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# Effects of use of carnation ethanol extract, *Aloe vera* gel and nano plastic on postharvest quantitative characteristics of Gaviota strawberry cultivar at the second and third weeks of storage

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## Abstract

The use of natural compounds with antimicrobial activity and coating properties, have been known since ancient times. These natural compounds are less harmful than synthetic compounds. Also use of nano plastic is a new strategy in post-harvest technology. In this study, the effects of carnation ethanol extract at concentrations of 0, 50, 100 and 150 ppm and Aloe Vera gel at concentrations of 0, 50, 75 and 100 percent with or without nano plastic examined based on a factorial experiment in a completely randomized design with 3 replicates on post-harvest quantitative characteristics of Gaviota strawberry cultivar. Traits consist of wet weight, pH, total soluble solids and titrable acidity was evaluated at the second and third weeks of storage. The results showed that the use of Aloe Vera gel and nano plastic significantly increased total soluble solids and titrable acidity of strawberry. Carnation extract significantly effects on weight and acidity of strawberry and best performance observed in 100 ppm treatment of carnation extract. Use of Aloe Vera gel also significantly increased the weight, total soluble solids and acidity of strawberry and best performance observed in 100% concentration of Aloe Vera gel. Use of plastic produced with nano technology showed the lowest rate of weight loss. The interaction effects of nano plastic, Aloe Vera gel and carnation ethanol extract significantly increased strawberry total soluble solids.

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**Introduction**

Strawberry has belongs to *Fragaria* genus and *Rosaceae* family. Wild strawberries are abundant in the forests of northern Iran. Strawberry due to high respiration, high water content and high sensitivity to the metabolic activity of microbial and fungal decay is a highly putrescible fruit with low lifetime. Thus, post-harvest handling and transfer of the fruit is a critical step. After harvesting, despite the lack of connection with the mother plant, fruits continue to respiration and transpiration. The materials that have been lost by respiration and perspiration, cannot be replaced by the sap. The fruit has used its reserves of water leads to decay of the fruit (Behnamian *et al.*, 2002). Studies carried out in order to control and reduce waste strawberry has resulted in a variety of ways and recommendations such as use of fungicides, sprayed strawberries with calcium, rapid cooling harvest, use of cold storage rooms, packaging in boxes made of perforated PVC thin film, controlling warehouse atmosphere, chemical and biological control and the use of radiation. Each of these methods has advantages and disadvantages and the use of some of them is practically restricted due to high cost or the need for special equipment (Hoseini, 1990). One of the new healthy and environmental friendly post-harvest control ways of fruits and vegetables is using of natural compounds found in plant extracts or essential oils. Essential oils are natural colorless compounds consisting of alcohols, aldehydes and esters which has its own flavor and a molecular weight less than water and uses as a food flavoring, antioxidant and antibacterial agent (Parvaneh, 1992). On the other hand, enzymatic browning in fruits and vegetables can cause adverse changes in quality of transferring, packing and storage processes. The reaction is done by the polyphenol oxidase and peroxidase enzymes. The use of vegetable oils helps prevent enzymatic browning due to their antioxidant activity (Boyraz and Ozcan, 2005). The coating composition consisting of galactose, xylose, arabinose and galacturonic acid with a high molecular weight are soluble in alcohol used for fruits and vegetables (Parvaneh, 1992). Edible coatings divided to protein coating, polysaccharide coating, lipid coating or a combination of them used in order to increase the shelf life of products and increased stored agricultural products by delaying the loss of water, keeping the aromatic compounds, shortness of breath and delayed fruit structural changes. These coatings are created a permeable membrane to oxygen and carbon dioxide (Del valle *et al.*, 2005). Protective effects of some natural essential oils have long been recognized. For example, fruits are proposed by soaking them in powdered carnations and salt (Dris *et al.*, 2001). On the other hand, the spices have been used as antimicrobial agents in food storage and prevent the growth of spoilage microorganisms (Vesaltalab *et al.*, 2009).

Strawberry as a non-climacteric fruit, needs post-harvest treatments in order to supplied to the market and increase its shelf life.

In this study, considering the role of antimicrobial and antibacterial characteristics of carnation extract and Aloe Vera gel as edible coatings and nano plastic, their effects on the mechanical integrity of the fruit during handling and reducing waste storage were studied. Also to investigate the simultaneous effects of increasing the shelf life of strawberry fruit, the interaction effects between carnation extract and Aloe Vera gel and nano plastic were studied.

**Materials and methods**

In order to evaluate the longevity of postharvest strawberry in the second and third weeks of storage, an experiment was conducted in postharvest laboratory of agriculture faculty of Abhar Islamic Azad University in 2012. The experiment consisted of 32 treatments with 3 replicates.

*Treatments*

Aloe Vera gel on the four-levels of control, 50, 75 and 100%, nano plastic treatment in 2 level of with and without nano plastic and carnation extract in four levels of control, 50, 100 and 150 ppm were used. The data were analyzed using SAS 9.2 analytical software.

*Strawberry cultivar*

Strawberry cultivar used in the experiment was Gaviota that has a large and rigid fruit with a conical shape that has good taste, resistant to powdery mildew and anthracnose decay and tolerant to *tetranychus urticae* mite (Ashkan, 2005). Strawberries were harvested at commercial maturity (25 to 30 days after flower opening) and when reached to full size when about 50 to 80 color percent were red. Fruits those have abnormal shape and physical symptoms were excluded and healthy uniform fruits were selected.

*Carnation ethanol extract*

Carnation extract was extracted by Soxhlet extractor. In this method, carnation buds dried with oven at 50 ° C for 5 hours. Extraction operation was performed within 5 hours with 96% ethanol after passing dried powder through a 1 ml sieve. Then concentrated extract effect was tested on strawberries (Gholami *et al.*, 2011). Essential oils content of carnation bud, carnation stem and carnation leaves is 16%, 5% and 2% respectively that these essential oils obtained from the distillation process (Vessaltalab *et al.*, 2009).

*Aloe Vera gel*

Aloe Vera gel was applied on strawberries after extraction and purification at different concentrations. Compounds that have been found in aloe Vera gel are polysaccharides that able to reduce and repair of inflammations (Aminifard, 2011). Aloe Vera gel also has anti-bacterial and antimicrobial properties. Antioxidants such as vitamins A, B, C, E, zinc amino acids and essential fatty acids are found in this compound (Martınez-Romero *et al*, 2005).

*Nano plastic*

Packaging is one of the key issues on safety of agricultural products and food industries. The use of nanotechnology can improve the quality and efficiency of packaging materials and thus ensure the safety of fruits and food. The use of nanotechnology in food packaging industry is common. This technology enables the study of manipulating matter on an atomic and molecular scale and made significant changes in the packaging industry, especially fruits and vegetables packaging (Ashori nejad, 2011). In the new plastics, nanoparticles are arranged in a zigzag form and as a barrier, preventing the penetration of oxygen. In fact, the movement of oxygen molecules take longer and delaying the process of fruit rot. Also produced materials based on nanotechnology have more safety and lower price and higher quality in comparison with ordinary packaging materials (koshkoli, 2011).

*Experimental procedure*

After washing fruits and selection of uniform strawberries in size and shape, twenty-one strawberry fruits were considered for each experimental unit. In the first week of experiment, before treating fruits with Aloe Vera gel and carnation extract, measurements were performed. Then fruits were immersed in treatments consist of different concentrations of Aloe Vera gel (0, 50%, 75% and 100%) for 5 min and carnation extract (0, 50, 100 and 150 ppm) for 1 min based on the experimental design. Then fruits were rinsed and poured in baskets. After approximately 20 minutes, the fruits were dried at room temperature and packed by non-plastic and without it as control. Then fruits were stored in a refrigerator at 4 ° C.

Total soluble solids, pH, titrable acidity and wet weight were evaluated in this experiment. Measurement of total soluble solids was obtained by manually refraction measuring by extracting of fruit brain tissue. After smooth of solution, put a few drops of fruit juice on the refractometer prism and the total soluble solids in brix measurement degrees were recorded (Parvaneh, 1992). Strawberry fruit juice pH was measured using a pH meter. Titrable acid computed by titration method on the basis of citric acid (Hoseini, 1990).

**Results and discussion**

*Effect of Aloe Vera gel*

Effect of Aloe Vera gel on increase the wet weight of strawberry at the second week of storage was significant ($P<0.01$). The highest wet weight (21.266)

was related to 75% concentration of Aloe Vera gel and the minimum wet weight (19.719) was related to the control level. There were no significant differences between control level and 50% and 75% concentrations of Aloe Vera gel. At the end of the third week, the use of Aloe Vera gel had no significant effects on wet weight of strawberry fruit.

At the second week of storage, the use of Aloe Vera gel had no significant effects on pH of strawberry. At the third week of storage, the highest pH (3.447) was related to Aloe Vera gel with 100% concentration that had not significantly difference in comparison with 75% and 50% treatments and the lowest pH (3.243) was related to the control level.

Effect of Aloe Vera gel on increase of the amount of total soluble solids of strawberry at the second week of storage was significant ($P<0.01$). The greatest amount of total soluble solids (5.862) was related to 50% Aloe Vera gel treatment and the minimum level (5.412) was related to the control level. There were no significant differences between control and 50% and 100% concentrations of Aloe Vera gel. Effect of Aloe Vera gel on increase the amount of total soluble solids of strawberry was significant at the end of the third week of storage ($P<0.01$). The greatest amount of total soluble solids (5.858) was related to 100% Aloe Vera gel treatment and the minimum level (5.408) was related to the control level. There were no significant differences between 50% and 75% concentrations of Aloe Vera gel.

At the second week of storage, Aloe Vera gel significantly increased the amount of titrable acidity of strawberry ($P<0.01$). The highest titrable acidity (0.701) was related to 100% concentration of Aloe Vera gel treatment and the less titrable acidity (0.545) was related to the control level. Also this effect was significant at the end of the third week of storage ($P<0.01$). The highest titrable acidity (1.405) was related to 100% concentration of Aloe Vera gel and the less content of titrable acid (0.664) was related to the control level.

Valverdo *et al.,* 2005 stated that Aloe Vera gel significantly increased pH levels in seedless grapes. The reasons are creating a modified atmosphere around the fruit and reduce the rate of respiration and reduction of ethylene production in fruit.

Vahdat *et al.,* 2009 in an experiment showed that the pH increased with increasing concentration of Aloe Vera gel. Notably, the pH depends on the concentration of hydrogen ions and stabilized capacity of hydrogen ion concentration of the juice.

Martinez *et al.,* 2005 showed that Aloe Vera gel significantly increased the amount of soluble solids in the cherry fruit. While Mirdehghan *et al.,* 2009 stated that Aloe Vera gel had no significant effect on increasing the amount of total soluble solids.

Vahdat *et al.,* 2009 stated that Aloe Vera gel significantly increased the amount of titrable acidity of strawberry and titrable acidity of fruit increased with higher concentrations of Aloe Vera gel.

*Effect of carnation ethanol extract*

At the second week of storage, the use of carnation ethanol extract had no significant effects on wet weight of strawberry. At the third week of storage, carnation extract significantly increased the wet weight of the strawberry. The highest wet weight (17.596) was related to 100 ppm concentration of the carnation extract and the least amount of wet weight (14.450) was related to the control level.

At the second week of storage, the use of carnation ethanol extract had no significant effects on pH of strawberry. At the end of the third week of storage, carnation extract significantly increased the pH of strawberry. Comparison of carnation extract treatments showed that the highest pH (3.452) was related to 100 ppm concentration of carnation extract and the lowest pH (3.365) was related to the control level. Carnation extract had no significant effects on total soluble solids of strawberry fruit at the second and third weeks of storage.

At the second week of storage, carnation extract significantly increased the amount of titrable acidity of strawberry. The highest titrable acidity (0.679) was related to 100 ppm concentration of carnation extract and minimum level of titrable acidity (0.503) was related to control level. At the third week of storage, the highest titrable acidity (1.021) was related to 150 ppm concentration of carnation extract and minimum level of titrable acidity (0.891) was related to the control level.

In an experiment, Gholami *et al.*, 2011 tested the effect of different concentrations of carnation extract on quality of strawberry. The experiment concluded that carnation extract increased the amount of titrable acidity in strawberry but this increase was not significant, which is corresponded with the results of the present study. It seems constituents of carnation extract for antifungal and antioxidant properties, prevents rotting of fruits.

*Effect of nano plastic*

At the end of the second week of storage, the use of nano plastic had no significant effects on wet weight of strawberry. At the third week of storage, use of nano plastic, significantly increase the amount of wet weight of strawberry. The highest wet weight (17.561) was related to the treatment of nano plastic and the lowest wet weight (14.601) was related to the control level without nano plastic.

At the end of the second week of storage, use of nano Plastic significantly increased pH of strawberry. The maximum amount of pH (3.483) was related to treatment with nano plastic and minimum level of pH (3.425) was related to the treatment without nano plastic. The use of nano plastic at the third week of storage, had no significant effect on pH of strawberry.

At the second week of storage, use of nano plastic significantly increased the amount of total soluble solids in strawberry. The most amounts of total soluble solids (5.737) was observed in treatment with nano plastic packaging and minimum level of total soluble solids (5.495) was related to treatment without nano plastic. Also at the third week of storage, nano Plastic usage significantly increased the amount of total soluble solids in strawberry. The most amounts of total soluble solids (6.229) was observed in treatment with nano plastic packaging and minimum level of total soluble solids (5.089) was related to the control level without nano plastic.

Use of nano plastic significantly increased the amount of titrable acidity in strawberry at the end of the second week of storage. The maximum amount of titrable acidity (0.676) was related to treatment with nano plastic and minimum level of titrable acidity (0.582) was related to the control level without nano plastic. At the end of the third week of storage, use of nano plastic significantly increases the amount of titrable acidity. The maximum amount of titrable acidity (1.161) was related to treatment with nano plastic and minimum level of titrable acidity (0.719) was related to the control level without nano plastic.

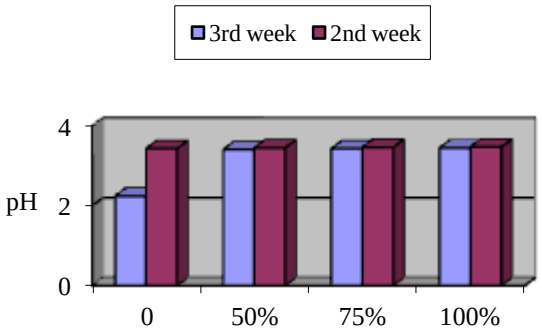


**Chart 1.** Comparison the effects of Aloe Vera gel treatments on strawberry pH at the 2nd and 3rd weeks of storage.

In an experiment, Mirdehghan *et al.,* 2009 investigated the effects of nano-based plastic on pomegranate arils. They concluded that the use of nano plastic was effective on increasing of wet weight of pomegranate arils.

Ashouri *et al.,* 2011 examined the effects of nano plastic on shadberry and Stated that the use of nano plastic significantly increased the pH of shadberry.

Mirdehghan *et al.,* 2009 showed that the use of nano plastic had no significant effect on the amount of total soluble solids in edible parts of pomegranate fruit. But the interaction of nano plastic and Aloe Vera gel increased the amount of soluble solids.

Ashouri *et al.,* 2011 showed that the nano plastic increased the amount of titrable acidity in shadberry but nano plastic does not show an increased rate of titrable acidity.

*Interaction effects between nano plastic and Aloe Vera gel*

The interaction effect between nano plastic and Aloe Vera gel was significant on the wet weight of strawberry at the second week of storage. The highest wet weight (21.95) was related to nano plastic with 75% concentration of Aloe Vera gel and the least amount of wet weight (18.21) was related to the treatment without non-plastic with 50% concentration of Aloe Vera gel. Also this interaction effect was significant at the third week of storage ($P<0.01$). The highest wet weight (19.14) was related to nano plastic with 100% concentration of Aloe Vera gel and the least amount of wet weight (13.23) was related to the treatment without non-plastic with 100% concentration of Aloe Vera gel.

At the end of the second week of storage, the interaction effect between nano plastic and Aloe Vera gel on increase of pH level of strawberry was not significant. But this interaction effect was significant at the third week of storage ($P< 0.01$). The highest pH level (3.560) was related to nano plastic treatment treated with 100% concentration of Aloe Vera gel and minimum level of pH (3.300) was related to the treatment without nano plastic and control level of Aloe Vera gel.

The interaction effect of nano plastic and Aloe Vera gel on increase the amount of total soluble solids of strawberry fruit at the second week of storage was significant ($P< 0.01$). The highest amount of total soluble solids (6.190) was related to the treatment containing nano plastic and 50% concentration of Aloe Vera gel and minimum level (5.03) was related to the treatment without nano plastic and 75% concentration of Aloe Vera gel. Also this interaction effect was significant at the end of the third week of storage ($P< 0.05$). The highest amount of total soluble solids (6.530) was related to the treatment containing nano plastic and 100% concentration of Aloe Vera gel and minimum level (4.280) was related to the treatment without nano plastic and control level of Aloe Vera gel.

The interaction effect between nano plastic and Aloe Vera gel was significant on increase of titrable acidity of strawberry at the end of the second week of storage ($P< 0.01$). The maximum of titrable acidity (0.870) was related to nano plastic treatment treated with 100% concentration of Aloe Vera gel and minimum level (0.530) was related to the treatment without nano plastic and control level of Aloe Vera gel. This interaction effect was significant at third week of storage ($P< 0.01$). The maximum of titrable acidity (1.970) was related to nano plastic treatment treated with 100% concentration of Aloe Vera gel and minimum level of titrable acidity (0.570) was related to the treatment without nano plastic and 50% concentration of Aloe Vera gel.

*Interaction effect between nano plastic and carnation extract*

The results of this experiment showed that at the end of the second and third weeks of storage, the interaction between nano plastic and carnation extract on the wet weight of the strawberry were not significant.

At the second week of storage, the interaction effect between nano plastic and carnation extract on increase the pH level of strawberry was not significant. This interaction effect at the third week of storage was significant ($P< 0.05$). The highest pH level (3.520) was related to the treatment containing

nano plastic and 100 ppm concentration of carnation extract and minimum level of pH (3.360) was related to the treatment without nano plastic and control level of carnation extract.

At the end of the second and third weeks of storage, the interaction effect between nano plastic and carnation extract on the total soluble solids in strawberry was not significant.

At the end of the second week of storage, the interaction effect between nano plastic and carnation extract on increasing of titrable acidity was significant (P< 0.01). The maximum of titrable acidity (0.760) was related to nano plastic treatment treated with 100 ppm concentration of carnation extract and minimum level of titrable acidity (0.500) was related to the treatment without nano plastic and control level of carnation extract. This interaction effect was significant at the end of the third week of storage (P< 0.01). The maximum of titrable acidity (1.380) was related to nano plastic treatment treated with 150 ppm concentration of carnation extract and minimum level (0.590) was related to the treatment without nano plastic and control level of carnation extract.

*Interaction effect between carnation extract and Aloe Vera gel*

At the second week of storage, the interaction effect between carnation extract and Aloe Vera gel on the wet weight of strawberry was significant (P< 0.01). The highest wet weight (23.13) was related to the control level of carnation extract and 75% concentration of Aloe Vera gel and the least amount of wet weight (15.50) was related to the treatment with control level of carnation extract and 50% concentration of Aloe Vera gel. Analysis of variance showed that the interaction effect between Aloe Vera gel and carnation extract was not significant on the wet weight of strawberry at the third week of storage.

At the end of the second week of storage, the interaction effect between carnation extract and Aloe Vera gel on increase the pH level of strawberry was not significant. But this interaction effect at the end of the third week of storage was significant (P< 0.01). The highest pH level (3.630) was related to the treatment containing 100% concentration of Aloe Vera gel and 100 ppm of carnation extract and minimum level of pH (3.310) was related to the treatment containing control level of Aloe Vera gel and 50 ppm of carnation extract.

At the second week of storage, the interaction effect between carnation extract and Aloe Vera gel on increasing the amount of total soluble solids of strawberry was significant (P< 0.01). The highest amount of total soluble solids (6.300) was related to the treatment containing 150 ppm level of carnation extract and 50% concentration of Aloe Vera gel and minimum level (5.200) was related to the control level of Aloe Vera gel and 100 ppm concentration of carnation extract. Also this interaction effect was significant at the end of the third week of storage (P< 0.01). The highest amount of total soluble solids (6.200) was related to the treatment containing control level of carnation extract and 100% concentration of Aloe Vera gel and minimum level (5.050) was related to the control treatments of carnation extract and Aloe Vera gel.

At the second week of storage, the interaction effect between carnation extract and Aloe Vera gel was significant on increasing of titrable acidity of strawberry (P< 0.01). The maximum of titrable acidity (0.910) was related to 150 ppm concentration of carnation extract and 100% concentration of Aloe Vera gel and minimum level of titrable acidity (0.470) was related to 50% concentration of Aloe Vera gel and 50 ppm concentration of carnation extract. Also this interaction effect was significant at the end of the third week of storage (P< 0.01). The maximum of titrable acidity (1.970) was related to 150 ppm concentration of carnation extract and 100% concentration of Aloe Vera gel and minimum level (0.4) was related to the control treatment of Aloe Vera gel and 150 ppm concentration of carnation extract.

*Interaction effects between nano plastic, carnation extract and Aloe Vera gel*

At the second week of storage, the interaction effect between nano plastic and carnation extract and Aloe Vera gel on wet weight of strawberry was significant (P<0.01). The maximum of wet weight (24) was related to the treatment without nano plastic, 75% concentration of Aloe Vera gel and control level of carnation extract and minimum wet weight (14.33) was related to the treatment containing control of carnation extract and 100% concentration of Aloe Vera gel with nano plastic. Also this interaction effect was significant at the third week of storage (P<0.01). The maximum of wet weight (22.3) was related to the treatment containing nano plastic, control level of Aloe Vera gel and 100 ppm concentration of carnation extract and minimum wet weight (10.70) was related to the treatment containing control of carnation extract and 100% concentration of Aloe Vera gel without nano plastic.

At the second week of storage, the interaction between nano plastic with carnation extract and Aloe Vera gel on increase the pH level of strawberry was not significant. But at the third week of storage, this interaction effect was significant (P<0.01). The maximum pH level (3.9) was related to the treatment containing nano plastic, 100% concentration of Aloe Vera gel and 100 ppm concentration of carnation extract and minimum pH level (3.23) was related to the treatment containing control of carnation extract and 100% concentration of Aloe Vera gel without nano plastic.

At the second week of storage, the interaction between nano plastic and carnation extract and Aloe Vera gel on total soluble solids of strawberry was significant (P<0.01). The maximum of total soluble solids (6.570) was related to the treatment containing nano plastic, 75% concentration of Aloe Vera gel and control treatment of carnation extract and minimum level (4.830) was related to the treatment containing 75% concentration of Aloe Vera gel and 50 ppm concentration of carnation extract without nano plastic. Also this interaction effect at the third week of storage was significant (P<0.01). The maximum of total soluble solids (7.100) was related to the treatment containing nano plastic, 100% concentration of Aloe Vera gel and control treatment of carnation extract and minimum level of total soluble solids (4.200) was related to the treatment containing control of Aloe Vera gel and carnation extract without nano plastic.

At the second week of storage, the interaction effect between nano plastic and carnation extract and Aloe Vera gel was significant on increasing of titrable acidity of strawberry (P<0.01). The maximum amount of titrable acidity (1.28) was related to the treatment containing nano plastic, 100% concentration of Aloe Vera gel and 150 ppm concentration of carnation extract and minimum level of titrable acidity (0.39) was related to the treatment containing nano plastic and 50% concentration of Aloe Vera gel and 50 ppm concentration of carnation extract. Also this interaction effect at the third week of storage was significant (P<0.01). The maximum amount of titrable acidity (2.830) was related to the treatment containing nano plastic, 100% concentration of Aloe Vera gel and 150 ppm concentration of carnation extract and minimum level titrable acidity (0.3) was related to the treatment containing nano plastic and control of Aloe Vera gel and 50 ppm concentration of carnation extract.

Ashori nejad *et al.,* 2011 examined the interaction effects between nano plastic and carnation extract on shadberry and stated that fruits treated with nano plastic and carnation extract had lower browning index and better quality in the end of storage. Weight loss, increase of total soluble solids and decrease of titrable acidity in fruits treated by nano plastic and carnation extract were significantly lower than control treatments.

Carnation extract significantly effects on weight and acidity of strawberry and best performance observed in 100 ppm treatment of carnation extract. These effects can be attributed to the presence of eugenol phenolic compounds in carnation extract. Use of Aloe

Vera gel also significantly increased the weight, total soluble solids and acidity of strawberry and best performance observed in 100% concentration of Aloe Vera gel. These effects may be associated with polysaccharide compounds, anti-bacterial and anti-fungal attributes of Aloe Vera gel. The Aloe Vera gel reduces breathing rate and delaying the loss of water of fruit which leads to increase the quality and length of storage of strawberry (Amini fard *et al.*, 2011). Use of plastic produced with nano technology showed the lowest rate of weight loss. This experiment showed that the use of nano plastic, significantly increased the acidity and total soluble solids in strawberry.

**Table 1.** Results of the comparison of the effects of carnation extract on traits measured in the third week of storage.

| Treatment | Wet weight (gr) | pH | Titrable acidity (%) | Total soluble solids |
|---|---|---|---|---|
| Without Carnation extract(control) | 14.45 $^{b}$ | 3.38 $^{b}$ | 0.89 $^{b}$ | 5.54 $^{a}$ |
| 50 ppm carnation extract | 15.10 $^{b}$ | 3.36 $^{b}$ | 0.92 $^{b}$ | 5.72 $^{a}$ |
| 100 ppm carnation extract | 17.17 $^{a}$ | 3.43 $^{ab}$ | 0.92 $^{b}$ | 5.66 $^{a}$ |
| 150 ppm carnation extract | 17.59 $^{a}$ | 3.45 $^{a}$ | 1.02 $^{a}$ | 5.7 $^{a}$ |

Means with at least one letter in common, has no significant difference.

**Table 2.** Analysis of variance of effects of Aloe Vera gel, carnation extract, nano plastic and their interaction effects on traits measured in the second week of storage.

| **Sources of Variation** | Mean square | | | | |
|---|---|---|---|---|---|
| | Degree of freedom | Wet weight (gr) | pH | Total soluble solids (%) | Titrable acidity (%) |
| Nano plastic | 1 | 82.51$^{ns}$ | 0.0793 $^{*}$ | 1.4016** | 0.2109** |
| Aloe Vera gel | 3 | 11.8 $^{**}$ | 0.0065$^{ns}$ | 0.8238** | 0.1078** |
| Carnation extract | 3 | 7.5395* | 0.0025$^{ns}$ | 0.2016 $^{ns}$ | 0.1120** |
| Nano plastic × Aloe Vera gel | 3 | 44.046** | 0.0311$^{ns}$ | 3.3744** | 0.1573** |
| Nano plastic × Carnation extract | 3 | 4.7056 $^{ns}$ | 0.0045$^{ns}$ | 0.0944 $^{**}$ | 0.0702** |
| Aloe Vera gel × Carnation extract | 9 | 24.2396** | 0.0202$^{ns}$ | 0.3540** | 0.1185** |
| Nano plastic × Aloe Vera gel × Carnation extract | 9 | 15.9130** | 0.005$^{ns}$ | 0.2372** | 0.1150** |
| | 64 | 1.8630 | 0.0123 | 0.0869 | 0.0071 |
| cv (%) | | | 3.2156 | 5.2508 | 13.3846 |

Significant at 5% and 1% and no significant singed by *, ** and ns respectively.

**Table 3.** Analysis of variance of effects of Aloe Vera gel, carnation extract, nano plastic and their interaction effects on traits measured in the third week of storage.

| **Sources of Variation** | Mean square | | | | |
|---|---|---|---|---|---|
| | Degree of freedom | Wet weight (gr) | pH | Total soluble solids (%) | Titrable acid (%) |
| Nano plastic | 1 | 21.2192** | 0.0201 $^{ns}$ | 31.1676** | 4.6905** |
| Aloe Vera gel | 3 | 5.4174 $^{ns}$ | 0.0513** | 0.8351** | 2.6060** |
| Carnation extract | 3 | 56.7030** | 0.0407** | 0.1512 $^{ns}$ | 0.0761** |
| Nano plastic × Aloe Vera gel | 3 | 35.9568** | 0.1276** | 0.4109* | 2.0927** |
| Nano plastic × Carnation extract | 3 | 7.4881 $^{ns}$ | 0.0288* | 0.1153 $^{ns}$ | 0.3828** |
| Aloe Vera gel × Carnation extract | 9 | 18.099** | 0.0393** | 0.8049** | 0.7504** |
| Nano plastic × Aloe Vera gel × Carnation extract | 9 | 12.5692** | 0.0287** | 0.6335** | 0.6703** |
| | 64 | 3.2539 | 0.0073 | 0.144 | 0.0132 |
| cv (%) | | | 0.5230 | 6.7066 | 12.2493 |

Significant at 5% and 1% and no significant singed by *, ** and ns respectively.

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