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Effect of exogenous putrescine and Aloe vera gel coating on post-harvest life of strawberry (Fragaria ananassa Duch.) fruit, cultivar Kamarosa

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ABSTRACT: In order to study the Effect of exogenous putrescine and Aloe vera gel coating on post-harvest life of strawberry(Fragaria ananassa Duch.) fruit, cultivar Kamarosa an experiment was conducted at Shahrekord University in 2012. Experiment was conducted in a completely randomized design, including 8 treatments (0.6, 1.2 and 1.8 mM putrescine, Aloe vera gel: 20,40 and 60%, distilled water ‘‘control’’ and dry treatment ‘‘without water or Aloe vera gel or putrescine’’) and three replications. The measured traits were Ascorbic acid, Titratable acidity(TA), Anthocyanin, Total Soluble Solids (TSS),firmness, Weight loss, pH, TSS/TA. Mean comparison was conducted using LSD range test (at 1% level). TSS(%) decreased with the increase in putrescine and Aloe vera gel levels. Putrescine, Aloe vera gel, dry treatments as well as controls had no significant effects on pH. Fruits treated with putrescine and Aloe vera gel alone showed a reduction in taotal soluble solids (TSS), weight loss, TSS/TA, but firmness, titratable acidity(TA) and ascorbic acid increased. Measurment of anthocyanin showed a significant difference between treatments (P≤0.01), and treatment with putrescine at level of 1.8 mM was the best and the shortest was related to control values.

Key words: Aloe vera gel; post-harvest; putrescine; strawberry.

INTRODUCTION

Estimates of post-harvest crop losses worldwide have also been given as 10-20% but 25-40% for the tropics by other researchers (Ogunleye and Adefemi, 2007). The post-harvest management of fruit and vegetables in most developing countries in the region is, however, far from satisfactory. The major constraints include inefficient handling and transportation; poor technologies for storage, processing, and packaging; involvement of too many diverse actors; and poor infrastructure (Rosa, 2006). Small-scale farmers in developing countries are faced with many problems and constraints. Pre- and post-harvest crop losses due to insects, diseases, weeds, and droughts result in low and fluctuating yields, as well as risks and fluctuations in incomes and food availability (Tonukari and Omotor, 2010).

Strawberries are highly perishable fruits due to their extreme tenderness, vulnerability to mechanical damage, high level of respiration and their susceptibility to fungal spoilage (Maxie et al, 1959; Dennis, 1978). Fresh strawberries, therefore, have a very limited postharvest life and cannot be stored except briefly (Dennis and Mountford, 1975).

In recent years, the use of Aloe vera in the formulation of various cosmetic and food products has increased substantially (Simal et al. 2000). It is used as a source of functional ingredients in drinks beverages, and ice creams and also applied as an edible coating according to a patent (Martinez-Romero et al. 2003). This gel has a potential to be used for food maintenance. Leaves parenchyma cells include mucilaginous clear gel, which is applied as Aloe vera gel. The raw pulp of Aloe vera contains about 98.5% water, while the mucilage or gel consists of about 99.5% water (Eshun and He 2004). Furthermore, it involves a number of nutrients such as vitamins, fatty acids, amino acids, sugars, minerals, and enzymes. Therefore, it can be used in different formulations as a functional ingredient for health benefits. The gel works as a barrier to O2 and CO2 and acts as moisture barrier, and thus reduces weight loss, browning, softening, and growth of yeast and molds. The material contains antimicrobial compounds and thus prevents decay (Valverde et al. 2005). Aloe vera contains malic acid-acetylated carbohydrates (including β-1, 4-g1ucomannans) with anti-inflammatory activity (Esua and

Rauwald 2006). The two major liquid sources of A. vera are a yellow latex (exudates) and a clear gel (mucilage), which proceeds from the large leaf parenchymatic cells (Ni et al., 2004). The predominant medical uses of the orally ingested gel juice are against ulcerous, gastrointestinal, kidney and cardiovascular problems and also reduces the cholesterol and triglyceride levels in blood. Moreover, other properties such as antiinflammatory and antibiotic activities against some diseases (diabetics, cancer, allergy, AIDS) have been reported (Eshun and He 2004). Although the main use of A. vera gel is in the cosmetic industry, including treatment of burns and scars and in wound healing (Aburjai et al., 2004). There are some reports on the antifungal activity of A. vera gel against several pathogenic fungi including Botrytis cinerea (Jasso de Rodriguez et al., 2005).In addition to the traditional role of edible coatings as a barrier to water loss and delaying fruit senescence, the new generation coatings are being designed for incorporation and/or for controlled release of antioxidants, nutraceuticals, chemical additives and natural antimicrobial agents (Vargas et al., 2008). It has also been reported that the Aloe vera extracts possessed antimicrobial activity against bacterial pathogens from gram positive and gram negative (Adetunji, 2008).

The sensory examinations of sweet cherry coated with Aloe vera gel showed useful effects in terms of delaying stem browning and dehydration and maintenance of fruit visual characteristic without any damaging effect on taste, aroma, or flavors (Martinez- Romero et al. 2006).

Polyamines and low temperature are known to improve the shelf-life of fruits by inhibiting ethylene biosynthesis and delaying the ripening process, respectively. Polyamines and ethylene has opposite effects on fruit ripening and senescence. Balance between the two is important to enhance and retard the ripening process of fruits. Usually, the concentration of polyamines decreases during tissue senescence with accelerated ethylene production (Valero et al., 2002). Pre and post harvest application of putrescine increased fruit firmness and also retarded colour development (Malik et al., 2003). Treatment with exogenous putrescine (PUT) inhibited ethylene production, thus, retarding the increase of MDA (malondialdehyde) content and membrane permeability and postponing the occurrence of chilling injury (Zhang et al., 2000). In Hayward kiwi fruit, 1 mM putrescine treatment resulted in inhibition of ethylene production, low respiration rate and higher flesh firmness (Wen et al., 2003).

MATERIALS AND METHODS

Ten kilograms of flawless strawberry (Fragaria ananassa Duch.) fruits, cultivar Kamarosa, were purchased from a private producer in Shahrekord city (Iran). Experiment was conducted in a completely randomized design, including 8 treatments (0.6, 1.2 and 1.8 mM putrescine, Aloe vera gel: 20,40 and 60%, distilled water ‘‘control’’ and dry treatment ‘‘without water or Aloe vera gel or putrescine’’) and three replications. Fruits were harvested at the commercial maturity stage (25–30 days after anthesis), when they were full-sized and50–80% red-colored and carefully transferred to the laboratory within 4 h. 300 grams of fruits was used for each replicate. They were immerged in putrescine solutions (18 ˚C), Aloe vera gel as well as distilled water (control) for 5 min, and transferred into the baskets for 20 min to be dried. Putrescine and Aloe vera gel -treated and - untreated fruits together with controls were then transferred into plastic containers and put into the fridge (4 ˚C). Determinations were carried out 7 and 14 days after the beginning of storage**.**

Matured leaves of Aloe vera plant was harvested and washed with a mild chlorine solution of 25%. Aloe vera gel matrix was then separated from the outer cortex of leave and this colorless hydroparenchyma was ground in a blender .The resulting mixture was filtered to remove the firbres. The liquid obtained constituted fresh Aloe vera gel.To eval uate weight loss, separate samples in 3 replicates of each treatments were used. The same samples were evaluated for weight loss each time at weekly intervals until the end of experiment. Weight loss was determined by the following formula:

Weight loss (%) = [(A−B)/A] × 100

where A indicates the fruit weight at the time of harvest and B indicates the fruit weight after storage intervals. (A.O.A.C., 1994).

Titratable acidity was measured using titration method. To do that, 10 mL fruit juice was added to 60 mL distilled water plus a few drops of phenolphthalein and titrated with 0.1N NaOH up to pH 8.1. The results were expressed as g of citric acid per 100 g fresh weight. Total Soluble solids content was determined using ATAGO PAL-3 (Japan) N1 refractometer at 20 ˚C and expressed as ˚Brix. The pH of fruit juice was measured using a MTT65(Japan) pH meter calibrated by pH 4 and 6.4 buffer solutions.

Flesh firmness determination was carried out using an FT327 (GFFECI, Italy) apparatus through two penetrations and the measurement of the force required for a6.4 mm probe to penetrate 6 mm fruit flesh. Two measurements were conducted for each fruit and five fruits were used as a replicate.

Vitamin C content of the samples was measured using 2, 6- dichlorophenol indophenol method as described by (A.O.A.C., 2000). The TSS/TA ratio of the samples was determined by dividing Total Soluble Solids by the Titratable acidity.

Anthocyanins measured by a spectrophotometer (model: JENWAY-6320-D, England), (Giusti and Wrolstand , 2001).

Ascorbic acid, titratable acidity(TA), total soluble solids (TSS) ,anthocyanin, fruit firmness, weight loss, pH, TSS/TA were measured.Data were analyzed using SAS statistical program and means were compared using an LSD test ($p < 0.01$).

RESULTS AND DISCUSSION

Total soluble solids (TSS) of the strawberry fruits was significantly decreased by the use of putrescine and Aloe vera gel ($p < 0.01$; Table 1). Total soluble solids (%)were higher in dry treatment and lowest were in 60 % Aloe vera gel treatment. Fig. 1 shows that TSS(%) decreased with the increase in putrescine and Aloe vera gel levels.

Similarly, Khan et al. (2008) reported that putrescine treated fruit stored at low temperature exhibited lower soluble solid content, delayed respiration rate and higher titratable acidity than untreated fruits in Angelino plum. Khosroshahi and Ashari (2008) also found out that there was low soluble solid content and high acidity in putrescine treated strawberry, apricot and peach fruits during storage than untreated fruits.

The coating with Aloe vera led to a lower increase in TSS, which indicated that control fruits presented a more pronounced maturation development than coated berries, similarly to that found in starch-coated strawberry (Martınez et al, 2003). In addition, the Aloe coating could produce a modification of the internal atmosphere, showing similar effects as MAP (Mali et al, 2003).

Table1.Mean of squares for Ascorbic acid, (TA), Anthocyanin, (TSS), Fruit firmness, Weight loss, pH, TSS/TA in strawberry (Fragaria ananassa Duch.) fruit, cultivar Kamarosa

Source of variance	TSS (%)	TA (gr/100gr fresh weight)	TSS/TA	pH	Ascorbic acid	Fruit firmness (newton)	Weight loss (%)	Anthocyanin
Treatment	2.5**	0.1105**	0.4057**	0.012$^{n.s}$	179.48**	0.103**	0.2331**	46.5**
Error	0.34	0.0064	0.0803	0.006	3.97	0.005	0.0837	0.053
Cv (%)	11.07	6.48	10.99	2.12	8.23	8.98	15.361	6.54

**,^{sn}:Significant difference in 1% level and non significant respectively

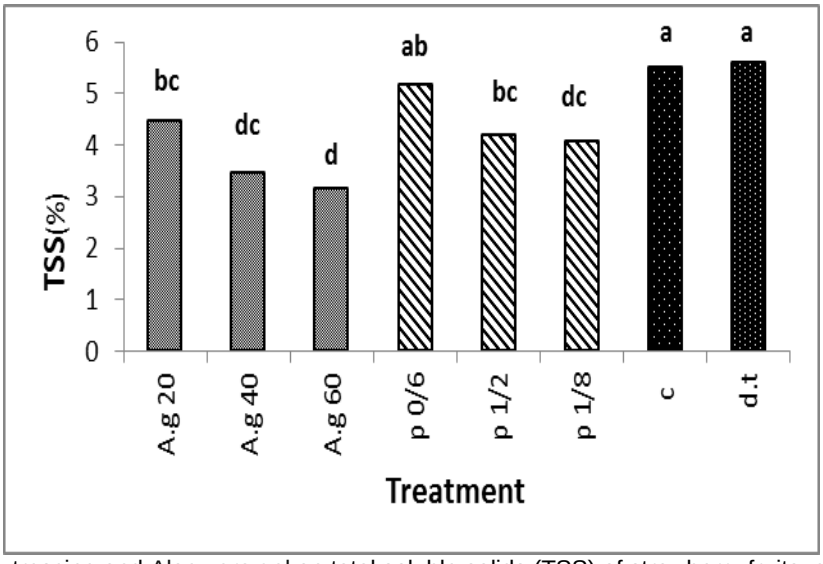

Figure 1. Effect of putrescine and Aloe vera gel on total soluble solids (TSS) of strawberry fruits, cv. Kamarosa, during storage.

A.g: Aloe vera gel, P: putrescine, C:control, d.t: dry treatment

Means that have at least one common letter didn,t show significant difference in 1% level

Analysis of variance showed that putrescine and Aloe vera gel significantly affected the titratable acidity (Table 1). Mean comparison indicated that the titratable acidity increased from1 (gr/100gr fresh weight) in control to 1.58 (gr/100gr fresh weight) in 20 % Aloe vera gel treatment (Fig. 2). The results obtained in this study are in agreement with those of Arowa et al. (2013) for oranges and Khan et al. (2008) for plum.

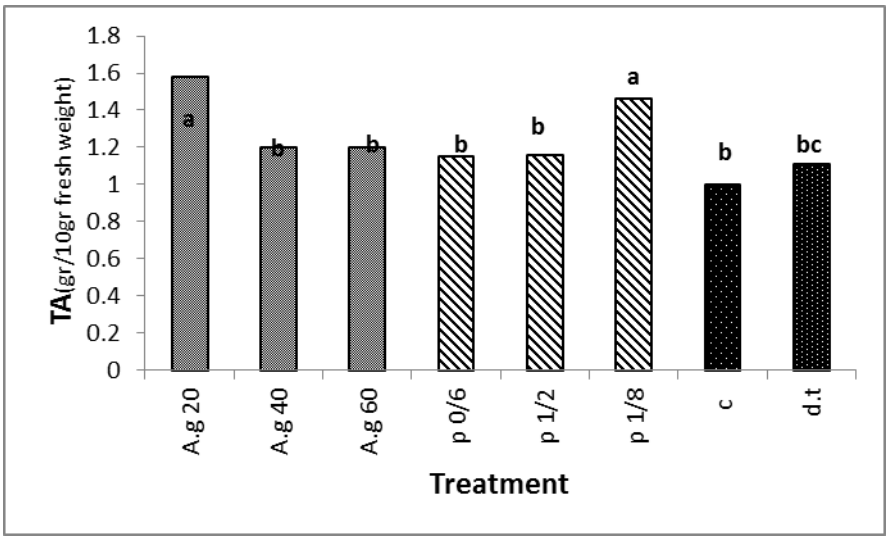

Figure 2. Effect of putrescine and Aloe vera gel on titratable acidity of strawberry fruits, cv. Kamarosa, during storage.
A.g: Aloe vera gel, P: putrescine, C:control, d.t: dry treatment
Means that have at least one common letter didn,t show significant difference in 1% level

Treatments have significant effects on TSS/TA ratio (P≤0.01). putrescine treatment at level of 1.8 mM and Aloe vera gel at level of 20% were the best treatments (Fig 3).

At the beginning of the ripening process, the TSS/TA ratio is low because of low total soluble solids and high fruit acid content, this makes the fruit taste sour. During the ripening process the fruit acids are degraded, the sugar content increases, and the TSS/TA ratio achieves a higher value. The increase in TSS/TA ratio level could be attributed mainly to breakdown of starch into water, soluble sugars, sucrose and glucose during ripening. The finding in this study was similar to the work carried out by Manzano et al. (1997) who had similar decreasing trend in Hadden mango treated with wax coatings and stored at different temperatures.

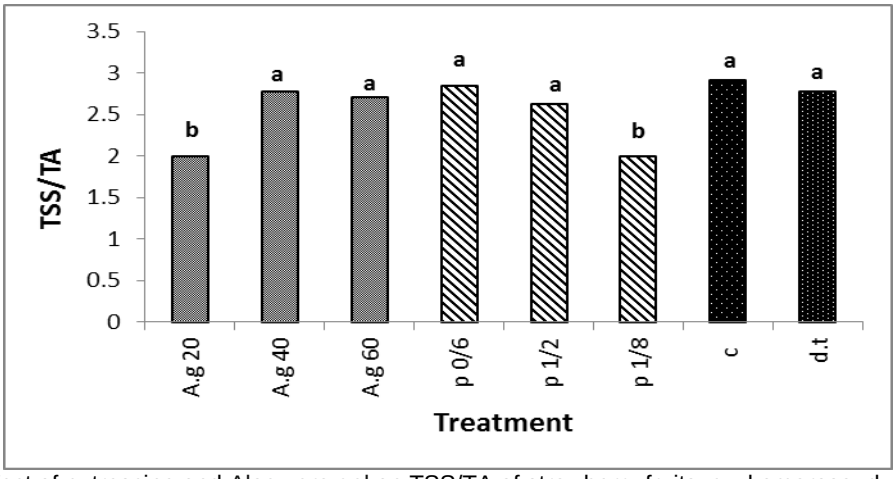

Figure 3. Effect of putrescine and Aloe vera gel on TSS/TA of strawberry fruits, cv. kamarosa, during storage.
A.g: Aloe vera gel, P: putrescine, C:control, d.t: dry treatment
Means that have at least one common letter didn,t show significant difference in 1% level

Putrescine, Aloe vera gel, dry treatments as well as controls had no significant effects on pH (Table. 1).

Putrescine and Aloe vera gel had highly significant effect on weight loss(%) in strawberry. Fig. 4 shows that weight loss (%)were higher in dry treatment and lowest were in 40 % Aloe vera gel treatment.

Aloe vera gel retarded the moisture loss, these effects being similar to those obtained with other edible coatings. The mechanism for these positive effects is based on their hygroscopic properties, which enables formation of a barrier to water diffusion between fruit and environment, thus avoiding its external transference (Morillon et al., 2002). Thereafter, composite coatings of polysaccharide-lipid are known to increase water barrier efficacy with increased lipid content and in turn more reductions of weight loss could be achieved (Perez-Gago et al., 2002). However, Aloe vera gel, the composition of which is mainly polysaccharides (Ni et al., 2004), was highly effective as a moisture barrier without the lipid incorporation.

The reduction in weight loss for coated strawberry was probably due to the effects of these coatings as a semi-permeable barrier against oxygen, carbon-dioxide, moisture and solute movement, thereby reducing

respiration, water loss and oxidation reaction rates (Baldwin et al., 1999; Park, 1999). The results obtained in this study are in agreement with the findings of Garcia et al., (1998) for strawberries coated with starch- based coatings and those of Joyce et al.(1995) who reported that waxing extended the storage life of avocado both through reduction in water loss and modification of the internal atmosphere. Similar results were obtained by Bai et al. (2003) who studied Galla apple coated with 10% zein (natural corn protein).

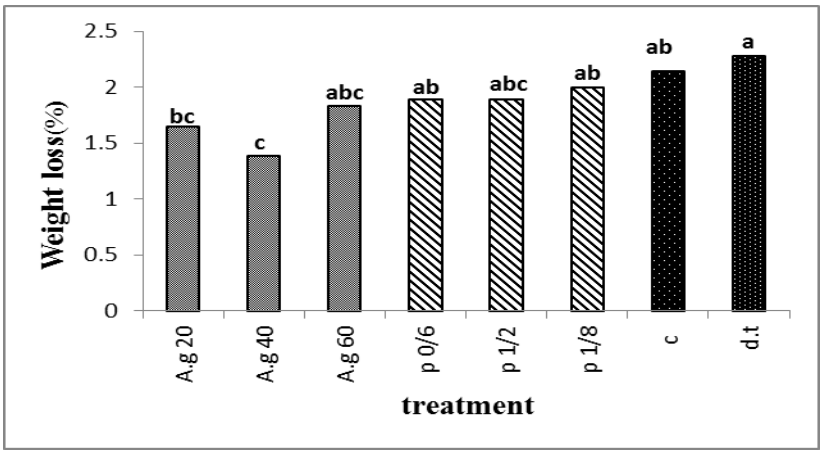

Figure 4. Effect of putrescine and Aloe vera gel on weight loss of strawberry fruits, cv. Kamarosa, during storage.
A.g: Aloe vera gel, P: putrescine, C:control, d.t: dry treatment
Means that have at least one common letter didn,t show significant difference in 1% level

Firmness is an important factor that influences the consumer acceptability of fresh-cut fruits and it is related to water content and metabolic changes (Rojas- Grau et al., 2008).

The effects of treatments on Fruit firmness have significant different (P≤0.01) and treatment with Aloe vera gel at level of 60%was the best treatment. The Shortest was related to control.

Fig. 5 shows that Fruit firmness increased with the increase in putrescine and Aloe vera gel levels. The mechanism by which polyamines increase fruit firmness is still unclear, but changes in polygalacturonic acids seem to be involved, specially by electrostatic bounds between the carboxylic groups and polyamines (Leiting and Wicker 1997).

The results obtained in this study are in agreement with those of Adetunji et al. (2012) for pineapple and Khan et al. (2008) for plum. Pre and post harvest application of putrescine increased fruit firmness and also retarded colour development (Malik et al., 2003).

Aloe vera based edible coatings have been shown to prevent loss of moisture and firmness, control respiration rate and maturation development, delay oxidative browning, and reduce microorganism proliferation in fruits such as sweet cherry and table grapes (Valverde et al., 2005; Matinez-Romero et al., 2005).

The retention of firmness in coated fruits was due to reduction in degradation of insoluble protopectins to more soluble pectic acid and pectin. It was found that during fruit ripening, depolymerization or shortening of chain length of pectin substances occurs with an increase in pectineesterase and polygalacturonase activities (Yaman and Bayoindirli, 2002). Hence low oxygen and high carbon-dioxide concentrations reduce the activities of these enzymes and allows retention of the firmness during storage (Salunkhe et al., 1991) .

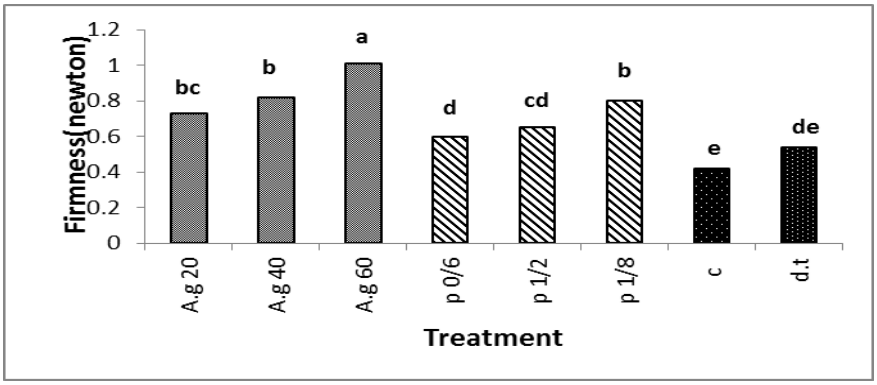

Figure 5. Effect of putrescine and Aloe vera gel on firmness of strawberry fruits, cv. kamarosa, during storage.
A.g: Aloe vera gel, P: putrescine, C:control, d.t: dry treatment
Means that have at least one common letter didn,t show significant difference in 1% level

Measurment of ascorbic acid showed a significant difference between treatments (P≤0.01), and treatment with putrescine at level of 1.8 mM was the best and The Shortest was related to control (Fig 6). Ascorbic acid of the strawberry fruits increased with the increase in putrescine and Aloe vera gel levels.

Polyamines and ethylene has opposite effects on fruit ripening and senescence. Balance between the two is important to enhance and retard the ripening process of fruits. Usually, the concentration of polyamines decreases during tissue senescence with accelerated ethylene production (Valero et al., 2002). The reduction of ascorbic acid loss in coated strawberry was due to the low oxygen permeability of Aloe vera gel coating which lowered the activity of the enzymes and prevented oxidation of ascorbic acid (Adetunji et al. 2012).

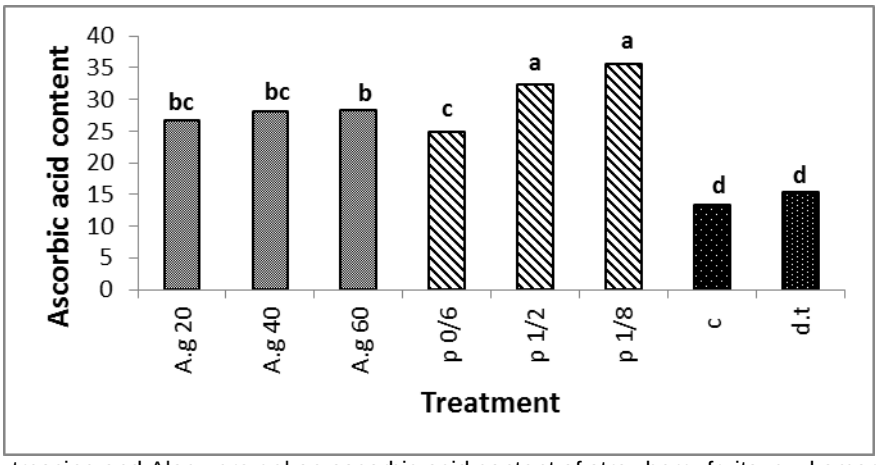

Figure 6. Effect of putrescine and Aloe vera gel on ascorbic acid content of strawberry fruits, cv. kamarosa, during storage.
A.g: Aloe vera gel, P: putrescine, C:control, d.t: dry treatment
Means that have at least one common letter didn,t show significant difference in 1% level

Measurment of anthocyanin showed a significant difference between treatments (P≤0.01), and treatment with putrescine at level of 1.8 mM was the best and the shortest was related to control values (Fig 7). Ascorbic acid of the strawberry fruits increased with the increase in putrescine and Aloe vera gel levels.

Pre-storage infiltrations by polyamines have been reported to reduce colour development in lemons and apricot (Valero et al., 1998; Martinez, 2001). Polyamines may inhibit chlorophyll degradation in skin tissues by inhibition of peroxidase activity (Ma-Jun et al., 1996).

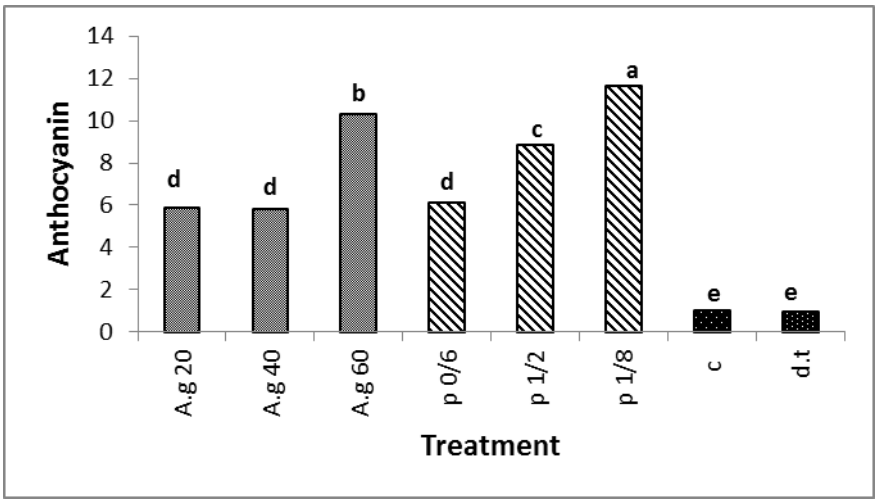

Figure 7. Effect of putrescine and Aloe vera gel on anthocyanin of strawberry fruits, cv. kamarosa, during storage.
A.g: Aloe vera gel, P: putrescine, C:control, d.t: dry treatment
Means that have at least one common letter didn,t show significant difference in 1% level

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