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EVALUATION OF YIELD AND PHYSICOCHEMICAL PROPERTIES OF SOME SUNFLOWER (*Helianthus annuus L.*) MUTANTS INDUCED BY GAMMA IRRADIATION

Z. M. Attia, E. M. Sallam and E.H. Nasr
Atomic Energy Authority, Nuclear Research Center, P.No. 13759, Egypt

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ABSTRACT: *This investigation aims to evaluate yield, physical and chemical properties as well as fatty acids composition of oil extracted from two commercial varieties of sunflower (Helianthus annuus L.) Giza 102 (G) and Sakha 53 (S) and ten radiation mutant sunflower seeds produced by radiation mutation breeding program at the Egyptian Atomic Energy Authority. The obtained results indicated that highly differences between genotypes in plant height, stem diameter, head diameter, head weight, 100seed weight and seed yield than the local varieties. Also radiation mutation of sunflower seeds showed markedly increased oil content as the main constituent of oil seeds, as well as total protein in some mutant of these seeds in return of decreasing in total carbohydrate. However, radiation mutation had no detectable effects on the refractive index and specific gravity did not alter by radiation mutation in sunflower mutants. While caused a slight decrease in the acid value, peroxide value and saponification number percentage of sunflower crude oil. On the contrary, radiation mutation caused a slight increase in the T.B.A. value of crude oil extracted from mutant sunflower seeds. On the other hand, radiation mutation caused an increase in oleic acid but decrease linoliec acid in comparison with both local commercial varieties.*

Key words: *Sunflower seed, oil, radiation mutation, fatty acids and gamma ray.*

INTRODUCTION

Oil crops are important in the world as a main source of edible oil, protein and other nutrients and have been cultivated since antiquity. For the past half century, the cultivation of oil-bearing plants has increased considerably. There are several species of plants in the world whose oil can be utilized for human consumption. Although forty different oil seeds have been described, there are only ten edible oil crops of commercial value in the world market. Seven of these are seed crops and includes cottonseed, groundnuts, rapeseed, safflower seed, sesame seed, soybean seed and sunflower seed. Sunflower seeds are very rich in oil, which is considered to be of high quality for human consumption due to the high content in linoleic acid, the high ratio of polyunsaturated to saturated fatty acids, the amino acid distribution within the protein fraction and the presence of relevant amount of vitamin E [Salgin, *et al* 2006]. Sunflower seed oil is largely utilized by the food industry and it finds even larger applications in the lubricant and cosmetic industries. Moreover, it could also be considered as a potential source for the development of vegetable oil based fuels.

Sunflower (*Helianthus annuus L.*) is one of the important annual crops of the world grown for oil. In Egypt, shortage in the local production of vegetable oils is considered of the acute problems. The local productions of edible oils represent about 10% of the total consumption. Research workers therefore should concentrate efforts aiming to increase the production of this crop per unit area as well as oil content quantity and quality of seed. The oil contains high proportion of unsaturated fatty acids and high levels of fat-soluble vitamins and sunflower protein are comparable to other oil seed proteins in their nutritional quality. There are two types of sunflower, the oil seed type and non-oil or confectionery type. The confectionery type sunflower seeds are consumed as whole roasted seeds. The dehulled seeds (kernels) are sold as confectionery nuts. The defatted sunflower meal is rich in proteins and is mostly used as animal feed. The seeds offer an attractive

raw material to the processors, particularly for the production of lecithin, tocopherol and furfural. Besides being used as cooking medium, sunflower oil is also used for the manufacture of margarine, butter and soap (Salunkhe, *et al*., 1991).

Several investigators have used ionizing radiation to increase variability and induce mutation in many crops. Promising results on this crop were obtained through mutation breeding by several researchers i,e Cvetkova (1970), Tsevetkova (1975), Sharafi and mirshahi (1976), Ahmed (1979), Hammed and Elgazar (1990), Abu Hegazi *et al* (1996), Attia and Abu Hegazi (1996) and Ibrahim *et al* (2010). Since induced mutation by gamma irradiation had a great value for improving agronomic character of economic value (i.e. yield lodging resistance, disease resistance, maturity, winter hardiness, shattering resistance, ease of harvesting, seed weight, sprouting resistance, drought resistance, salinity resistance and adaptability), radiation mutation breeding program is being carried out at Plant Research Department, Radiation Applications Division, Nuclear Research Center, Inshas, Atomic Energy Authority, Egypt. This program aims to improve cultivate of oil crops, among them sunflower seeds.

Therefore, this investigation aims to evaluate yield, physical and chemical properties as well as fatty acids composition of oil extracted from control and radiation mutant sunflower seeds produced by radiation mutation breeding program at the Egyptian Atomic Energy Authority.

MATERIALS AND METHODS

Materials

Source of seeds

The commercial varieties of sunflower (*Helianthus annuus L.*) Giza 102 (G) and Sakha 53 (S) seeds were obtained from Agriculture Research Center, Giza, Egypt. While the mutants sunflower seeds were obtained from Plant Breeding Unit,. Plant Research Department, Radiation Applications Division, Nuclear Research Center, Inshas, Atomic Energy Authority. All seeds undertaken were carefully cleaned and tightly packed in polyethylene bags and kept at room temperature until analysis.

Mutants seeds

Seeds of the sunflower variety Giza1 were irradiated with gamma ray doses of 40, 80, 120 and 160 Gy and planted in an isolated field till M3 generation where 40 mutant plants were selected and starting from M2 generation. The mutants comprised plant height, head diameter and seeds color and size. Those mutant characters studied in M3 and the next generation.. The forty mutants lines were grouped into 12 mutant types where their characters of seeds were evaluated in the next generation . Ten mutant were selected and evaluated in this study and their characteristics are presented in Table (1) in comparison with the local varieties Sakh53 and Giza102. Randomized complete block design was used in this investigation with four replications. The area of the experimental plot was 10.8 m^2 containing 6 rows (ridges) each of 3 meter length and 60 cm apart. Sowing was carried out on 24 of April (2011). The cultural practices were done as usual in sunflower fields. The data were statistically analyzed according to Sendecor and Cochran (1967). L.S.D method test was used to compare between the treatments mean.

Methods

Chemical analysis of seeds

Moisture, oil, protein and ash contents were determined according to the official methods described by the A.O.A.C. (1995).

Total carbohydrates, were calculated by the formula according to Egan *et al.,* (1981) as follows: Total carbohydrates % = 100 - (% moisture + % crude protein + % total lipids + % ash).

Preparation of sunflower meals

Sunflower meals which remained after oil extraction from all samples undertaken were desolventized at 60 ^{o}C under vacuum for two hr., tightly packed in polyethylene bags and kept at room temperature for further analysis.

Table (1): The characteristics of the induced mutants obtained and the respective dose of gamma rays.

Varieties or mutants	Characteristics	Designation mutant mark	Dose (Gy)
Mut.1	White small seed	W.S.S	40
Mut.2	White long seed	W.L.S	40
Mut.3	White long seed	W.L.S	40
Mut.4	Brown small seed	B.S.S	80
Mut.5	Brown medium seed	B.M.S	80
Mut.6	White/Black medium seed	W/B.M.S	80
Mut.7	Brown long seed	B.L.S	120
Mut.8	Violet small seed	V.S.S	120
Mut.9	Violet medium seed	V.M.S	160
Mut.10	Black medium seed	B.M.S	160
Sakha 53	Black small seed	B.S.S	-
Giza 102	Black small seed	B.S.S	-

Oil extraction

Seed samples were ground using stainless steel mill. Then the oil was extracted by n-hexane using 2 liters capacity. Soxhelt apparatus units for 16 hr. After oil extraction, the solvent was evaporated under vacuum at 60 ^{0}C and the crude oil was dried over anhydrous sodium sulfate, filtered, packed in dark brown bottles without further purification and kept till analysis, according to A. O. C. S (1989).

Physical and Chemical Properties of oils

Refractive index

Refractive index was determined according to the method described by the A.O.A.C. (1995), using a Refractometer (NYRL 3 Poland). The results were standardized to 25 ^{0}C.

Color

Color was determined according to the method described by the A.O.C.S. (1989) using Lovibond Tintometer, model 6, serial No. E13293, and a 5.25-inch cell for sunflower seed oil.

Specific gravity

Specific gravity was determined according to the method described by the A.O.A.C. (1995).

Chemical properties of oils

Acid value, peroxide value, iodine number, saponification number were determined according to the methods described by the A.O.A.C. (1995).

Thiobarbituric acid (T.B.A.) value

T.B.A value was determined according to the method described by Sidwell, *et al.,* (1954) which could be summarized as follows:

Three gm of lipids were dissolved in 10 ml carbon tetrachloride, then 10 ml of T.B.A. solution (0.67 gm T.B.A. + 99.3 ml glacial acetic acid) were added and the solution was shaken for 4 min. The mixture was transferred to a separating funnel and the aqueous solution was separated in a test tube and heated up to 90^{o}C on a water bath for 30 min., then cooled down and the developed color was spectrophotometrically measured at 530 nm as absorbance using a double beam spectrophotometer Perkinelmer-Hitachi 200 spectrophotometer.

Fatty acid composition

Gas Liquid Chromatographic analysis was applied to identify the fatty acid composition as follows:

Preparation of fatty acids methyl esters

The methyl esters were prepared using sulfuric acid in methanol (2.5:97.5 v/v) as reagent and the methylation process was carried out by refluxing the oil for 2.5 hr according to the method reported by Stahl, (1969)

Identification of the fatty acids methyl esters (FAME)

The fatty acid methyl esters were analyzed by using a Hewlett Packard 6890 gas chromatograph instrument equipped with a flam ionization detector. The column used for all analysis was a capillary column, innowax-crosslinked polyethylene glycol column 30 m x.0.32 mm I.D, and 0.5 mm film thickness. Carrier gas was nitrogen at a flow of 1.5 ml/min. The temperature Program was 150 ^{0}C for 1 min., then 150 ^{o}C - 235 ^{o}C at 17 ^{0}C / min. 235 ^{0}C - 245 ^{0}C at 1 ^{0}C /min at which the oven was hold for maximum of 5 min. The temperature of injection port and detector was 260^{0} C and 275 ^{0}C, respectively. The Peak areas and retention times were measured using A Hewlett Packard 3392 A integrator.

RESULTS AND DISCUSSION

(1) Mean values of the studied characters of the ten mutants sunflower and the two commercial varietes Giza 102 and Sakha 53.

(A) Growth characters:

Plant height and stem diameter .

The analysis of variance indicated highly significant differences among the twelfth entries (ten mutant and two commercial varieties). Plant height and stem diameter were significantly increased in all mutants as compared to the two local varieties Giza 102 and Sakha 53 Table (2)

The mutant (8) produced the highest means of plant height and stem diameter which were 224 and 2.4 cm. respectively. On the contrast, the lowest means produced from Giza 102 variety which were 150 and 1.4 cm for plant height and stem diameter, respectively. These results are in agreement with those obtained by Attia and Abu Hegazi (1996) and Ibrahim *et al* (2010).

(B) Yield and its components characters:

Head diameter.

The analysis of variance indicated significant differences among the twelfth entries and the averages ranged from 17 cm. to 22.5 cm. for the mutants number 4 and 10, , respectively. Head diameter were significantly increased in all mutants except mutant 4 in comparison with to the two local varieties and except the mutants 3,6 and 7 in comparison with the local variety Giza 102 only (Table 2). These results are in agreement with those obtained by Cvetkova (1970), Attia (1996), Attia and Abu Hegazi (1996) and Ibrahim *et al* (2010).

Head and seed weight gm/plant:

Data presented in Table (2) showed clearly that all mutants were increased significantly in head and seed weight in comparison with the two local varieties Giza 102 and Sakha 53. Mean of head weight ranged from 114 for mutant 4 to 131 gm/ plant for mutant 10 in comparison with 75 gm and 79 gm for Giza 102 and Sakha 53, respectively.

The same trend of results was shown in seed yield gm/ plant, it was showed clearly significant differences among the 12 entries. Means of various mutants ranged from 85 gm for mutants 5 and 6 to 100 gm/plant for mutant number 10 in comparison to 58 and 61 gm/plant for Giza102 and Sakha53 local varieties, respectively.

From the present data it could be shown that head and seed weight gm/plant was significantly higher for all mutants in comparison with the two local varieties Giza 102 and Sakha 53. These results are in agreement with those obtained by Abu Hegazi *et al* (1996), Attia (1996), Attia and Abu Hegazi (1996) and Ibrahim *et al* (2010).

Table (2): Mean values of the studied characters of the ten mutant sunflower and the two commercial varietes Giza 102 and Sakha 53.

Variety or mutant	Plant height cm	stem diameter cm	Head Diameter cm	Head weight /plant gm	Seed weight /plant gm	Seed Index gm
Mut.1	250	1.9	19	120	90	8.2
Mut.2	230	2.4	20	120	85	11.3
Mut.3	215	1.9	18	122	95	12.1
Mut.4	200	2.3	17	114	93	9.2
Mut.5	210	2.0	19	115	85	10.3
Mut.6	215	2.0	18	120	85	11.1
Mut.7	220	2.1	18	117	90	13.3
Mut.8	224	2.4	20	130	95	9.0
Mut.9	180	1.9	22	125	95	10.2
Mut.10	190	2.4	22.5	131	100	10
Sakha 53	160	1.6	14	79	61	5.6
Giza 102	150	1.4	15	75	58	5.4
L.S.D 5%	12.1	0.35	4.0	11.2	8.9	1.7

Seed index (100 seed weight):

It is clear from the data presented in table (2) that all mutants were increased significantly in seed index. Means ranged from 8.2 gm for mutant number 1 to 13.3 gm for mutant number 7 in comparison with 5.4 gm and 5.6 gm for the local varieties Giza $_{102}$ and S_{53}, respectively. These results are in agreement with those obtained by Ibrahim *et al* (2010).

From the present study it could be concluded that all studied sunflower mutants were superior in all character studied as compared with the two local varieties Giza 102 and Sakha 53. The further studies well be carried out to evaluate those mutant under some agriculture practices.

(2) Effect of radiation mutation on the chemical composition of sunflower seeds.

The effects of mutation with gamma irradiation of control and mutant sunflower seeds on the gross composition (moisture, total protein, oil content, total carbohydrates and ash contents) were determined and the obtained results are presented in Table (3).

From data in Table (3) , it could be noticed that the moisture, total protein, crude oil content, ash and total carbohydrates contents were 5.91, 25.22, 32.28, 2.56 and 39.94 % for S_{53} and 5.73, 24.23, 32.48, 2.74 and 40.55 % for G_{102} sunflower seeds, respectively. These results are in agreement with those obtained by Nwokolo and Smartt (1996) Amer, *et al*., (2001), Ali (2003) and Ahmed (2007) who mentioned that sunflower seed contain about 3.2 to 7.1 % moisture, 21 to 51.4 % crude oil, 15.9 to 25.8 % protein and 22 to 52 % carbohydrates depending on varieties of seeds. The same table illustrates that moisture and ash contents did not change by radiation mutation of sunflower seeds. On the other hand, a noticeable increase were observed in oil and protein content of mutants Mut.$_3$, Mut.$_7$ and Mut.$_8$ .The rate of increase was higher in oil content than protein one. On the contrary, total carbohydrate content decreased in mutants Mut.$_3$, Mut.$_7$ and Mut.$_8$ by radiation mutation of sunflower seeds. These results agreed with those obtained by Abu-Hegazi, *et al.,* (1996), Fernandez-Martinez, *et al.,* (1997) and Ali (2003) who found that radiation mutation of sunflower seeds increased oil content of these seeds.

Table (3): Effect of radiation mutation on the chemical composition of sunflower seeds.

Components (%)	Control		Sunflower seeds mutant									
	S_{53}	G_{102}	Mut.1	Mut.2	Mut.3	Mut.4	Mut.5	Mut.6	Mut.7	Mut.8	Mut.9	Mut.10
Moisture	5.91	5.73	5.44	5.70	5.89	5.74	5.48	5.58	5.83	5.72	5.60	5.69
Crude protein*	25.22	24.23	24.27	25.10	26.18	24.23	24.68	25.87	26.54	26.07	25.48	25.37
Total oil *	32.28	32.48	32.97	32.89	34.06	32.39	32.02	32.38	34.88	34.18	30.80	32.36
Total ash *	2.56	2.74	2.89	2.65	2.73	2.69	2.81	2.68	2.71	2.64	2.85	2.78
Total carbohydrates*	39.94	40.55	39.87	39.36	37.03	40.69	40.49	39.07	35.87	37.11	40.87	39.49

* = On dry weight basis

Generally, it could be concluded that, radiation mutation of sunflower seeds markedly increased oil content as the main constituent of oil seeds, as well as total protein of these seeds in return of decreasing in total carbohydrate.

(3) Effect of radiation mutation on oil properties of sunflower seeds

Physical and chemical properties as well as fatty acid profiles of crude oil extracted from control and mutants of sunflower seeds were determined and the obtained results are tabulated in Tables (4,5)

(A) Physical properties of crude oils

Refractive index

Data in Table (4) indicated that the refractive index (R.I) at 25 ^{0}C was 1.4690 and 1.4710 for oil extracted from control (S_{53} and G_{102}) sunflower oil . Similar observations were also noticed by El-Hdidi, (1994); Hui, (1996) , Afifi, and El-Niely, (2002) and Ahmed (2007) as they found that R.I of sunflower crude oil was ranged from 1.4670 to 1.4710. The same phenomena were also observed on R.I upon radiation mutation of sunflower seeds. It is obvious that the R.I of oil extracted from mutant sunflower seeds was not alter upon radiation mutation.

Generally, it is obvious that no appreciable differences were detected between R.I of crude oils extracted from radiation mutation and non-irradiated sunflower seeds. These results are in agreement with those obtained by Ali, (2003) who found that radiation mutation had no effect on the refractive index (R.I) at 25 ^{0}C of sunflower oil .

Color

The results in Table (4) shows that the absorbance of oils extracted from control and radiation mutation sunflower seeds at460 nm (as an index of color change) were measured. It could be noticed that, the absorbance of oils showed a slight increased in color of mutants $Mut._3$ and more increased in mutants $Mut._6$ than the control one, as it increased from 0.048 and 0.065 of control sample to 0.169, and 0.54 for mutants samples , $Mut._3$ and $Mut._6$,respectively. These results are in agreement with those obtained by Weiss (1990) and Ali, (2003) mentioned that the red color of sunflower oil ranged from 0.1 to 0.6 .

Specific gravity

Data in table (4) indicate that the specific gravity at 25^{0}C was 1.149 and 1.425 for crude oil extracted from control (S53 and G102) sunflower seeds, respectively. These results agreed with those obtained by Ahmed (2007)

The same Table (4) shows that the specific gravity at 25^{0}C did not alter by radiation mutation in mutants sunflower.

Table (4): Effect of radiation mutation on the physical properties of sunflower seeds crude oil.

Properties	Control		Sunflower seeds mutant									
	S_{53}	G_{102}	Mut.1	Mut.2	Mut.3	Mut.4	Mut.5	Mut.6	Mut.7	Mut.8	Mut.9	Mut.10
R. index	1.4690	1.4710	1.4680	1.4660	1.4685	1.4670	1.4670	1.4680	1.4670	1.4670	1.4700	1.4650
Color	0.048	0.065	0.052	0.049	0.169	0.044	0.056	0.54	0.054	0.038	0.038	0.035
Specific gravity	1.149	1.125	1.227	1.213	1.212	1.273	1.212	1.271	1.212	1.274	1.326	1.208

(C) Chemical properties of crude oils

Acid value

The acid values (A.V) of crude oils extracted from control and radiation mutants sunflower seeds were determined and the obtained data are presented in Table (5)

From these data it could be noticed that the acid value was 0.412 and 0.311 for control S_{53} and G_{102} sunflower seeds crude oil. These results agreed with those obtained by El-Hdidi, (1994), Afifi, and El-Niely, (2002), Ali, (2003) and Ahmed (2007) who found that the acid value of sunflower crude oil was ranged from 0.2 to 1.39. The same phenomena were also observed on acid value of sunflower crude oils by radiation mutation of sunflower seeds as it were 1.356 and 0.714 for mutant sample $Mut._5$ and $Mut._6$, respectively.

Peroxide value

In spite of the fact the peroxide value (P.V) is an important for the quality assessment of fats and crude oils, peroxide value was determined to follow up the autoxidation of fats and crude oils.

Data in Table (5) indicate that the P.V. of crude oils extracted from control sunflower crude oil was 2.980 for S_{53} and 4.892 for G_{102} meq /Kg crude oil. These results agreed with those obtained by El-Hdidi, (1994), Hui, (1996) and Afifi, and El-Niely, (2002) as they noticed that the P.V. of sunflower crude oil was ranged from 1.7 to 10 meq /Kg crude oil. It is clear that the radiation mutation caused a slight decrease in the P.V. of sunflower crude oil as it reached to 2.591, 1.o49 and 0.973 meq /Kg for crude oil extracted from mutant sunflower seeds $Mut._3$, $Mut._5$ and $Mut._{10}$, respectively. These results agreed with those obtained by Ali (2003). While, P.V. were zero in crude oil extracted from mutant sunflower seeds $Mut._4$, $Mut._5$, $Mut._7$ and $Mut._8$. This my be attributed to the radiation mutation effects and decreasing of peroxide compounds.

Thiobarbituric acid (T.B.A)

Thiobarbituric acid (T.B.A) test is usually conducted to measure the secondary oxidation products, which are responsible for the off-flavor. Table (5) show that the T.B.A. (as absorbance at 530 nm) of control sunflower crude oil was 0.126 for S_{53} and 0.196 for G_{102}. These results agreed with those obtained by Weiss, (1994), Afifi, and El-Niely (2002) and Ahmed (2007), they reported that T.B.A value of sunflower crude oil was ranged from 0.16 to 1.0. It is obvious that, radiation mutation caused a slight decrease in the T.B.A value of sunflower crude oil from 0.126 for crude oil extracted from control sunflower seeds to 0.096 for crude oils extracted from mutant sunflower seeds $Mut._7$. These results agreed with those obtained by Ali, (2003). On the contrary, it is obvious that radiation mutation caused a slight increase in the T.B.A. value of crude oil extracted from mutant sunflower seeds as it was 0.302 for $Mut._2$. this increase in T.B.A. (as absorbance at 530 nm) value could attributed to the increase of aldehydes formed from the decomposition of peroxides.

Table (5): Effect of radiation mutation on the chemical properties of sunflower seed crude oils.

Properties	Control		Mutant sunflower seed crude oils									
	S_{53}	G_{102}	Mut.1	Mut.2	Mut.3	Mut.4	Mut.5	Mut.6	Mut.7	Mut.8	Mut.9	Mut.10
Acid Value	0.412	0.311	0.507	0.590	0.429	0.474	1.356	0.714	0.421	0.476	0.498	0.582
Peroxide value (meq /kg oil)	2.980	4.892	4.530	4.897	2.591	0.0	1.049	0.0	0.0	0.0	3.402	0.973
T. B. A. *	0.126	0.196	0.252	0.302	0.215	0.180	0.196	0.118	0.096	0.130	0.153	0.160
Saponification Number	192.43	193.99	190.97	183.20	189.48	196.15	198.52	182.82	195.34	193.04	193.70	196.25
Iodine Number	131.72	130.15	143.20	132.20	131.83	146.55	141.41	137.27	142.98	132.99	136.75	134.38
Unsaponifiable matter %	0.312	0.328	0.340	0.335	0.342	0.315	0.317	0.329	0.331	0.335	0.328	0.325

*Thiobarbituric acid (absorbance D. at 530 nm)

Saponification number

Data in Table (5) show that the saponification value (S.V) of control sunflower crude oil was 192.43 and 193.99 for S_{53} and G_{102}, respectively. These results are in agreement with those obtained by Weiss (1990) Hui (1996) and Ali, (2003) who found that the S.V of sunflower crude oil ranged from 188 to 194..

On the other hand, from the same table it could be noticed that radiation mutation caused a slight decrease in the S.V of sunflower crude oil as it were 190.97, 183.20, 189,48 and 182.82 for mutant sample $Mut._1$, $Mut._2$, $Mut._3$ and $Mut._6$, respectively. These results are in agreement with those obtained by Ali, (2003). On the other hand, there was a slight increase in the S.V for some mutant sunflower which were 196.15, 198.52, 195.34 and 196.25 for mutant sample $Mut._4$, $Mut._5$, $Mut._7$ and $Mut._{10}$, respectively .

Iodine number

The obtained results from table indicate that, the iodine number of control sunflower crude oil was 131.72 and 130.15 for S_{53} and G_{102}, respectively. These results are in agreement with those obtained by Weiss (1990) Hui (1996), Afifi, and El-Niely, (2002) and Ahmed (2007) who found that the iodine number of sunflower crude oil ranged from 125 to 144

It is clear that radiation mutation increased the iodine number of sunflower crude oil where it reached to 143.40, 146.55, 141.41, 137.27, 142.98., 136.75 and 134.38 for crude oil extracted from mutant sunflower seeds $Mut._1$, $Mut._4$, $Mut._5$, $Mut._6$, $Mut._7$, $Mut._9$ and $Mut._{10}$, respectively. Iodine values increased by irradiation, this may be due to oxidation of lipids.

Unsaponifiable matter

The obtained results in Table (5) indicate that the unsaponifiable matter percentage of control sunflower crude oil was 0.312 for S_{53} and 0.338 for G_{102}, respectively. These results are in agreement with those obtained by Hui, (1996) and Afifi and El-Niely, (2002) as they noticed that the unsaponifiable matter of sunflower crude oil was ranged from 0.3 to 1.5%. From the same table it could be noticed that the unsaponifiable matter percentage of mutant sunflower crude oil was slightly increased in some mutant sample than the control.

(4) Effect of radiation mutation on the fatty acids profiles of

crude oils extracted from sunflower seeds.

The obtained results in Table (6) show that the control sunflower seeds crude oil contained 6.753 and 9.724 % total saturated fatty acids for S_{53} and G_{102}. Upon fractionation, saturated fatty acids (SFA) consisted of only 6.753 % palmitic in S_{53}.while G_{102} contained 7.659 % palmitic and 2.065 % behnic. It is clear that the palmitic acid was the major saturated fatty acids in control (S53 and G102) sunflower seeds crude oil. On the other hand, sunflower seeds crude oil contained 91.707% for S_{53} and 84.192 % for G_{102} unsaturated fatty acid (USFA) and linoleic acid was the major unsaturated fatty acid (53.942 and 56.663 %), followed by oleic acid (37.765 and 25.610 %) for S_{53} and G_{102}, respectively. These results almost agreed with those obtained by Salunkhe, et al., (1991), Miller and Vike (1999), Ali (2007) and Abaza (2010) who mentioned that the fatty acid composition of sunflower seed crude oil ranged from 5.200 to 8.472 % palmitic acid, 16.200 to 40.475% oleic acid and 43.666 to 72.500% linoleic of crude oil extracted from sunflower seeds depending on varieties and country of origin.

Table (6) indicated also that, radiation mutation induced remarkable changes in fatty acids profiles of sunflower seed oil, total SFA decreased, while total USFA increased by radiation mutation and the main SFA, namely palmitic acid markedly decreased in all mutant samples than the local variety one G102 as it was 7.659%. Also the eight mutant sample 1,2,3,6,7,8,9 and 10 produced decease in palmitic acid in comparison with the other control samples (S53), except two mutant sample number 4 and 5 produced increase in palmitic acid from 6.753 % to 7.377 and 6.931% , respectively. The same trend was also observed in behnic acid which appeared only in small amount by radiation mutation and amounted by 1.274,1,124 , 1.266 and 0.865 for Mut.$_{2}$, Mut.$_{6}$, Mut.$_{9}$ and Mut.$_{10}$, respectively. While it was not found in other mutant sunflower seeds.

Concerning USFA, radiation mutation had a real effect on the predominant USFA (linoleic) as it decreased in all mutant sunflower seeds oil and the rate of decrease was higher in Mut.$_{4}$ as it reached to 14.100% from 53.942 and 56.663% for local two variety S53 and G102, respectivly . On the contrary, oleic acid increased by radiation mutation in all mutant sample under investigation, but the highest mean value was observed in Mut.$_{4}$ as it was 76.179% in comparison of the two local variety S53 and G102 . These results are in agreement with those obtained by Ali (2007) Hafez *et al.,* (1985), Alam-Zeb (2004) and Abaza (2010)

Table (6): Effect of radiation mutation on the fatty acids profiles of crude oils extracted from sunflower seeds.

Fatty acids Composition	Control		Mutant sunflower seed									
	S_{53}	G_{102}	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Palmitic $C_{16:0}$	6.753	7.659	5.675	5.708	5.340	7.377	6.931	6.003	6.017	6.462	6.390	5.790
Palmitoleic $C_{16:1}$	-	1.919	-	-	-	-	-	-	-	-		-
Oleic $C_{18:1}$	37.765	25.610	51.802	49.225	52.994	76.179	45.786	49.140	46.318	46.355	43.312	46.069
Linoleic $C_{18:2}$	53.942	56.663	40.834	41.136	41.665	14.100	47.282	42.032	46.492	43.983	42.461	44.511
Behnic C22:0	-	2.065	-	1.274	-	-	-	1.124	-	-	1.266	0.856
S. F. A	6.753	9.724	5.675	6.982	5.340	7.377	6.931	7.127	6.017	6.462	7.656	6.646
U. S. F. A	91.707	84.192	92.636	90.361	94.659	90.279	93.068	91.172	92.810	90.338	93.429	90.580
Total fatty acids	98.460	93.916	98.311	97.343	99.999	97.656	99.999	98.299	98.827	96.800	101.085	97.226

S.F.A = Saturated fatty acids
U.S.F.A = Unsaturated fatty acids

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تقييم الصفات المحصولية والفيزوكيميائية لبعض طفرات عباد الشمس المستحدثة بأشعة جاما

زكريا محمد على عطية ، عصام محمد سلام ، عصام حسن نصر

هيئة الطاقة الذرية–مركز البحوث النووية–قسم البحوث النباتية–أبوزعبل–ص ب١٣٧٥٩ – مصر

الملخص العربى

يهدف هذا البحث إلى دراسة تقييم الصفات المحصولية والطبيعية والكيميائية وكذلك تركيب الأحماض الدهنية لزيت عباد الشمس المستخلص من بعض الطفرات المستحدثة بأشعة جاما والمنتجة من خلال برنامج التربية لتحسين عباد الشمس بالتطفير الإشعاعى بالمزرعة التجريبة بقسم البحوث النباتية – مركز البحوث النووية – هيئة الطاقة الذرية بالمقارنة بالصنفين المحليين جيزة ١٠٢ وصنف سخا ٥٣ .

وقد أظهرت النتائج وجود زيادة واضحة بين الطفرات المستحدثة بالإشعاع فى طول النبات وقطر كلا من الساق والقرص ووزنه وزيادة فى وزن المائة بذرة والمحصول بالمقارنة بالأصناف المحلية.

كما أوضحت النتائج أيضا أن بعض الطفرات أظهرت زيادة ملحوظة فى نسبة الزيت والبروتين بعكس الحال فى الكربوهيدرات حيث أدى التطفير الإشعاعى إلى إنخفاضها ولم يحدث تغيير فى الخواص الطبيعية فى قيم كلا من معامل الإنكسار والكثافة النوعية بينما إنخفضت قيم كلا من رقم الحموضة والبيروكسيد والتصبن وعلى العكس لوحظ وجود زيادة طفيفة فى قيم حامض الثيوباربيوتريك فى الأصناف المطفرة بالإشعاع عن الأصناف المحلية. كما أدى التطفير الإشعاعى إلى حدوث إختلافات ملحوظة فى نسب الأحماض الدهنية الغير مشبعة حيث لوحظ زيادة فى نسب الحمض الدهنى أولييك وإنخفاض فى نسب الحامض الدهنى اللينولييك مقارنة بالصنفين المحليين جيزة ١٠٢ و سخا ٥٣ .