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EFFECT OF GAMMA RADIATION ON PHYTOCHEMICAL COMPOUNDS IN FABA BEAN (*Vicia faba* L.)

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ABSTRACT: The objective of the present study was to investigate the effect of gamma radiation on phytochemical compounds in faba bean. Samples of faba bean seeds were exposed to gamma radiation at doses of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 kGy. Then the contents of total phenolic and flavonoid compounds in non-irradiated and irradiated samples were determined. The contents of total phenolic compounds in samples of non-irradiated faba bean was found to be 220.55 ± 0.040 µg gallic acid equivalent/g dry matter, while the total flavonoids in non-irradiated samples were found to be 106.33 ± 0.450 µg quercetin equivalent/g dry matter. Exposing faba bean seeds to ascending doses of gamma irradiation induced significant gradual increases in the contents of total phenolic and flavonoid contents. The maximum increases were observed in samples irradiated at dose of 9 kGy showing increase by about 183% and 283% in phenolic and flavonoid contents, respectively. Based on these results, phenolic and flavonoid compounds in the ethanolic extracts of non- irradiated faba bean seeds and those irradiated at dose of 9 kGy were fractionated and quantified by High Performance Liquid Chromatography (HPLC). The results showed that 21 phenolic and 14 flavonoid compounds could be separated and quantified from the extract of non-irradiated faba bean seeds by HPLC. The same compounds were identified in the extract of seeds irradiated at 9 kGy dose but at increased concentrations. The effect of gamma irradiation on the contents of macronutrients in seeds as well as their water absorption properties was also determined. Significant differences were observed in the proximate chemical composition between samples of non-irradiated faba beans and those irradiated at doses up to 10 kGy. However, irradiation treatments generally induced slight, but statistically significant, increases in the values of water absorption properties as measured gravimetrically (hydration properties) and volumetrically (swelling properties). From the obtained results for total phenolic and flavonoid contents in non-irradiated and irradiated faba bean, it is clear that irradiation dose of 9 kGy can be selected as an optimal dose for increasing of these phytochemicals in faba bean.

Key words: Faba beans, phenolic compounds, flavonoids, chemical composition, water absorption.

INTRODUCTION

Faba bean is a worldwide important crop constituting an important part of diet in several countries. In Egypt, faba bean constitutes a common staple food eaten in different popular dishes by both rich and poor consumers (**El-Mergawi and Taie, 2014; Chaieb *et al.,* 2015; Abu-Reidah *et al.,* 2017**).

There is a constant changing in consumer's eating habits with a new trend of consumption for the natural and healthy diet including vegetables which help to prevent diseases (**De Rosas *et al.,* 2019**). Due to its positive nutritional benefits, a growing interest is devoted to faba bean (**Turco *et al.,* 2016**). Faba bean is excellent source of many nutrients (**Grela *et al.,* 2017; Kan *et al.,* 2018; Mattila *et al.,* 2018**).

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Furthermore, faba bean is rich in many functional phenolic and flavonoid compounds (**Magalhães *et al.*, 2017; Kan *et al.*, 2018; Kwon *et al.*, 2018**). These compounds play an important role in human health and nutrition having the advantage of reducing the risk of several diseases including cancers and cardiovascular diseases (**Hu *et al.*, 2015; Guti Errez-Grijalva *et al.*, 2016; Ha, 2016; Martins and Ferreira, 2017**).

Food irradiation is an efficient technology that can address both food safety and quality. There is increasing interest in this technology which approved in more than 50 countries including Egypt and more than 60 products are being irradiated in the world (**Osterholm and Norgan, 2004; Kume and Todoriki, 2013; Woodside, 2015; Ehlermann, 2016; Maherani *et al.*, 2016**). Studies have shown that irradiation treatment can increase the contents of certain phytochemicals and enhance the biological value of some plants (**Zevallos-Concha *et al.*, 2016; Vardhan and Shukla, 2017; Pereira *et al.*, 2018 a,b**). Therefore, the objective of the present study was to investigate the effect of gamma radiation on phenolic and flavonoid compounds in faba bean seeds and assessing the effect of irradiation treatments on macronutrients in seeds as well as their hydration properties.

MATERIALS AND METHODS

Materials

Whole faba bean seeds (*Vicia faba* L.) were obtained from a local market at Bilbies City Sharkia Governorate, Egypt. The seeds were carefully cleaned by hand to remove any foreign materials, divided into appropriate samples of about 200 g and packaged in polyethylene pouches. Pouches were sealed by heat and transferred for irradiation treatment. Solvents and chemicals were of analytical grade and purchased from El-Gomhoria Company for Chemicals and Drugs, Cairo, Egypt.

Irradiation Treatment

Packaged samples of faba bean seeds were exposed to gamma radiation at doses of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 kGy. Irradiation treatment was carried out using a ^{60}Co Russian gamma chamber (providing a dose rate of 670.687 Gray/hr.) belonging to Cyclotron Project, Nuclear Research Center, Atomic Energy Authority, Egypt.

Analytical Methods

Phenolic and flavonoid compounds

Ethanolic extraction of phenolic compounds

Samples of non-irradiated and irradiated faba bean seeds under investigation were milled into a fine powder to pass a 0.4 mm mesh size screen. The ground samples were defatted in a Soxhlet apparatus for 6-8 hr., using n-hexane, then defatted samples were dried in an oven at 45ºC for 1 hr. The extraction of phenolics was carried out as described by **Oomah *et al.* (2008)** with some modifications. In this method, 200 mg portion of the defatted ground sample were extracted with 8 ml of aqueous ethanol 80% (*V/V*) by constant magnetic stirring for 2 hr., at room temperature followed by centrifugation at 1100 g for 10 min. To obtain all phenolic compounds, extraction was performed three times, then the obtained three supernatants were combined and evaporated under vacuum using rotary evaporator to a volume of about 25 ml. The obtained ethanolic extracts were stored at -18°C in the dark until analysis.

Determination of total phenolic compounds

The Folin-Ciocalteu method was applied for the determination of total phenolic compounds according to **Arabshahi-Delouee and Urooj (2007)**. Briefly, 200 µl of the ethanolic extract were mixed with 1 ml of Folin–Ciocalteu's reagent (1 ml reagent with 9 ml distilled water) for 5 min, then 1.5 ml distilled water and 1ml of 75 g l^{-1} Na_2CO_3 solution were added. After shaking at ambient temperature for 60 min, the absorbance at 760 nm was measured by the spectrophtometer. Gallic acid was used as a standard for the calibration curve and the total phenolic content was expressed as µg gallic acid equivalent (GAE) /g dry matter.

Determination of total flavonoid content (TFC)

The contents of total flavonoids were determined as described by **Ordon *et al.* (2006)**. A 0.5 ml aliquot of $AlCl_3$ ethanolic solution (20 g/l) was added to 0.5 ml of faba bean ethanolic extract. The mixture was left for 1 hr., at room temperature, and then the absorbance was

measured at 420 nm by the spectrophotometer. Total flavonoid content was expressed as µg quercetin equivalent (QE)/g dry matter.

Characterization and quantification of phenolic compounds by HPLC

Individual phenolic compounds in the ethanolic extracts of non- irradiated faba bean seeds and those irradiated at dose of 9 kGy were fractionated and quantified using a Hewlett Packard (HP 1100) HPLC instrument equipped with a 1100 HP series ultraviolet diode array detector, an alpha bond C_{18} 125A column (4.6 × 250 mm, particle size 5 µm) and an Agilent 1100 series Chem Station software. The mobile phases were 2.0% acetic acid in distilled water (A) and acetonitrile (B). Sample was injected at volume of 20 µl and the column was eluted under linear gradient conditions as described by **Elbadrawy and Sello (2016).** The detection of phenolic compounds was performed at 280 nm and identified by comparing their relative retention times with those of the standard mixture chromatogram. The concentration of an individual compound was calculated on the basis of peak area measurement and expressed as µg GAE/g dry extract.

Characterization and quantification of flavonoid compounds by HPLC

Fractionation and quantification of flavonoid compounds in ethanolic extracts of non-irradiated faba bean seeds and those irradiated at dose of 9 kGy were performed by the same HPLC instrument. The mobile phase consisted of two solvents, 2% phosphate buffer at pH 3 (A) and methanol (B), and the applied linear gradient conditions as described by **Skerget *et al.* (2005**). The detection of compounds was performed at 367 nm, then their quantification was made with an external standard and expressed as µg µg QE/g dry extract.

Chemical composition:

The contents of moisture, protein, lipids and ash were determined in samples of non-irradiated and irradiated faba bean seeds according to the methods described by **AOAC (2005)**. Total carbohydrates was calculated by difference between one hundred and summation of the percentages of moisture, protein, fat and ash. The contents of protein, lipids, ash, and carbohydrates were calculated on dry weight basis.

Physical properties

For all samples of non-irradiated and irradiated faba bean seeds, the hydration capacity, hydration index and swelling capacity were determined according to **Sood *et al.* (2002).** Swelling index of seeds was calculated according to **Williams *et al.* (1983).** Hydration and swelling coefficients were determined in faba bean seeds as described by **Youssuf (1978).**

Statistical Analysis

Data were statistically analyzed using the PROC ANOVA procedure of Statistical Analysis System (**SAS, 1998**).

RESULTS AND DISCUSSION

Contents of Total Phenolic Compounds and Total Flavonoids in Faba Beans as Affected by Gamma Irradiation

The contents of total phenolic compounds and total flavonoids in samples of non-irradiated and irradiated faba bean seeds were determined and the obtained results are shown in Table 1. From these results, it could be seen that the contents of total phenolic compounds in samples of non-irradiated faba beans were 220.55±0.040 µg GAE/g dry matter, while the total flavonoids in the non-irradiated samples were found to be 106.33 ± 0.450 µg QE/g dry matter. Several studies showed that faba bean is an important source of phenolic and flavonoid compounds and their levels largely varied in seeds of different varieties (**Turco *et al.*, 2016; Magalhães *et al.*, 2017; Kwon *et al.*, 2018**).

The results in Table 1 further show the effect of gamma irradiation on the contents of total phenolic and flavonoid contents in faba bean. From these results, it is obvious that exposing faba bean seeds to the ascending doses of gamma radiation, significantly increased, the contents of total phenolic and flavonoid compounds in seeds. As shown, irradiation of faba bean seeds induced gradual increase in the total phenolic and flavonoids contents. The maximum increase was observed in samples irradiated at dose of 9 kGy showing increase by

Table 1. Contents of total phenolic and total flavonoids compounds in faba bean seeds as affected by gamma irradiation

Irradiation dose (kGy)	Contents (Mean ± SD)	
	Total phenolics (µg GAE/g dry matter)	Total flavonoids (µg QE/g dry matter)
0	220.55±0.040 k	106.33±0.450 K
1	255.71±0.710 J	128.97±0.508 J
2	288.46±0.070 I	164.90±0.825 I
3	319.94 ±0.040 H	190.38±0.825 H
4	357.58±0.030 G	208.76±0.676 G
5	394.03±0.030 F	332.36±0.776 F
6	432.90±0.600 E	271.33±1.074 E
7	478.60±0.400 C	311.72±0.740 D
8	519.29±0.710 B	370.66±0.650 B
9	623.64±0.090 A	497.18±0.800 A
10	460.07±0.070 D	343.29±0.710 C
LSD	2.6891	1.2407

GAE: gallic acid equivalent. QE: quercetin equivalent.

about 183% and 283% in phenolic and flavonoids contents, respectively. Then significant decreases in these compounds started to appear in faba bean seeds irradiated at dose of 10 kGy. These results clearly indicated that the dose of 9 kGy can be the optimum irradiation dose for increasing the contents of these compounds in faba bean. These results agree with different studies which reported the increase of phenolic and flavonoid contents in different plant seeds due to irradiation treatments (**Bhat *et al.,* 2007; Tresnia and Mohan, 2012; Tresina *et al.,* 2017).** The increase in phenolic compounds might be attributed to their higher extractability due to depolymerisation and dissolution of cell wall polysaccharides by irradiation **(Siddhuraju *et al.,* 2002**). Also soluble phenols may resulted from the break of covalent bonds of polyphenolic components by irradiation leading to an increase in total phenolic contents (**Jamshidi *et al.,* 2014).**

Identification and Quantification of Phenolic and Flavonoid Compounds in the Ethanolic Extract of the Treated Faba bean

Phenolic compounds

From the obtained results for total phenolic and flavonoid contents in non-irradiated and irradiated faba bean seeds, it is clear that irradiation dose of 9 kGy can be selected as an optimum dose for increasing of these phytochemicals in faba bean. Therefore, the separation of phenolic and flavonoid compounds in the extracts from non-irradiated and 9 kGy irradiated seeds was carried out by HPLC and the obtained results are shown in Tables 2. From Table 2, it is obvious that 21 phenolic compounds could be separated from the extract of non-irradiated faba bean seeds by HPLC. The separated phenolic compounds were gallic acid, pyrogallol, 4-amino-benzoic, protocatchuic, catechin, chlorogenic acid, catechol, caffeine, P-O-H-benzoic, caffeic,vanillic acid, p-cumaric, ferulic acid, iso-ferulic acid, ellagic acid, alpha-cumaric, benzoic acid, salicylic acid, 3,4,5-methoxy-cinnamic, coumarin and cinnamic acid. The major phenolic compounds were found to be catechin, chlorogenic acid, pyrogallol, iso-ferulic acid, protocatchuic and salicylic acid and their concentrations were 1455.59, 631.6, 277.14, 159.45, 144.11 and 140.33 µg GAE/g dry extract, respectively. The results in Table 2 further show that the same phenolic compounds were identified in the extract of seeds irradiated at 9 kGy dose but the irradiation treatment increased the concentration of all phenolic components.

Table 2. Identification and concenteration (µg/g dry extract) phenolic of compounds in the ethanolic extract of non-irradiated and 9 kGy irradiated faba bean seeds by HPLC

Phenolic compound	Irradiation /Dose (kGy)	
	0 kGy	9 KGy
Gallic acid	33.31	64.36
Pyrogallol	277.14	893.35
4- Amino-benzoic	44.40	103.13
Protocatchuic	144.11	557.52
Catechin	1455.59	1782.58
Chlorogenic acid	631.60	1949.10
Catechol	161.97	318.83
Caffeine	136.78	463.02
P-OH-benzoic	97.62	426.05
Caffeic	87.71	281.63
Vanillic acid	130.19	680.55
***P* – cumaric**	16.95	68.89
Ferulic acid	49.96	231.21
Iso – ferulic acid	159.45	724.10
Ellagic acid	27.94	795.43
Alpha-cumaric	2.59	14.84
Benzoic acid	106.32	235.72
Salicyllic acid	140.33	421.54
3, 4, 5-methoxy-cinnamic	15.09	195.26
Coumarin	3.73	30.44
Cinnamic acid	0.92	2.75

Flavonoid compounds

The identification of flavonoid compounds in the extracts of non-irradiated and 9 kGy irradiated faba bean seeds was also carried out by HPLC analysis and the results are presented in Table 3. From this Table, it is noticeable that 14 flavonoid compounds were identified in the extract of non-irradiated faba bean samples. The identified compounds were Apig. 6- arabinose - 8- glactose, Apig.6- rhamnose 8- glucose, Luteolin 7-glucose, Naringin, Rutin, Hespirdin, Apig.7-o-neohespiroside, Quercetrin, Quercetin, Acacetin neo.rutinoside, Naringinin Hespirtin, Kampferol and Apegnin. The major compounds were Hespirdin, Naringin, Quercetrin, Luteolin 7- glucose, Apig.6- rhamnose 8- glucose, Rutin, Apig.6- arabinose - 8- glactose and Apig.7-o-neohespiroside, and their amounts were 369.9, 169.12, 43.31, 36.98, 30.11, 23.91, 16.67 and 10.75 µg QE/g dry extract, respectively. While the rest were found at concentration less than 10 µg QE/g dry extract. The results in Table 3 further show that the same flavonoid compounds were identified in the extract of faba bean seeds that received a radiation dose of 9 kGy. However,

Table 3. Identification and concentration (µg/g dry extract) of flavonoid compounds in the ethanolic extract of non-irradiated and 9 kGy irradiated faba bean seeds by HPLC

Flavonoid compound	Irradiation/Dose (kGy)	
	0 kGy	9 KGy
Apig.6- arabinose - 8- glactose	16.67	153.73
Apig.6- rhamnose 8- glucose	30.11	99.97
Luteolin 7- glucose	36.98	294.70
Naringin	169.12	463.11
Rutin	23.91	58.43
Hespirdin	369.90	5082.31
Apig.7-o-neohespiroside	10.75	50.23
Quercetrin	43.31	232.24
Quercetin	4.24	31.56
Acacetin neo.rutinoside	9.20	63.30
Naringinin	0.87	10.36
Hespirtin	4.95	40.33
Kampferol	1.55	24.53
Apegnin	1.84	12.83

the concentration of all flavonoid compounds increased by this irradiation treatment.

Many previous studies showed different profiles for phenolic and flavonoid components in faba bean extracts (**El-Mergawi and Taie, 2014; Pasricha *et al.,* 2014; Magalhães *et al.,* 2017; Kan *et al.,* 2018**). This may reflect the effect of different factors, including those of climatic, environmental and genotype differences, on the variations in these compounds. **Magalhães *et al.* (2017)** also showed that each variety of faba bean presented different phenolic profiles. Meanwhile, the increase in phenolics might be observed from the release of phenolic compounds from glycosidic components as illustrated by **Harrison and Were (2007)**.

Effect of Gamma Irradiation on Chemical Composition of Faba bean

The proximate chemical composition was determined in samples of non-irradiated and irradiated faba beans and the results are presented in Table 4. As shown, the content of moisture in samples of non-irradiated faba beans was 8.756 ± 0.097%, while the percentages of total fat, ash, protein and carbohydrates in the non-irradiated faba bean samples reached 4.194 ± 0.058, 3.825 ± 0.030, 33.171 ± 0.503 and 58.81±0.478% on dry weigh basis, respectively. It has been reported that the contents of protein, lipids and carbohydrates in faba bean seeds were in the range of 20-41,1.2-4 and 51-68 %, respectively, as illustrated by **Turco *et al.* (2016).** Moreover, the chemical composition of plant foods is influenced by many factors including cultivar and genotype, environment and irrigation conditions **(Longobardi *et al.,* 2015; Vonapartis *et al.,* 2015; Mattila *et al.,* 2018).**

The results in Table 4 also show that significant, differences were observed in the proximate chemical composition between samples of non-irradiated faba beans and those subjected to gamma irradiation at doses up to 10 kGy. The observed differences may be due to differences between samples. Similar results were

Table 4. Chemical composition of faba beans as affected by gamma irradiation

Irradiation Dose (kGy)	Component (%) (Mean±SD)				
	Moisture	Fat	Ash	Protein	Carbohydrates
0	8.756±0.097A	4.194±0.058A	3.825±0.030F	33.171±0.530A	58.81±0.478D
1	8.736±0.080A	4.127±0.051AB	3.904±0.055E	32.397±0.681ABC	59.572±596CD
2	8.663±0.054AB	4.065±0.035BC	3.955±0.055CE	32.444±0.513AB	59.536±0.509CD
3	8.620±0.050B	4.012±0.032CD	3.957±0.045CE	31.918±0.351BC	60.113±0.407BC
4	8.636±0.061BC	3.965±0.045DE	3.974±0.040BC	32.070±0.200BC	59.991±0.198BC
5	8.646±0.037AB	3.901±0.038EF	4.014±0.035ABC	31.854±0.300BC	60.231±0.340BC
6	8.523±0.065CD	3.903±0.040E	3.985±0.050BC	31.811±0.040BC	60.301±0.366ABC
7	8.463±0.080DE	3.813±0.060FG	3.945±0.040CE	31.644±0.351BC	60.598±0.279AB
8	8.419±0.007DE	3.774±0.050GH	4.025±0.057AB	31.412±0.351BC	60.789±0.432AB
9	8.386±0.065E	3.772±0.025GH	3.991±0.050BC	31.691±0.907BC	60.546±9.001AB
10	8.253±0.066F	3.684±0.030H	4.050±0.040A	31.209±0.451C	61.057±0.434A
LSD	0.1084	0.0741	0.0546	0.8337	0.8579

Contents of fat, protein, ash and carbohydrates were calculated on dry weight basis.

reported by **Al-Kaisey *et al.* (2003)** as they showed that no major differences were observed between the chemical composition of non-irradiated broad bean seeds and those irradiated at doses up to 10 kGy.

Water Absorption Properties of Faba beans as Affected by Gamma Irradiation

The effect of gamma irradiation treatments on water absorption properties as measured gravimetrically (hydration properties) and volumetrically (swelling properties) was determined for faba bean seeds (Tables 5 and 6). As it could be seen from Table 5, the values of hydration capacity, hydration index and hydration coefficient showed general slight, but statistically significant, increases in samples of irradiated faba bean seeds when compared with those for the non-irradiated samples. The same observation was noticed for the values of swelling capacity, swelling index and swelling coefficient for faba bean seeds which also showed general slight, but statistically significant, increases in irradiated samples as compared with non-irradiated ones (Table 6). Similar observations were reported by **Kŏksel and Çelik (2011)** for dry beans and **Tresina and Mohan (2012)** for irradiated *Vigna unguiculata* subsp. *unguiculata* seeds. It has been illustrated that such increase in water absorption might be related to degradation of starch **(Tresina and Mohan, 2012)**. It is well known that water retention capacity or hydration capacity determine the swelling ability of any seeds and constitute important characteristics for their processing. Legumes with high hydration and swelling coefficients require less cooking time **(Shimelis and Rakshit, 2005; Nciri *et al.*, 2014).**

Conclusion

From these results, it could be concluded that treatment of faba bean seeds by gamma irradiation significantly increased their contents of phenolic and flavonoid compounds. In addition, irradiation treatments had no detrimental effects on the proximate chemical composition of faba bean seeds, while generally induced slight, but statistically significant, increases in their values for water absorption properties.

Table 5. Effect of gamma irradiation on hydration properties of faba bean seeds

Irradiation dose (kGy)	property (Mean±SD)		
	Hydration capacity (g/seed)	Hydration index	Hydration coefficient (%)
0	0.566± 0.004DE	0.631± 0.005DE	176.68± 0.301F
1	0.562± 0.003E	0.667± 0.006C	177.26±0.251EF
2	0.592± 0.003AB	0.701± 0.003A	177.79± 0.261E
3	0.572± 0.005CD	0.623± 0.005EF	177.65± 0.350E
4	0.554± 0.003F	0.609± 0.005F	173.36± 0.814G
5	0.591± 0.005AB	0.662± 0.006C	179.58± 0.520D
6	0.577± 0.005C	0.664± 0.006C	179.50± 0.500D
7	0.585± 0.005B	0.687± 0.007AB	180.23±0.057CD
8	0.587± 0.003B	0.691± 0.004AB	180.66±0.577BC
9	0.598± 0.003A	0.678± 0.003BC	181.66± 0.577A
10	0.587± 0.005B	0.643± 0.005D	181.26± 0.251A
LSD	0.0075	0.0178	0.8743

Table 6. Effect of gamma irradiation on swelling properties of faba bean seeds

Irradiation dose (kGy)	property (Mean±SD)		
	Swelling capacity (g/seed)	Swelling index	Swelling coefficient (%)
0	0.604±0.002G	0.727±0.004F	194.78±0.623E
1	0.640±0.008F	0.768±0.011E	196.24±2.27E
2	0.677±0.104C	0.814±0.011C	210.03±1.39C
3	0.653±0.009E	0.784±0.003D	205.88±0.00D
4	0.660±0.009DE	0.791±0.011D	206.76±1.32D
5	0.674±0.005C	0.807±0.004C	211.56±1.62BC
6	0.673±0.009DC	0.807±0.010C	212.54±1.35B
7	0.680±0.004C	0.817±0.004C	212.15±0.68CB
8	0.694±0.005B	0.834±0.008B	218.75±0.00A
9	0.703±0.008AB	0.842±0.009A	219.58±1.44A
10	0.710±0.011A	0.851±0.014A	213.68±1.81B
LSD	0.0129	0.0152	2.2559

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تأثيـــر أشـــعة جـــامـــا علـــى المركبـــات الفيتـــوكيميائيـــة فـــى الفـــول البلـــــدى

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يهدف هذا البحث إلى دراسة تأثير أشعة جاما على المركبات الفيتوكيميائية فى الفول البلدى، حيث عرضت بذور الفول لأشعة جاما بالجرعات صفر، ١، ٢، ٣، ٤، ٥، ٦، ٧، ٨ ، ٩ و١٠ كيلو جراى ثم تم تقدير المحتويات الكلية للمركبات الفينولية والمركبات الفلافونية فى كل من العينات غير المشعة والمشعة، وقد بلغت المحتويات الكلية للمركبات الفينولية ٢٢٠,٥٥ ميكروجرام/جرام مادة جافة بينما بلغت المحتويات الكلية للمركبات الفلافونية ١٠٦,٣٣ ميكرو جرام/جرام مادة جافة وذلك فى بذور الفول غير المشعة، فى حين أدى تعريض بذور الفول إلى الجرعات المتزايدة من أشعة جاما إلى حدوث زيادة معنوية تدريجية فى كل من المركبات الفينولية والفلافونية وكانت أقصى زيادة فى العينات المعرضة للجرعة ٩ كيلو جراى حيث بلغت النسبة المئوية للزيادة فى هذه المركبات ١٨٣% و٢٨٣% - على التوالى، وبناءا على هذه النتائج تم فصل وتقدير كل من المركبات الفينولية والفلافونية كميا باستخدام التحليل الكروماتوجرافى السائل عالى الكفاءة حيث أمكن فصل وتقدير ٢١ مركبا من المركبات الفينولية وعدد ١٤ مركبا من المركبات الفلافونية فى مستخلص بذور الفول غير المشعة ،كما أمكن فصل نفس المركبات من العينات المشعة إلا أن المعاملة الإشعاعية أدت إلى زيادة تركيز هذه المركبات، فضلا عن ذلك، فقد تمت دراسة تأثير أشعة جاما بالجرعات تحت الدراسة على التركيب الكيميائى وخواص إمتصاص الماء للبذور وأظهرت النتائج وجود فروق معنوية إحصائيا إلا أنها ليست كبيرة فى التركيب الكيميائى للعينات المشعة وغير المشعة بينما أدت المعاملات الإشعاعية إلى حدوث زيادة طفيفة ولكنها معنوية إحصائيا فى جميع القيم الخاصة بتقديرات امتصاص الماء، ومن النتائج المتحصل عليها لمحتوى الفينولات والفلافونويد في الفول البلدي المشعع وغير المشعع يتبين أن التشعيع بجرعة ٩ ك جراي هى المثلى لزيادة محتوى الفيتوكيميائية في الفول البلدي.

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