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Colored plastic mulches and harvest times affect on antioxidant capacity and total anthocyanin contents on strawberry fruit "cv.camarosa"

Saeid shiukhy[1*], Mahmoud raeini sarjaz[1] and Vida chalavi[2]

1- Department of Agricultural Engineering, Sari Agricultural Sciences and Natural Resources University, PO-Box 578, Sari, Iran
2- Department of Horticulture, Sari Agricultural Sciences and Natural Resources University, PO-Box 578, Sari, Iran

***Corresponding author*:** Saeid Shiukhy

ABSTRACT: Strawberry *(Frag aria x ananasa)* is one of the most important garden products which its fruit is full of vitamins, antioxidant and anthocyanin. For studying affect of colored plastic mulches and harvest times on antioxidant and anthocyanin properties, strawberry cv. Camarosa was studied on complete randomized block design with four testing treatments of colored plastic mulch (red, black, white and control treatment (traditional farming)) and three time of harvesting (May30, 25, 20) in three replication on 2011. The most amount of anthocyanin and the least one were seen in red and white plastic mulches and control respectively. Also, black plastic mulch had the least amount of anthocyanin within plastic mulches. The best treatment in term of antioxidant activity of the fruit (IC50= 2/13) belongs to white plastic mulch in the first of harvest time. The highest amount of total phenol and flavonoid compositions of the fruit at second harvest time in red plastic mulch was seen as 0.02 Gallic acid g/ dry weight and 9.22 quercetin mg/dry weight. The least amount of these compositions as 42.5 g Gallic acid per dry weight and 7.13 mg/ dry weight was related to the first harvest time of control.

***Keywords*:** white plastic mulch, weight, garden product, quercetin, phenol.

INTRODUCTION

Strawberry *(Frag aria x ananasa)* fruit size and flavor are important to both growers and consumers. The study of the influence of cultivation techniques in the strawberry crop has been an important matter in the last decades. The performance of different mulches on plant health and fruit yield is often in constant (Passos, 1997) and their effect seems to be related to changes in the microclimate (Maas, 1998) Plastic mulches are frequently used in raised-bed culture to conserve water, control weeds with less herbicides, keep fruit clean and produce ripe berries earlier in the season (Kasperbauer, 2001). Soil disinfestation or solarization has been used successfully (Voth & Bringhurst, 1990; Hartz ., 1993; Himelrick ., 1993), resulting in good control of weeds and some pathogens (Maas, 1998; Sugimura ., 2001; Shalaby & Mohamed, 2005), with consequent strawberry yield increases (Hartz ., 1993; Larson & Shaw, 1995; Umang & Harender, 2004). An important first step toward development of colored mulch technology was the documentation that far-red light (FR) reflected from nearby plants (Barllare ., 1987;Kasperbauer,1971 and 1988; Kasperbauer .,1984) affected the far-red to red (FR/R) photon ratio enough to act through the natural phytochrome system within a growing plant to regulate allocation of photoassimilate (Kasperbauer,1987; Kasperbauer,1988). Recently developed colored mulch technology combines the benefits of black plastic mulch with additional growth regulatory benefits of reflected morphogenic light to improve yield and quality of field-grown plant products (Kasperbauer .,1984). Drip irrigation presents a number of advantages, contributing to avoiding the formation of a humid microclimate favorable to diseases (Howard ., 1992; Madden .,1993; Tanaka ., 2005; Tanaka, 2002). In addition, it allows automation, frequent irrigations, fertigation, and obtaining high yields (McNiesh ., 1985; Voth & Bringhurst, 1990; Serrano ., 1992; Passos,1997; Pires, 1998; Rolbiecki ., 2004). Based on earlier controlled

environment experiments (Kasperbauer,1971), it was predicted that a FR/R photon ratio higher than the ratio in incoming sunlight (at the same time and place) would favor shoot crops, and a FR/R ratio lower than the ratio in incoming light would favor below-ground crops. Plant responses were as predicted (Kasperbauer,1992). The controlled environment experiments, combined with field studies of shoot crops grown over painted panels (with known reflection spectra), led to the development of a specially formulated red plastic mulch that increased the yield of tomato *(Lycopersicon esculentum Mill.)* relative to yield over standard black plastic mulch (Kasperbauer,1998). Because developing strawberry fruits are closer to the reflecting surface of colored mulch, it was hypothesized that strawberry yield advantage would be greater (in terms of percentage) than that of tomato grown over the red versus those grown over standard black plastic mulches. The hypothesis was proven correct in a 2 year, two-location experiment (Kasperbauer,2000). Increased size per strawberry fruit contributed to greater yield when grown over the new red versus over standard black plastic mulch. Because strawberry is a high-value food crop that is consumed fresh or after processing it was important to determine whether the reflected light combination that resulted in increased yield would also affect flavorand/or phytonutrient content.

MATERIALS AND METHODS

The effect of plastic mulch color on yield of strawberry experiment based on randomized complete block design with four treatments plastic mulch, white, black, red, and control (traditional culture) in three replications in the field of agriculture and horticulture was normal. In this study, the varieties were camarosa..The uniform distribution of water, the drip irrigation system was used as a dropper on the side of each plant were placed in 4 lit/sec. During the test, depending on the plant, Fruits, depending on the speed range examined in a few days to a week were harvested. Fourteen times the fruits of the third quarter, April to June, were harvested. The fruit harvest dates, fruit harvested at the time (20 May), (25 May) and (30May) to evaluate antioxidant activity, total phenolic and flavonoid content were used. At this time all the harvested fruits were mixed together. Total soluble solid (TSS) in the juice was determined with a hand- refractometer (PR-32 palette, Atago Co., Japan) at room temperature and expressed as a Percentage),(Piga ., 2000). Titratable acidity (TA) was determined in the presence of phenolphthalein unit 8.2 and expressed as citric acid percent (Ghasemnegad, 2006). pH of the juice was measured using a pH meter (Jenway, 3020). Anthocyanins reversibly change color with pH (Fig. 1), which limits their effective use as food colorants for many applications, but also provides an easy and convenient method for measuring total pigment concentration (Giusti& Wrolstad, 2001). The described method is a modification of methods originally described by Fuleki & Francis (1968a, 1968b). Samples are diluted with aqueous pH 1.0 and 4.5 buffers and absorbance measurements are taken at the wavelength of maximum absorbance of the pH 1.0 solution. The difference in absorbance between the two buffer solutions is due to the monomeric anthocyanin pigments. Finally, the results were analyzed using the software SAS and was compared to Duncan method.

RESULTS AND DISCUSSION

Anthocyanin

Figure (1) shows amount of anthocyanin within control treatments. The results showed that effect of plastic mulch on amount of anthocyanin was significant ($p< 0.01$). so that red and white plastic mulch treatments had the most amount of anthocyanin while the lesast of belonged to control treatment (traditional farming). Also, black plastic mulch had the least amount of anthocyanin within plastic mulches.

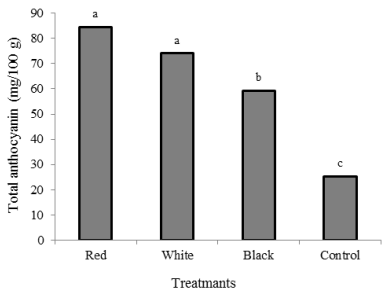

Figure 1. Total anthocyanin content (mg/100g) of black, red and white plastic mulches and control treatments during strawberry harvest times. Numbers with the same letters have no significance difference (5%)

One of the most important environmental factors effective on synthesis of anthocyanin is light which impresses display of associate gens with biosynthesis of anthocyanin. Density of anthocyanin is different in terms of growing steps of the fruit and different parts of it. Sunlight is one of the most important external factors of synthesis of anthocyanin in hull of apple. It has been improved that fruit bagging causes increase of sensitivity to light while removing the bag and its insolating stimulate synthesis of anthocyanin again. Therefore, there is no anthocyanin in lack of light during all steps of fruit growing.

Study of Zaldivar . (2005) about affect of harvesting date on qualitative properties of strawberry in California showed that amount of anthocyanin in "Aromas" and "Selva" strawberries was different in the fruits harvested on May and August and depended to date of harvesting but similar in "Diamont" strawberry. These results were similar to the results of last year harvesting strawberries on September 1999.

Antioxidant capacity, total content of phenol and flavonoid compounds

The results of average comparison in the table showed that treatments of time of harvesting and type of plastic mulch have significant affect on measured properties. Study of Sing . (2006) showed that planting Chandler strawberry with black plastic mulch in semidry regions of India in the middle of September in creased operation and quality of the fruit. Regardless type of plastic mulch, antioxidant activity of the fruit changes by time of its harvesting. At the second of harvest time, it was seen the most antioxidant activity (IC50=2.94 mg/ml) and amount of flavonoid with 7.91 quercetine mg/dry weight. Phenols and phenol compounds such as flavonoid, are widely found in food products gained from plant sources and showed considerable antioxidant activity.

Total Phenol content of the fruit also increased with harvest time and the sample was more than other steps in third harvesting as 57.3 Gallic acid mg/ dry weight (table 1).

Table 1. Antioxidant capacity, total content of phenol and flavonoid compounds in different harvest times

Time	Anti(1/ic50)	Flavonoid	Phenol
1	2.99^{a}	7.8^{b}	48.65^{c}
2	2.94^{a}	7.91^{a}	56.55^{b}
3	4.05^{b}	7.8^{b}	57.34^{a}

Values followed by the same letter are not significance difference (5%)

Researches of Ghasemi . (2011) showed similar results. They concluded that approaching to the end of growing season and harvesting time of nectarine, amount of phenol compositions and flavonoid decreased. Type of plastic mulch affect on measuring properties, so that fruits harvested from white mulch had the most antioxidant activity (IC50=2.85 mg/ml). On the other hand, flavonoid of the fruits harvested from red mulch was more than other mulches. Total Phenol content as 55.6 Gallic acid mg/ dry weight was more in white mulch than others (table 2).

Table 2. Antioxidant capacity, total content of phenol and flavonoid compounds along treatments

Treatments	Anti(1/ic50)	flavonoid	Phenol
White	2.85^{a}	7.63^{c}	55.66^{a}
Red	3.37^{c}	8.57^{a}	54.07^{b}
Black	4.01^{d}	7.73^{b}	53.97^{c}
Control	3.09^{b}	7.43^{d}	53.02^{d}

Values followed by the same letter are not significance difference (5%)

Correlation between total Phenol content and antioxidant activity was widely studied in fruits and vegetables. Antioxidant activity of fruits and vegetables increases notable at presence of high density of total Phenol content.

Studying average comparison of interactions between harvest times and plastic mulch and antioxidant activity of fruit showed that the most and the least antioxidant activity was gained respectively (IC50=5.12 mg/ml and IC50=2.13 mg/ml) from the fruits harvested from white mulch at first harvesting and black mulch at third harvesting. The most amount of flavonoid of the fruit was gained as 9.2 quercetine mg/dry weights at second harvesting from red mulches and the least one was gained at first harvesting from control treatment. The most and the least total Phenol content of fruit as 63 and 42.5 Gallic acid ml.g/ dry weight of sample was gained respectively from the second and first harvesting from red plastic mulch and control. As seen, the most and the least amount of flavonoid and total Phenol content of fruit was gained respectively from red plastic mulch at first harvesting and control at first harvesting. As flavonoids are part of phenol compositions, it is natural to see this result.

Table 3. Antioxidant capacity, total content of phenol and flavonoid compounds in different harvest times and along treatments

Treatments	Time	Antioxidant(1/IC50)	Flavonoid	Phenol
White	1	2.13[a]	8.33[b]	52.6[h]
White	2	3.71[i]	7.28[h]	52.86[h]
White	3	2.66[d]	7.28[h]	61.27[b]
Red	1	2.49[b]	8.18[c]	45.24[i]
Red	2	2.69[e]	9.22[a]	63.02[a]
Red	3	4.92[k]	8.33[b]	53.97[f]
Black	1	4.01[j]	7.58[f]	53.97[f]
Black	2	2.78[f]	7.73[e]	53.17[g]
Black	3	5.12[l]	7.88[d]	54.76[e]
Control	1	3.3[g]	7.13[i]	42.54[j]
Control	2	2.54[c]	7.43[f]	57.14[d]
Control	3	3.47[h]	7.73[e]	59.37[c]

Values followed by the same letter are not significance difference (5%)

Erturk . (2006-2007) studying seasonal fluctuation of total Phenol content, antioxidant activity of fresh branch of tea showed that total Phenol content of the samples was low in cold months of year from May on both years. After that, total Phenol contents increased at all warmer months from July to September. Also antioxidant activity showed similar trend so that it increased from the first harvesting in May to third harvesting in September. All samples showed nearly 100% antioxidant activity toward BHA standard antioxidant at second and third harvesting.

Conclusion

The results show that using colorful plastic mulches for raised- bed of strawberry cv. camarosa has significant affect on antioxidant properties and anthocyanin amount of the fruit toward control treatment while within plastic mulches, black plastic mulch had its least amount. Also within harvest times, the fruits harvested at the first time (20 May) had the most antioxidant activity. Total Phenol content and flavonoid compositions increased along with time of harvesting so that third harvesting had the most total Phenol content. Regardless harvest times, plastic mulches had affect on total Phenol content and flavonoid compounds so that white plastic mulch and the red one had the most total Phenol content and flavonoid compounds respectively.

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