agrotechnical concept that is used when researchers aim at altering the quality of transmitted light, in addition to benefitting the protective function of the netted bags against hails, wind, pests and excessive solar radiation. The nets are made of luminous threads, and their photo-selective nature screens out distinct spectral bands of light that enter and pass through them. The nets predominantly absorb UV radiation and/or specific ranges of the visible spectrum. They also scatter the direct light entering them. This spectral manipulation promotes beneficial physiological responses, while the scattering improves the permeation of light into the innermost regions of the plant canopy, thereby enhancing the efficiency of light-dependent processes within more sections of the canopy (Shahak et al., 2004; Rajapakse and Shahak, 2007).

Previous studies on ornamental crops have shown that plants can respond notably to photo-selective shading, compared with the traditional black shading (Ovadia et al., 2009). Other researchers also found that branching is improved under the grey and pearl-colored nets (Oren-Shamir et al., 2001). Specific reactions may vary among plant species (Stamps, 2009). Covering bell peppers in a semi-arid region showed that red, yellow and pearl nets remarkably increased productivity, compared with the black nets which are used commonly (Fallik et al., 2008). Similarly, previous studies on several fruit trees (e.g. apples, pears, table-grapes, peach, and high bush blueberry) have resulted in multiple reactions to photo-selective shading. Various parameters were reportedly affected, such as photosynthesis, stem water potential, vegetative development, fruit-set, fruit maturation rate, fruit size, color and quality (Shahak et al., 2004; Retamales et al., 2006; Shahak et al., 2006).

The available literature contains few reports in relation to the effects of photo-selective netting on fruit growth and quality in fruit trees (Shahak et al., 2004; Shahak et al., 2006; Solomakhin and Blanke, 2010). Accordingly, the objective of this study was to apply different photo-selective types of netting to reduce the extent of sunburn and enhance the quality characteristics of pomegranate fruit at harvest.

MATERIALS AND METHODS

Plant Material

This study was conducted in a commercial orchard located in the city of Neyriz (29° N/ 54° E) in the central area of Fars province, during the years of 2018 and 2019. The experiment was performed in a randomized-complete-block design (RCBD) with seven treatments and three replications on 10 years old ‘Rabab-e-Neyriz’ pomegranate trees planted in a square system at a distance of 5×5 m. The treatments were applied on two uniform branches of each tree, in the north and in the south directions and sampling was done on these two branches. The treatments included no-netting (control) and five colored-polyethylene (120 × 60 cm) nets (MTurine baft company, Iran) including white, green, yellow, gray and blue nets, and 5% kaolin (Kimiasabz Sepidan, Iran). Kaolin was used as an aggregate of particles less than 50 microns. Two branches in each tree were covered with plastic nets after the full blossom stage and remained until harvest. Then, the fruit of covered branches were harvested and transferred to the laboratory.

Light Interception by Nets

The solar transmission in bags was measured using a solar power apparatus (General Tools DBTU1300 Digital Solar Power Meter, Taiwan) once a month for a period of four months.

Measurement of Nets Inner Temperature

An infrared instrument was used to measure the inner temperature of the bags (Digital Infrared Thermometer Model: DT- 8811, Taiwan).

Fruit Quality Parameters

Fruit Size

Five fruit were selected randomly and the length and diameter of the fruit were measured using a caliper (1113, Iran).

Color Values

Pomegranate arils and peel color were measured using a colorimeter (CR 400, Minolta, Japan). Juice color was assessed according to the Commission International de I'Eclairage (CIE) and expressed as L*, a*, b*, C, and H˚ color values. In this coordinate system, the L* value is a measure of lightness, ranging from 0 (black) to +100 (white); the a* value ranges from −100 (greenness) to +100 (redness), and the b* value ranges from −100 (blueness) to +100 (yellowness) (Basile et al., 2008).

Percentage of Peel Sunburn and Aril Whitening

After counting the total fruit in each net, the percentage of skin sunburn was determined and the percentage of aril whitening was determined in 200 g of arils in each fruit sample of the net.

Juice Analysis

Total Soluble Solids (TSS), Titratable Acidity (TA), and Ascorbic Acid (AA) Contents

TSS in the extracted juice of fruit was measured using a hand-held refractometer (RF 10, USA), and the results were expressed in percentage. For measurement of TA, 5 ml of extracted fruit juice was titrated with 0.1 N sodium hydroxide (NaOH). TA was calculated as a percentage of citric acid using the following formula (# 1) (Nielsen, 2010).

Formula # 1: $TA = N \times V1 \times Eq.\ Wt / V2 \times 10$

where N = normality of titrant (NaOH (mEq/ml)), V1 = volume of titrant (ml), Eq. wt. = equivalent weight of predominant acid (mg/mEq), V2 = volume of sample (ml).

The pH of the juice was also measured using a digital pH meter (Extech Co., USA).

AA content of arils was determined by 2, 6-dichlorophenolindophenol method (Tefera et al., 2007). An aliquot of 100 µl of pomegranate juice extract was diluted to 10 ml using 2% meta phosphoric acid and vortexed for 30 s. Then, one ml of that mixture was taken and diluted with nine ml of indophenol. After vortexing, the ascorbic acid content was measured at 515 nm wavelength using a spectrophotometer (Shimadzu UV 240, Japan).

Antioxidant Activity

Antioxidant activity of the aril juice was assessed using 2,2-diphenyl picryl hydrazyl hydrate (DPPH). The DPPH radical scavenging activity of pomegranate extracts was quantified according to the method reported by Mirdehghan et al. (2006) with minor modifications. Briefly, one ml of extract was mixed with one ml of tris and one ml of DPPH. After leaving for 30 minutes in the dark at room temperature, the light absorbance was read at 517 nm wavelength using a UV visible spectrophotometer (UV 1601, Shimadzu, Japan). The antioxidant activity was calculated using the following formula (# 2).

Formula # 2: DPPHsc (%) = [1– (ASample / AControl)] ×100

where DPPHsc = inhibitory percentage, ASample = Absorption Rate of Sample + DPPH, AControl = DPPH Absorption Rate

Total Phenolic Compounds

Total phenolic content in the juice was determined using the Folin–Ciocalteu (FC) method (Ghasemnezhad and Shiri, 2010) with some modification. Briefly, 900 µl of diluted juice was mixed with 180 µL of 50% FC reagent and 900 µl of 2% sodium carbonate. The mixture was allowed to stand for 90 min at room temperature in the dark before the light absorbance was measured using a UV– visible spectrophotometer at 760 nm wavelength. The results were expressed as mg gallic acid equivalent in 100 mL of juice (mg GAE100^{-1} mL of juice).

Anthocyanin Content

Anthocyanin content was determined using the pH differential method described by Kirca et al., (2007). Two samples of 150 µl were taken from the upper phase of pomegranate juice, and each one was placed in a 25 ml flask. The first flask was diluted with buffer solution pH=1 (1.49 g KCl/100 ml and 0.2 N HCl) and the second one with buffer solution pH = 4.5 (1.64 g sodium acetate/100 ml). After standing for 30 min at room temperature, absorbance was measured at 520 and 700 nm, using a spectrophotometer (UVwin 5.0, Japan). Pigment content was calculated, based on cyanidin-3-glucoside using the following formula (# 3).

formula # 3: A= (A520-A700) pH 1.0- (A520-A700) pH 4.5

where A is light absorbance.

The monomeric anthocyanin pigment content in the original sample was calculated according to the following formula (# 4).

Formula # 4: AC=A x MW x DL x 1000 / εL

Where, A = difference of sample absorbance between pH 1 and pH 4.5, AC = molar extinction coefficient for cyanidin-3-glucoside (26,900); L = path length of the spectrophotometer cell (1.0 cm), DL = dilution factor and MW (molecular weight) of cyanidin-3- glucoside (449.2 g/mol), 1000 = factor for conversion g to mg. The result was expressed as mg cyanidin-3-glucoside equivalent/100 g extract.

Statistical Analysis

The experiment was conducted in a randomized complete block design (RCBD) with 3 replications. Data of the two years were analyzed using the SAS software (Ver. 9.1) package and significant differences among the mean values were compared by LSD at $P \leq 0.05$.

RESULTS

In both years of this study, fruit quality at harvest was significantly affected by treatments (Table 1). Fruit under the blue netted bags had the highest ascorbic acid content (10.31 mg/100 ml juice) compared to the other treatments (Table 1), whereas the lowest ascorbic acid content was measured under the white bags (8.06 mg/100 ml). Total soluble solids were higher in fruit covered with the grey, green, and white netted bags than control fruit (Table 1). The pH of fruit in the green bag was significantly higher than the pH of fruit of the other treatments (3.62) (Table 1). Fruit covered with blue, gray and yellow bags had higher TA in comparison with control and their differences with un-bagged treatments were significant at 5% level of probability (Table 1).

In the first year, the treatments affected the percentage of aril whitening at harvest (Table 2). So that the percentage of aril whitening of fruit covered with the blue bags (51.53%) was significantly higher than those of the other treatments. Whereas the amount of aril whitening in fruit covered with white bags was the lowest in both years (Table 2). The maximum (23.13 mg / 100 ml) and minimum (12 mg/ 100 ml) content of anthocyanin obtained in arils of fruit covered with white and blue netted bags, respectively (Table 2). Indeed, there was a negative correlation (R^2 = -0.6649) between anthocyanin content and the percentage of aril whitening of fruit (Fig 1).

In the experiment of the second year, the application of white net led to a significant ($P \leq 0.005$) increase in the content of anthocyanin with values of 20.81 (mg/100ml) for white net covered fruit compared to un-netted fruit of the control trees (Table 2). Additionally, the same as the experiment of the previous year, the reverse trend was detected between fruit anthocyanin content and aril whitening (Fig 1).

Fruit grown under the blue netted bags showed the highest antioxidant activity and total phenolic content, whereas the lowest ones were determined in fruit covered with the white nets (Table 2). Furthermore, in all treatments, antioxidant activity was highly correlated with total phenolic contents (R^2= 0.8476) (Fig 2).

In the experiment of the second year, total antioxidant activity and phenolic content in fruit arils were also affected by the photo-selective nettings (Table 2). Fruit grown under the gray nets had the highest antioxidant activity and total phenolic contents (45.22%, 50.08 mg/100 g FW, respectively), and the lowest amount of the aforementioned chemical characteristics was found under the white netted bags (23.41%, 30.74 mg/100 g FW, respectively).

On the other hand, no significant differences were observed between either the netted bags or kaolin treatments compared with untreated branches for fruit diameter and length (data not shown).

Fruit grown under the yellow netted bags had the highest amount of fruit skin L* in skin compared with un-netted fruit, but there were no significant differences between netted pomegranate fruit (Table 3). Fruit skin a* factor was highest in fruit under the blue, white and gray nets in both years of this study, but aril a* factor was highest in fruit under white, green and yellow nets (Table 3). There was a substantial increase in b* factor of skin of fruit covered with green net in comparison with the fruit of the control treatment (Table 3). However, its difference was not significant in pomegranate arils. In the second year, skin fruit L* factor at harvest was higher in all fruit covered with the netted bags and treated with 5% kaolin compared to control treatment (Table 3). Although, L* factor of arils at harvest increased in fruit of gray netted bags and fruit of control treatment. The gray and blue nets resulted in the greatest amount of skin a* factor of arils compared to those of the arils of un-netted trees. On the contrary, white netted bags resulted in the highest a* factor of arils and the blue nets resulted in the lowest one (Table 3). Despite the fact that the b* factor of skin was intensified in gray netted bags compared to control treatment, the b* factor of arils was not significantly affected by treatments (Table 3).

Fruit under the un-netted bags had the highest percentage of sunburn (32.26%) compared to those of the other treatments (Table 2). whereas the lowest percentage (0%) of fruit sunburn was measured under the blue and white nets . In the second year, the percentage of sunburn in pomegranate fruit was lower under all netted bags compared to the un-netted fruit, especially in the blue netted bags treatment (Table 2).

The inner temperature of netted bags and radiation transmission of the bags were affected by the different types of netted bags (Table 4). In the second year, maximum and minimum inner temperature and radiation transmission belonged to kaolin (5%) and white netted bags, respectively (Table 4). Furthermore, the inner temperature and radiation transmission were the lowest amounts during August and September compared with other months of the experiment (Table 5).

Table 1. Effect of different netted color bags on some chemical characteristics of pomegranate cv. Rabab-e-Neyriz.

Type of netted bags	**Vitamin C** (mg/100 ml)	**TSS** (%)	**pH**	**Acidity** (%)
Un-netted	10.15 ^{ab}	19.83 ^{bc}	3.57 ^{abc}	1.38 ^{d}
Blue	10.31 ^{a}	20.33 ^{ab}	3.50 ^{de}	1.60 ^{a}
White	8.06 ^{d}	20.66 ^{a}	3.55 ^{bcd}	1.45 ^{cd}
Gray	9.36 ^{abc}	20.66 ^{a}	3.58 ^{ab}	1.57 ^{ab}
Yellow	9.15 ^{bc}	20.33 ^{ab}	3.48 ^{e}	1.49 ^{abc}
Green	8.50 ^{cd}	20.75 ^{a}	3.62 ^{a}	1.42 ^{cd}
Kaolin 5%	9.25 ^{bc}	19.41 ^{c}	3.51 ^{cde}	1.48 ^{bcd}

Within columns, means followed by different letters are significantly different according to the LSD test ($P \leq 0.05$). TSS is abbreviation of Total Soluble Solids.

Table 2. Effect of different netted color bags on qualitative characteristics of pomegranate cv. Rabab-e-Neyeriz.

	Year									
	First					Second				
treatments	**nthocyanin Content (mg / 100 mL)**	**Aril whitening (%)**	**Antioxidant (% DPPHsc)**	**Phenol (mg / 100 g FW)**	**Sunburn (%)**	**Anthocyanin Content (mg / 100 mL)**	**Aril whitening (%)**	**Antioxidant (% DPPHsc)**	**Phenol (mg / 100 g FW)**	**Sunburn (%)**
No bagging	16.38^{b}	32.75^{c}	46.54^{bc}	50.7^{cd}	42.26^{a}	5.17^{e}	82.13^{a}	37.52^{b}	41.85^{b}	73.90^{a}
Blue net	12.00^{c}	51.53^{a}	53.40^{a}	58.40 7^{a}	0.00^{e}	7.48^{ed}	61.27^{b}	33.26^{c}	47.17 ^{a}	4.90^{e}
White net	23.13^{a}	22.77^{d}	44.41^{c}	48.58^{d}	0.00^{e}	20.81^{a}	20.67^{e}	23.41^{e}	30.74 ^{c}	14.56^{d}
Gray net	12.89^{bc}	44.91^{b}	45.06^{bc}	50.26^{cd}	14.10^{c}	17.24^{b}	23.46^{e}	45.22^{a}	50.08 ^{a}	21.07^{c}
Yellow net	22.63^{a}	32.46^{c}	47.92^{bc}	52.7^{bc}	14.72^{c}	11.77^{c}	31.11^{d}	40.13^{b}	43.12 ^{b}	20.45^{c}
Green net	13.38^{bc}	33.84^{c}	36.15^{d}	39.81^{e}	8.11^{d}	15.53^{b}	24.79^{e}	27.05^{d}	32.20 ^{c}	17.73^{cd}
Kaolin 5%	16.24^{b}	32.92^{c}	48.46^{b}	54.2^{b}	19.34^{b}	10.27^{cd}	52.96^{c}	39.3^{b}	41.63^{b}	35.05^{b}

Within columns, means followed by different letters are significantly different according to the LSD test ($P \leq 0.05$).

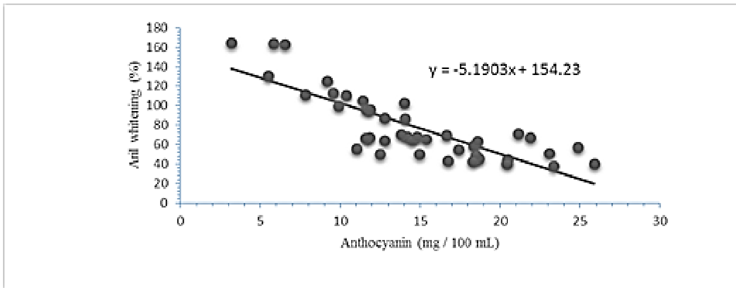

Fig 1. Correlation between anthocyanin content and aril whitening of pomegranate fruit

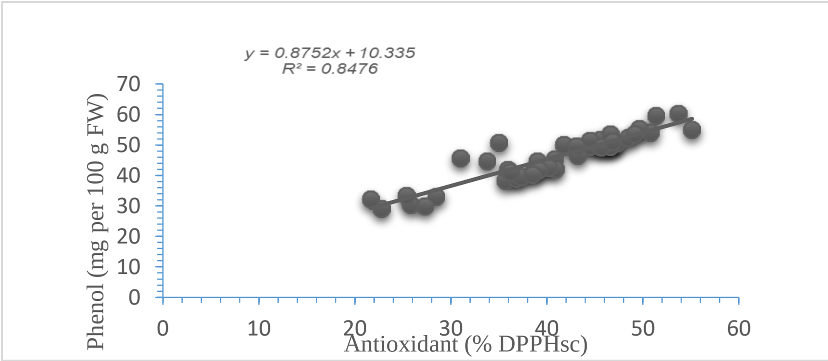

Fig 2. Correlation between antioxidant activity and total phenolic compound content in pomegranate fruit.

Table 3. Effect of different netted bags on fruit color of pomegranate cv. Rabab-e-Neyriz.

Treatments	Year											
	First						Second					
	Peel			Aril			Peel			Aril		
	*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**
No bagging	35.02^{b}	30.9^{c}	12.70^{c}	22.6^{a}	9.42^{b}	6.90^{a}	43.69^{b}	36.1^{c}	19.17^{b}	24.64^{a}	12.86^{c}	11.24^{a}
Blue net	41.09^{a}	40.40^{a}	15.49^{ab}	21.83^{a}	12.97^{a}	6.65^{a}	47.64^{ab}	45.03^{a}	22.64^{a}	20.02^{b}	11.70^{c}	10.88^{a}
White net	41.11^{a}	40.34^{a}	15.51^{ab}	21.54^{a}	12.03^{ab}	6.31^{a}	46.97^{ab}	42.63^{ab}	18.86^{b}	16.71^{bc}	17.72^{a}	9.90^{a}
Gray net	37.22^{ab}	40.09^{a}	14.23^{abc}	22.06^{a}	11.18^{ab}	6.41^{a}	48.78^{a}	45.75^{a}	22.04^{a}	24.75^{a}	13.74^{c}	9.42^{a}
Yellow net	42.01^{a}	39.17^{ab}	15.80^{a}	18.99^{a}	13.22^{a}	6.01^{a}	49.3^{a}	42.09^{ab}	22.02^{a}	15.11^{c}	14.04^{cd}	10.94^{a}
Green net	41.05^{a}	38.63^{ab}	15.81^{a}	21.24^{a}	12.36^{ab}	6.71^{a}	47.71^{ab}	41.7^{ab}	21.57^{a}	13.89^{c}	17.18^{ab}	9.53^{a}
Kaolin 5%	36.04^{b}	35.60^{b}	13.49^{bc}	22.06^{a}	10.32^{ab}	6.72^{a}	47.87^{a}	38.7^{bc}	21.18^{a}	16.99^{bc}	12.23^{c}	9.80^{a}

Within columns, means followed by different letters are significantly different according to the LSD test ($P \leq 0.05$).

Table 4. Effect of different netted- bags on canopy temperature and radiation transmission of pomegranate cv. Rabab-e-Neyriz (Second year).

Treatments	Inner temperature of netted bags (ºC)	Radiation transmission in the netted bag (Wm^2)
No bagging	34.33^{ab*}	225.89^{b}
Blue net	32.08^{de}	144.50^{e}
White net	31.43^{e}	143.92^{e}
Gray net	33.56^{bc}	203.03^{c}
Yellow net	33.66^{bc}	201.69^{c}
Green net	32.93^{cd}	182.96^{d}
Kaolin 5%	34.93^{a}	234.90^{a}

* Within columns, means followed by different letters are significantly different according to the LSD test ($P \leq 0.05$).

Table 5. The inner temperature and radiation transmission in the netted bags at each month of experiment in pomegranate cv. Rabab-e-Neyriz (Second year).

Month	Inner temperature (ºC)	Radiation Transmission (Wm2)
May-Jun	32.93 c *	173.36 c
Jun- July	36.27 a	252.27 a
July-Aug	34.52 b	201.17 b
Aug-Sep	d	137.13 d

*Within columns, means followed by different letters are significantly different according to the LSD test ($P \leq 0.05$).

DISCUSSION

In the current study, branch bagging had significant effects on fruit quality in both years. The most and the lowest amount of ascorbic acid contents were found in fruit covered with blue and white bags, respectively (Table 1). It has been reported that ascorbic acid is synthesized in plants from glucose or other simple carbohydrates (Ishikawa et al., 2006). The increase in ascorbic acid content in fruit of blue netted bags might be due to the lower rate of respiration processes as a result of the lower temperature inside the blue bags (Table 4). Table 1 shows that the color of bags had no significant effect on TSS, however, control and kaolin treated fruit had lower TSS compared with the other treatments. The significant decrease of TSS in un-bagged fruit might be due to higher temperature and higher light transmission. These results are in line with the results of a previous study conducted on kiwifruit that was reported by Pailly et al., (1995).

In both years of this study, blue netted bags increased the percentage of aril whitening and reduced the anthocyanin content of aril juice (Table 2), which might be due to lower radiation transmission compared with control fruit (Table 4). Also, a negative linear relationship between anthocyanin content and the percentage of aril whitening ($R2= 0.66$) (Fig 1) was found in the current study. This finding agrees with the previous report on Chinese sand pear (Huang et al., 2009). They found that bagging inhibited anthocyanin synthesis in fruit peels. The results of this study showed that bagging pomegranate fruit with white netted bags promoted anthocyanin synthesis and reduced the percentage of aril whitening. Similarly, it was reported that pear fruit kept under white bags (80.31% photo permeability) accumulated more anthocyanin than those of fruit kept under red liners (Huang et al., 2009). It has been proven that the wavelength of the transmitted light could influence anthocyanin synthesis (Claudia Dussi and Sugar, 1995). In both years of the current study, fruit under white bags had greater anthocyanin content in aril juice at harvest than other treatments (Table 2). It was found that fruit with blue netted bags had the highest antioxidant activity and total phenolic content compared with the fruit of other treatments. It has been reported that the accumulation of phenolic compounds is responsible for higher antioxidant activity (Huang et al., 2009). Correlation analysis showed that phenolics accumulation correlated significantly ($R2= 0.8476$, Fig 2) in pomegranate fruit under blue netted bags. In general, the color of bags had no significant effect on a*, b*, and L* values. The percentage of sunburn in the first year was lower than that in the second year probably due to the higher temperature in the second year which reduced the number of leaves during the growing season. Fruit under blue and white netted bags had the lowest sunburn (Table 2). Inner temperature and radiation inside the blue and white netted bags were lower than those in the other bags and also kaolin treatments. The data of this study showed that solar radiation was dependent on net color and solar radiation. Under blue (144.50 Wm2) and white (143.50 Wm2) netted bags, radiation was lower in comparison to un-bagged branches (225.89 Wm2).

The data obtained in this study were in line with the results obtained on tomatoes (Ilić et al., 2012). In this study, solar radiation increased until the end of July and then decreased toward the end of the season. A direct relationship between light intensity and raising the temperature (Table 5) was found in the current study.

CONCLUSIONS

Photo-selective nets can differentially affect sunburn and the quality of field-grown pomegranate trees. The blue and white nets are useful to reduce sunburn by reducing inner temperature and solar radiation inside the bags. Furthermore, blue and white nets increase phenolic compounds and antioxidant activity in aril juice. Unlike blue nets, white nets induce the synthesis of anthocyanin in arils. Photo-selective netting represents a promising way to reduce sunburn of skin and positive effects on the quality of pomegranate fruit.

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کاربرد تورهای رنگی برای جلوگیری از آفتاب سوختگی و افـزایش کیفیت میوه انار

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کیسه‌های توری

چکیده - یک مشکل شایع در میوه انار (*Punica granatum* L.) آفتاب سوختگی است که باعث کاهش کیفیت میوه می شود. هدف از این مطالعه، کاهش میزان آفتاب سوختگی در طی رشد میوه انار با پوشاندن آنها با تورهای رنگی بود. برای مقایسه کارایی تورهای رنگی از کائولین (۵٪) به عنوان یک روش سنتی برای کاهش آفتاب سوختگی استفاده شد. کیسه های توری به رنگ‌های سفید ، سبز ، زرد ، خاکستری یا آبی بودند. این مطالعه در مدت دو سال متوالی بر روی انار رقم تجاری رباب نی ریز انجام شد. رنگ تورها در زمان برداشت بر محتوای آنتوسیانین انار دانه‌ها تأثیر داشت. آنها همچنین آسیب های ناشی از آفتاب سوختگی را کاهش دادند. میوه های گروه شاهد در مقایسه با آنهایی که با تورهای آبی و سفید پوشانده شدند (۰٪) به طور قابل توجهی (۳۲/۲۶٪) در اثر آفتاب سوختگی آسیب دیدند. بیشترین میزان اسید اسکوربیک و کمترین مقدار آنتوسیانین در میوه های پوشیده شده با تورهای آبی ثبت شد. کمترین میزان سفید شدن انار دانه در اثر پوشاندن میوه‌ها با تورهای سفید مشاهده شد. پوشاندن میوه‌ها با تورهای خاکستری باعث بیشترین فعالیت آنتی اکسیدانی و بالاترین میزان ترکیبات فنلی کل در انار دانه‌ها شد. به طور کلی، پوشاندن میوه با تور برای جلوگیری از آفتاب سوختگی و افزایش کیفیت میوه توصیه می شود.