Arab J. Nucl. Sci. Appl., Vol. 51, 3, 51-61 (2018)

Arab Journal of Nuclear Sciences and Applications

ISSN 1110-0451 ***Web site: ajnsa.journals.ekb.eg*** **(ESNSA)**

Comparison of Effects of Gamma Irradiation and Edible Coating Films on Storage Ability and Quality of Leconte Pears (Pyrus Communis L.)

Naweto, Mohamed*, Mostafa , Mahmoud and Salem, Ehab Ahmed

Food Irradiation Department, National Center for Radiation Research and Technology (NCRRT),Atomic Energy Authority, Cairo, Egypt

Received 13th Nov. 2017
Accepted 9th Jan. 2018

Irradiation doses (2.00 and 2.50kGy) and Edible coating film Jojoba (*Simmondsiachinensis*) oil 99.0% and poly vinyl alcohol (PVA) have been used for preserving the quality and safety of fresh fruit and vegetables. The objective of this research is to evaluate the effect of irradiation doses, jojoba oil and poly vinyl alcohol (PVA) on the shelf-life and quality of Le Conte pear fruits during cold storage at 0±1°C and relative humidity (RH) 85 – 90%. The results indicated that Edible coating film PVA, Jojoba oil 99.0% and irradiation 2.00kGy dose showed a significant loss of weight, firmness, total soluble solids, shelf life, peroxidase activity and soluble protein in (peel and core) compared to untreated (control) ones. The results showed also that coating PVA , Jojoba oil 99.0% and irradiation 2.00 kGy dose maintained the visual quality of Le Conte pear fruits during the storage time.

Keywords: Cold storage,Gamma ray irradiation, Jojoba (*Simmondsiachinensis*) oil, Le Conte pear fruits, poly vinyl alcohol PVA

Introduction

Le Conte pear is one of the most important deciduous fruit in the world, it is important to consider reductions in fruit quantity and quality. A major loss due to postharvest disease may occur in the production, transportation and storage of fresh commodities. Many studies have been carried out in order to develop suitable preservation methods for several food items. Among the methods tested, gamma irradiation, Jojoba (*Simmondsia chinensis*) oil and poly vinyl alcohol (PVA).

Gamma irradiation is used as the potential method of food preservation. It is widely used as a quarantine treatment for export purposes and has emerged as a potential alternate to the use of chemical preservatives. Radiation processing of most of the tropical fruits has been extensively studied at Food Technology Division (FTD), Bhabha Atomic Research Centre (BARC), and Mumbai over decades. The commendable efforts of radiation processing studies carried out at FTD enabled the market access to Indian Mango from Deogarh to DC, Washington [1, 2, and 3].

Moreover, gamma irradiation treatment can be performed at room temperature and can be applied to bulk as well as prepackaged food, thus obviating the chances of cross contamination.

Additionally, it can improve food security by cutting down food losses caused by storage insects, microorganisms and physiological changes.

Gamma irradiation has been successfully used as an alternative treatment for microbial disinfection [4] and longevity of shelf life of fresh produce [5].

The limiting factor in the use of irradiation to extend shelf-life of the fruits is the textural change (softening) which is the result of the breakdown of cell wall constituents (pectin , cellulose and hemicellulose) [6,7]. The degradation of pectic

Corresponding author: ehab_salem97@yahoo.com
DOI: 10.21608/ajnsa.2018.2070.1013

and cellulosic materials resulted in architectural weakening in tissue and damage in the semi permeability of the cell membranes leading to loss of turgor [8]. The loss in the firmness is shown to be associated with the activity of cell wall degrading enzymes [9,10], particularly polygalacturonase [11].

The use of edible coating has received more attention in recent years, due to the growing interest for reducing environmental pollution caused by plastics, the need to extend the shelf life of foods, and the increasing demand for healthier and ecological foods [12]. Edible coatings preserve fruit quality by surrounding the product with a modified atmosphere that serves as a partial barrier to gases (such as O2 and CO2), water vapor and aroma compounds, decreasing the respiration and water loss rates of the fruit and preserving texture and flavor[12,13].

Polysaccharide-based coatings i.e. Alginate, pectins, cellulose and derivatives, starch and sucrose polyestershave been used to extend the shelf-life of fruits and vegetables [14, 15, 16].

Lipids also include waxes, acylglycerols and fatty acids have been used for extending the shelf-life of fruits and vegetables [17, 18].
When mineral oil is used, it is typically a low viscosity oil <15 cST at 40℃ {19}. In this regard, several authors noted that certain types of MHC oils and waxes have been shown to cause adverse effects in laboratory test animals [20, 21, and 22].

The objectives of this research were to evaluate the potential of gamma irradiation, Jojoba (Simmondsia chinensis) oil and poly vinyl alcohol PVA to extend the shelf-life and quality of pear during cold storage and to compare the effect of these alternative materials on quality pear fruits.

Materials and Methods

This investigation was carried out during 2014 and 2015 seasons to examine fruit quality improvement of Le Conte pear fruits (Pyruscommunis, L.) due to gamma irradiation , Jojoba (Simmondsiachinensis) oil andpoly vinyl alcohol PVA. Pear fruits were harvested from a private orchard located in El Samman City, Menofia Governorate. Pears fruits were picked in early morning hard green mature stage according to suitable maturity indices to pear fruit using a combined flesh firmness and total soluble solids (TSS) index that is further modified by fruit size and skin color (if yellowish green, no firmness or TSS limits). Healthy fruits free from any physiological and pathological disorders were chosen. Moreover, the uniformity of fruits shape and size were observed. Fruits harvested at early morning directly transferred to the National Center for Radiation Research and Technology (NCRRT) located in Nasr City, Cairo, Egypt. The fruits were cleaned, divided into 5 groups and then treated according to the following plan of work treatments: Each group of experimental materials (fruits) was 90 fruits of fresh and healthy fruits (5 treatments X 3 replicates X 2 boxes X 15 fruits for each box = 450fruits for each).

Five different experiments were carried out as follows:-

Treatment 1: Control (untreated).
Treatment 2: Irradiation at 2.0kGy.
Treatment 3: Irradiation at 2.5kGy.
Treatment 4: Fruits were coated with thin layer of Jojoba (Simmondsia chinensis) oil (99.0%).
Treatment 5: Fruits were edible coated with thin layer of poly vinyl alcohol (PVA).

Each replicate was consisted of two boxes, one box for studying physical properties and the other for determining chemical constituents. Control fruits were kept in carton boxes in each box without any treatment, and all treatments were stored at 0±1℃ and relative humidity (RH) 85 –90%.

Control treatments

The pear fruits were kept in carton boxes in each box without any treatment, and stored at (0±1℃, 85-90% RH).

Irradiation treatments

The irradiation facility located at NCRRT in the Egypt Industrial Mega Gamma-(.Model "AECI, JS" was used, where the irradiator is provided with two automatic conveyer. The principal conveyer being devoted for radiation sterilization of medical products, whereas, the auxiliary conveyor is used for pilot scale irradiation. The irradiation source was CO60 and average dose rate was 0.15 Gy /sec. in dimension, was utilized in this irradiation

process. For both seasons two irradiation doses have been used (2.0 and 2.50 kGy).

The Pear fruits were carried out at room temperature using CO60source at the National Center for Radiation Research and Technology (NCRRT), Nasr City, Cairo, Egypt. The irradiation facility used was an Egypt's Mega Gamma-1, of the type J-6500 supplied by the Atomic Energy of Canada Limited. The applied doses were 0.0, 2.0 and 2.50 kGy for Pear fruits. The dose rate delivered during the experimental duration was 0.15 Gy/ hr., as monitored by radiochromic film [23]. After irradiation treatment the experimental materials (fruits) were transferred into a coldstorage room adjusted at 0 ±1°C, 85-90% RH.

Edible coatings films

Jojoba (Simmondsia chinensis) oil was obtained from Alkanz Co., Zagazig, Egypt. Mature fruits were immersed in Jojoba oil for two minutes, and lifted to be air – dried,and then coated fruits were placed in carton boxes and stored at 0 ±1°C, 85-90% RH.

Poly vinyl alcohol (PVA)

Technical procedures: Plasticized Starch (PLST) blends with poly vinyl alcohol (PVA) was prepared. The required amount of starch (1.2g) was added to 60 ml. of distilled water at room temperature with stirring. When the mixture was completely suspended the temperature was slowly raised to reach 90˚C with continuous stirring and glycerol 20% was then added to the solution, the stirring was continued for 3 hours to reach complete gelatinization of starch. The required amount of PVA (0.7g) dissolved in 35ml. hot water and chitosan (0.1g) dissolved in5ml. hot water, was added to the gelatinized starch. After raising the temperature to 90˚C, the mixture was removed and the solution was sprayed on pears fruits, then dried and stored at 0 ±1°C, 85-90% RH [24] .

Fruit physical properties

1- Fruit weight loss(WL, %)It was determined as described by {25} as follow:-

WL, % = (Fruit initial weight – fruit weight at each sampling date / Fruit initial weight) X 100

2- Fruit firmness (Lb./inch²), it was determined by using a Magness-Taylor type pressure tester by a standard 5/16 of inch plunger.

3- Fruit shelf- life (in days), a fruit sample from each replicate was taken out from the storage cold room and left at room conditions (25 °C ± 2), when 50 % of fruits were scalded, the experiment was terminated and the number of days was calculated and considered as shelf-life or marketing ability of fruits.

Fruit chemical properties*:* It was determined that:

- **Total** soluble solids(T.S.S%)

using hand refractmeter, according to [26].

- **Determination** of Peroxidase activity

  - Extraction procedure, the previous procedure to extract PPO was used to extract
  - Peroxidase enzyme except. The citrate –phosphate buffer was adjusted to pH 5.
  - Assay of POD activity, POD activity was measured as the change in absorbance at 470 nm using guaiacoland H2O2 as substrates according to [27].The substrate solution of 0.5% (v/v) guaiacol in 0.1 ml K2HPO4 (pH6) was stirred for 30 min.0.008%(v/v) 30% H2O2 was added immediately before use .Enzyme solution (50µl) was added to 2.5 mlsubstrate solution in curette and absorbency was recorded [28].
  - Calculation, Enzyme activity was calculated from the linear part of optical density and time curve. One unit of POD activity was defined as a change of 0.1 absorbency unit per min per g.,[28].
  - Specific activity, specific activity was expressed in unit of POD activity per mg protein as Mentioned by [29].
  - Specific activity = (specific activity, POD/min. / protein concentration, mg/ml)

- Protein contents of the acetone powders were determined by macro Kjeldahl method
- as mentioned in a previous study [30].
- Activity percentage was calculated from the following equation according to Sapers et al. [31].
- Percent activity =(Enzyme activity of treated sample / Enzyme activity of control sample X100

- **Determination of soluble protein**

The dried material of pear samples was ground in a mortar and pestle. Then, extraction buffer tris borate pH 7.9 was added in a ratio of 1: 2.5 (w/v). The extracted samples were centrifuged for 15min.at 4000rpm at room temperature. Then supematants containing the soluble proteins were used for further chemical determinations. The soluble protein was measured according to [32].

Experimental design and statistical analysis

All treatments used 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 [33], where appropriate treatment means were separated using Duncan's multiple range test [34] and all percentages were transferred to angles before statistical analysis.

Results and Discussion

Physical properties

Weight loss percentage

The data indicated that the weight loss was significantly higher in untreated (control) samples as well as all radiation doses samples as compared to coating Jojoba oil and poly vinyl alcohol (PVA) treatments.(Table 1).The data analysis also revealed that after 10 days of cold storage at 0±1°C with relative humidity (RH) 85 – 90% , there was no significant difference in weight loss between coating Jojoba oil and poly vinyl alcohol (PVA) treatments recorded 0.31and 0.30, respectively while control, 2.0 and 2.5 kGy doses recorded 0.40, 0.32 and 0.37 respectively. However, in case of coating Jojoba oil and poly vinyl alcohol (PVA) treatments, the weight loss was significantly higher compared to control samples. After 20 days of cold storage, the weight loss was increased in control 0.85 and 2.5 kGy irradiated samples 0.78 while decreased in irradiated 2.0 kGy, Jojoba oil and poly vinyl alcohol (PVA)recorded 0.70, 0.65 and 0.60 respectively. After 30 days of cold storage, the fruits treated with 2.0 kGy, Jojoba oil and poly vinyl alcohol (PVA) showed the lowest values of weight loss than those irradiated 2.5 kGy dose or those untreated. This reduction in the weight loss was probably due to the effects of moisture loss from the fresh fruits and vegetables by vapor-phase diffusion driven by a gradient of water vapor pressure at different locations [35]. On the other hand, respiration causes a weight reduction because a carbon atom is lost from the fruit in each cycle. It was reported in the literature that the effects of these coatings as a semi permeable barrier against oxygen, carbon dioxide, moisture and solute movement, lead to reducing respiration, water loss and oxidation reaction rates. The same trend of results was also found in the second season of study (Table 1) [36,20,37,38].

Fruits firmness

Data presented in Table (2) indicate that there was a decrease in flesh firmness value in all pear samples after 20 and 30 days of cold storage in comparison with those of zero time groups. After 10 days of cold storage in the first season, the highest fruit firmness (13.0 Lb./inch2) was recorded by those fruits treated by 2.0 kGy irradiation dose followed by control 12.00 , Jojoba oil 11.00 and PVA10.30.on the other hand, after 30 days of cold storage, the highest fruit firmness 9.50 Lb./inch2 was recorded by PVA next 2.0 kGy irradiation dose and Jojoba oil were recorded (9.0 Lb./inch2). But the lowest fruit firmness 8.0 Lb./inch2 was recorded by 2.50 kGy irradiation dose at 30 days of cold storage.

These results are in harmony with data observed by [39], who studied the Flesh firmness is one of the most important parameters as regards consumer acceptance and eating quality of apples. However, [35] who found that the retention of firmness can be explained in terms of retarded degradation of insoluble protopectins to the more soluble

pectic acid and pectin. During fruit ripening, depolymerization or shortening of chain length of pectin substances occurs with an increase in pectinesterase and polygalactronase activities. The same trend of results was also found in the second season (Table 2).

Shelf-life (marketability)

Results presented in Table (3) show the effect of some treatments on the shelf life (days) of Le Conte pear fruits stored at 0 ±1°C, 85-90% RH.

It is obvious that as days of cold storage were increased, the shelf life decreased. However, long shelf life (9.76 and 9.66 days) was recorded for the fruits treated with PVA and Jojoba oil followed by irradiation dose 2.0 kGy compared to control which recorded 8.66 and 7.00 respectively in the first season. It is clear that, the treated fruits significantly differed from the untreated fruits(control) in their firmness. However, the fruits treated with 2.5 kGy had less marketing life (5.66 day) than those received the other treatments. Slight differences were noticed during the second season of study (Table 3).

The present results are in agreement with those of **Seung et al.** [40] who found that Ionizing radiation may be used for sprouting inhibition, insect control or delay of ripening of certain fruits and vegetables. In general, irradiation doses of 2-3 kGy combined with refrigeration were useful for extending the shelf- life of strawberries [41].

Table (1): Effect of irradiation, edible coatings film with Jojoba oil and poly vinyl alcohol on the weight loss of Le Conte pear fruits during cold storage of 2014& 2015 seasons

Treatments	Storage period in days of 2014 season		
	10 days	20 days	30 days
	Weight loss, %		
Control	0.40	0.85	1.20
2.0 kGy	0.32	0.70	1.07
2.5 kGy	0.37	0.78	1.17
Jojoba oil	0.31	0.65	1.07
PVA	0.30	0.60	1.07
2015 season			
Control	0.45	0.82	1.15
2.0 kGy	0.40	0.69	1.05
2.5 kGy	0.35	0.78	1.10
Jojoba oil	0.30	0.76	1.04
PVA	0.30	0.78	1.00

kGy : Irradiation (kilo gray) PVA : poly vinyl alcohol

Table (2): Effect of irradiation, edible coatings film with Jojoba oil and poly vinyl alcohol on fruits firmness of Le Conte pear fruits during cold storage of 2014& 2015 seasons

Treatments	Storage period in days of 2014 season			
	0 time	10 days	20 days	30 days
	Fruits firmness (Lb./inch2)			
Control	13.00	12.00	10.00	8.50
2.0 kGy	14.00	13.00	9.80	9.00
2.5 kGy	10.90	9.90	9.50	8.00
Jojoba oil	12.00	11.00	10.00	9.00
PVA	11.30	10.30	10.00	9.50
2015 season				
Control	13.10	12.05	10.60	9.10
2.0 kGy	14.05	12.80	9.80	9.15
2.5 kGy	10.50	9.30	9.00	9.00
Jojoba oil	12.00	11.00	10.70	10.00
PVA	11.30	11.00	10.70	10.05

kGy : Irradiation (kilo gray) PVA : poly vinyl alcohol

Table (3): Effect of irradiation, Edible coatings film with Jojoba oil and poly vinyl alcohol on Shelf- life(market ability) of Le Conte pear fruits during cold storage of 2014 & 2015 seasons

Treatments	Storage period in days of 2014 season			
	0 time	10 days	20 days	30 days
	Shelf- life (marketability)			
Control	12.00	11.33	10.00	7.00
2.0 kGy	13.26	12.33	11.66	8.66
2.5 kGy	9.90	8.66	5.66	5.66
Jojoba oil	11.00	10.33	10.00	9.66
PVA	10.33	10.33	10.00	9.76
2015 season				
Control	12.05	11.00	10.00	7.33
2.0 kGy	13.00	12.33	10.60	8.55
2.5 kGy	9.50	9.00	6.70	4.75
Jojoba oil	11.60	11.10	10.80	9.80
PVA	10.33	10.33	10.00	10.00

kGy : Irradiation (kilo gray) PVA : poly vinyl alcohol

Chemical determinations

Total soluble solids (TSS,%)

Data illustrated in Table (4) demonstrate the effect of irradiation doses, PVA and Jojoba oil on total soluble solids % of Le Conte pear fruits stored at 0 ±1°C, 85-90% RH.

It is clear that TSS of Le Conte pear fruits were increased with the progress in cold storage time. At the beginning of cold storage duration, no significant differences were observed between the used treatments and control. However, with the increase of cold storage durations and after 20 days in the first season, the lowest TSS (13.60%) was obtained with the use of Jojoba oil after cooling .On the other hand, after 30 days of cold storage. The higher TSS percentage values were recorded (16.20) with control and Jojoba oil after cooling and the lowest value with irradiation dose 2.0,2.5 kGy and coating PVA were recorded (15.00%).The increase in total soluble solids with increasing cold storage period could be attributed to the conversion of some complex substances such as starch to simple substances like sugar and other solutes and consequently sugars content which presented and major content of total soluble solids increased.The same trend of results was also found in the second season.

Peroxidase enzyme (POD)

Pearpeel

Table (5) indicates that, the POD activity was 25.00 unit/g acetone powder in the peel of un-irradiated pear fruits which increased considerably to 17.60 after 10 days of storage at 0 ±1°C, 85-90% RH. The increase was more pronounced after 30 days of cold storage, since the POD activity was unit/g acetone powder with all treatments .There was a noticeable decrease in the POD activity in the peel after 20 days of cold storage, followed by all treatments increase after 30 days of cold storage. For 2.0 kGy treatment, the activity of POD enzyme was 52.00 unit/g acetone powder in the peel before storage then decreased considerably to 46.00 unit/g acetone powder after 20 days of cold storage in the peel, then increased to 69.00 unit/g acetone powder after 30 days of cold storage.

For 2.5 kGy treatment, the POD activity was 34.00 unit/g acetone powder in the peel before storage then decreased to 25.50 unit/g acetone powder after 20 days of cold storage, then a slight increase in POD activity was observed to 45.45 unit/g acetone powder after 30 days of cold storage. With edible coatings film Jojoba oil and PVA treatments, the POD activity was 22.40 and 27.42 unit/g acetone powder in the peel before storage then decreased to 29.55 and 26.50 unit/g acetone powder after 20 days of storage at 0 ±1°C, 85-90% RH ,respectively, whereas after 30 days of cold storage, the increase in the POD activity were 32.43 and 30.05 unit/g acetone powder respectively.

The highest values of POD enzyme activity during storage 69.00 unit/g acetone powder was reached in the peel of 2.0 kGy treatment after 30 days of storage at 0 ±1°C, 85-90% RH. The same trend of results was also found in the second season.

Pear core

Data presented in Table (6) indicate a gradual increase in the POD enzyme activity in the core of un-irradiated pear with increasing storage period at 0 ±1℃, 85-90% RH. The POD activity was 8.50.60 unit/g acetone powder in the core of un-irradiated pear fruit before storage and increased noticeably to 11.00 unit/g acetone powder after 20 days of storage at 0 ±1℃, 85-90% RH, whereas after 30 days of cold storage, the POD activity reached 20.25 unit/g acetone powder. For all treatments, there was a noticeable decrease in the POD enzyme activity in the core after 20 days of cold storage, followed by an increase with all treatments after 30 days of cold storage. For 2.0 kGy treatment, the POD enzyme activity was 40.50 unit/g acetone powder in the core before storage and decreased to 26.00 unit/g acetone powder after 20 days of cold storage, such decrease was followed by a slight increase in POD activity which reached 34.80 unit/g acetone powder after 30 days of cold storage. For 2.5 kGy treatment, the activity for POD enzyme was 24.90 unit/g acetone powder in the core before storage which decreased considerably to 22.80 unit/g acetone powder after 20 days of cold storage, then a slight increase in the activity of POD enzyme was detected to reach 37.80 unit/g acetone powder after 30 days of cold storage.

For edible coatings film Jojoba oil and PVA treatments, the POD enzyme activity was 18.25 and 13.50 unit/g acetone powder in the core before the storage and decreased slightly to be 12.40 and 10.75 unit/g acetone powder after 20 days of cold storage respectively, then a considerable increase in the activity of POD enzyme was recorded 20.20 and 15.80 after 30 days of cold storage respectively .

The highest values of POD activity during storage period was detected in the peel or core of pear fruits of 2.00 and 2.5 kGy irradiating doses treatments after 30 days of storage at 0 ±1℃, 85-90% RH.The previous data about POD enzyme activity are in agreement with the finding of [42] on korean pears and [43] on grapefruits.

Soluble protein content

Pear peel

Table (7) shows the soluble protein content in the peel of all treated and untreated pear fruits samples during storage at 0 ±1℃, 85-90% RH. Data revealed a gradual and clear decrease in soluble protein of all treatments and un-treatment peel of pear with increasing storage period. After 20 days of cold storage, the detected increase ranged from 100.00 to 106.00 mg/100g dry wt. with irradiation dose 2.0 kGy, 72.30 was to 80.60 mg/100g dry wt. with irradiation dose 2.5 kGy,170.80 to 185.35 mg/100g dry wt. With edible coatings film Jojoba oil and 184.00 to 197.00 mg/100g dry wt. with edible coatings film PVA. Such increase in soluble protein amount was observed with increasing storage period. Also, the aforementioned decrease in soluble protein was detected in case of the peel of untreated pear, which contained 175.0 mg/100g dry wt. and increased considerably to 180.0 and 183.0 mg/100g dry wt. after 20 days of cold storage respectively. A continuous decrease occurred to reach 160.80 mg/100g dry wt. after 30 days of storage at 0 ±1℃, 85-90% RH.

The higher amount of soluble protein was detected in the peel of pear with edible coatings film PVA 184.00 mg/100g dry wt., which increased to 197.00 mg/100g dry wt. after 20 days of cold storage. Then a gradual decrease was observed and reached 188.00 mg/100g dry wt. after 30 days of storage at 0 ±1℃, 85-90% RH. On the other hand the lower content of soluble protein was observed with the use of 2.5 kGy irradiation dose 72.30 mg/100g dry wt. which increased to 80.60 mg/100g dry wt. after 20 days of storage at 0 ±1℃, 85-90% RH and then decreased gradually to 78.50 mg/100g dry wt. after 30 days at 0 ±1℃, 85-90% RH. The same trend of results was also found in the second season (Table 7).

Pear core

Data presented in Table (8) show the soluble protein content in the core of all treatments and un-treatment pear fruits samples during storage at 0 ±1℃, 85-90% RH. Such data revealed a gradual and clear decrease in soluble protein of all treatments and un-treatment core of pear with increasing storage period.

The soluble protein content in the core of un-treatment pear 71.10 mg/100g dry wt. were relatively lower than these of edible coatings film Jojoba oil and edible coatings film PVA(70.20 and 67.30 mg/100g dry wt. respectively) treatment during the cold storage period.

The higher amount of soluble protein was found in the core of pear exposed to edible coatings film

PVA 70.20 mg/100g dry wt., which decreased gradually and reached 63.90 mg/100g dry wt. after 30 days of cold storage. On the other hand the lower content of soluble protein was detected in the core of pear treated by 2.5 kGy 30.90 mg/100g dry wt. which decreased gradually and reached 28.00 mg/100g dry wt. after 30 days at 0 ±1℃, 85-90% RH. The same trend of results was also found in the second season (Table 8).

According to the previous data that deal with soluble protein in the peel or core of pear fruits under the influence of irradiation , edible coatings film (PVA or Jojoba oil) and during storage period, a slight increase accurred in soluble protein of the treated fruits with 30 days in PVA or Jojoba oilduring storage at 0 ±1℃, 85-90% RH.

The slight increase in soluble protein under the influence of gamma radiation and during storage may be due to the destructive effect of gamma radiation on the protein helix, which produce some amino acids free radicals producing peptides. Thus, the soluble protein increased.

On the other hand, the decrease in soluble protein could be attributed to the radiation damage of the soluble protein producing amino acids and free radicales as degradation products.
Such observations are in agreement with the finding of [44] on tomato, and [45] on potato.

Table (4): Effect of irradiation, edible coatings film with Jojoba oil and poly vinyl alcohol on total soluble solids of Le Conte pear fruits during cold storage of 2014 and 2015 seasons

Treatments	Storage period in days of 2014 season			
	0 time	10 days	20 days	30 days
	Total soluble solids (TSS, %)			
Control	12.00	13.00	14.20	16.20
2.0 kGy	12.20	13.20	14.00	15.00
2.5 kGy	12.00	13.00	14.00	15.00
Jojoba oil	11.80	12.50	13.60	16.20
PVA	12.20	13.40	14.00	15.00
2015 season				
Control	12.00	13.10	14.50	16.50
2.0 kGy	12.30	13.40	14.10	15.50
2.5 kGy	12.00	13.00	14.50	15.50
Jojoba oil	11.60	12.60	14.00	16.50
PVA	12.50	13.00	14.50	15.50

kGy : Irradiation (kilo gray) PVA : poly vinyl alcohol

Table (5): Effect of irradiation, edible coatings film with Jojoba oil and poly vinyl alcohol on peroxides activity in the peel of Le Conte pear fruits during cold storage of 2014&2015 seasons

Treatments	Storage period in days of 2014 season			
	0 time	10 days	20 days	30 days
	Peroxides activity (units /g acetone powder)			
Control	25.00	17.60	19.10	32.60
2.0 kGy	52.00	62.50	46.00	69.00
2.5 kGy	34.00	44.50	25.50	45.45
Jojoba oil	22.40	30.60	29.55	32.43
PVA	27.42	29.00	26.50	30.05
2015 season				
Control	26.50	27.90	29.10	33.70
2.0 kGy	48.90	60.15	45.05	62.00
2.5 kGy	35.20	44.00	25.40	48.60
Jojoba oil	30.60	32.60	29.55	33.30
PVA	27.00	29.20	24.80	32.10

kGy : Irradiation (kilo gray) PVA : poly vinyl alcohol

Table (6): Effect of irradiation, edible coatings film with Jojoba oil and poly vinyl alcohol on peroxides activity in the core of Le Conte pear fruits during cold storage of 2014&2015 seasons

Treatments	Storage period in days of 2014 season			
	0 time	10 days	20 days	30 days
	Peroxides activity (units /g acetone powder)			
Control	8.50	9.55	11.00	20.25
2.0 kGy	40.50	50.60	26.00	34.80
2.5 kGy	24.90	26.60	22.80	37.80
Jojoba oil	18.25	20.50	12.40	20.20
PVA	13.50	15.50	10.75	15.80
2015 season				
Control	7.90	9.80	11.20	20.40
2.0 kGy	43.60	50.53	26.65	37.75
2.5 kGy	25.00	26.92	23.75	39.85
Jojoba oil	19.00	20.50	12.80	21.20
PVA	13.00	15.50	10.84	15.90

kGy : Irradiation (kilo gray) PVA : poly vinyl alcohol

Table (7): Effect of irradiation , edible coatings film with Jojoba oil and poly vinyl alcohol onsoluble protein content in the peel of Le Conte pear fruits during cold storage of 2014& 2015 seasons

Treatments	Storage period in days of 2014 season			
	0 time	10 days	20 days	30 days
	Soluble protein content (mg/100g dry weight)			
Control	175.00	180.00	183.05	160.80
2.0 kGy	100.00	103.20	106.00	101.30
2.5 kGy	72.30	79.00	80.60	78.50
Jojoba oil	170.80	184.15	185.35	181.07
PVA	184.00	195.00	197.00	188.00
2015 season				
Control	175.00	180.05	183.00	160.90
2.0 kGy	90.00	93.20	100.00	92.00
2.5 kGy	62.30	69.10	82.23	80.05
Jojoba oil	170.65	180.00	182.20	180.00
PVA	180.00	190.00	175.05	180.00

kGy : Irradiation (kilo gray) PVA : poly vinyl alcohol

Table (8): Effect of irradiation, edible coatings film with Jojoba oil and poly vinyl alcohol on soluble protein content in the core of Le Conte pear fruits during cold storage of 2014& 2015 seasons

Storage period in days				
Treatments	2014 season			
	0 time	10 days	20 days	30 days
	Soluble protein content (mg/100g dry weight)			
Control	71.10	65.21	64.70	60.30
2.0 kGy	33.00	32.61	32.05	30.85
2.5 kGy	30.90	30.50	30.00	28.00
Jojoba oil	67.30	66.82	65.30	63.50
PVA	70.20	69.20	68.00	63.90
2015 season				
Control	68.20	64.05	63.00	61.50
2.0 kGy	33.00	32.61	31.90	30.00
2.5 kGy	33.00	31.10	30.75	30.10
Jojoba oil	70.00	68.20	65.00	63.00
PVA	71.20	68.20	66.00	65.00

kGy : Irradiation (kilo gray) PVA : poly vinyl alcohol

References

1- A.Sharma "Radiation technology enabled market access to Indian mango – Journey FromDeogarh to DC". BARC News Letter 296: 2 – 8(2008).
2- S. N.Hajare, S.Saxena , S. Kumar, S. Wadhawan , V. More, B. B. Mishra, M. N. Parte, S. Gautam and A.;Sharma "Quality profile of litchi (Litchi chinesis) cultivars from India and effects of radiation processing". Radiation Physics and Chemistry 79: 994 – 1004(2010).
3- P.Thomas, Radiation preservation of foods of plant origin. Part –III. Tropical fruit Banana, mangoes and papayas. CRC Critical Reviews in Food Science & Nutrition 23: 147-205(1986).
4- G.J.Hallman Potential increase in fruit fly (Dipteratephritidae) interceptions using ionizing irradiation phytosanitary treatments .J. Economic Entomol. 101: 716-719(2008).
5- A.Prakash, P. Inthajak, H. Huibregtse, F. Caporaso and D. M. Foley Effect of dose gamma irradiation and conventional treatments on shelf life and quality characteristics of diced celery. J. Food Sci. 65: 1070-1075(2000).
6- 1.Jr L.M. Massey and M. Faust Irradiation- Effects on polysaccharide s in carbohydrates of fruits and vegetables . Food Techno! Q. , 559 - 564 (1969).
7- WJ. Bramlage and HM. Covey Gamma radiation of fruits to extend market life. MkL.RpL.No.217.Agricultural Research Service, U.S. Department of Agriculture Washington, DC, 1(1975).
8- Jr. LM . Massey Food Irradiation, U. S .Dep. Agr i c . Sci. Rev . 2· 29. In : FoodIrradiation . Proceedings of a Symposium IAEA/FAO Karlsruhe , 6 -10 (1969) .
9- w.Pilnik and A.G.J. Voragen Pectic substances and other uronides .In Hulme,AC.theBiochemistry of Fruits and their Products. Academic Press ,London pp 58 - 80(1970).
10- M.Lieberman Post harvest physiology and c r op preservation . NATO Advances institutes Series , Plenum Press, New York and London . pp . 14 0 - 1 7 5 (1983) .
11- D.Grierson, GA. Tucker and NG. Robertson The molecular biology of ripening .In:frienJ ., Rhodes MJC . (eds), Recent Advances in the Biochemistry of Fruit and Vegetables. Academic Press , London , pp .147-158 (1981).
12- M. Espino-Díaz, J. De JesúsOrnelas-Paz, MA. Martínez-Téllez , C. Santillán , GV. Barbosa-Cánovas, PB. Zamudio-Flores and GI. Olivas Development and characterization of edible films based on mucilage of opuntiaficus-indica (L.) J Food Sci.;75:E347–E352(2010).
13- G. Gonzalez-Aguilar, J. Ayala-Zavala, G. Olivas , L. de la Rosa and E. Alvarez-Parrilla Preserving quality of fresh-cut products using safe technologies. J Verbr Lebensm.;5:65–72(2010).
14- F. Mancini and T.H. McHugh Fruit-alginate interactions in novel restructured products. Nahrung, 44: 152-157(2000).
15- J.W. Rhim Physical and mechanical properties of water resistant sodium alginate films. Lebens mittel Wiss. Und. Technol., 37: 323-330(2004).
16- M.A. Rojas-Grau , M.S. Tapia, F.J. Rodríguez, A.J. Carmonac and O. Martin-Belloso Alginate and gellan-based edible coatings as carriers of antibrowning agents applied on fresh-cut Fuji apples. Food Hydrocolloids, 21: 118-127(2007).
17- M.B. Perez-Gago, M. Serra and M.A. Del Rio Color change of fresh-cut apples coated with whey protein concentrate-based edible coatings. Postharvest Biol. Technol., 39: 84-92(2006).
18- M.M.Falcão -Rodrigues, M. Moldão-Martins and M.L. Beirão-da-Costa DSC as atool to assess physiological evolution of apples preserved by edibles coatings. Food Chem., 102: 475-480(2007).
19- J.T. Heimbach, A.R. Bodor, J.S. Douglass, L.M. Barraj, S.C. Cohen, R.W. Biles and H.R.Faust Dietary exposures to mineral hydrocarbons from food-use applications in the United States. Food Chem. Toxicol., 40: 555-571 (2002).
20- S.R. Bhowmik and J.C. Pan Shelf life of mature green tomatoes stored in controlled atmosphere and high humidity. J. Food Sci., 57: 948-953(1992).
21- M.J. Scotter, L. Castle, R.C. Massey, P.G. Brantom and M.E. Cunninghame A study of the toxicity of 5 mineral hydrocarbon waxes and oils in the F344 rat, with histological examination and tissue-specific chemical characterisation of accumulated hydrocarbon material. Food Chem. Toxicol., 41: 489-521(2003).
22- R.S. Farag, M.M. Farag , A.M. Basuny and F.M. Rehab Safety evaluation of individual non-fried and fried sunflower oil, paraffin oil, jojoba oil and their binary mixtureson rat health. Int. J. Food Sci. Technol., 43: 1742-1753(2008).
23- W.L. McLauchlin , W.Chen, H.Jia and J.C.Humphreys Response of radichromic film dosimeter to gamma rays in different atmospheres Radiat. Phys. Chem. 25:793 - 797 (1985).
24- H. A.El-Shahat, Modification of edible food packaging materials based on natural polymer blends by ionizing radiation. Ph.D. dissertation. Chemistry, University College for Girls, Ain Shams University (2010).
25- N.M. Kabeel Physiological studies on increasing the keeping quality of Balady Egyptian lime fruits (Benzaer) Ph.D. thesis, Faculty of Agriculture, Cairo University(1990).

26- A.O. A. C. Official methods of Analysis .The Association of Official Analytical Chemist. Arlington West Virginia, USA, 15th Ed Washington D.C(1990).
27- R. L. Thomas, J.J. Jen and C.V. Morr, Changes in soluble and bound peroxidase –IAA during tomato fruit development. Journal of Food Science, 47: 158(1981).
28- B.E. Halpin and C.Y. Lee Effect of blanching on enzyme activity and quality change in green peas. Journal of Food Science, 52: 4, 1002-1005(1987).
29- G. Prestamo Peroxidase of Kiwifruit. Journal of Food Science,54:3, 760 – 762(1989).
30- W.H. Flurkey and J.J. Jen Peroxidase and polyphenol oxidase activities in developing peaches. Journal of Food Science. 43, 1826 – 1828, 1831 (1978).
31- G.M. Sapers and F.W.Jr. Doglas Measurement of enzymatic browning at cut surfaces and in juice of raw apple and pear fruits. Journal of Food Science,52: 5, 1258 –1262
(1987).
32- M. Bradford A rapid and sensitive method for the quantitation of microgram Quantities of protein utilizing the principle of protein – dye binding. Anal. Biochem. 72: 248(1976).
33- SAS "Statistical Analysis System" SAS/STAT User's Guide: statistics,
Version 6. 0.3 Edition. SAS Institute Ic. Cary, N. C. USA (1985).
34- D. B. Duncan Multiple Range and Multiple F.Tests. Biometrics, 11:1- 42(1955).
35- O.Yaman and L. Bayoindirli Effects of an edible coating and cold storage on shelf-life and quality of cherries. Lebensm. Wiss Und. Technol., 35: 146-150(2002).
36- T.P. Labuza Moisture Sorption: Practical Aspects of Isotherm Measurement anuse. Association of Cereal Chemists, Minneapolis, MN (1984).
37- E.A.Baldwin, J.K. Burns, W. Kazokas, J.K. Brecht, R.D. Hagenmaier, R.J. Bender and E. Pesis Effect of 2 edible coatings with different permeability characteristics on mango (Mangiferaindica L.) ripening during storage. Postharvest Biol. Technol., 17: 215- 226 (1999).
38- H.J. Park Development of advanced edible coatings for fruits. Trends Food Sci. Technol., 10: 254-260(1999).
39- R.B.H. Wills, P.A. Bambridge and K.J. Scott Use of flesh firmness and other tests to determine consumer acceptability of Delicious apples. Aust. J. Exp. Agric. Anim. Husb., 20: 252-256. (1980).
40- Seung and Adel A. Kader Pre harvest and post harvest factors influencing vitamin C content of horticultural crops. Postharvest Biology and Technology 20 (3): 207- 220 (2000).
41- W. D. Graham and M. H. Stevenson Effect of irradiation on vitamin C content strawberries and potatoes in combination with storage and with further cooking in potatoes. J. Sci. Food Agric. 75: 371- 377(1997).
42- Z. Y.Li , and Z. F. Zhao Studies on peroxidase isozymic patterns of Pyrus sp. And irradiation by 60Co gamma-ray varieties of Korean pear. Journal of fruit science. 8:2, 83-86(1991).
43- M.G. El-Shemy, M.A. Abdallah and S.A. Farag Relation between irradiation doses and browning, oxidative enzymes and phenols of grape fruits. Thrid conference of Agriculture Development Research, Ain Shams Univ. Cairo, Egypt, Dec. 22-24. pp. 221-233(1990).
44- M. S.Yasia, K. Chachin and T. Lwata Effect of gamma irradiation on tissue firmness, some cell wall degrading enzyme and pectic substances of tomato fruit. Bulletin of University of Osaka Prefecture, Series-B Japan. 39, 9-20 (1987).
45- B. Bhushan , and P.Thomas effect of gamma irradiation storage temperature on
46- lipoxygenase activity and carotenoid disappearance in potato tubers (Solanumtuberosum L.). Journal of Agricultural and Food Chemistry,38:7,1586-1590 (1990).