Effect of gamma irradiation and coating with jojoba oil on quality of strawberry fruits

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Abstract: The aim of the present study was effects of gamma radiation and Jojoba oil coating on treatment of sound and decay strawberry fruits. Also, the same effects were studied on quality parameters of strawberry fruits, such as total soluble solids, firmness and ascorbic acid of strawberry fruits during cold storage. Strawberry fruits are exposed to a gamma source at different doses ranging from 1.0 to 2.5 kGy, and coating by different concentration of Jojoba oil from 1.0% to 4%. The obtained results were summarized as following: Different concentrations of Jojoba oil (1%, 2% and 4%) were used to control decay of strawberry fruits caused by *Botrytis cinerea*, at 13°C at different storage periods. Jojoba oil coating (4%) significantly reduced the decay of strawberry fruits and cause increasing fruit firmness and TSS decreases by increasing storage time. While vitamin C gives fluctuating results. For gamma irradiation at 2.5 kGy, severity percentage of infected fruits was reduced from 57.5%, 100% and 100% to 30.2%, 42.3% and 48.0%, respectively and in healthy fruits severity percentage was reduced from 45.2%, 100% and 100% to 21.5%, 24.7% and 27.8% in different storage periods 1, 2 and 3 weeks, respectively.For combination of gamma irradiation (2.5 kGy) and Jojoba oil (4%) were more effective in reducing severity percentage of strawberry fruits, since severity percentage reduced in infected fruits from 57.5%, 100% and 100% to 7.8%, 20.1% and 25.0%. Healthy fruits severity percentage were reduced from 44.4%, 100% and 100% to 3.5%, 9.1% and 19.9% in different storage periods, respectively.
Keywords: gamma irradiation, jojoba oil, strawberry fruits, quality

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1 Introduction

Strawberries (*Fragaria x ananassa Duch.*) are a highly perishable fruit with a short postharvest life mainly due to fungal decay. The shelf-life of fresh Strawberry fruits at low temperatures (0°C-4°C) is usually around 5 days.

Postharvest decay represents major losses in horticultural industry. During storage and shipment of strawberries decay losses caused by Botrytis cinerea called gray mould and soft rot caused by Rhizopus stolonifer (Braun and Sutton, 1987).

Application of fungicides is the most effective method to control postharvest disease. However, chemical control programs face imminent problems first

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there are reports of an increasing number of fungicide-resistant strains of postharvest pathogens and second due to health risk concerns. Thus, there is a growing need for one approach that is being actively pursued that involves the use of bioactive substances (Tarek, 2004).

Barzegar et al. (2004) Coating of fruit can bring about the lowering of respiration activity, delay in ripening and softening and reduced incidence of physiological disorders and decay-causing pathogens (Romero et al., 2005; Ziedan and Farrag, 2008).

Coating technique was used in Crimson Table grapes cluster by Romero et al. (2005), in mango fruit by Tripathi and Shula (2009), in citrus crops by Fatemi et al. (2011). Exposing pomegranate arils to radiation doses increase toxic of the pathogens and reduced cellular oxidative stress damage **Rubir**a et al. (2005).

Gamma irradiation at present is used as a method of food preservation. Gamma irradiation effectively delays the ripening, prevents sprouting and reduced microbial count leads to extending shelf-life.

Combinatory treatments have also widely been investigated as they often result in synergistic effects. Gamma irradiation in combination with other treatments (e.g., heat, washing, modified atmosphere storage and edible coating process) gives an effective result in extending shelf-life of the fruits (Hussain et al., 2008).

The objectives of this study are: evaluate the effects of gamma irradiation and coating with Jojoba oil on sound and decay strawberry fruits. Also, study effect of cold storage on total soluble solids (TSS), firmness and ascorbic acid of strawberry fruits.

2 Materials and methods

The present study was investigated to study the effects of quality parameters of different doses of gamma radiations and coating with Jojoba oil on TSS, firmness and ascorbic acid of strawberry fruits. The experiments were carried out during season 2020 at the Laboratory of Food Irradiation Department, National Center for Radiation Research and Technology, Atomic Energy Authority, Egypt.

2.1 Collection of strawberry fruits

The mature fruit materials of strawberry fruits (“Festival” Variety) were collected from farm of El-Sharkia governorate, Egypt. After collection, fruits were classified into two group's healthy and decayed fruits. Decayed fruits were examined after 3 day of storage at 13°C the developing fungal colonies were picked up and examined.

2.2 Isolation, purification and identification of causal organisms

Rotted fruits of strawberry were rinsed several times with sterilized water, surface disinfected with 70% ethanol, and cut into small pieces. These parts were cultivated in sterilized Petri dishes containing potato dextrose agar (PDA) and incubated at 20°C for 3 days. The growing fungi were isolated and purified on PDA and identified. The purified cultures were maintained on PDA and identified according to Raper and Thom (1968) in Mycological lab.2 (ML2) Faculty of science, Zagazig University. The media used for identification was Czapek’s – Dox agar medium.

2.3 Preparation of inoculums

Botrytis cinerea was isolated from infected Strawberries and maintained on PDA.

Condia of *B. cinerea* were recovered by filtering the mycelial suspension of 2 weeks old culture through 3 layers of sterile cheese cloth. The concentration of the conidial suspension was adjusted to 2×10^5 conidia per mL.

Strawberries were immersed in a conidial suspension of *B. cinerea* containing 0 .1% of Tween 80 (1% of Polysorbate 80) and allowed to air dry at room temperature for 2 hrs., in order to fix fungal infection.

After treating healthy and infected Strawberries with chitosan or with gamma irradiation Strawberry fruits were examined for disease assessment (severity,%) through different storage periods (weeks) under 13°C.

2.4 Fruits irradiation

Strawberry fruits were exposed to different gamma irradiation doses 1.0, 1.5 and 2.5 KGy in Indian Co^{60} gamma cell at the dose rate was 0.9 kGy/hr., at the time of experiment. Each treatment was replicated three times, each replicate contains 15 fruits. Treated and

control fruits were packed in perforated plastic containers and then stored the Strawberry fruits were examined for disease infection assessment at different storage periods.

Strawberry fruits were used and the initial quality measurements of different treatments were done as follow:-

1- Control (Strawberry fruits without any treatments)

2- Strawberry fruits were irradiated with 1.0 kGy.

3- Strawberry fruits were irradiated with 1.5 kGy.

4- Strawberry fruits were irradiated with 2.5 kGy.

5- Strawberry fruits were coated by 1% of Jojoba oil.

6- Strawberry fruits were coated by 2% of Jojoba oil.

7- Strawberry fruits were coated by 4% of Jojoba oil.

8- Strawberry fruits were irradiated with 2.5 kGy and coated by 4% of Jojoba oil.

2.5 Quality parameters

1- **TSS:** TSS content expressed in ^{0}(Brix) was determined using a refractmeter according to Kader (1991).

2- **Firmness:** Firmness (Firm) was measured as the maximum penetration force reached during Tissue breaking of each fruit with hand penetrometer equipped with 1-9 mm diameter plunger (g Cm^{-2}) according to Kader (1991).

3- **Ascorbic acid (Vitamin C):** Ascorbic acid content was determined by titration in the presence of 2.6 dichlorophenol- indophenol dye as an indicator against 2% oxalic acid solution as substrate. Ascorbic acid was calculated as milligram L - ascorbic acid per 100 mL of juice as described by Lucoss (1994).

2.6 Experimental design and statistical analysis

All treatments in this study were arranged in complete randomized design. The obtained data were subjected to analysis of variance using the general linear module procedure of SAS (1985), where appropriate treatment means were separated using Duncan's multiple range test (Duncan, 1955) and all percentages were transferred to angles before statistical analysis.

3 Results and discussions

3.1 Effect of Jojoba oil on gray mold of strawberry fruits during cold storage

Figure 1 illustrate that effect of different Jojoba oil concentrations (0%, 1%, 2% and 4%) coating strawberry fruits on severity percentage of infection for gray mold during different storage periods (1, 2 and 3 weeks), which stored at 13°C.

Regarding to the data in Figure 1 show that the relationship between Jojoba oil percentages on severity percentages at different storage times, it was shown that, treated strawberry samples with Jojoba oil were significantly decreased the severity percentages (58.5% – 8.3%), (90.1% – 30.1%) and (100% – 39.1%) of infected strawberry samples by increasing storage time (1, 2, and 3 weeks) respectively at increased Jojoba oil percentage from 0.0% to 4%. Also, the severity percentages of healthy strawberry samples were decreased of (44.4% – 3.1%), (78.1% – 14.8%), and (100% – 19.8%) for increasing storage time (1, 2, and 3 weeks) respectively, at increased Jojoba oil coating at different concentrations (from 0% to 4%).

The obtained data show that as Jojoba oil percentage was increased, the severity percentage decreased, the lowest severity percentage was obtained at 4% of Jojoba oil, also as the storage period increase, the severity percentage was increased.

3.2 Effect of different gamma irradiation doses on severity% of strawberry fruits at different storage periods (weeks)

Figure 2 show that effect of different gamma irradiation doses (0, 1, 1.5 and 2.5 kGy) on severity percentage of strawberry fruits at 13°C for different periods (1, 2, and 3 weeks).

According to the data in Figure 2 show that the relationship between Jojoba oil percentages on severity percentages at different storage times, it was showed that, treated strawberry samples with gamma radiation were significantly decreased the severity percentages (57.5% – 30.2%), (100% – 42.3%) and (100% – 48%) of infected strawberry samples by increasing storage time (1, 2, and 3 weeks) respectively at increased gamma radiation doses from 0.0 to 2.5 kGy. Also, the severity percentages of healthy strawberry samples were decreased of (45.2% – 21.5%), (100% – 24.7%),

and (100% – 27.8%) for increasing storage time (1, 2, and 3 weeks) respectively, at increased gamma radiation doses (from 0.0 to 2.5 kGy)

The obtained data show that as storage period increase, the severity percentage increased and a different dose of gamma ray decreased the severity percentage and at 2.5 kGy is the effective dose decrease severity percentage in different storage periods.

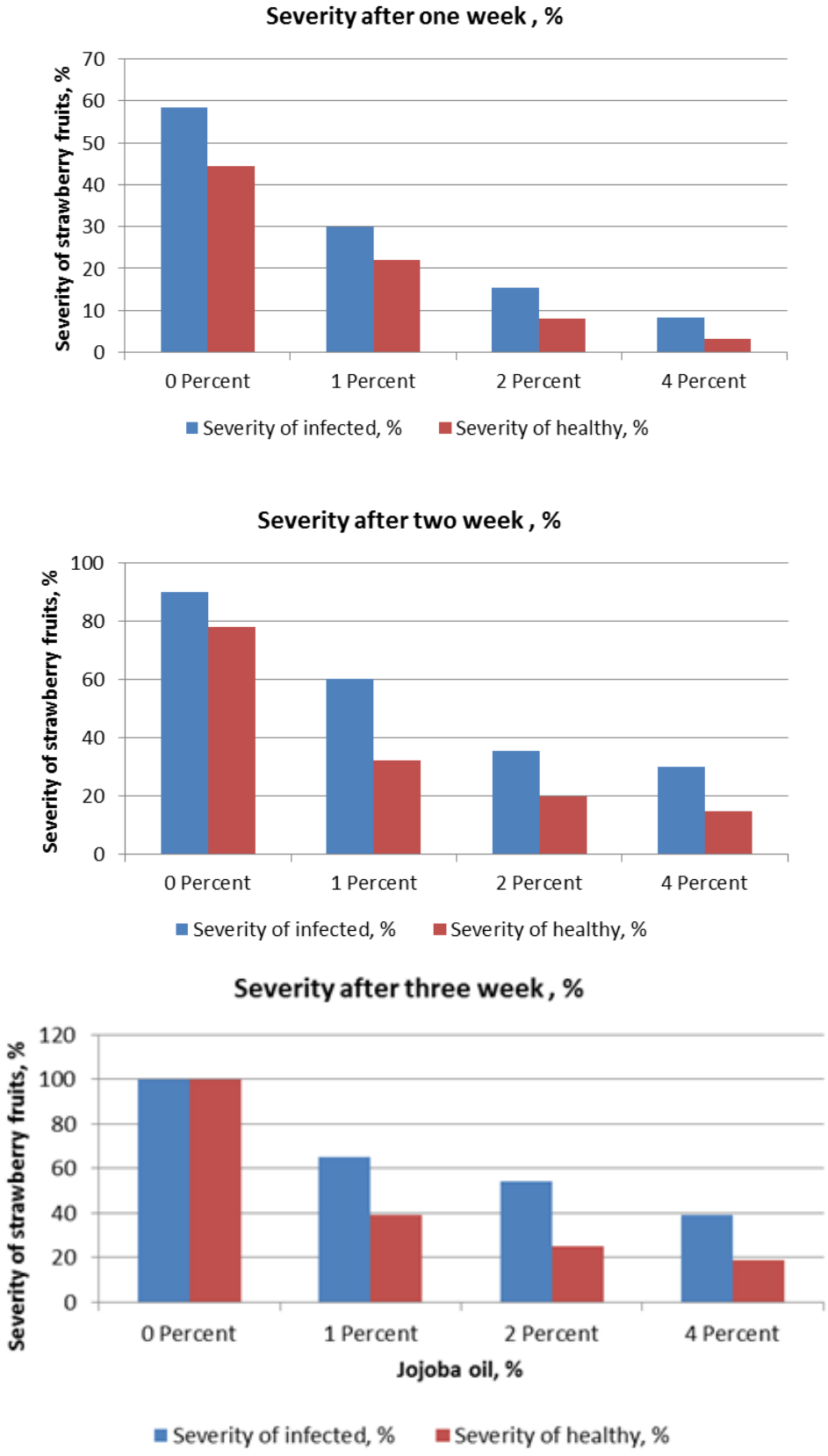


Figure 1 Effect of Jojoba oil on gray mold of strawberry fruits for different storage periods at 13 ℃.

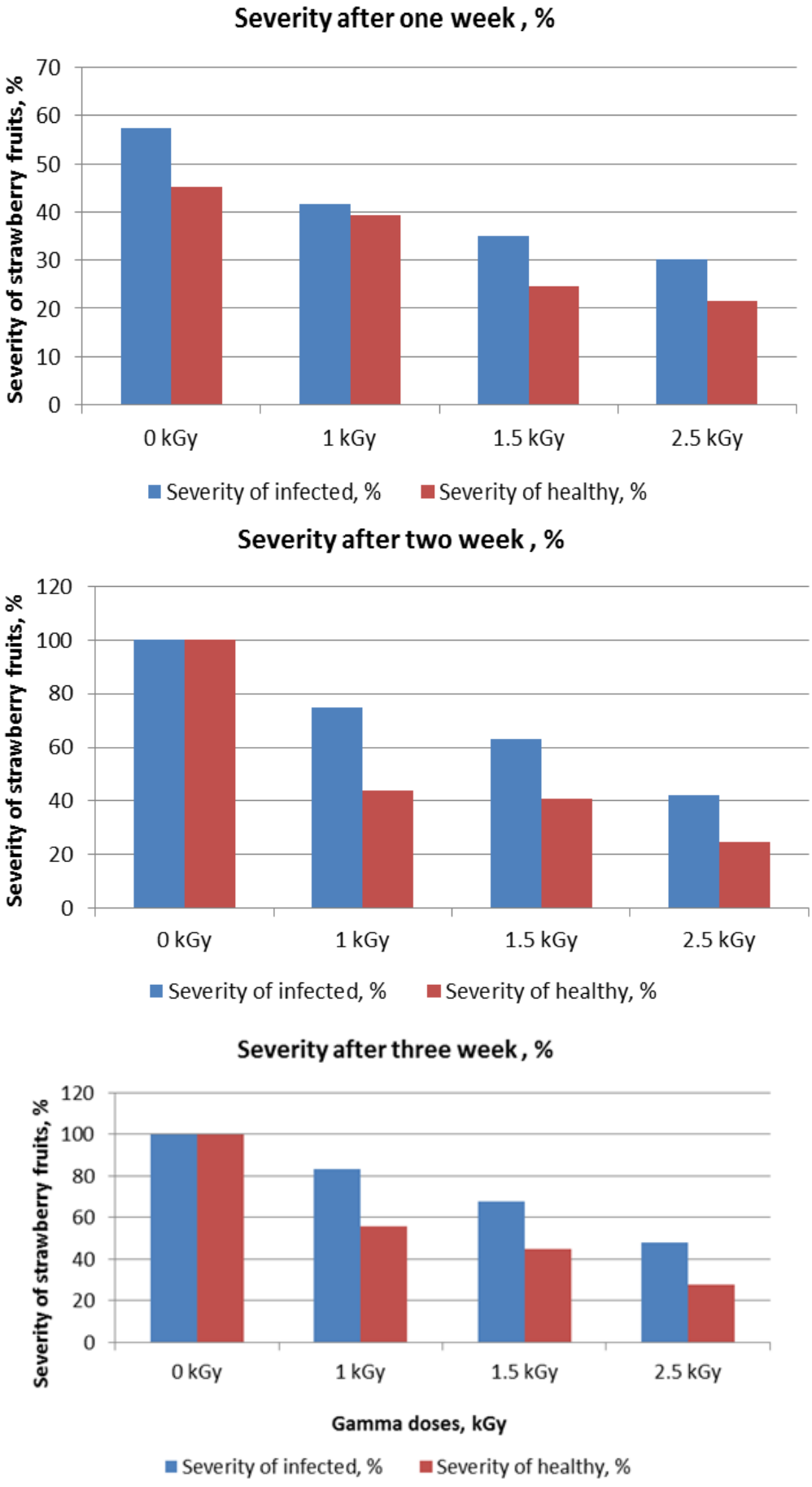


Figure 2 Effect of gamma doses on gray mold of strawberry fruits for different storage periods at 13 ℃

3.3 Effect of Jojoba oil and storage time on strawberries quality

Figures 3, 4 and 5 show that interaction between storage time and Jojoba oil treatments on quality parameters of strawberry fruits. Data in Figure 3 show that the relationship between Jojoba oil percentages on TSS at different storage times, it was indicated that, treated strawberry samples with Jojoba oil were significantly decreased the values of TSS (9.1- 6.1), (6.2-6.1) and (6.0 – 4.1 Brix) of infected strawberry samples by increasing storage time (1, 2, and 3 weeks) respectively. Also, the TSS values of healthy strawberry were decreased (from 7.8 to 4.9 Brix), (from 5.8 to 5.3 Brix), and (from 6.1 to 5.2 Brix) for storage time of 1, 2, and 3 weeks, respectively. By using Jojoba oil coating at different concentrations (0%, 1%, 2% and 4%),

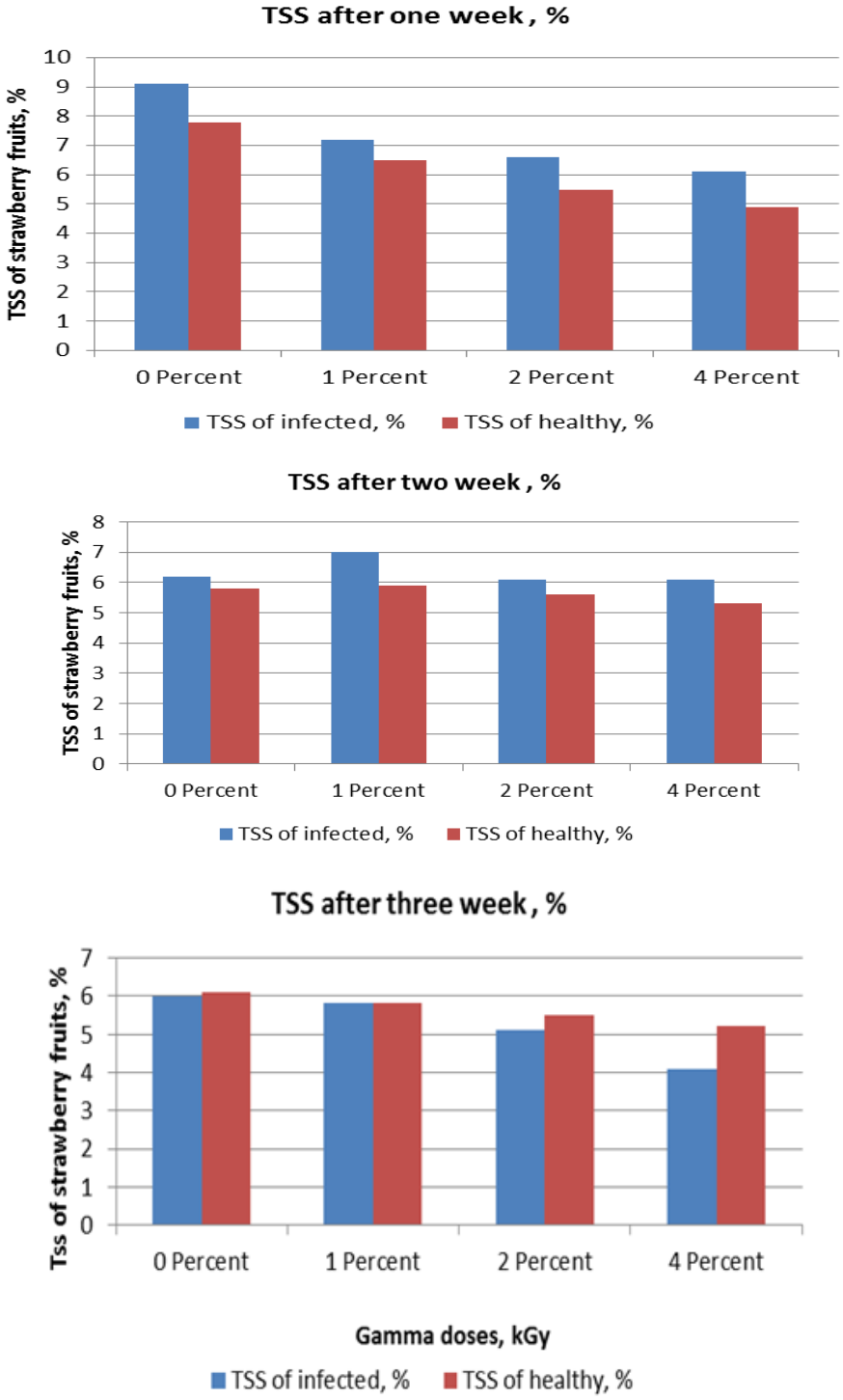
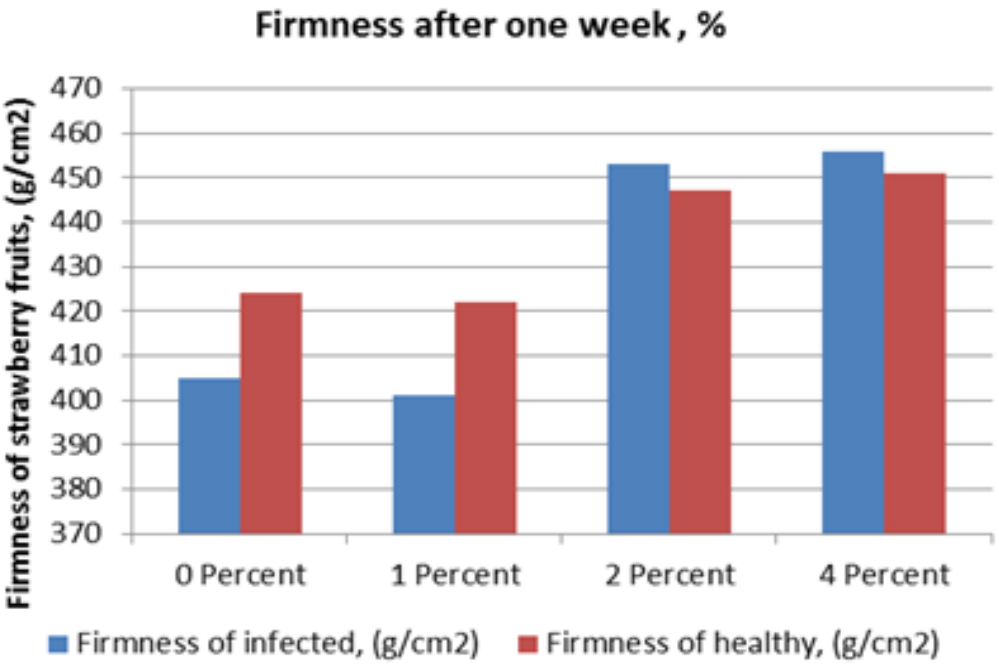


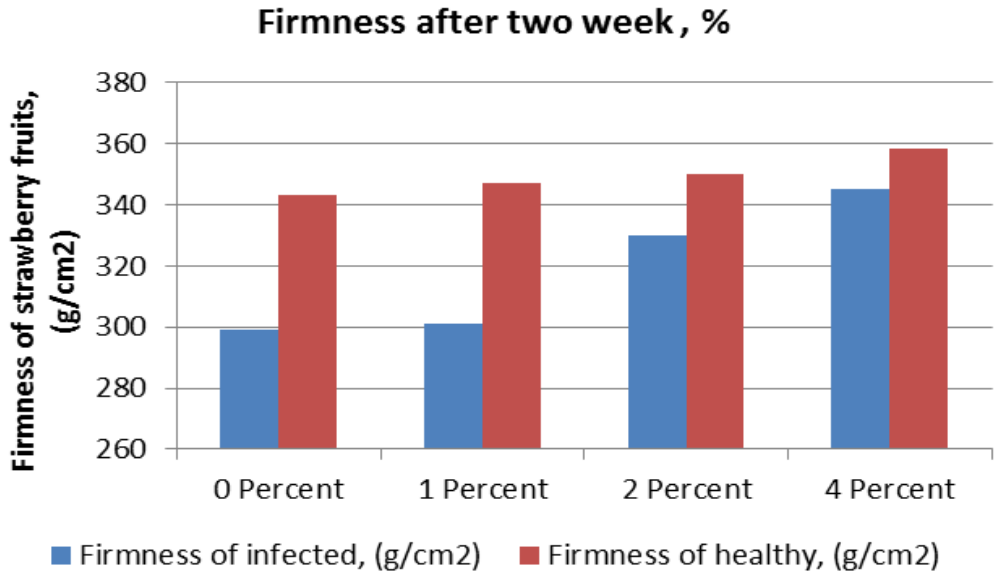
Figure 3 Effect of jojoba oil percentage on TSS of strawberry fruits for different storage periods at 13 ℃

Meanwhile, regarding to data in Figure 4 show that the relationship between Jojoba oil percentages on firmness at different storage times, an opposite effect was obtained in firmness which increased of (405 – 456), (299 – 345), and (199 – 220 g cm^{-2}) for infected strawberry samples by increasing storage time (1, 2, 3 weeks) respectively. Also, firmness values which increased of (424 – 451), (343 – 358), and (224 – 245 g cm^{-2}) for healthy strawberry samples by increasing storage time (1%, 2%, and 3% weeks) respectively. By using Jojoba oil coating at different concentrations (0%, 1%, 2% and 4%), since at 4% Jojoba oil give the highest values of firmness at different storage periods.

According to data in Figure 5 show that the relationship between Jojoba oil percentages on vitamin C at different storage times, it was indicated that, treated infected strawberries with Jojoba oil slightly decreased the values of vitamin C (0.032% – 0.016%), (0.025% - 0.021%) and (0.029% – 0.030%) for storage times of 1, 2, and 3 weeks, respectively. Also, the TSS values of healthy strawberry samples were decreased of (0.022% – 0.019%), (0.019% – 0.019%), and (0.028% – 0.032%) for storage times of 1, 2, and 3 weeks, respectively. By using Jojoba oil coating at different concentrations (0%, 1%, 2% and 4%).

Regarding vitamin C, the obtained data show that vitamin C would not be detected in clear level of amounts.





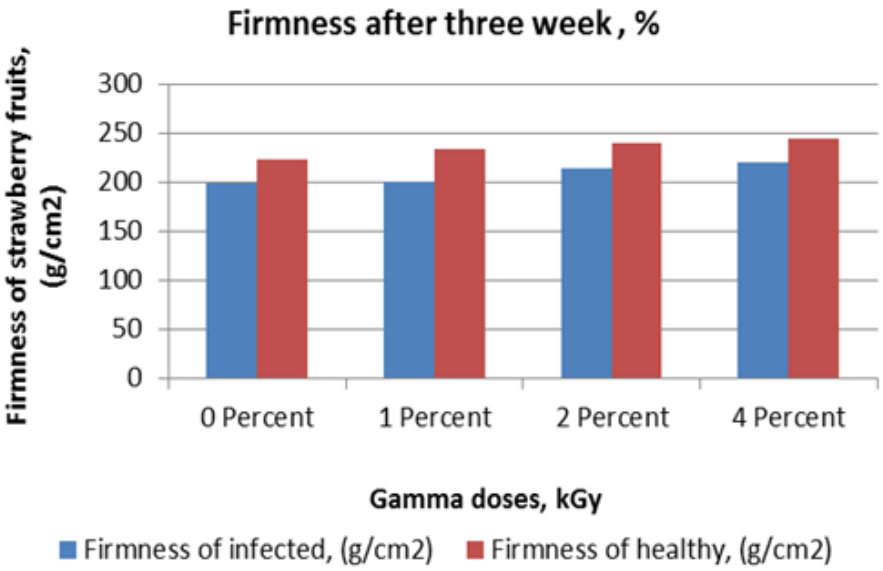
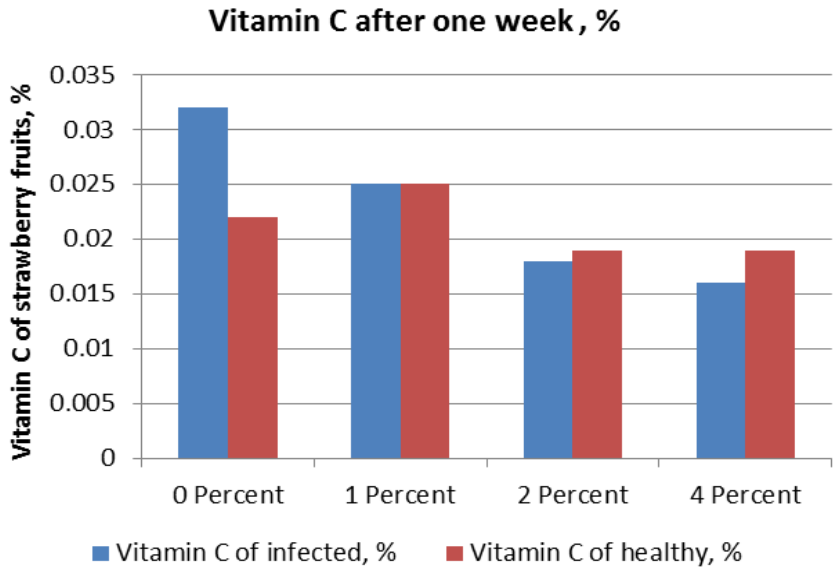
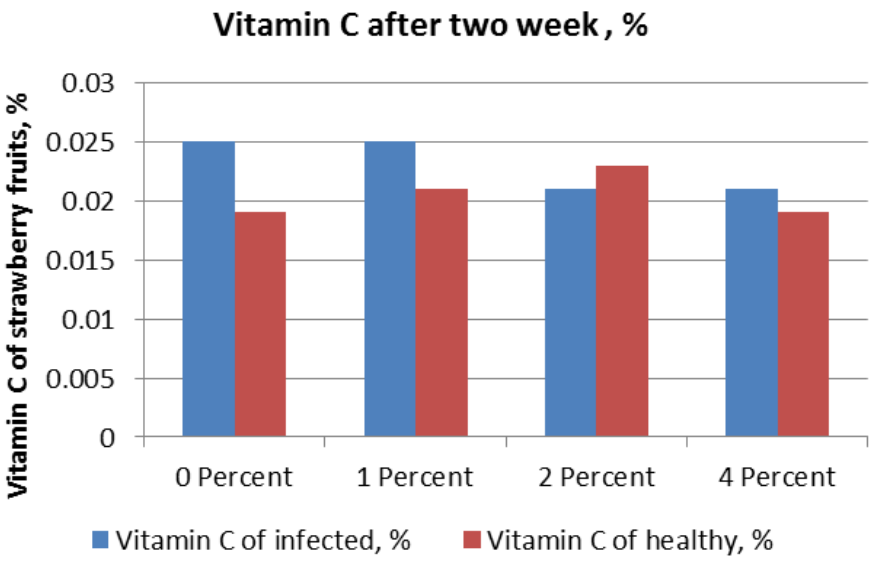


Figure 4 Effect of jojoba oil percentage on Firmness of strawberry fruits for different storage periods at 13 ℃





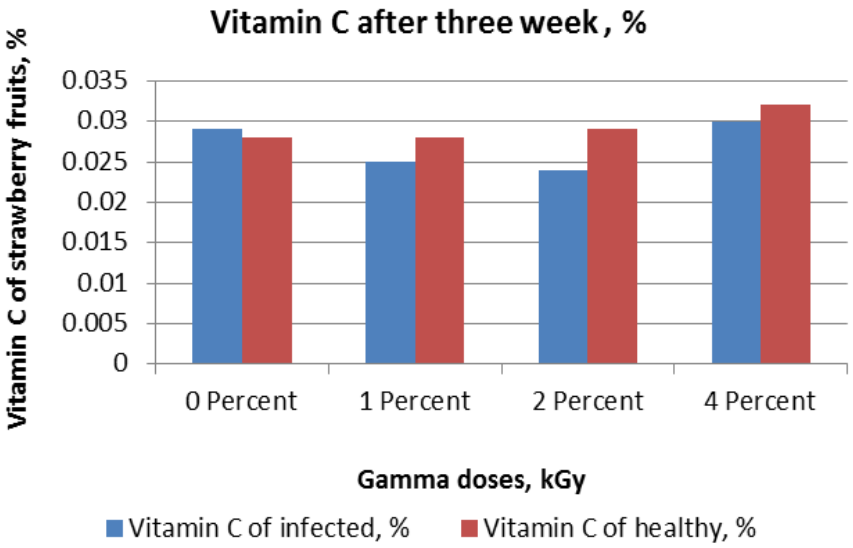
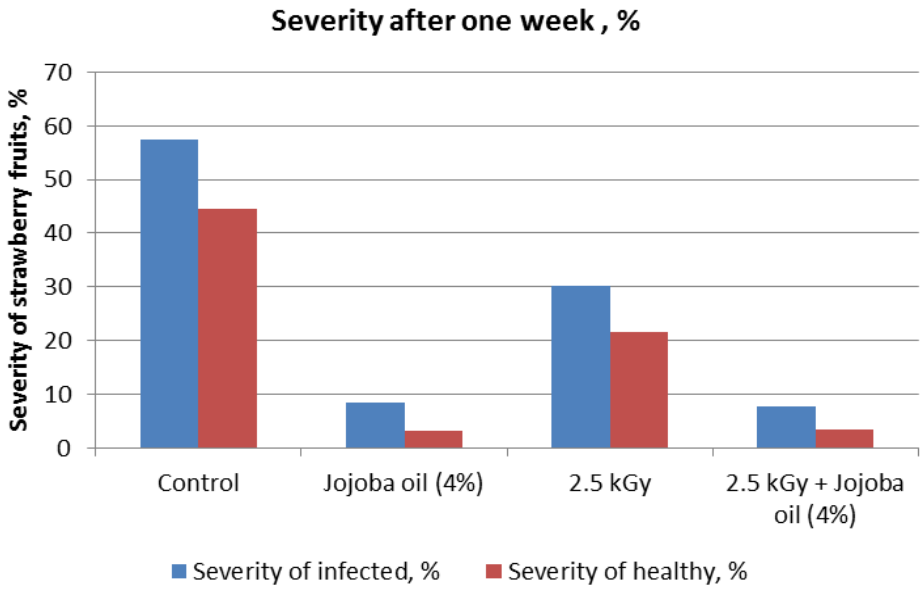
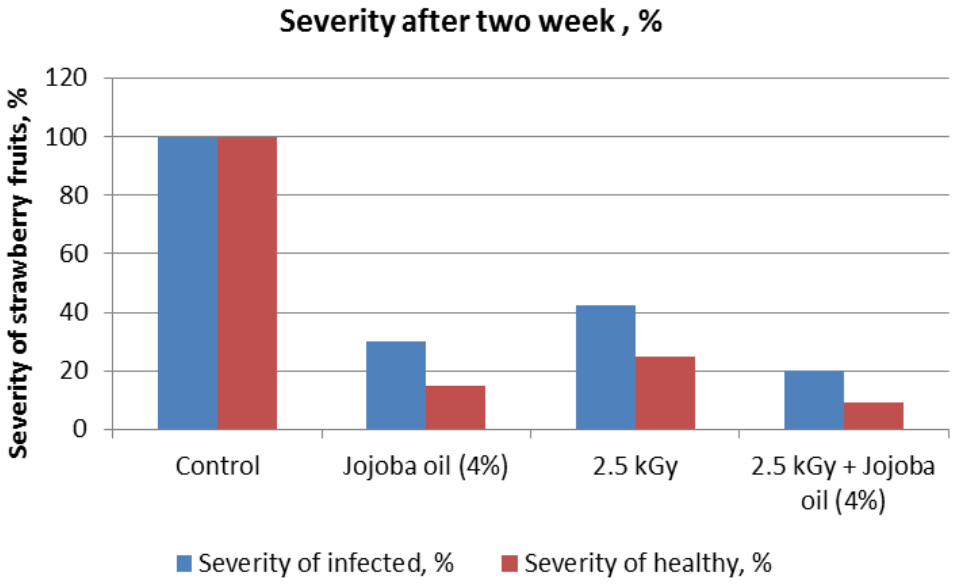


Figure 5 Effect of jojoba oil percentage on Vitamin C of strawberry fruits for different storage periods at 13 ℃





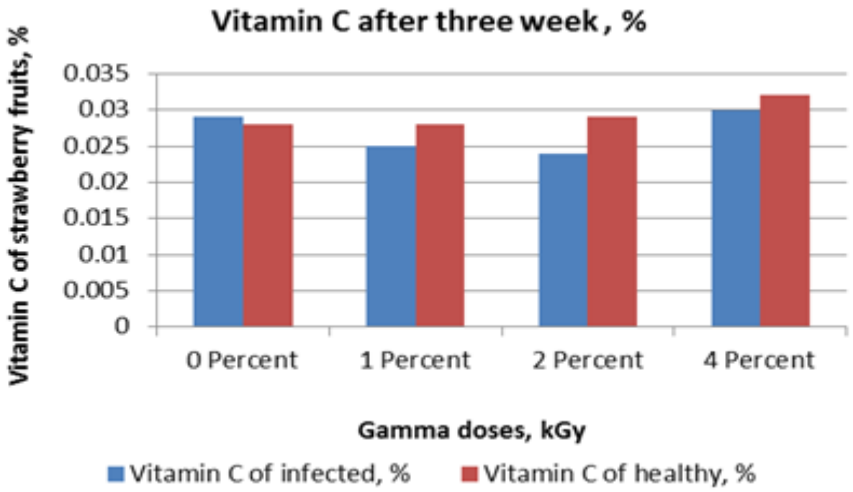


Figure 6 Effect of combine gamma doses and Jojoba oil on gray mold of strawberry fruits for different storage periods at 13 ℃

3.4 Effect of combination gamma irradiation and Jojoba oil on gray mold of strawberry fruits (during storage periods at 13°C)

Data illustrated in Figure 6 show that relationship between combination of Jojoba oil percentages and gamma radiation doses at different storage times. it was noticed that the effect of gamma ray (2.5 kGy) and jojoba oil (4%) on severity percentage of gray mold of strawberry fruits, the obtained results showed that the combination between gamma ray (2.5 kGy) and Jojoba oil (4%) were more effective to reduce severity percentage (7.8%, 20.1% and 25%) and (3.5%, 9.1%, and 19.9 %) for infected and healthy strawberry samples.

4 Discussion

Several studies have been performed to extend strawberry fruits shelf-life, using alternative methods rather than chemicals to avoid residues such as fungicide residues for the fruit itself (Peng and Sutton, 1991) and moreover to avoid pathogen populations from developing resistance to pesticides (Bakkali et al., 2008).

Our results indicated that treating strawberries with jojoba oil significantly decreased the value of TSS by increasing storage time (weeks) while an opposite effect was obtained in firmness which increased by jojoba oil coating but vitamin C would not be detected in clear level of amounts. These results are in agreement with (Luna et al., 2011).

Gamma irradiation doses reduced the severity percentage of strawberry fruits in our obtained results and 2.5 kGy doses was the most effective doses decreased the severity percentage these obtained results are in agreement with Shadi and Ehab (2011) confirmed that gamma radiation decreased the percentage of infection of strawberry fruits artificially inoculated with *B. cinerea* and naturally infected at 2.5 KGy compared with control.

Regarding the combination of Jojoba oil and gamma radiation, our results show that the combination of Jojoba oil and gamma radiation was more effective in reducing severity percentage as compared to when using every method alone.

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References

Bakkali, F., S. Averbeck, D. Averbeck, and M. Idaomar. 2008. Biological effects of essential oils-A review. *Food and Chemical Toxicology*, 46(2): 446-475.

Barzegar, M., A. Fadavi, and M. H. Aziz. 2004. An investigation on the physic-chemical composition of various pomegranates (Punica granalum L.) grown in Yazd. *Iranian Journal of Food Science and Technology*, 1(2): 9-14.

Braun, P. G., and J. C. Sutton1987. Inoculum sources of *Botrytis cinerea* in Fruit rot strawberries in Ontario. *Canadian Journal of Plant Pathology*, 9(1): 1-5.

Duncan, D. B. 1955. Multiple range and multiple F. tests. *Biometrics*, 11: 1-42.

Fatemi, S., M. Jafarpour, S. Eghbolasaied, A. Rezapoin, and H. Borji. 2011. Effect of essential oils of Thymus vulgaris and Mentha piperita on the control of green mould and postharvest quality of Citrus Sinensis cv. Valencia. *African Journal of Biotechnology*, 10(66): 14932.

Hussain, P. R., R. S Meena, M. A. Dar, M. A. Mir, F. Shafi, and A. M. Wani. 2008. Effect of gamma irradiation and refrigerated storage on mold growth and keeping quality of strawberry (*Fragaria* sp. Cv. Confitura). *Journal of Food Science and Technology*, 44(5): 513-516.

Kader, A. A. 1991. Quality and its maintenance in relation to the postharvest physiology of strawberry. In *The Strawberry into the 21st. Century: Proc, Third North Amer. Strawberry Conf*, 145-152. Portland, Accessed 14-16 February, 1990.

Lucoss, E. H. 1994. Determination ascorbic acid in large numbers of plant samples. Ind. Eng. Chem. Anal., 15: 649-652.

Luna, D., L. M. Bustamanta, G. Gonzalez, S. J. Dominguez, B. S. Bautista, K. Shirai, and M. E. Bosquez. 2001. Treatments on the quality of papaya fruit during storage. In *Proceeding of The Eighth International Congress on Engineering Food*, Lancaster: Technomic Publishing Co. Inc. 1042-1046.

Peng, G., and J. C. Sutton. 1991. Evaluation of microorganism for bio-control of *Botrytis cinerea* in strawberry. *Canadian Journal of Plant Pathology*, 13(3): 247-257.

Raper, K. B., and C. Thom 1968. *A Manual The Penicillia*. New York and London: Hafner Publishing Company.

Romero, D. M., S. Castillo, J. M. Valverds, M. Serrano, F. Cullen, and D. Valero. 2005. The use of natural aromatic essential oils helps to maintain postharvest quality of "Crimson" table gropes. *International Society for Horticultural Science*, 682: 1723-1730.

Rubira, V. L. A. Conesa, A. Allende, and F. Artes. 2005. Shelf life and overall quality of minimally processed pomegranate arils modified atmosphere packaged and treated with UV-C. *Postharvest Biology and Technology*, 37(2): 174-185.

Shadi, A. A., and A. S. Ehab 2011. Effect of some antioxidants, caraway oil (*Carium carvum* L.) and gamma radiation on gray mold of strawberry fruits during storage. *Journal of Radiation Research and Applied Sciences*, 4(B): 1415-1428.

Statistical Analysis System (SAS). 1985. *SAS/STAT User's Guide: Statistics, Version 6*. USA: SAS Institute Inc.

Tarek, S. S. S. 2004. Integrated control for minimizing postharvest diseases of strawberry. M.S. thesis, Egypt, Fac. Agric. Ain shams Univ.

Tripathi, P., and A. K. Shula2009. Application of essential oils for postharvest control of stem an rot mango fruits during storage. *International Journal of Postharvest Technology and Innovation*, 1(4): 405.

Ziedan, H. E. E. S., and E. S. H. Farrag. 2008. Fumigation of peach fruits with essential oils to control postharvest decay. *Journal of Agriculture and Biological Sciences*, 4(5): 512.