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Composition and Physic-chemical Analysis of Fresh and Dehydrated Egg, and Gamma Irradiated Egg Powder

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This paper describes selected chemical, physical and analytical composition of fresh chicken egg (FCE), whole egg powder (WEP), and irradiated whole egg powder (IWEP). WEP samples were irradiating at 0, 5, 10 and 15 kGy using gamma irradiator. Analysis determined the approximate compositions, chemical and physical properties including the percentage of moisture, crud fat, crude protein, total sugar, reducing sugar, and ash, total acidity, pH value, total volatile basic nitrogen (TVBN), viscosity and color changes in FCE, WEP and IWEP. The results indicate that the FEP and WEP could be a fine resource of nutrients for consumers to select. In general, no considered differences observed in proximate components of WEP and IWEP. The results shows some differences in the analyzed chemical and physical parameters between WEP and IWEP. However, the tested physical and chemical parameters were all well within the acceptable limits for samples of FCE, WEP and IWEP.

Key words: Fresh egg, Egg powder, Gamma irradiation, Proximate composition, Physic-chemical properties

Chicken eggs are a good food supply a upper-balanced source of nutrients, and have been documenting as one of the best sources of most of the essential amino acids and unsaturated fatty acids for human diet throughout the world (Mohanta *et al.*, 2018). Eggs are used for nutritional enrichment of some types of food and food products, since the egg have the macro and micro nutritional components. Egg components mainly proteins have an important portion to the food preparation due to the functional characteristics (Radvanyi *et al.*, 2012).

The exterior and interior egg property is one of the most important indicators for the producers, processors and consumers. Therefore, the scientists are giving more emphasis to maintain the quality of eggs (Peric *et al.*, 2017). Moreover, the fresh eggs are highly perishable food type, which can reduce its quality quickly during the storage period. Raw egg has short shelf life at the ambient conditions, and a little extended under refrigeration storage (Orishagbemi *et al.*, 2017).

At present, the use of fresh egg in food preparation, as the raw material has decreased with the development of food industry technology and egg products technology such as dried egg products have gained popularity (Kumaravel *et al.*, 2012).

The evaluation of radiation-induced some chemical modifications could supply important acknowledgment on the possible risk factors of irradiation treatment for food quality and food safety (Al-Bachir and Othman, 2018; Al-Bachir, 2010; Al-Bachir *et al.*, 2010). The process used to irradiate eggs to decontamination, and extent the shelf life of eggs and its products may be linking to an alternative cold pasteurization or sterilization method without increase the temperature of the treated products (Al-Bachir and Zeino, 2006).

Several studies showed that irradiating fresh egg and egg products to dosage of about 2 to 3 kGy was effective to eliminate pathogenic microorganisms including Salmonella without significant alterations in quality or sensory properties (Aquino *et al.*, 2017). The irradiation treatment may produce some changes in the secondary structure of the egg, which can also induce significant alteration in functional properties of fresh egg and egg products due to the oxidation of egg components by free radicals which produced during the ionizing the water molecules (Min *et al.*, 2005; Min *et al.*, 2012). However, major concerns with irradiating animal food for human nutrition are quality changes such as the occurrence of off-flavor and the acceleration of lipid oxidation (Al-Bachir, 2013).

There is no report on the assessment of composition, and physical and chemical properties of irradiated or un-irradiated egg produced under Syrian conditions. Therefore, this study has been undertaken to evaluate the proximate composition of fresh chicken egg (FCE), whole egg powder (WEP) and gamma irradiated whole egg powder (IWEP) that produced under Syrian conditions.

MATERIALS AND METHODS

The fresh chicken eggs (FCE) used in this study were obtained from Sidnaia Poultry Farms, in Damascus Syria. The samples of 30 eggs was considered as replicate (three replicates for each treatments) were analyzed immediately after laid. The eggs were candling to confirm their freshness and were cleaning by dusting, washing and allowed to prepare. They were carefully de-shelling and separated as whole egg (WE), egg weight (EW); egg yolk (EY), and egg shell (ES). Egg weight was measuring on a precision scale. Chemical composition and physical and chemical properties of all parts of FCE were determined immediately after collection within 7 day of being laid.

Dried eggs preparation

The FCE were carefully de-shelled and whole egg liquid obtained in a graduated cylinder. Whole egg liquid was mixed in a blender (WARING commercial blender model 32BL80 made in U.S.A) for 1-2 min, liquid egg was spread thinly (0.5 – 1.0 mm thickness) on tray and oven dried at 60 ºC for 48 hours in a laboratory oven (MEMMERT model 600) to constant mass and allowed to cool. The egg flakes were scooping, milling and sieving with 60 mm mash and then weighed. The whole egg powders (WEP) were packing into different polyethylene pages for further investigation (each page considered as replicate).

Irradiation treatment

Whole egg powder (WEP) were irradiated with dose of 0, 5, 10 and 15 kGy, using a gamma source 60CO (ROBO, Russa) at dose rate of 7.775 kGy h^{-1}. The absorbed dose was monitoring by alcoholic chlorobenzene dosimeter (Al-Bachir *et al.*, 2010).

Chemical composition, physical and chemical characteristics of whole egg powder (WEP) and irradiated whole egg powder (IWEP) were determined immediately after irradiation.

Chemical analysis

The proximate contents of FCE, WEP and IWEP samples including moisture (water content) by drying for 6 h at 105 ºC, ash (mineral content) by ashing for 4 h at 550 oC, crude fat (in term of component extracted by Soxhlet apparatus), crude protein (in term of kjeldahl nitrogen), total sugar (as absorbance at 620 nm by spectrophotometer, (PG Instrument Ltd)), reducing sugars (in term of g glucose 100 g^{-1} products) were determined according to the standard methods (AOAC, 2010).

The chemical properties of FCE, WEP and IWEP samples including pH values (using an HI 8521 pH meter (Hanna Instruments, Woonsocket, RI, USA)). aacidity value (AV) as (Oleic acid %), total volatile basic nitrogen (TVBN) as (mg VBN kg^{-1} eggs (ppm)), thiobarbituric acid (TBA) number in term of mg MDA kg-1 sample were measured according to the standards methods as described by Al-Bachir (2014) and Al-Bachir and Zeino (2006).

Physical analysis

Viscosity values were determined and expressed as mPa s-1 using a viscometer (Model RTM, Townson and Mercer, Altrincham, UK) according to the methods as described by Min *et al.* (2012). Color analysis was performed by using AvaSpec Spectrometer Version 1, 2 June 2003 (Avantes, Holland) and expressed as color L* is lightness (black point L*=0, white point L*=100), a* is characteristics to red-green color, and b* is the blue-yellow color (sign; +a* red, -a* green, +b* yellow, -b* blue), and overall color difference (ΔE). Reflectance values were obtaining at wavelength of 568 nm by exposing the samples to the illuminant (Kwon *et al.*, 2009). However, the reported results (L*, a*, b*) are the mean of 9 determination.

Statistical analysis

Data collected during the study were subjected to the analysis of variance test (ANOVA) utilizing the SUPERANOVA computer package (Abacus Concepts Inc, Berkeley, CA, USA; 1998). The model included the main effects of the irradiation doses of egg powders. The differences among means (at $p<0.05$ were compared by using Duneans multiple rang test. The degree of significance was denoted as: $p<0.05$*.

RESULTS AND DISCUSSION

Proximate compositions of FCE

Table 1 shows the real values of the different tests as well as our measuring results. The weight of tested fresh chicken egg (FCE) was 66.43±1.32 g. The mean egg weight reported in this study was higher than the present estimates and ranged from 34.25 to 38.98 g for FCE (Mohanta *et al.*, 2018). However, the studied FCE consist of 57.80% egg weigh (EW), 27.07% egg yolk (EY), and 12.29% egg shell (ES). Bertechini and Mazzuco (2013) reported that the interior edible part of FCE has two compartments, which are the EW (59%) and EY (31%). Eggshell makes up from 9-12% of the total egg weight (Ray *et al.*, 2017). As shows in Table 1, among all parts of FCE, EY showed slightly higher crude protein (16.71%), and crude fat (24.40%) content, followed by WE (12.25% and 5.75%), and EW (10.40% and 0.00%), respectively. The relatively lower crud protein and crud fat content of WE and EW could be due to the high-water contents of FCE, which represent 49.97%, 79.95 and 86.06% of EY, WE and EW, respectively. Furthermore, EY from tested FCE had higher ash content (3.59%) followed by WE (1.95%) and WE (1.15%). Finally, EY showed slightly higher total sugar (2.82%), and reducing sugar (2.16%) content, followed by EW (2.20% and 1.53%), and WE (2.04% and 1.11%), respectively. Therefore, FCE provide a well-balanced source of nutrients, and could be a fine resource of nutrients for consumers to select. The Food and Agriculture Organization of United Nations (FAO) rated the whole egg protein's biological value at (93.7) which based on a 100-point scale (Asghar and Abbas, 2012).

Moister, crud protein, crud fat, carbohydrate and ash contents of the tested FCE samples were in accordance to the contents determined previously by other researchers (Akpinar-Bayizit *et al.*, 2010). Nevertheless, although different compositions have been determined by some authors, in general, the macronutrient content of FCE include low carbohydrate (0.67 g) and about 12 g per 100 g of protein and fat (Asghar and Abbas, 2012; Naderi *et al.*, 2017). It is well establishing that diet, strain, hen age, and other environmental factors, quality of the raw materials and processing procedure affect the size and composition of eggs (Rossi *et al.*, 2010).

Chemical properties of FCE

The analytical findings of chemical properties on the FCEs are presenting in Table 2. The total acidity (% lactic acid) content in different parts of FCE varied between, 0.028% (EW), 0.066 % (WE), and 0.92% (EY). Also, the pH value in different parts of FCE varied between, 9.58 (EW), 8.45 (WE), and 6.33 (EY), which were higher compared with those of Farag *et al.* (2012) who stated that pH value of WE and EW of shell eggs were 7.5, 8.0 and 6.6, respectively. Staldelman and Cotteril (2007) reported that pH value of FCE could be 7.6. According to Min *et al.* (2012) the pH value of EW product was around 9.0. The rise in the pH of the egg solutions may be causing by the loss of carbon dioxide from the egg product through the pores in the shell (Eke *et al.*, 2013). Egg albumen has super food foaming properties. The foam stability was increased at pH = 8.6, and decreased with changing pH value (Lomakina and Mikova, 2006).

It shows in Table 2 that the tested FCE contained a total volatile based nitrogen (TVBN) in the order of 35.33 part per million (ppm) (WE), 44.77 ppm (EW), and 9.06 ppm (EY). Accordance with our results, other authors reported that TVBN could be founding in FCE (Al-Bachir and Zeino, 2006). However, these authors reported much higher TVBN concentrations (120 ppm) than those presented in the present study.

The TVBN value, which is regarding as one of the standard chemical indices of freshness of animal food for human nutrition including eggs was assessing. The TVBN is relating to protein breakdown, and the reported increases may be attributing to the generation of ammonia or other like compounds due to the growth of microorganisms and its activity (Al-Bachir, 2013). It is clear that FCE had a good quality as evidenced by their low TVBN values. This may be attributing to the presence of some antioxidant compounds presumably coming from the hens' fed to the hens (Al-Bachir and Zeino, 2006).

Physical properties of FCE

Table 2 presents the results of physical properties of different parts of the FCE, including the color and viscosity. Rheological properties of eggs in term of viscosity are very important in food industry and technology, therefore, the viscosity of the FCE was studding in the present work. As indicated in Table 2, the viscosity of WE, EW and EY were 55.0, 35.67 and 471.00 mPa. s-1, respectively. The results show that the analyzed samples of FCE were in agreement with the results of the literature. Atilgan and Unluturk (2008) reported that the viscosity of WE measured at temperature of 4 and 20 oC were 132.61 and 97.87 mPa. s-1, respectively. Review of the literature showed that WE have known to exhibit a Newtonian rheological behavior at temperature below 60 ^{o}C (Dadashi *et al.*, 2017). Viscosity of the slurry would reflect the change in fluid friction with dispersed egg particles. The present viscosity values could be fair indicators of a deterioration under thermal stress with controlled moisture contents (Nakagawa, Adachi and Handa, 2017).

Color analysis was performing by using spectrometer color analyzer for measuring reflect light color of FCE. The lightness "L* value" of EW (84.41) was higher than observed for EY (76.07) or WE (63.13). While the redness "a* value" and yellowness "b* value" of EY (28.60 and 90.47) was higher than observed for EW (7.73 and 44.37) or WE (3.56 and 40.66) respectively. This is because EW have no color pigments, which provides the red or yellow color of the EY. Egg color relates mainly with the content of some components such as oxycarotenoids, their concentrations are connected to intensity of color (Jesus *et al.*, 2013).

Total color differences (ΔE) is a parameter which measure the total difference in color that occurs in the value of L*, a*, b*. As showed in Table 2 the total color differences (ΔE) of WE (61.34) was higher than observed for EW (58.30) and EY (38.65). The visual impression of egg color determines the acceptability of products preparing from egg. Color is an important property of foods because it can increase or reduce it acceptability by consumers (Goldberg *et al.*, 2012).

Proximate compositions of irradiated and un-irradiated WEP

The chemical content of whole egg powders (WEP) (mix of edible parts) was determined, because in human nutrition, in general, Wes used, consumed as its, or included in a prepared product. The proximate compositions obtained from the WEP samples are showing in Table 3. The overall average contents of moisture, ash, crude fat, crude protein, total sugar, and reduced sugar content of WEP samples are 3.75%, 47.42%, 35.43%, 5.27%, 3.36% and 2.24% respectively. The composition estimated, showed high nutritional value when compared to that of FCE. Proximate compositions content of studied WEP samples were similar to the percentages measured previously by other workers (Akpinar-Bayizit *et al.*, 2010). The results of this study indicated that the studied WEP had high percentage (above 95 g 100 g-1 WEP) solid matter content. The solid matter contents of WEP were in agreement with the criteria of the international database in which solid matter of dried egg must be above 95 g 100 g-1 powder in order to ensure stability (Kudre *et al.*, 2018). The moisture contents of WEP (3.75%) are low enough to improve the storability of the WEP in an condition of low humidity. Water content can influence several important quality characteristics of egg products (Kumaravel *et al.*, 2012), but that fact was not indicated in this work.

Ash content of the studied WEP (5.27%) are higher than reported for spray-drying hen eggs (3.61%) (Akpinar-Bayizi *et al.*, 2010). From the results of this study, it is worth highlighting that WEP from Syrian hen egg were richer in minerals and a good source of minerals for consumer to choose. The crud protein (47.22%) and crud fat (35.43%.) content of studied WEP are similar to (47.68% and 36.1%), that reported for spray-drying hen (Akpinar-Bayizi *et al.*, 2010). The relatively higher crud protein content of WEP could be explaining by its low crud fat content.

According the obtained result, the irradiation treatments (at 5, 10 and 15 kGy) had no significant ($p<0.05$) effect on the moisture, crud protein, ash and reducing sugar of WEP (Table 3). However, there was a slight but significant ($P<0.05$) decrease in crud fat and total sugar in the WEP samples irradiated with highest doses (10 and 15 kGy) (Table 3). Results of this study are in accordance with finding of Al-Bachir and Zeinou (2006), Kim *et al.* (2016) and Farag *et al.* (2012) who reported that no differences were founding in the moisture, crude fat, crude protein, and ash contents of egg white or yolk after gamma irradiated shell eggs. The non-significant effects of gamma irradiation on the compositions of eggs may be attribute to the fact that energy associated with these doses was not enough to change the moisture contents, change the structure of protein or produce a strong radical attack to influence the configuration of protein molecules themselves (Farag *et al.*, 2012).

Chemical properties of non-irradiated and gamma irradiated WEP

The values of chemical properties of both irradiated and non-irradiated samples of WEP including total acidity (% lactic acid), pH, TBA and TVBN values are shown in Table 4. As indicated in Table the total acidity of control (non-irradiated) sample of WEP was 0.18%. Total acidity of WEP was significantly ($p<0.05$) influenced by irradiation doses. The total acidity of WEP was significantly increased by irradiation treatment ($P<0.05$) and the increase was irradiation dose dependent (Table 4).

As shown in Table 4, the pH values of control sample of WEP was 6.18. Irradiation with higher doses of gamma irradiation (10 and 15 kGy) did not affect the pH of WEP (Table 4). This result indicated that irradiation did not influence the pore structure of the WEP. The pH of irradiated WEP with 5 kGy (6.69) measured in this study was lower than that (6.80) of non-irradiated control sample of WEP. Aquino *et al.*, (2017) demonstrated that the gamma irradiation treatment showed no significant changes to the pH values to the non-irradiated control samples of WEP and 5 kGy (p=0.847) and to the non-irradiated and 10 kGy (p=0.270). Irradiation can cause ionizing of water molecule, which produces various radicals including hydrogen ion that can influence the total acidity and pH of egg (Min *et al.*, 2012). Several authors indicated an increase in free fatty acids (FFAs) for oils obtained from gamma irradiated oil seeds, which might be due to slight random decomposed of triglycerol molecules to FFAs and diacylglycerols (Bhatti *et al.*, 2013). Given the very low water content of WEP and the relatively low irradiation doses used, it is the most probable that small amount of FFAs were produced through triglycerides hydrolyses.

Considering the Thiobarbituric acid value (TBA) of WEP, the TBA value of un-irradiated control sample of WEP was 0.24 mg malonaldehyde MDA kg-1 WEP. Whole egg powder lipid oxidation determined as TBA increased significantly ($p<0.05$) with increasing the irradiation doses (Table 4). These results are somehow in accordance with those of Al-Bachir (2014) who indicated that TBA values of gamma irradiated oil seeds increased significantly ($p<0.05$) at used doses up to 6 kGy. The earlier studies reported that the role of ionizing irradiation in the production of free radicals that induce lipid oxidation in irradiated products (Kim *et al.*, 2016). The oxidation adversely effects sensory characteristics of foods, therefore, oxidation is the major factors in the quality of irradiated WEP (Lee *et al.*, 2012).

Total volatile basic nitrogen value (TVBN) of WEP as function of irradiation treatment is showing in Table 4. Results of analysis of variance (ANOVA) showed that changes in TVBN content were significant in all three irradiated samples ($p>0.05$). As seen in Table 4, an increase in irradiation doses caused a decrease in the TVBN. The minimum change in TVBN (10.24 milligrams malonaldehyde kg-1 WEP (ppm)), was recorded at the lowest irradiation dose (5 kGy), whereas, the maximum change in TVBN (8.78 milligrams malonaldehyde kg-1 WEP (ppm)) was recorded at the highest irradiation dose (15 kGy). The results of this study are in good accordance with those of Al-Bachir (2014) who found that, TVBN values of un-irradiated samples of pistachio nuts were more higher than those of the gamma irradiated ones. On the other hand, some results are in contradiction to our results, for TVBN value of fresh egg (Al-Bachir and Zeino, 2006). TVBN of fermented sausages was increasing with increasing the gamma irradiation doses (Kim *et al.*, 2012).

Physical properties of non-irradiated and gamma irradiated WEP

The color changes and viscosity values as physical properties of irradiated and non-irradiated samples of WEP are showing in Table 4. The color components in terms of lightness (L* value), redness (a* value), yellowness (b* value) and color differences (ΔE value) for the WEP samples were 78.78, 17.04, 23.92 and 80.79, respectively. This observation reported that the WEP sample evaluated in this study showed a light yellowish color improved from the combination of egg parts (yolk and egg white). Statistical analysis indicated that the redness (a* value) was not affected by irradiation, but the lightness (L*), yellowness (b*) and ΔE values are shown to be significantly ($p<0.05$) affected by gamma irradiation treatment, but humans could not recognize the differences. The ΔE* value was calculated with respect to the color of WEP sample, the results showed that there was a significant increase in the ΔE* value of irradiated WEP. However, a substantial increase in the ΔE* value was founding in samples irradiated with 15 kGy. Compare to the control sample of WEP, the WEP irradiated with 5 kGy become significantly lighter (higher L* value). While, WEP irradiated with 10 kGy become significantly darker (lower L* value). Also, WEP irradiated with 5 kGy or 15 kGy become less yellow (lower b* value).

Studies conducted by Farage *et al.* (2012) support our results, stating that the loss in yolk color by irradiation. They mentioned that oxidation of carotenoids was a likely cause of the discoloration of egg yolk exposed to irradiation. However, Kim *et al.* (2016) indicated that Hunter color L* value of the WEP increase, while the a* and b* values decreased accordance to irradiation dose. Froehlich *et al.* (2015) reported that the parameters L*, and b* did not difference in irradiated powdered egg white, while the parameter a* had negative values, suggesting green color.

The slight increase in ΔE value of WEP during irradiation is possible that the Maillard reactions, where sugars and protein components react with each other, and water in the reaction system gives mobility for the reactants which caused a higher browning rate (Katekhong and Charoenrein, 2017). Therefore, we suggest that gamma irradiation dose up to 15 kGy does not generate significant color differences in WEP. The differences in yellowness of egg yolks during irradiation could have been produced by the breakdown of carotenoids which contain unsaturated double bonds and able to be oxidized (Kim *et al.*, 2016}. Egg color relates mainly with the content of some components including oxycarotenoids; their concentrations are related to intensity of color (Jesus *et al.*, 2013).

The analytical finding on the viscosity of irradiated and control samples of WEP are presenting in Table 4. The viscosity of WEP varied between 38.33 mPa. s-1 (control sample) and 39.33 mPa. s-1 (irradiated sample at 15 kGy).

Data reported by Lee *et al.* (2003) support our results: They reported that gamma-irradiation below 10 kGy did not significantly affect the viscosity values of irradiated samples of bovine and porcine plasma protein powders. On the other hand, some results are in contradiction with our results, for the viscosity of WEP, gamma irradiation considerably decreased the viscosity values of egg white solution in an irradiation dose-dependent manner (Min *et al.*, 2012; Al-Bachir and Zeinou, 2006; Kim *et al.*, 2016).

Table 1: Proximate composition of fresh chicken egg (FCE).

Characteristics	WE	EW	EY	ES	P-level
Weight (gm)	66.43±1.32	38.46±3.01	17.99±1.88	8.17±0.56	0.0001
Percentage of components	100	57.80±4.10	27.07±3.04	12.29±0.83	0.0001
Moisture (%)	79.95±0.45	86.06±0.33	49.97±2.56		0.0001
Crud protein (%)	12.25±0.82	10.40±0.40	16.71±1.13		0.0002
Crud fat (%)	5.75±1.64	0.00±0.00	24.40±1.25		0.0001
Ash (%)	1.95±0.12	1.15±1.01	3.59±0.51		0.0105
Total sugar (%)	2.20±0.02	2.04±0.01	2.82±0.03		0.0001
Reducing sugar (%)	1.53±0.02	1.11±0.02	2.16±0.02		0.0001

(WE): Whole egg, (EW): Egg white, (EY): Egg yolk, (ES): Egg shell.

Table 2: Biochemical properties of fresh chicken egg (FCE).

Characteristics	WE	EW	EY	P-level
Total acidity (% Lactic acid)	0.066±0.06	0.028±0.01	0.92±0.08	0.0001
PH value	8.45±0.34	9.58±0.10	6.33±0.04	0.0001
Volatile basic nitrogen (ppm)	35.33±2.82	44.77±1.10	49.06±1.2	0.0001
Viscosity (mPa.s^{-1})	55.00±2.00	35.67±0.58	471.00±4.58	0.0001
Color changes				
L(Lightness)	63.13±0.91	84.41±0.34	76.07±0.33	0.0001
a (redness/greenness)	3.56±0.32	27.73±0.8	28.60±0.48	0.0001
b (yellowness/blueness)	40.66±0.96	44.37±1.58	90.47±4.46	0.0001
ΔE (Total color difference)	61.34±1.11	58.30±1.56	38.65±1.30	0.0001

(WE): Whole egg, (EW): Egg white, (EY): Egg yolk.

Table 3: Effect of gamma irradiation on moisture, ash, protein, total sugar, reducing sugar and fat contents (%) of whole egg powder (WEP).

Characteristics	Treatments				P-level
	Control	5 KGY	10 KGY	15 KGY	
Moisture (%)	3.75±0.15a	3.38±0.31b	3.59±0.14ab	3.58±0.07ab	NS
Crud protein (%)	47.42±0.04b	47.22±0.59b	47.87±0.70ab	48.87±0.71a	NS
Crud fat (%)	35.43±0.15a	35.09±0.24b	33.90±0.16c	33.72±0.08c	**
Ash (%)	5.27±0.25a	5.22±0.78a	5.24±0.25a	5.29±0.10a	NS
Total sugar (%)	3.36±0.03b	3.46±0.02a	3.29±0.06c	3.28±0.03c	*
Reducing sugar (%)	2.24±0.12b	2.43±0.02a	2.27±0.02b	2.29±0.01b	NS

[abc] Means values in the same row not sharing a superscript are significantly different..

NS: not significant.

***** Significant at p<0.05.

****** Significant at p<0.01.

Table 4: Effect of gamma irradiation on biochemical properties of whole egg powder (WEP).

Characteristics	Treatments				P-level
	Control	5 KGY	10 KGY	15 KGY	
Total acidity (% Lactic acid)	0.18±0.10d	0.20±0.01c	0.22±0.01b	0.24±0.01b	**
PH value	6.80±0.05a	6.69±0.06b	6.79±0.02a	6.83±0.03a	*
Volatile basic nitrogen (ppm)	13.82±0.56a	10.24±0.45b	9.54±1.00c	8.76±0.47c	**
TBA value (mg MDA/kg)	0.24±0.04b	0.38±0.08a	0.37±0.06a	0.37±0.01a	*
Viscosity (mPa.s-1)	38.33±2.08a	38.67±0.58a	38.33±2.08a	39.33±0.58a	NS
<u>Color changes</u>					
L (Lightness)	78.78±0.67b	82.25±0.40a	72.75±0.18b	78.71±0.24c	**
a (redness/greenness)	17.04±2.86a	15.72±0.81a	16.47±1.12a	17.36±0.46a	NS
b (yellowness/blueness)	23.92±1.60a	18.13±1.48b	24.51±2.65a	17.17±0.57b	**
ΔE (Total color difference)	80.79±1.30b	85.24±1.46a	81.2±2.62b	87.27±0.67a	**

[abc] Means values in the same row not sharing a superscript are significantly different..

NS: not significant.

***** Significant at p<0.05.

****** Significant at p<0.01.

There was no significant difference among different irradiation doses with respect to the viscosity value. The slight differences were not significant because its protein structure was not damaging by the irradiation treatment. One could observe that the viscosity of the deteriorated WEP increased with deterioration. In other words, the present viscosity values could be fair indicators of a deterioration of egg powders (Nakagawa *et al.*, 2017). The viscosity of egg and egg products makes it an ideal substrate for inclusion of air cells during the processes. During processing of liquid whole eggs, air bubbles decreases in size while the number increases as they are surrounding by egg proteins throughout the whole process (Ikegwu *et al.*, 2017).

CONCLUSION

The analytical parameters studied of fresh chicken eggs (FCE) and whole egg powders (WEP) produced under Syrian conditions including proximate components (percentage of water, crud protein, crud fat, total, sugar, reducing sugar, and ash,), chemical and physical indicators (total acidity, pH value, volatile basic nitrogen, viscosity and color changes) were within the limits established and reported in the literature. It can be concluded that, 5, 10 and 15 kGy, which were recommended in the literature for decontamination of dried foods, could be suitable for enhancing hygienical and extending the storage period of WEP without negative effect of nutrition value, physical and chemical properties of its products.

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CONFLICTS OF INTEREST

The authors declare that they have no potential conflicts of interest.

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