Journal of
Microbial & Biochemical Technology

Farag et al., J Microb Biochem Technol 2013, 5:1
DOI: 10.4172/1948-5948.1000091

Research Article Open Access

Physicochemical-Microbiological Studies on Irradiated Date Fruits with Studying Migration Monomers of Packages Materials

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Abstract

Different food packaging materials (LDPE, $HDPE_{colorless}$, PET and $LDPE_{blue}$) were packaged with dates, and irradiated with **γ**-rays at 0.0, 1.0, 3.0 and 5.0 kGy. Physical, chemical analysis of Polyethylene low density LDPE-blue layer and colorless–were used. Besides studying the changes of stored dates quality, which extend to nine months under room temperature (23-25°C, 70-75% RH%) and freezing (-3°C), no significant effects were observed in LDPE, as in the permeability of oxygen, carbon dioxide transmission rate and water vapor, or migration tests up to 20.0 kGy; whereas the differences were significant in the mechanical characters. Detection of free radicals using Electron Spin Resonance (ESR) proved presence of free radicals at high dose (20.0 kGy), then disappeared after three weeks. GC-MS analysis of polymers showed produce 18 compounds after irradiation processes, which are volatile or non–volatile compounds at the applied doses. The major constituent was di-n-butylphthalate, which was affected by irradiation. Its concentration was 98.33 % (control), and then decreased to 95.91%, 72.57% by 5.0 and 20.0 kGy, respectively. One of the Radiolytic Products (RPs) are more toxic as bis(2-ethylhexyl)phthalate (0.59%), as mentioned by WHO. Irradiation did not cause significant changes in date's quality, except the color; only more darkening in color during long storage was observed at room temperature, light color resulted at frozen storage. γ-rays eliminated insects completely and decreased the microbiological contamination in irradiated samples.

Keywords: γ-irradiation; Migration; Fruits; Polyethylene; Dates

Introduction

The packaging materials in contact with the food must be analyzed before using, in order to investigate the potential migrants that could be transferred from the material to the food [1]. A recently approved proposal by the Council of Europe requires the control and analysis of a series of contaminants, such as heavy metals, plasticizers, aromatic amines, polyaromatic hydrocarbons, benzophenone, Diisopropyl-naphthalenes (DiPN's), Fluorescent Whitening Agents (FWA), Penta-chlorophenol (PCP), and residual solvents, among others [2]. Some of these studies have been carried out, but mostly depend on using food stimulants; for instances, solvents at different factors, as temperatures and pH values [3-5]. The interaction for food contact can affect on flavor, aroma, taste of product [6], or the mechanical properties of polymers [7]. The dietary exposures to RPs formed in the materials surveyed were determined to be less than 0.5 µg/kg in the daily diet, less than the threshold of regulation concern level, as per 21 CFR 170.39. However, the author noted that in contrast to the base polymers, the adjutants identified in the survey were not currently listed in 21 CFR 179.45 [8,9].

The conventional method of date conservation after harvest is cold storage at -3°C. This is the most suitable method for the sensitive soft-fruit cultivars, but it is highly energy consuming, as showed by different workers in Israel [9-11]. Recently, more than 40 countries used γ-irradiation on commercial scale for 125 food commodities as spices, fruits, dried vegetables, and other food stuffs.

Therefore, the present work aims to study the effects of γ-rays on used package materials of date fruits, determine the rate of monomer migration by using simulants solvents models, after irradiation of different materials, besides studying the biochemical and quality characters of dates during storage.

Materials and Methods

Irradiation of packaging materials

The used bags practically in food irradiation are multilayer packages, which already contain two craft layers, then polyethylene blue layer, which has contact with food directly. Therefore, LDPE-blue layer was selected for testing migration and GC-MS analysis. In the same time, all over migration test was done for famous package materials $LDPE_{colorless}$, $HDPE_{colorless}$ and PET. Different types of polymers were irradiated with different doses as followed in table 1.

Irradiation process and storage conditions

Packaged dates were exposed to different doses as 0, 1.0, 3.0 and 5.0 kGy. Dates were **γ**-irradiated by using Cobalt-60 source (Indian cell), with dose rate10 kGy. hr^{-1} at room temperature (20°C). The irradiation source had been calibrated by the National Physical Laboratory (NPL, Teddington, UK), using the dichromate dosimetry system. Every dose had two types of bags, multilayer bags (6 bags) and $LDPE_{colorless}$ bags (6 bags). Dates were divided to two groups: first one was stored at room temperature (20°C, 70-75% RH%), whereas, the second stored at (-3°C)

Polyethylene type	Doses (kGy)	Thickness(mm)
$LDPE_{colorless}$	0.0, 3.0, 5.0, 10 and 20	0.02
$LDPE_{blue}$/2 craft layer	0.0, 3.0, 5.0, 10 and 20	0.02
$HDPE_{colorless}$	0.0, 3.0, 5.0, 10 and 20	0.02
PET	0.0, 3.0 and 5.0	0.4

Table 1: The tested packaging materials.

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Received November 03, 2012; **Accepted** December 12, 2012; **Published** December 17, 2012

Citation: Farag SEA, Shaltoot A, Emam M, El Nawawey M, El Dien AE (2013) Physicochemical-Microbiological Studies on Irradiated Date Fruits with Studying Migration Monomers of Packages Materials. J Microb Biochem Technol 5: 006-012. doi:10.4172/1948-5948.1000091

for 9 months. Every treatment had three replicates (each 250 gm), for each type of bags.

Parameters of packaging materials

A- Physical and mechanical properties of packaging materials: Some characteristics of the packaging materials were tested like thickness, elongation at break% (Iso R-527), tensile strength MPa (Iso R-527), and permeability properties (O_2, CO_2, H_2O). The thickness of the package materials was measured using a micrometer "Caliper". These measurements were determined at central lab in NCRRT, Nasr City, Cairo, Egypt, whereas, the permeability for LDPE–blue was measured in Food Industries Development Center, Kaha, Kalubia, Egypt. All parameters were determined using the American standard test method [12].

B-Chemical analysis

Overall migration test: Overall migration tests from LDPE (colorless) HDPE (colorless), LDPE (blue) and PET into food stimulants were conducted using two food stimulants (acetic acid 3% v/v, iso-octane), according to the recommended techniques [13-19].

GC-MS of migrated compounds: All samples of exposed stimulants of LDPE (blue), blanks and standards were analyzed by GC-MS. With column: DB-5MS (30 m×0.25 mm×0.25 μm), oven temperature program was 50°C/5min, then 280°C/5min, and the end at 15°C/min the injector temperature: 280°C, GC-MS interface temperature: 280°C and MS source temperature: 230°C; Electron Impact (EI) ionization; scan mode, whereas, Helium flow rate: 1.5 mL/min [20-22].

Electron Spin Resonance (ESR)

4.5.1) ESR-spectroscopy measurements: The dried samples were prepared; ESR measurements were carried out two weeks after irradiation, to avoid any false signal due to grinding, according our preliminary experiment in preparation samples [23]. ESR spectra were measured with an X-band ESR spectrometer (Bruker, EMX) at room temperature, using a standard rectangular cavity (4102 ST) operating at 9.75 GHz., with a 100 kHz modulation frequency. The ESR parameters were chosen to provide the maximum signal-to-noise ratio for non-distorted signal. The microwave power and modulation amplitude were 6.3 mW and 1 G, respectively. The response time constant was 40 ms, with the field-sweeping rate of 100 G/164 s. The intensity of each sample was measured three times as the peak-to-peak height, and average values of these measurements were plotted. The standard deviation was about 0.5% from the mean value. Standard samples of MgO doped with Mn^{2+}, weak pitch and DPPH (a; a-diphenyl-b-picrylhydrazyl) were used to calibrate the ESR intensity and the g-factor of the signal. ESR measurements and analysis were carried out at National Institute for Standards (NIS) [24].

Physiochemical and microbiological characters of dates

Date palm (*Phoenix dactylifera*) fruits, semi dry variety siwi were used in the present experiment. The following characters were studied.

Physical characteristics: The main physical of dates characters as weight loss, Total Soluble Solid (TSS) and texture were measured, according to AOAC [24,25]. Physical observations of insect infestation were examined, recorded and calculated as percentage of the sound dates by staff members of Entomology Lab., NCRRT.

Chemical analysis: Moisture content and pH-values were determined as methods of AOAC [25]. HPLC-analysis of monosaccharide was determined and quantified by Shimadzu Shim-Pack SCR-101N column (7.9 mm×30 cm), using deionized water as the mobile phase (flow rate 1 ml/min at 40°C) and refractive index detection [26]. UV/visible scan were done using the mixtures of dates with UV/visible spectrophotometer Unicam 8625 (Japan) [24].

Microbiological analysis: Total Bacterial Count (TBC) and Total Fungal Count (TFC) were determined using plate count method [27,28].

Statistical analysis: Data were analysed statistically using ANOVA programme, using computer with Duncan analysis [29].

Results

γ-irradiation- effects on packaging materials

Mechanical properties: As shown in table 2, γ-irradiation increased the elongation (E%) of HDPE from 83.83% (control) to 210.50%, after using 5.0 kGy significantly, then E% decreased by increasing doses**.** Whereas**,** same values increased with LDPE only, by using 3.0 kGy significantly, but no significant effects were observed with the other doses. In the same time, proportion increase of E% resulted by increasing dose for LDPE-blue at 10.0 kGy, 20.0 kGy, significantly**.** Same trend was observed for PET at 3.0 kGy, which increased significantly, then decreased at 5.0 kGy. The opposite trend was in parallel with tensile strength values (Mpa).

Effect on permeability: Oxygen, carbon dioxide transmission rate, and water vapor permeability of tested LDPE-blue–common used for dry food irradiation-results as shown in table 3. No significant effect was observed for using γ-rays with different doses on these parameters.

Over all migration test: As shown in table 4, using simulants solutions as iso-octane, acetic acid (3%) for overall migration of irradiated LDPE, proved that no significant effect by irradiation doses up to 20 kGy.

ESR signals for tested samples: The ESR spectra for radical species in irradiated plastic samples are characterized by signal with spectroscopic splitting factor (g-factor) of $g^{\perp}$=2.00663 (Table 5). ESR signal ascribed to free radical induced free radicals of cupper

Dose	$HDPE_{colorless}$		$LDPE_{colorless}$		$LDPE_{blue}$/2craft layer		PET	
kGy	E (%)	T (Mpa)	E (%)	T (Mpa)	E (%)	T (Mpa)	E (%)	T (Mpa)
0.0	83.83 b	6.943 c	134.70 b	11.040 d	107.20 c	11.873 b	32.02 a	29.550b
3.0	208.38ab	41.250 a	383.33 a	33.333 ac	114.33 b	18.246 b	20.10 b	50.533 a
5.0	210.50 a	27.917ab	318.33ab	30.257abc	130.12ab	55.013ab	3.87 c	20.083b
10	2.90 c	13.820bc	270.17ab	19.167bcd	160.67 a	65.000 a	-	-
20	2.90 c	21.593bc	335.43ab	35.833 a	167.90 a	1.733 a	-	-

-"E": Elongation at Break, and "T": Tensile strength. Values with the same letter(s) are insignificant difference at 5%.

Table 2: Mechanical properties of irradiated packaging materials.

Dose	O_2 (c^3/m^3)	CO_2(c^3/m^3)	H_2O(g/m^2)
0.0kGy	1090	3300	3.2
10 kGy	1100	3400	3.14
20 kGy	1070	3200	3.12

-Values with the same letter(s) are insignificant difference at 5%

Table 3: Effect of γ-rays doses on the permeability of LDPE-blue.

Weight loss of packaging material (mg/200cm^2)	Dose (kGy)				
PET(Italy)	PET(local)	HDPE	LDPE	LDPE blue	-Isooctane (20°C/2 days:
29 a	5.0 a	4.0 a	5.0 a	3.0 a	0.0
28 a	4.0 a	4.0 a	4.0 a	2.0 a	1.0
28 a	4.0 a	4.0 a	4.0 a	2.0 a	1.0
3.0 a	4.0 a	4.0 a	3.0 a	1.0 a	-0.0 Acetic acid 3% (70°C/2 hr)
2.0 a	3.0 a	3.0 a	2.0 a	1.0 a	1.0
2.0 a	2.0 a	3.0 a	1.0 a	1.0 a	5.0

(same letter mean no differences at 5%)

Table 4: Migration test results as changes of weight tested materials.

Dose	Period after irradiation (week)			
kGy	0	1	2	3
0.0	40.718	-	-	-
10	61.868	40.404	-	-
20	94.257	82.34	67.172	41.15

Table 5: ESR-intensity of irradiated plastic during storage.

with LDPE-blue. The signal was clear even 2 weeks for 10.0 kGy, but disappeared after three weeks, and gradually decreased to 20.0 kGy in three weeks.

GC-MS analysis: As shown in table 6 and figures 1-3, GC-MS analysis of LDPE-blue proved presence of 18 compounds. The major one are Di-n-butyl phthalate (DBP), which occupied 98.33% in un-irradiated sample, then decreased to 95.91% at 5.0 kGy and 72.57% at 20 kGy, respectively. In the same time, GC/MC analysis proved that irradiation degradation effects were observed at 5.0 kGy on the major compound (DBP), to produce new traces as some toxic volatile or non–volatile compounds as Octane (0.12%), Undecane (0.18%), Gamma-Himachalene (0.28%), Hexadecane (0.78%), n-pentacosane (0.39%), 2-methylheptadecane (0.01%), Nanodecane (1.01), henicosane (2.00%), tetracosane (0.41%), pentacosane (17%), bis(2ethylhexyl)phthalate (0.49%), heptadecane (0.48%), Octadecane (0.82%), and docosane (1.80%). Trace of these compounds and concentration depends on dose as in table 6.

Physical, chemical and microbiological properties of dates

Effect of packaging materials on quality of stored dates after irradiation: No significantly effect was observed for using irradiation of packaging materials on dates quality as in table 7.

Effect of storage period and temperature on quality of dates: Storage at room temperature was more significantly effective than freezing on the physical dates characters as WT (%), texture, moisture (%), TSS (%), and chemicals as pH and browning values, as recorded in table 8; whereas freezing affected only on WT (%), moisture (%), besides TSS and pH of freezing date fruits.

Effect of irradiation dose on quality of stored dates: γ-irradiation dose as shown in table 9 showed that WT (%) and browning values at room temperature were more affected significantly. Irradiation decreased WT (%) compared with untreated samples, but the brown dates was more darkening. On the contrary, freezing improved color of dates with attractive color for consumers, even at all doses. Also, freezing decreased WT (%) and increased TSS values.

Sugars: Sugar content is considered as the main component in dates, as shown in table 10, HPLC-analysis proved presence of sucrose, glucose, fructose and xylose. Sugars content is present with different concentration (%) and more affected with storage conditions. Sucrose increased rapidly for control samples from 0.64 (at zero time of storage) to 1.24 (room temperature), and 2.75 after storage of nine months at freezing conditions. Generally, freezing caused accumulation sugars, either in irradiated or not irradiated date's samples. Results showed that storage period and temperature caused significant changes, whereas irradiation not affected most of these characters.

Browning: The recorded values of measuring browning chemically showed that storage temperatures are the main role affecting, as in table 8**.** Stored samples at room temperature, especially at zero time after nine month at room temperature were more darkening, especially the irradiated samples at higher doses (3.0 and 5.0 kGy). Whereas, freezing dates samples were more attractive in color, regardless of irradiation doses. Only low dose gave the lower value of non-enzymatic browning. These data are in parallel with Hunter color (Table 11), whereas, Lighting (L) values increased from storage at room temperature to more lighting at freezing; for instance, 22.09 to 26.64 (control), 22.54 to 25.64 (1.0 kGy), 23.28 to 28.27 (3.0 kGy), and 22.82 to 25.68 for 5.0 kGy, respectively, at same conditions.

Contamination with insects and microorganisms: Physical examination of dates by using binocular showed that irradiation was more effective on controlling all stages of insects, as in table 12, either during or end of storage. Whereas, freezing keep all dates, but it is more expensive than room temperature. Most of dates in un-irradiated samples contain phases and stages of *Ephestia spp* insects, as pupa and eggs.

Discussion

High loss of date quality is recorded annually due to infestation, contamination with microorganisms, either during handling or storage, under unsuitable conditions [9]. Using **γ**-rays after packaging process for fruits proved the possibility for keeping quality and shelf life in the present work. Different packaging materials are recommended for food irradiation by some authorities, from physical view, not from human health side. Using different recommended package materials (LDPE, $HDPE_{colorless}$, PET and $LDPE_{blue}$) in food irradiation containing dates after irradiation with 1.0, 3.0, 0.5 kGy, besides untreated samples were done to study the different sides view either for packages or date fruits quality. Physical, chemical analysis of Polyethylene low density LDPE-blue layer and colorless–were used. **γ**-rays caused some increase

No.	RT	compound	0.0 kGy	5.0kGy	20 kGy
1	3.47	Octane	-	12.12	1.07
2	9.38	Undecane	-	0.18	-
3	13.66	Gamma-Himachalene	-	0.28	-
4	13.69	Pentadecane	-	-	0.69
5	14.5	Hexadecane	-	0.78	1.56
6	14.89	n-pentacosane	-	0.39	-
7	15.3	heptadecane	0.32	1.48	3.62
8	15.79	2-methylheptadecane	-	1.01	-
9	15.93	Octadecane	0.54	2.82	8.13
10	16.41	Nanodecane	-	3.41	4.79
11	16.59	Haxadecanoic acid	-	-	2.7
12	16.77	Diethylphthalate	0.37	-	-
13	16.88	di-n-butylphthalate	98.33%	95.91%	72.57%
14	17.44	henicosane	-	2.25	2.77
15	17.97	docosane	0.43	2.73	2.1
16	19.95	tetracosane	-	0.41	-
17	20.52	pentacosane	-	0.17	-
18	21.01	bis(2-ethylhexyl)phthalate	-	0.59	-

Table 6: GC-MS of migrated compounds from irradiated PET.

Browning	p -value	T.S.S. (%)	Moisture (%)	Firmness (g/cm²)	Weight loss (%)	Type of polyethylene
Storage room temperature						
1.190 a	5.746 a	24.22 a	8.910 a	1.870 a	1.080 a	LDPE(blue)
1.180 a	5.759 a	24.02 a	9.240 a	1.890 a	0.530 a	LDPE (colorless)
Storage at freezing(-3°C)						
1.060 a	5.980 a	24.91 a	9.247 a	1.295 a	0.170 a	LDPE(blue)
1.060 a	5.980 a	24.91 a	9.247 a	1.295 a	0.170 a	LDPE(blue)

Table 7: The interaction effect analysis of packaging materials with other factors on quality of stored dates.

Browning	pH -value	T.S.S. (%)	Moisture (%)	Texture (g/cm²)	Weight loss (%)	Storage period (month)
Storage room temperature						
1.180b	6.529a	25.75 a	10.16 a	1.290 b	0.010 b	Zero time
1.180b	6.529a	25.75 a	10.16 a	1.290 b	0.010 b	Zero time
Storage at freezing(-3 C°)						
1.180a	6.520a	25.75 a	10.16 a	1.290 a	0.000 b	Zero time
1.150a	5.430b	24.08b	8.500 b	1.300 a	0.320 a	After 9 months

-Values following by the same letter(s) are not significantly different 5%

Table 8: The interaction effect analysis of storage period with other factors on quality of stored dates.

Browning	pH-values	T.S.S. (%)	Moisture (%)	Firmness (g/cm²)	Weight loss (%)	Irradiation dose (kGy)
At room temperature						
1.430 b	5.860 a	24.30 a	8.408 a	1.900 a	1.510 a	0.0
1.440 ab	5.790 a	24.40 a	8.908 a	1.800 a	0.560 b	1.0
1.590 a	5.560 a	23.86 a	8.930 a	1.750 a	0.620 b	3.0
1.980 a	5.816 a	24.33 a	9.075 a	2.030 a	0.530 b	5.0
At freezing (-3°C)						
0.880 a	6.010 a	24.43 c	9.070 a	1.250 ab	0.280 a	0.0
0.950 a	5.950 a	25.46 a	9.240 a	1.430 a	0.090 b	1.0
1.190 a	5.930 a	24.66 bc	9.590 a	1.210 b	0.140 b	3.0

-Values following by the same letter(s) are not significantly different 5%

Table 9: Interaction analysis of **γ**- irradiation dose and other factors on quality Siwi dates**.**

Dose(kGy)	Sucrose%	Glucose%	Fructose%	Xylose%
-Zero time of storage				
0.0	0.64	43.4	53.3	2.63
1.0	1.8	44.3	52.8	1.8
5.0	1.01	44.2	52.6	2.42
-After 9 months at room temperature				
0.0	1.24	44.3	53.2	1.26
1.0	1.48	41.3	55.9	1.23
5.0	1.43	44.8	52.6	1.19
-After 9 months at -3°C				
0.0	2.75	43.8	52.3	1.14
1.0	2.53	44.2	51.5	1.01
5.0	2.49	42.4	51.5	0.91

Table 10: Effect of gamma irradiation on sugars content of dates during storage.

Storage	Hunter values	Dose (kGy)			
		0.0	**1.0**	**3.0**	**5.0**
RT	L	22.09	22.54	23.28	22.82
	A	6.27	5.27	7.21	5.47
	B	6.27	5.27	7.58	5.55
-3C°	L	26.64	25.64	28.27	25.68
	a	12.79	11.79	13.05	11.83
	b	14.05	10.05	14.97	10.94

RT= Room Temperature

Table 11: Hunter parameters (L, a, b) of treated date fruits after 9 months of storage at room temperature and at -18°C.

Dose kGy	Zero time	End of storage
0	0.0 ± 0.0	78.4 ± 2.12
1	0.0 ± 0.0	0.0 ± 0.0
3	0.0 ± 0.0	0.0 ± 0.0
5	0.0 ± 0.0	0.0 ± 0.0

Table 12: Percentage of insect infestation for irradiated dates during storage at room temperature.

Dose(kGy	Control	1.0kGy	3.0kGy	5.0 kGy
Total bacterial count (T.B.C)				
Zero time	**13.89×10^2**	**3.04×10^2**	**-------**	**-------**
After 9 months: -Room temperature -Freezing	 500×10^3 100×10^3	 200×10^3 5.5×10^3	 54.5×10^3 3.5×10^3	 32×10^3 1×10^3
Total fungal count (T.F.C)				
Zero time	52×10	16.77×10	8.25×10	------
After 9 months: -Room temperature -Freezing	 155×10 25×10	 10×10 10×10	 10.5×10 10×10	 10×10 ------

Table 13: Microorganisms load of irradiated date fruits during storage period.

of significance in the mechanical characters as elongation [7,12-14,30], but insignificant as gas permeability [30,31].

Additives are commonly introduced during polymer processing and production, to prevent loss of mechanical properties and discoloration caused by the oxidation of polymers [32,33]. Dibutyl phthalate (DBP) is commonly used as plasticizer. After the food has been sealed in its packaging, additives in the packaging polymer can remain in the polymer, partition to the polymer/food or polymer/air interface, or migrate from the polymer into the food [33]. Our results of migration at applied doses for food can be considered undetectable or very low, as traces for detection by used methods [20].Whereas, using GC-MS of LDPE-blue plastic proved presence of 18 compounds due to radio-degradation of polymer, to produce volatile or non–volatile compounds at the applied doses. The major constituent in LDPE-blue is DBP, which was more affected by irradiation. Its concentration was 98.33% (control), which decreased to 95.91%, 72.57% by 5.0 and 20.0 kGy, respectively. DBP and their metabolites have the greatest potential for toxicity [3,20].The World Health Organization's International Agency for Research (WHO) showed that some of the Radiolytic Products (RPs) are more toxic, as bis(2-ethylhexyl) phthalate cause cancer [18-21,34-40]. Also, the gases and low molecular weight radiolysis products are reported to produce in polymers after ionizing radiation treatment [18,19,38-41]. Some authors showed that the radio-degradation volatiles may induce off-odors in fruits or polymers [20]. Unfortunately the packaging process in the present work was done in presence of oxygen, which activate the degradation and oxidation of the new products upon irradiation. Therefore, better in the future, using under vacuum is preferred to avoid these fast degradation [20,34,40]. Therefore, these materials are not safe, not suitable for human healthy consumption, especially in presence of oxygen [35].

The traceability of free radicals in irradiated tested plastic (LDPE-blue) proved that ESR spectra for radical species are characterized by signal with spectroscopic splitting factor (g-factor) of $g_{\perp}$=2.00663. ESR-signals were observed even three weeks in irradiated packages. Same results on plastic sheet were obtained by many workers [21]. No hazardous effect for presence of free radicals in packaging materials was seen, especially it disappeared completely after few weeks, whereas, no signals were observed with other plastic samples (LDPE $_{colorless}$- HDPE $_{colorless}$- PET) directly after irradiation.

Studying, the changes of stored dates quality which extend to nine months under room temperature (23-25°C, 70-75% RH%) and freezing (-3°C); irradiation did not cause significant changes in dates quality, except the color; only more darkening in color during long storage, especially at room temperature where best color resulted with frozen fruits. γ-rays eliminated insects completely and decreased the microbiological contamination in irradiated samples. Sugar

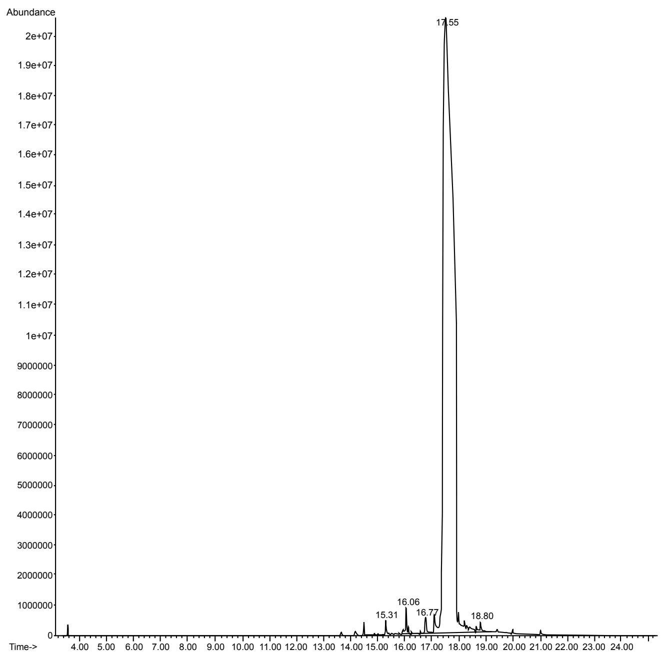

Figure 1: Migration without irradiation.

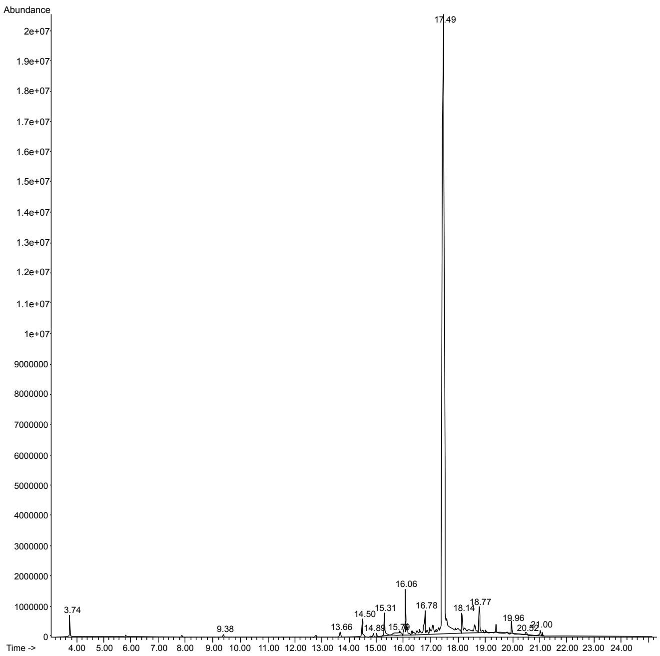

Figure 2: Effect of 5 kGy on migration of Di-n-butyl phthalate.

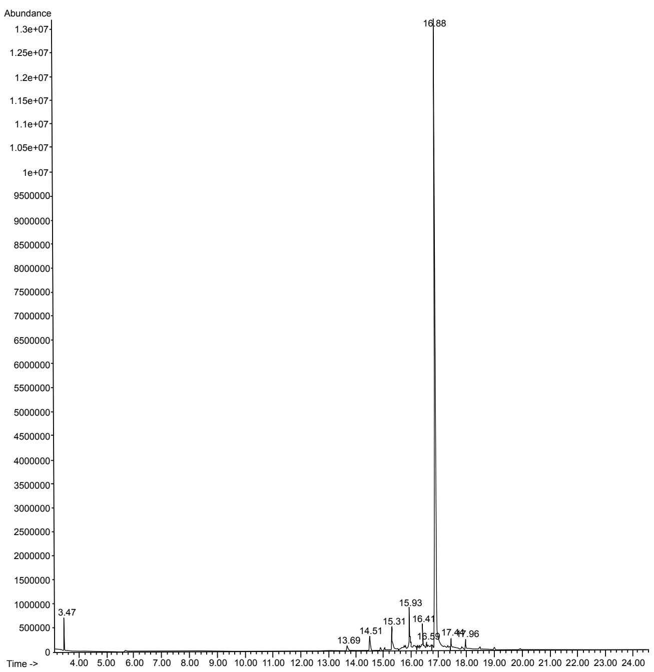

Figure 3: Effect of 20 kGy on migration of Di-n-butyl phthalate.

content occupied high content in dates, as shown in table 10, many monosacharides are present as sucrose, glucose, fructose and xylose. These sugars are present with different percentages and more affected with storage conditions. Generally, freezing caused accumulation of date sugars, either irradiated or not [41]. Also, storage time or temperature caused significant changes on most of these characters; whereas, irradiation did not affect significantly on most of the present characters, except browning, which was more sensitive for storage condition, temperature and irradiation doses.

The physical examination of dates by using binocular proved eliminated insects by irradiation completely during long storage period (Tables 12 and 13). Also, either the Total Bacterial Count (T.B.C) or total fungal count (T.F.C) of irradiated samples of date fruits was less in irradiated date fruits even after nine months, especially during freezing storage. Irradiation at 3.0 and 5.0 kGy which was considered a factor for improving the health side of date's samples for consumers' health was less in irradiated date fruits even after nine months, especially during freezing storage. Irradiation in all doses improved the healthy for human health; same results were obtained by workers [30].

Conclusion

Generally, using γ-irradiation at low dose for packaging horticultural products, especially under vacuum-using polyethylene colorless (LDPE), are the best way to avoid the degradation upon irradiation process. The used polymers should undergo for migration test and GC-MS, to assist that used polymers in packaging horticultural upon irradiation are resistant to produce toxic substances for human health. In the same time, using low doses of γ-rays are enough for disinfestations and decontamination at room temperature than freezing from economical side, to keep quality of dates during long storage.

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