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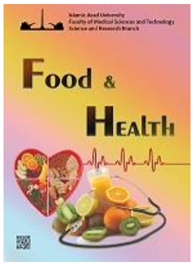

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Evaluation of the effect of plastics bags containing silver nanocomposite of grapefruit's peel on cucumber postharvest nutritional value and their possible penetration in tissue

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ABSTRACT

The increasing need for enhanced fresh food shelf life, as well as require of protection against forborne diseases, stimulate the growth of antimicrobial food packaging. Among the most impressive ways, the mixture of organic-inorganic, packaging, i.e. polymer inserted metal nanoparticles demonstrate to be extremely, useful. Silver nanoparticles, particularly, have antimicrobial, anti-fungi, anti-yeasts, and anti-viral activities and can be joined with both non-degradable and edible polymers for fresh packaging. The present application of AgNPs in fresh vegetable packaging is arranged by EU and USA food safety authorities carefully, due to the incapability to make certain bulletin on their toxicity. Hence, their use is figuring out in terms of Ag^+ transformation into the packed food. This study was done to determine the effect of plastics embedded silver nanoparticles at concentrations of 10, 20, 30, 40, 50, and 60 ppm on some cucumber postharvest traits. In addition, it was examined the evaluation of the efficacy of AgNPs-containing hybrid materials to assure fresh vegetable safety. The results indicated that plastic bags were made successfully and 60 ppm concentration of silver nanoparticles was more effective than all other treatments on postharvest characters. Soluble solids concentration, TSS, Vitamin C, Zn, Cu, Fe, Mn, Mg, and K, is significantly affected by using bags. Cucumbers shelf life is relatively long, lasting 21 days whereas control was 13 days. In addition, the highest level of silver penetration (1.99±0.002 ppb) in exocarp, (0.25±0.006 ppb) in mesocarp, and (0.30±0.006 ppb) in endocarp was associated with the treatment of 60 ppm silver nanoparticles in cucumber. So, these bags could be used for increasing shelf life in cucumber.

1. Introduction

One of the major challenges in food processing is the preservation of foodborne pathogens, which still illustrate a worldwide issue of general health. The Center for Disease Control and Prevention (CDC) survey, that the effect of foodborne pathogens in countries such as the USA consequence each year in 76 million sick people, 325,000 of which are hospitalized, and 5000 dies (1). The necessity, of barricading foodborne pathogens needs speed in the advancement of antimicrobial packaging, a special packaging that abandon active biocide materials to precede development the quality of the vegetable, increasing shelf life, and hamper or put off the spoilage. The antimicrobial practice may be gain by releasing the biocide immediately into the food or in the place at intervals the food (2). However, using the silver nanoparticle as antimicrobial factors in food packaging is a major technology, concerns on the risks related to the possible ingestion of the silver ions move into food and drinks still keep. This will result in a cautious state of food safety permission. (3). The European Food Safety Authority (EFSA) panel stated that services for food packaging and that contain Ag ion are not licensed in the EU unless authorized representative (4). According to (EFSA) recommendations are not to exceed 0.05 mg/ L in water and 0.05 mg/kg in food (5). Some plants have been investigated as a renewable and inexpensive resource for the production of nanomaterials. One of these agricultural products is grapefruit. The flavonoid

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composition of this plant originates from decreasing the Ag ion and confirms the produced nanoparticles (6). North of Iran, especially Alborz province is the large area and original habitat of different species of *Citrus paradisi* and this is why this zone is very significant. Moreover, Iran has a wide diversity of vegetation coverage. However, so far, few studies have been accomplished to consider the capability of this plant in the extraction of nanoparticles. Anticipated results can be established by accomplishment plans in this area. This can be an easy and inexpensive way to produce silver nanoparticles. Cucumber is one of the main vegetables that can be grown during the year. Require for fresh cucumber has enhanced the emphasis of its greenhouse production throughout the year. Iran is the third-largest producer country in the world; according to the Agriculture and Growing Industry (7). Cucumber fruit has a restricted postharvest life due to its watery texture and high metabolism. Up to 50 percent of agricultural products are destroying due to damage, annually, which can increase the postharvest life if new methods are applied. The purpose of this experiment was to calculate the potential of *Citrus paradisi* peel extract in the production of bags contains silver nanoparticles and the impact of its coatings on postharvest on the nutrition value of cucumbers.

2. Material and methods

The grapefruit was gathered at Samandak Village located at Mazandaran province, Iran, during 2015. Then they carried to 25-28 C°, with a photoperiod of 16/8 hours and 70% RH at the horticulture laboratory of Science and Research Branch, Islamic Azad University, Tehran, Iran. Cucumbers we recollected from the greenhouse in Pakdasht. At the previous stage, Grapefruit mesocarp has notable potential as a source of natural bioactive flavonoids, so it was consumed to produce Ag ions. Then, agents assuming the flavonoids attributes such as pH, temperature, and plant extract volume were tested. The data were analyzed by the UV-VIS. The characters of the nanoparticles were calculated-using TEM, X-ray electron microscopy methods to define the size and specific surface area of the particles. Total flavonoid contents were 45.06 mg/g of grapefruit's peel. Our evidence showed that the aqueous *Citrus paradisi* peel extract could be synthesized Ag^{2+} nanoparticles in 60˚C, pH=7, and 20:80 volume (8). In order to pack *Cucumis sativus*, a plastic bag containing silver nanoparticles was produced. Due to the gelatin adhesion properties, the nanoparticles were completed with gelatin. First, 5g gelatin was added to 100 ml distilled water and allow to cool for one hour at high temperature, then add 3 ml of the grapefruit extract, which is in the previous step in the procedure. The extraction as a reducing factor as well as a stabilizer was combined to the solution and placed on a shaker at 100˚C for 20 minutes; then, set a pH to 8. Subsequently, different concentrations of silver nitrate solution (10, 20, 30, 40, 50, 60 mg/L) and control treatment (gelatin), were added in 5 hours, it was placed on a shaker until the color changed to reddish-brown and then equilibrated on a plastic surface of polyethylene at (25-22˚C) for two days. It was kept until it was completely dried. Then the cucumbers were placed in the plastic bags prepared in the previous stage and were stored in a 12˚C at cabinet for 7 days. After that, they were transferred to (26˚C), for 15 days. Treatments were as following: Treatment was plastics bags containing nanosilver (10, 20, 30, 40, 50, and 60 ppm). Carbohydrate concentration was measured according to (9). Total soluble solids concentration (SSC) of the juice's extracts was determined by refractor meter. Fruit vitamin C was measured by titration with Potassium Iodide and was calculated with the formula of Shafiee et al. (10). Cu, Fe, Zn, Mg, Mn, and K were determined by Atomic absorption spectrometers (Varian- SpectrAA.200). This research was conducted as a completely randomized design with three replicates. Duncan test was used for mean comparison at 1%. All statistical analyses were calculated using Minitab 16 Statistical software and the graphs were drawn in Microsoft Office Excel 2013.

3. Results and discussion

According to the results of the analysis of variance (Table 1), the effect of treatment on elements was significant at 1% level. The results showed that the highest amount of Zn (0.19 mg/100 g fresh weight) was related to treatment with silver nanoparticles at 60 ppm. The lowest amount of Zn (0.13 mg/100g fresh weight) was reported on the control group. 60 ppm silver nanoparticles were the ones with the highest Fe content (0.23 mg/100 g fresh weight), while the control treatment had the lowest values (0.14 mg/100 g fresh weight) (Fig. 1(a, b)).

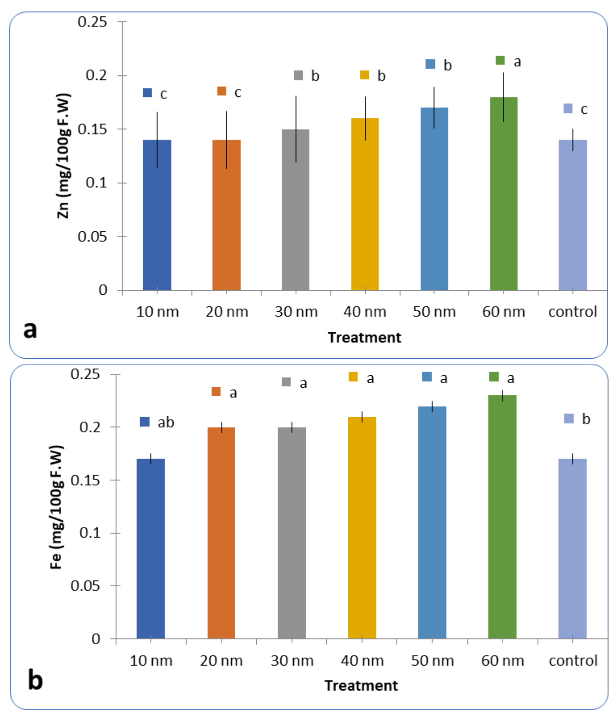

Fig. 1(a, b). Changes in Zn, Fe trace supplemented with different silver nanoparticle; [error bars indicate standard deviation].

Table 1. Analyze variance of trace.

SOV	DF	Zn	Fe	K	Mg	Cu	Mn	Vitamin C	TSS
Rep	2	0.09	0.09	0.7	0.9	0.31	0.01	0.01	0.07
Treatment	6	0.75*	12.28*	13.20*	12.27*	24.60*	11.14*	13.02**	15.01*
CV	-	9.1	9.11	10	11.1	16.1	11.4	10.2	10.4

The interactions were significant for K. 60 ppm silver nanoparticles reached the highest K (260 mg/100 g fresh weight). Control treatment had the lowest K than others (200 mg/100 g fresh weight). The highest rate of Mg was observed in the treatment of silver nanoparticles with a concentration of 60 ppm on (16 mg/100 g fresh weight) and the lowest rate is about to the control (13 mg/100 g fresh weight) (Fig. 2(c, d)).

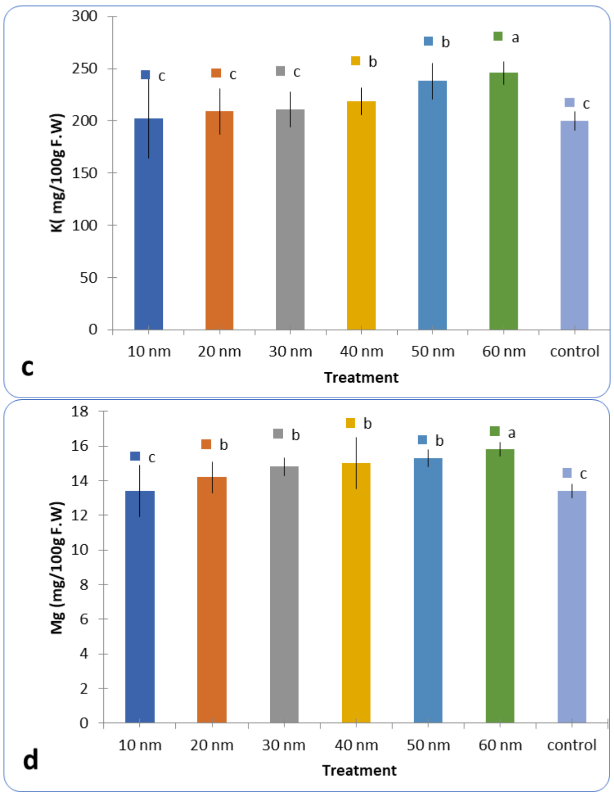

Fig.2 (c, d). Changes in K, Mg trace supplemented with different silver nanoparticle; [error bars indicate standard deviation].

The lowest Cu is associated with the control sample of storage and the highest rate is the application of 60 ppm silver nanoparticles (0.055 mg/100 g fresh weight). In addition, the amount of Mn in 60 ppm nanosilver treatment is higher than other treatments (0.6 mg/100g fresh weight) (Fig. 3(e, f)). A comparison of the mean Vitamin C showed that the highest (9.5 %) was seen in the control treatment and the lowest TSS (8.85 %) was at 10-ppm silver nanoparticles. Fruits treated with 60 ppm nanosilver have higher TSS (4.26%) than plants in the other treatments (Fig. 4(g, h)). Results show the effect of treatment on the penetration of silver (Table 2). Silver penetration into the pericarp appeared in all treatment. It showed that the highest amount of silver (1.99±0.002 ppb) was related to the treatment of 60 ppm silver nanoparticles in cucumber pericarp and the lowest amount of silver in all parts belonged to the control group (0 ppb).

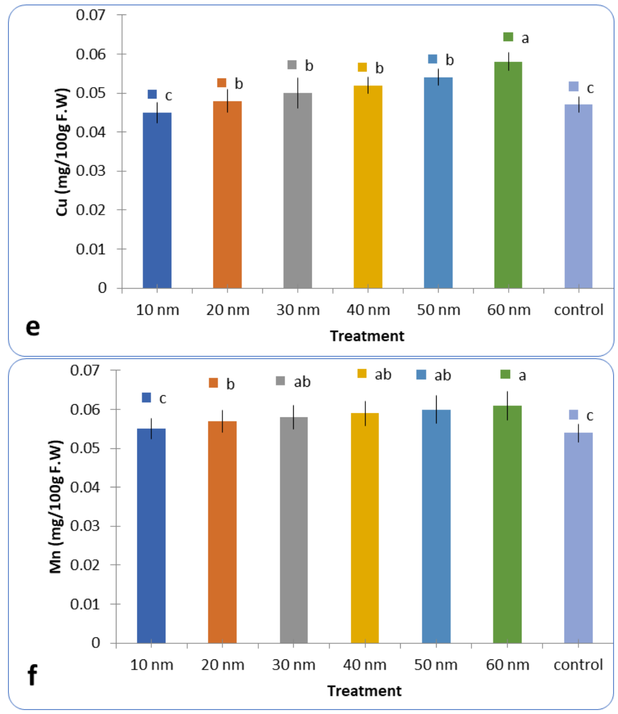

Fig. 3(c, d). Changes in Cu, Mn trace supplemented with different silver nanoparticle; [error bars indicate standard deviation].

Table 2. Nano silver penetration in cucumber tissue.

Silver nanoparticle (nm)	Exocarp	Mesocarp	Endocarp
10	0.68 ± 0.0012^{d}	0^{f}	0^{f}
20	0.78 ± 0.004^{c}	0^{f}	0^{f}
30	0.89 ± 0.002^{b}	0^{f}	0^{f}
40	1.83 ± 0.062^{ab}	0.22 ± 0.004^{e}	0^{f}
50	1.97 ± 0.032^{a}	0.23 ± 0.007^{e}	0^{f}
60	1.99 ± 0.002^{a}	0.25 ± 0.006^{e}	0.30 ± 0.006^{e}
Control	0^{f}	0^{f}	0^{f}

Silver ion penetration was revealed in the nanoparticle treatment of 40, 50 and 60 ppm in mesocarp, and only in 60 ppm at endocarp. Cucumbers shelf life is relatively long, lasting 21 days whereas control was 13 days. The results of this study relieved that plastic bags with different concentrations of silver nanoparticles had a positive impact on all evaluated nutritional values. By enhancing concentration of nanosilvers, a better result was achieved. According to with above results, enhancement life shelf might be due to maintaining more moisture and reducing the oxygen entry and carbon dioxide removal in these packages.

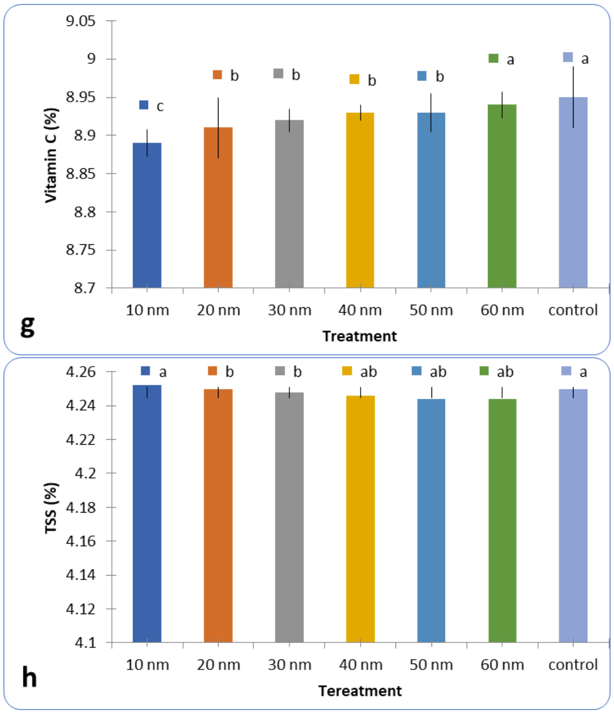

Fig. 4(g, h). Changes in Vitamin C, TSS (%) supplemented with different silver nanoparticle; [error bars indicate standard deviation].

The reduction in the content of soluble solids is likely due to the breakdown of carbohydrates, the hydrolysis of proteins, and the decomposition of carbohydrates into smaller units during the respiration process; which showed a strong increase in soluble solids in the control group. Any factor breaking the walls prevents or reduces cellular activity and abnormal solubility of solids (11). In the case of packaging in silver nanoparticles bags, our results were similar to the following, which was conducted to evaluate the effect of silver nanoparticles on postharvest, vitamin C, and electrolyte leakage of *Citrus sinensis* vc. *Valencia* (12). Mousavi et al. (13) kept the *Phoenix dactylifera* cv. *Mazafati* in coatings containing silver nanoparticles, and found that it could significantly increase storage period. Silver nanoparticles on the shelf life of Valencia oranges were tested by (14). It showed that different concentrations of silver nanoparticles had a positive effect on maintaining fruit freshness and vitamin C content, also when the concentration of silver nanoparticles enhanced, vitamin C would be changed. Nanosilver is among the most applied nanoparticles, contain to their established antimicrobial activity against numerous pathogenic agents (15). Furthermore, bacterial types, nanosilver are recognized to be inhibitory against many fungi and several (16). Fayaz et al. (17) stated an edible antibacterial film of alginate and silver nanoparticles over sterilized vegetables and fruits. An et al. (18) showed that the coating of fresh asparagus spears with nanocomposite silver films increased its shelf life by 25 days at storage. Li et al. (19) reported that When the Chinese jujube fruit was kept in bags produced by silver nanoparticle, lesser-ruined level along with delayed ripening over 12 days. Orange juice kept at 4°C (TiO_2 and 10 nm silver nanoparticle, mixture) illustrated a notable reduction in *Lactobacillus plantarum* growth during storage period of 112 days (20). In fact, the major relation between nanotechnology and the food industry are increasing food security, enhancing shelf life, boosting flavor and nutrient value, choosing pathogen/toxin/pesticide detection, and serving basic foods. Bioactives, such as vitamins, iron (21, 22), calcium (23), curcumin (24), etc., have been widely tested in nano-delivery systems. There are different techniques such as nanocomposite, nano-emulsification, and nano-structuration which have been used to encapsulate the materials in tiny shape to more beneficially transfer nutrients like protein, elements, and antioxidants for precisely targeted nutritional and healthy profits. Polymeric nanoparticles are found to be suitable for bioactive compounds (e.g., flavonoids and vitamins) to protect and transport bioactive compounds to target functions (25).

4. Conclusion

In conclusion, results showed that grapefruit's peel could be increased successfully on low concentration of nutritional value because elements compounds enhanced under condition coating bags. Also, a tiny amount of this nanoparticle penetration into the pericarp appeared in all treatment.

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