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# IRRADIATION OF BANANA FRUITS TO SAFE STORAGE USING GAMMA RADIATION

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## ABSTRACT

The aim of this study was using chemical and irradiation processing of banana fruit, to increase the storage period. The chemical treatment (Topsen 70% WP) with rate of 80g/100 liter water, then fruit soaked in the solution about for 10 minutes. Even as, irradiation treatments were used four doses as 2.1, 4.2, 6.3 and 8.4 krad, at Laboratory of Irradiation Middle Eastern Regional Radioisotopes Center for the Arab Countries, Dokki, Giza, Egypt. The obtained results were as follows: (1) The fruit decay time was increased in about 48h that is the banana fruit was extended shelf life fruit in 48h using chemical treatment compare in untreated fruits (control). (2) The fruit mass losses were 1.35 and 2.33g for chemical treatment and un-treated fruits. Therefore, the mass losses of chemical treated fruits were reducer in about 0.98g than un-treated fruits (control). (3) The highest fruit decay and mass losses percentages were obtained with irradiation treatments 2.1 krad at cold storage 192h. In the meantime, the lowest fruit decay was recorded 6.3 krad at cold storage 240h. (4) All treatments were effective for increasing shelf-life as compared with an untreated fruit after 240 h of cold storage. An increases fruit shelf life 72, 96, 120 and 120 were observed in irradiation doses of 2.1, 4.2, 6.3 and 8.4 krad compare in fruit chemical treatment, which were 120; 144; 168 and 168h compare in untreated fruits (control).

## INTRODUCTION

The WHO recommended removing any dosage limit so that it would be possible to achieve commercial sterility as in canning high dose irradiated foods are particularly suitable for uncompromised people who often require a sterile diet. The radiation resistance of a specific organism may vary according to the environment in which it is irradiated Anonymous (1999). While, Lopezet *et al*. (1999) mentioned that one ml of the standardized inoculums was surface inoculated in each sterile sample and left overnight at 4°C. Inoculated samples were then exposed to 2, 4, 6, 8 and 10 kGy radiation doses of gamma rays (Co-60) in NCRRT three samples for each dose) while the control samples (zero kGy) were left un-irradiated. The dose rate was 4.3 kGy/h. Serial dilutions from each sample were made and assayed for CFU by standard pour plate technique using nutrient agar (oxide). Petri's plates were incubated at 35°C for 24 h before counting. Linear regression was applied to produce the best-fitting line for each treatment. Updhugay *et al*. (1994) found that irradiation significantly reduced rotting, delayed color development, preserved quality and extended shelf life. In terms of shelf life and quality, a hot-water treatment followed by irradiation at 0.3 kGy was found to be the suitable combination treatment of red mango.

The mango fruit firmness was determined in the 4th week of cold storage period and after the five-day shelf life of this period. After four weeks of cold storage, fruit firmness ranged from 1.70 to 2.10 lb in the first season and from 1.80 to 2.10 lb in the second seasons of Awais mango fruits (El-Hefnawi, 2002). However, El-Shiekh (2002) mentioned that there were picked at maturity stage with 4.5lb firmness, 7.5% total soluble solids content (TSS) and 1.74% acidity. Healthy and uniform size fruits were washed in tap water and air dried. On the other hand, Moy and Wong (2002) demonstrated that the irradiation treatment has efficiency as a quarantine treatment in terms of efficiency and retention of product quality. El-Salhy *et al*. (2006) mentioned that the mature Awais mango fruits were tested with gamma rays at (0.5,1.0, 1.5 and 2-0 kGy) and hot water (45°C) for 5 minutes to storage ability of Awais mango at 10 ±1 °C and 85-90% RH. The hot water and higher irradiation treatment (1.5 and 2.0 kGy) greatly affected fruit decay, weight loss percentage and causing black spots on the peel of fruits. In addition, hot water and radiation treatment were superior to the treatments in affecting chemical constituents of Awais mango and the applied radiation dose at 1.0 and 0.5 kGy are quite enough to be used for extending the shelf life of fruits and improving their chemical contents.

The food irradiation as the process in which foods are exposed to certain forms of ionizing energy from radioactive sources, mainly gamma rays are identified (Satin-2002). Cobalt-60 is a highly penetrating source of ionizing radiation used in food either fresh or after processing and packaging. Furthermore, he added that the food irradiation cannot be used to destroy microbial toxins nor viruses and spores be killed at the low doses used to kill vegetative pathogens (below 10 $kG_y$). That is why irradiation treatments below 10 $kG_y$ are regarded similarly to heat pasteurization. However, irradiation is not a standalone process that can guarantee safe food.

Bustos *et al*. (2004) found that irradiation, waxing and hot water had a great effect on chemical constituents of fruits. The use of irradiation treatments on mangos fruits are shown to be promising alternatives for post-harvest treatments. A dose of 1.5 kGy is recommended. Furthermore, Gonzalez *et al*. (2004) mentioned that the fruit fly infestation is a major problem for exporting tropical fruit. Irradiation is an economically viable technology for reducing post-harvest losses, extending the shelf-life of perishable commodities and maintaining hygienic quality of fresh produce. Furthermore, Sritananan *et al*. (2005) studied that the effects of irradiation and chitosan coating on physiological changes of mango's teen fruit. Fruits were treated with gamma ray and chitosan coating following treatments: untreated, irradiated with 300Gy gamma irradiation, coated with 2% chitosan and irradiation combined with 2% chitosan coating. Fruits were stored in the ambient air and determined the physicochemical parameters, respiration and ethylene production at five-day intervals. The result showed that application of chitosan coating only reduced weight loss of irradiated mangosteen fruit. Chitosan did not affect SSC, but maintained pericarp softening (lower fruit firmness). Irradiation induced respiration rate and ethylene production, but chitosan coating could reverse this effect. The results indicated that gamma irradiation combined with chitosan coating was better than irradiation only. Asmahan and Nada (2006) studied the effect of the two mutagens gamma rays at three doses (2, 4 and 6 krad) and sodium aside at three concentrations (0,001, 0.002, and 0.003 ml/L) on the expressivity of the genes controlling economic traits on tomato hybrid named "madeer". Mutagenic treatments with 2 and 4 krad gamma rays and 0,001 ml/L sodium azide enhanced all studied tomato traits. On the other hand, 4 krad gamma rays were the best mutagenic treatments than the others.

The objectives of this research were: 1) To study of gamma irradiation and chemical treatments effects on the storage ability of banana fruits. 2) To choice of suitable irradiation doses of banana fruits, in order to extended shelf life of fruits.

## MATERIALS AND METHODS

**Sample's preparation**

Banana fruits (Baldi variety) were harvested from the agricultural farm season 2011 located in Qalubia Governorate, Egypt and transported to the Laboratory of Irradiation at Middle Eastern Regional Radioisotopes Center for the Arab countries, Dokki, Giza, Egypt. Thirty fruits were packed in each paper box. Fruits were irradiated with doses of 2.1, 4.2, 6.3 and 8.4 krad. Irradiation was conducted at the office of Atoms for Peace-Giza Egypt, and Cobalt's 60 were used as a gamma source. Fruits were stored in cold room at 10$^{o}$C and ambient air at about 30°C.

**Source of gamma irradiation**

The source of irradiation used for the tested was (Cobalt-60 gamma cell 3500). This source is located at Middle Eastern Regional Radioisotopes Center for the Arab Countries, Dokki-Giza, Egypt. The dose rate was 0.78 rad/sec.

**Treatments**

The following simples under treatments were:

- Control, fruits were left without any treatment.
- Chemical treatment, clean fruits were soaked in chemical solution (Topsen 70% WP) with rate of 80 g/100 liter water and left to dry at room temperature.
- Irradiation treatment, 5 kg fruits were irradiated at doses of 2.1, 4.2, 6.3, and 8.4 krad.
- . All treatments were evaluated as supplementary refrigeration treatments during cold storage of the fruits at 10$^{o}$C and 85-90%, RH.

**Measurements and determinations:**

1. Fruit decay (%), number of decayed fruits either by physiological or pathological factors were counted, and fruit decay percentage was calculated.
2. Mass loss (%), was calculated by weighting each treatment separately using digital balance. Source of manufacture is Germany Model of SBA 51 and with accuracy of 0.01g and mass loss percentage was calculated.
3. Shelf life (day), a sample of 5 fruits for each treatment was taken out of the cold store and left at room temperature (30°C). When 50% of fruits were scalded, the number of days was recorded and considered as shelf life.

# RESULTS AND DISCUSSION

**Chemical fruit treatment**

**Decay and mass losses percentage of banana fruits:**

Table 1 shows the decay and mass losses percentages of banana fruit using chemical treatment compare with control. The chemical treatments of banana fruit were the best of un-treatment fruits to reduce decay percentage and mass loss of banana fruits. The decay times of banana fruits at chemical treatment were 120 h. Meanwhile, it was 72 h for un-treated fruits. Therefore, the decay time was increased in about 48 h that is the banana fruit was extended shelf life fruit in 48h using chemical treatment. Mass losses were 1.35 and 2.33 g for chemical treatment and untreated fruits respectively. Therefore, the mass losses of chemical treated fruits were reducer in about 0.98 g than untreated fruits.

**Table 1: The fruit decay and mass losses percentages**

| Storage time, h | Decay, % | | Mass losses, g | |
|---|---|---|---|---|
| | Control | Chemical treatment | Control | Chemical treatment |
| 24 | 12 | 5 | 2.22 | 1.28 |
| 48 | 25 | 10 | 2.27 | 1.30 |
| 72 | 50 | 25 | **2.33** | 1.32 |
| 96 | 70 | 35 | 2.38 | 1.33 |
| 120 | 100 | 50 | 2.44 | **1.35** |

The Fig. 1 shows the decay and mass losses percentages of banana fruits using chemical treatment compared with control during the cold storage period. From figure 1, it was easy to find that the decay and mass losses percentages gradually increased as a function of the cold storage period at 10°C, up to 120 hours compared in un-treated fruits. However, after 72 and 120h cold storage for untreated fruits and chemical treated fruit were lost 50% of each treatment for decay percentage, respectively. While, there were reduced 2.33 and 1.35 g of each treatment for mass losses, respectively. The decay percentage for treated fruits with chemical ranged between 5, 10, 25, 35, and 50%, and they were 12, 25, 50, 70, and 100% for un-treated fruits. Meanwhile, the mass losses for treated fruits with chemical ranged between 1.28, 1.30, 1.32, 1.33, and 1.35 g, and they were 2.22, 2.27, 2.33, 2.38, and 2.44 g for un-treated fruits for the storage period of 24, 48, 72, 96 and 120 hours, respectively.

**Shelf life**

The effect of chemical treatment and un-treated fruits on shelf life of banana fruits was illustrated in Fig. 1. By increasing the shelf life of fruits, cold storage period was increased. The storage period was 24, 48, 72, 96, and 120 h (at 50% damage fruit) for chemical treated fruits. Meanwhile, it was 24, 48, and 72 h at 50% damage fruit for un-treated banana fruit. Therefore, after 120 h of the cold storage chemical treated fruits were effective for increasing shelf life as compared with after 72 h for un-treated fruits. Therefore, at the end of the cold storage period, this extended to 120 h, as a function of chemical treated, that mean an increase in a shelf life of stored fruits with 48 hours, was observed in chemical treated fruit compared in untreated fruits (control). Generally, fruit decay percentage and mass losses were higher in all storage time of control treatment than chemical treatment.

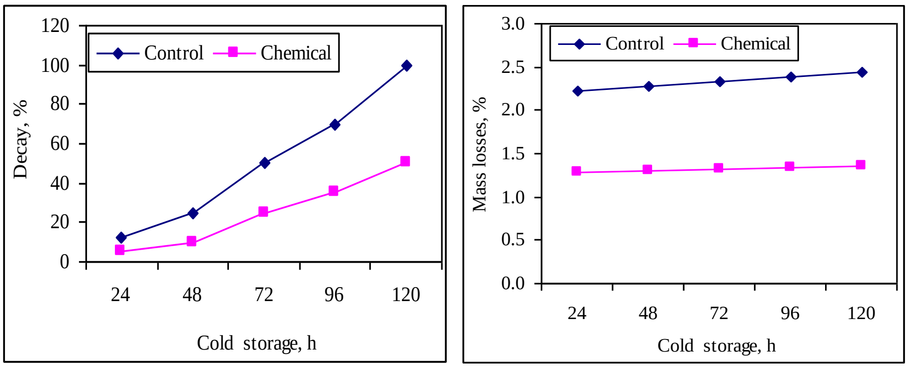


**Fig. 1: Fruit decay and mass losses percentages using chemical treatment during cold storage period.**

**Irradiation fruits treatment:**

The valuation of irradiation fruits were as the following:-

**Decay fruit percentage:**

The relationship between the decay time and mass losses percentage of banana fruit for irradiation treatments was illustrated in figure 2. It shows that the fruit decay percentage was gradually increased as a function of the increased cold storage period at 10°C and up to 240 hours for irradiated treated fruits. However, after 72- hour storage, the untreated fruits lost 50% of their decay. The fruit's decay percentages of treated fruits were 5, 10, 15, 20, 25, 30, 35, 50, 70, and 100 % for storage times of 24, 48, 72, 96, 120, 144, 168, 192, 216 and 240h in that order at 2.1 krad. In the intervening time, at 50 % damage fruits, the storage times were 192, 216, and 240 hours of banana fruits at irradiation doses of 2.1, 4.2, 6.3 and 8.4 krad, respectively. The highest fruit decay percentage was found at irradiation treatments of 2.1 krad and cold storage of 192 h. Meanwhile, the lowest fruit's decay was recorded at 72, 120 and 240 hours for untreated, chemical treated, and irradiation with 6.3 krad respectively (table 2).

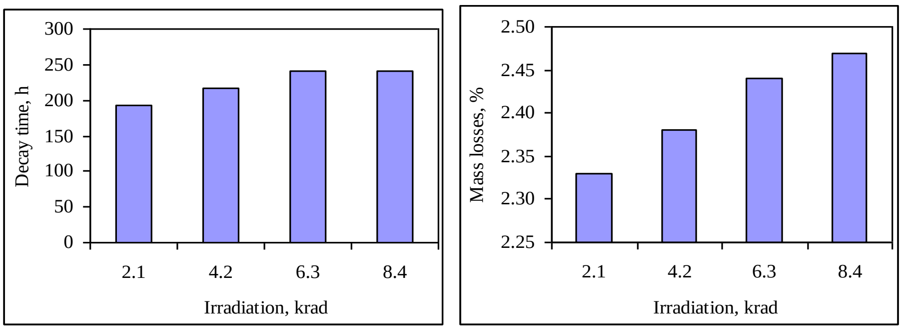


**Fig. 2: Fruit decay and mass losses using irradiation treatment.**

**Table 2: Fruit decay percentage using irradiation treatment during cold storage period.**

| Storage time, h. | Decay fruit percentages | | | |
|---|---|---|---|---|
| | **2.1 krad** | **4.2 krad** | **6.3 krad** | **8.4 krad** |
| 24 | 5 | 2 | 0 | 0 |
| 48 | 10 | 5 | 2 | 2 |
| 72 | 15 | 7 | 3 | 3 |
| 96 | 20 | 10 | 5 | 5 |
| 120 | 25 | 15 | 8 | 8 |
| 144 | 30 | 20 | 10 | 10 |
| 168 | 35 | 22 | 15 | 15 |
| 192 | **50** | 35 | 20 | 20 |
| 216 | 70 | **50** | 30 | 30 |
| 240 | 100 | 70 | **50** | **50** |

**Mass loss percentage:**

Table 3 and Figure 2 show the decay and mass losses percentages of Banana fruit using irradiation treatment. Regarding to the effect of irradiation treatments on the loss percentage of banana fruits mass, it is easy to clarify that the fruit mass loss is directly proportional with the increase in storage duration in all irradiation treatments. However, the lowest irradiation doses (2.1 - 4.2 krad) integrated the lowly mass losses (2.33– 2.38%) at the storage of 192 and 216 h. The inverse results were found at increasing the irradiation doses. For example, at the highest irradiation doses of 6.3 krad lead to the peak of mass losses at 2.44 g was found at 240 h of storage time. From the previous result, it noticed that the lowest value of mass loss percentage of fruit was obtained with irradiation fruit at 2.1 krad treatment. While, the highest value of irradiated fruit was obtained at doses of 6.3 krad. The highest value of mass loss of fruit was recorded at 72, 120, and 240 h for each of un-treated fruits, chemical treated fruits, and irradiation treated fruits respectively with 6.3 krad.

**Table 3: Fruit mass losses percentage using irradiation treatment during storage period.**

| Storage time, h | Fruit mass losses, % | | | |
|---|---|---|---|---|
| | **2.1 krad** | **4.2 krad** | **6.3 krad** | **8.4 krad** |
| 24 | 1.24 | 1.58 | 1.61 | 1.89 |
| 48 | 1.67 | 1.61 | 2.04 | 1.92 |
| 72 | 2.13 | 2.04 | 2.08 | 1.96 |
| 96 | 2.17 | 2.08 | 2.13 | 2.00 |
| 120 | 2.22 | 2.13 | 2.17 | 2.04 |
| 144 | 2.27 | 2.17 | 2.22 | 2.08 |
| 168 | 2.30 | 2.22 | 2.27 | 2.13 |
| 192 | 2.33 | 2.27 | 2.33 | 2.17 |
| 216 | 2.44 | 2.38 | 2.38 | 2.22 |
| 240 | 2.50 | 2.40 | 2.44 | 2.47 |

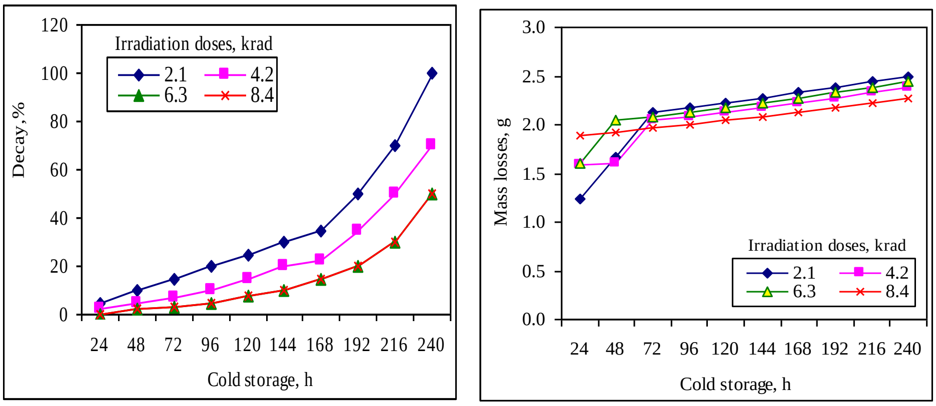


**Fig. 3: Fruit decay and mass losses at irradiation treatment during cold storage period.**

**Shelf life:**

Table 4 and Figure 3 show the decay and mass losses percentages of banana fruits using irradiation treatment at different doses level. From tables and figure, it noticed that the irradiation treatments as a significant effect on shelf life of Banana fruits. In all treatments, shelf life decreased with increasing cold storage time. However, after 240 h of cold storage all treatments were effective for increasing shelf life as compared with and untreated fruits. Meanwhile, at the end of cold storage time, which extended to 240 h, as a function of radiation dose 6.3krad, an increase in a shelf life of stored fruits, compared to other treatments.

**Table 4 : Fruit decay time and mass losses percentage at irradiation treatment during cold storage.**

| Irradiation doses, krad | Decay time, h. | Mass losses, % |
|---|---|---|
| 2.1 | 192 | 2.33 |
| 4.2 | 216 | 2.38 |
| 6.3 | 240 | 2.44 |
| 8.4 | 240 | 2.47 |

## CONCLUSIONS

1) The fruit decay time increased in about 48h That is mean the banana fruit extended shelf life fruit in 48h using chemical treatment compare in untreated fruits (control).
2) The fruit mass losses were 1.35 and 2.33 g, after 72 and 120 hours for un-treated and chemical treatment fruits.
3) Storage time of chemical fruit treatment increased in 48 hours and mass losses decreased in 0.98 g in compare to untreated fruits (control).
4) The mass losses of irradiated fruits were 2.33, 2.38, 2.44 and 2.47 % for irradiation doses 2.1, 4.2, 6.3 and 8.4 krad.
5) Storage time of irradiated fruits was increased 120, 144, 168 and 168 hours for irradiation doses 2.1, 4.2, 6.3 and 8.4 krad in compare to

untreated fruit (control). While, they were about 72, 96, 120, and 120 hours in compare to chemical treatment.

6) Irradiated banana fruits with dose of 6.3 krad were preferred, because of the storage time were increased about 168 and 120 hours in compare to untreated fruits (control) and chemical fruits treatment, respectively.
7) The highest fruit decay and mass losses percentages obtained with irradiation treatments 2.1 krad at cold storage 192 hours. While, the lowest fruit decay was recorded 6.3krad at cold storage 240 h.

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## تشعيع ثمار الموز للتخزين الآمن بإستخدام أشعة جاما

**عبد الرحمن عبد الرؤف عبد الرحمن**

**معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية - الدقى - مصر**

يهدف البحث الى استخدام عمليات المعالجة الكيميائية باستخدام مادة توبسين ٧٠% WP بمعدل ٨٠ جم/ ١٠٠ لتر ماء ثم نقع الثمار لمدة ١٠ دقائق ، وباستخدام المعالجة الأشعاعية بجرعات ٢.١ ، ٤.٢ ، ٦.٣ ، و ٨.٤ كيلو راد فى مركز المعلجة الأشعاعية – للبلاد العربية – بالدقى – جيزة – مصر.

**وكانت النتائج المتحصل عليها كالتالى :**

١- فقدت ثمار الموز ٢.٣٣% من وزنها وتتعرض للتلف بعد زمن تخزين ٧٢ ساعة فى حالة الثمار الغير معاملة (كنترول) .. بينما فقدت الثمار ١.٣٥ % من وزنها وتعرضت للتلف بعد ١٢٠ ساعة فى حالة الثمار المعاملة كيميائيا.

٢- زاد زمن التخزين فى الثمار فى المعالجة كيميائيا حوالى ٤٨ ساعة .. بينما الوزن المفقود حوالى ٠.٩٨ مقارنة بالثمار الغير معاملة (كنترول).

٣- فقدت ثمار الموز ٢.٣٣ ، ٢.٣٨ ، ٢.٤٤ ، ٢.٤٧% من وزنها وتعرضت للتلف بعد زمن تخزين ١٩٢ ، ٢١٦ ، ٢٤٠ ، ٢٤٠ ساعة فى حالة الثمار المعرضة للتشعيع بجرعات ٢.١ ، ٤.٢ ، ٦.٣ ، ٨.٤ كيلو راد على التوالى.

٤- زاد زمن تخزين ثمار الموز بحوالى ١٢٠ ، ١٤٤ ، ١٦٨ ، ساعة فى حالة الثمار المعرضة للتشعيع بجرعات ٢.١ ، ٤.٢ ، ٦.٣ ، ٨.٤ كيلو راد على التوالى مقارنة بالثمار الغير معاملة (كنترول) .. بينما زاد زمن تخزين الثمار بحوالى ٧٢ ، ٩٦ ، ١٢٠ ، ١٢٠ ساعة مقارنة بالثمار المالجة كيميائيا.

٥- أقل قيمة فى التلف والوزن المفقود كانت فى الثمار المعاملة اشعاعيا بجرعة ٢.١ كيلو راد ، بينما كانت أعلى قيمة فى الثمار المعاملة بجرعة ٦.٣ كيلو راد.

٦- يفضل تشعيع ثمار الموز بجرعة ٦.٣ كليوراد والتى عندها يزيد زمن التخزين ١٦٨ ساعة مقارنة بالثمار الغير معاملة (كنترول) وزاد زمن التخزين ١٢٠ ساعة مقارنة بالثمار بالمعاملة كيميائيا.

**قام بتحكيم البحث**

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