RESULTS AND DISCUSSION

Effect of gamma irradiation and storage on the physical and chemical properties of soybean oils:

Physical and chemical properties of oils extracted from un-irradiated and irradiated soybean seeds and stored for different periods were determined and the obtained results are shown in Table (1) and Table (2) .

Data presented in Table (1) illustrated that soybean seeds contained 20.26% oil. This percentage within the rang mentioned by Collins and Sedgwick (1959); Swern et al., (1964) and El-Nikeety (1981).

Gamma irradiation had no effect on the oil percentage of soybean seeds. The same Table indicated that refractive index of soybean oil was 1.4741. Both gamma irradiation and storage treatments induced a slight change in refractive index of soybean oil.

The same results revealed also that the acid value of soybean oil was 0.55. It is obvious that the acid value of soybean oil was not affected by exposing soybean seeds to gamma irradiation doses. On the other hand, the storage of both unirradiated and irradiated soybean oils led to a gradual increase in their acid value parallel to storage periods. The acid value increa-

Table (1): Effect of gamma irradiation and storage on the refractive index of soybean oil.

Period of storage	Gamma-irradiation doses K. rad.				
	0	100	250	500	1000
Zero time	1.4741	1.4745	1.4745	1.4745	1.4745
6-weeks	1.4745	1.4744	1.4744	1.4745	1.4745
12-weeks	1.4745	1.4745	1.4747	1.4746	1.4746
Soybean oil %	20.26	20.26	20.26	20.26	20.26

Table (2): Effect of gamma irradiation and storage on the chemical properties of soybean oil.

	Acid value			Peroxid value			Saponification value			Iodine value			unsaponifiable matter %		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Control	0.55	0.98	1.21	3.72	6.18	14.55	190.27	190.73	190.94	132.12	132.20	128.82	0.73	0.73	0.72
100	0.55	0.96	1.23	3.31	8.64	11.22	189.72	190.14	190.42	132.31	132.29	129.21	0.70	0.70	0.71
250	0.55	0.95	1.19	3.75	6.47	16.75	189.90	190.33	190.54	133.46	133.46	130.91	0.76	0.75	0.77
500	0.54	0.98	1.21	2.61	4.52	16.52	189.59	190.50	190.27	133.45	133.36	131.48	0.78	0.78	0.79
1000	0.54	0.81	0.97	2.06	2.87	11.66	190.72	190.97	191.15	133.73	133.66	132.18	0.79	0.78	0.79

A = Soybean oil at zero time.
B = Soybean oil after storage for six weaks .
C = Soybean oil after storage for tewelve weeks.

sed from 0.55, 0.55, 0.55, 0.54 & 0.54 to 0.98, 0.96, 0.95, 0.96 and 0.81 after six weeks of storage and 1.21, 1.23, 1.19, 1.21 and 0.97 after end of storage period for control, 100, 250, 500 and 1000 K. rad, respectively. It is evident from these data that the increase in acid value during storage was lower in sample irradiated with high dose. These results agreed with Kavalam and Nawar (1969) and Han et al., (1974).

Table (2) shows also that peroxide value of soybean oil was 3.72. It is clear from these results that high doses 500 and 1000 K.rad decreased peroxide value of soybean oil, as it decreased from 3.72 in control sample to 2.61 and 2.06 in samples irradiated with 500 and 1000 K.rad respectively. On the other hand, peroxide value of soybean oil was not affected by lower doses (100 and 250 K.rad). Furthermore, peroxide value of samples under investigation showed a gradual increase during storage periods. The peroxide value increased from 3.72, 3.31, 3.75, 2.61 and 2.06 at the initial stage of storage to 6.18, 8.64, 6.47, 4.52 and 2.87 after six weeks of storage and 14.55, 11.22, 16.75, 16.52, and 11.66 after three months of storage for control and samples irradiated with 100, 250, 500 and 1000 K. rad respectively.

The data obtained in Table (2) indicated that the saponification value of soybean oil was 190.27. These value was not nearly affectedby gamma irradiation or storage. The values were 190.27, 189.72, 189.90, 189.59 and 190.72 at begining of the storage and 190.94, 190.42, 190.54, 190.27 and 191.15 at the end of the storage for control and sample irradiated with ascendant doses mentioned before respectively. Data presented in Table(2) illustrate that iodine number of soybean oil was 132.12. Gamma irradiation induced a minute increase in iodine value of oils of irradiated samples. The iodine value increased from 132.12 in control to 132.31, 133.46, 133.45 and 133.73 for samples irradiated with the above mentioned doses of gammarays respectively. The iodine value of all samples under investigation showed no change when samples were stored for six weeks. Meanwhile, the same value decreased after oil samples storage for three months. Iodine number decreased from 132.12, 132.31, 133.46, 133.45 and 133.73 at Zero time to 128.82, 129.21, 130.91, 131.48 and 132.18 at the end of the storage for control, 100, 250, 500 and 1000 K.rad. The rate of decrease in iodine value of soybean oil was higher in control sample than in irradiated ones. Moreover, the rate of decrease in iodine value was also higher in lower doses than in higher ones. This decrease in iodine value of these samples due to storage treatment may be

atributed to the formation of peroxide compounds, as shown in the increasing of peroxide values of these samples due to the same treatment as mentioned before.

From the same results it is seem that soybean oil contained 0.73% unsaponifiable matter. This value within the range obtained by Hoffmann et al., (1962) and Itoh et al., (1973). It is clearly observed from the same results that unsaponifiable matter (%) was not affected when soybean seeds were exposed to different doses of gamma rays. This finding was previously observed by Rady (1981), who studied the effect of gamma irradiation on the unsaponifiable matter (%) of rice branc oil. The same picture was also observed when oils of there samples were stored for six and twelve weeks respectively.

Chemical composition of residual meals of irradiated and un-irradiated soybean seeds :

The meals of ground un-irradiated and irradiated soybean seeds were collected after the extraction of oils by n-hexane. The meals were analyzed for their moisture, protein, total crude fibers and ash contents, as well as, Fe, Cu, Pb, Na and K in ash.

The corresponding results are shown in Table (3). From which it could be noticed that moisture content

Table (3): Chemical analysis of control and irradiated soybean meal.

Contents	Gamma-irradiation doses K. rad.				
	0*	100	250	500	1000
Moisture	10.62	10.51	10.53	10.53	10.52
Total nitrogen (protein)	36.82	36.66	36.67	36.67	36.64
Crude fiber	7.64	7.58	7.64	7.62	7.58
Ash	8.67	8.60	8.70	8.59	8.64
Fe	0.02	0.02	0.02	0.02	0.016
Cu	0.003	0.003	0.004	0.004	0.004
Pb	0.001	0.001	0.001	0.001	0.001
Na	0.086	0.087	0.088	0.090	0.090
K	3.64	3.68	3.70	3.62	3.67

* . Control sample .

was 10.62%. The moisture content seemed to be in the range previously obtained by Pacigalupo (1968) and El-Shatanovi (1983). It is evident from the same results that the residual meal of non-irradiated soybean seeds contained higher protein content (36.82%) than that reported by Pacigalupo (1968) and El-Shatanovi (1983). Meanwhile this value was lower than obtained by El-Habbal (1983).

Data presented in the same Table showed that soybean meal (control) contained 7.64% crude fibers. W ich was higher than that obtained by Fleming et al., (1974) and Fellers et al., (1976). Meanwhile, El-Shatanovi (1983) gave a higher value of 9.29.

The same results revealed also that, soybean meal contained 8.67% ash. This value agreed with the results obtained by El-Habbal (1983). While the same value was higher than that obtained by Horan (1966) and Pacigalupo (1968).

It is clearly observed from Table (3) that the ash of soybean meal control sample contained 0.02% Fe, 0.003% Cu, 0.001% Pb, 0.086% Na and 3.64% K, there results agreed with those results reported by El-Shatanovi (1983) who proved that K. was the major element presented in soybean meal.

It is obvious from the same Table that application of gamma irradiation did not induce changes in moisture content, protein percentage, crude fibers and ash content of soybean meal. Furthermore, exposure of soybean seeds to different doses of gamma rays showed no change in the percentages of Fe, Cu, Pb, Na and K in ash of soybean meals. These results agreed with those reported by Kennedy and Ley (1971); Rattory et al., (1974) and Metta and Johnson (1956).

Effect of gamma irradiation on trypsin inhibitory activity:

Trypsin activity (T.A.) and trypsin inhibitory activity (T.I.A.) were determined in both water and buffer extract of meals remained after extraction the oils from un-irradiated and irradiated soybean seeds and the results are shown in Table (4).

From these results it could be observed that T.A. and T.I.A. were 12.6 and 37.4 in the water extract of soybean seed meal (control) respectively. These results are in close agreement with Roy and Bhat (1974) who determined the T.I.A. in five varieties of soybean meals and found that the main value was 37.7.

It is obvious from these results that the application of ascendant doses of gamma rays led to a gradual

Table (4): Effect of gamma irradiation doses on trypsin inhibitor.

-irradiation doses K. rad.	Water extract			Buffer extract		
	A	B	C	A	B	C
Z e r o	50.00	12.6	37.4	50.00	12.8	37.2
100	50.00	13.5	36.5	50.00	13.2	36.8
250	50.00	14.2	35.8	50.00	14.7	35.3
500	50.00	15.6	34.4	50.00	15.3	34.7
1000	50.00	19.1	30.9	50.00	18.5	31.5

A = Control value (Activity of pure enzym).
B = Trypsin activity of samples (T.A.).
C = Trypsin inhibitor activity of samples (T.I.A.).

increase in T.A., as it increase from 12.6 in control sample to 13.5, 14.2, 15.6 and 19.1 (T.U.) in water extract of the samples exposed to 100, 250, 500 and 1000 K. rad gamma-rays respectively. Meanwhile an opposite trend was observed in T.I.A., as it showed a gradual decrease, when samples subjected to the ascendant doses of gamma rays. T.I.A. decrease from 37.4 in (control) to 36.5, 35.8, 34.4 and 30.9 in water extract of the above mentioned samples respectively. This decrease in T.I.A. in soybean meal due to gamma-irradiation was previously observed by Lynn and Raoult (1975).

Table (4) declared that the extraction of soybean meal by buffer solution caused a minor changes in T.A. and T.I.A. either in un-irradiated or irradiated samples. These results agreed with those results obtained by Roy and Bhat (1974), who studied the effect of water and buffer extraction on T.I.A. of five varieties of soybean meals.

Generally it could be concluded that high doses of gamma irradiation decreased T.I.A. and increased T.A. of soybean meals, These results mean that gamma irradiation induced a partial in activation in the inhibitors of trypsin enzyme in soybean seed meals. This decrease in T. I.A. of soybean meals may be due to gamma irradiation effect on the denaturation in protein of the inhibitors as found by Coehlo (1966).

Effect of gamma irradiation on fatty acid composition of soybean oil:

The degree of complexity of glycerides basically depends on the number of fatty acids and their amounts as well. Besides, the chemical behaviour of lipids largely depend on their fatty acid consistuents.

Separation and determination of long chain fatty acid methyle esters were carried out by Gas-liquid-Chromatography in order to identify their types and amounts. This has been carried out for oils of irradiated and unirradiated soybean seeds. The obtained results are shown in Table (5) and are graphically represented in Figures (1-5).

From these results and figures it could be observed that crude soybean oil (control) contained 19.55% saturated fatty acids. Upon fractionation saturated fatty acids consisted of three acids namely 13:0, palmitic and stearic. Palmitic acid was present as a major saturated acid, as it amounted to 15.52%, while other two saturated acids were present in minor concentration and they amounted to 0.73% and 3.30% respectively. However, soybean oil contained 80.44% unsaturated fatty acids. The isolation of unsaturated fatty acids of crude soybean oil

Table (5): Effect of gamma irradiation on fatty acids composition of soybean oil.

Fatty acids		R.R.T	Gamma rays doses				
			0	100	250	500	1000
	13:0	0.17	0.73	-	-	-	-
Palmitic	16:0	0.47	15.52	11.52	9.50	9.92	13.62
Stearic	18:0	0.99	3.30	1.49	2.19	1.54	1.76
Oleic	18:1	1.00	17.60	17.59	15.89	15.62	15.90
Linoleic	18:2	1.21	57.46	67.27	67.01	70.56	65.83
Linolenic	18:3	1.55	5.38	2.12	5.40	2.35	2.88
Total saturated F.A.			19.55	13.01	11.69	11.46	15.38
Total un-saturated F.A.			80.44	86.98	88.30	88.53	84.61

indicated that di-unsaturated fatty acid (linoleic) represented the prodominant unsaturated fatty acid of 57. 46% . Meanwhile, mono-unsaturated fatty acid (oleic) was present in moderate concentration, 17.60%.

On the other hand, tri-unsaturated fatty acid (linolenic) was present at minor concentration (5.38%). This results partialy agreed with Gurdev et al., (1976); Khadzhinski et al., (1979) and El-Nikeety (1981). It is evident from the same results obtained in Table (5) and Figures that the exposure of soybean seeds to different doses of gamma-irradiation induced a remarkable changes in the relative percentage of some fatty acids. Total saturated fatty acids showed a noticable decrease, when soybean seeds exposed to gamma-irradiation doses. As it decreased from 19.55% in control to 13.01%, 11.69, 11.46% and 15.38% in oils for seeds irradiated with 100, 250, 500 and 1000 K.rad respectively. Among saturated fatty acids palmitic acid decreased from 15.52% in control to 11.52 , 9.50 , 9.92 and 13.62% in samples irradiated with the above mentioned ascendant doses respectively.

Similarly, stearic acid decreased from 3.30% in control sample to 1.49 , 2.19 , 1.54 and 1.76% in the oils of seeds subjected to the above mentioned doses respectively. On the other hand, 13:0 disappered when soybean seeds treated with different doses of gamma-rays.

Furthermore, total unsaturated fatty acids showed a pronounced increase as it increased from 80.44% in unirradiated samples to 86.98%, 88.30%, 88.53% and 84.61% in samples subjected to ascendant doses under investigation respectively.

Among unsaturated fatty acids, oleic acid decreased from 17.60% in control sample to 15.89, 15.62% and 15.9% in samples exposed to 250, 500 and 1000 K.rad. respectively. Meanwhile an opposite trend occured in diunsaturated fatty acids (linoleic) which showed a progressive increase, as it increase from 57.46% in control sample to 67.27 , 67.01 , 70.56 and 65.83% in samples irradiated with ascendant doses respectively. Furthermore, the doses 100, 500 and 1000 K.rad decreased the relative percentage of linolenic acid, as it decreased from 5.38% in control sample to 2.12, 2.35 and 2.88 for the corresponding irradiated samples respectively.

Generally it could be concluded that application of gamma irradiation induced . remarkable increase and decrease in unsaturated and saturated fatty acids of soybean oil respectively, Also the relative percentage of some acids showed a pronounced changes due to gamma-irradiation. The increase in total unsaturated fatty acids and the decrease in saturated fatty acids are in agreement with results obtained by El-Sayed et al., (1979) and Rady (1981).

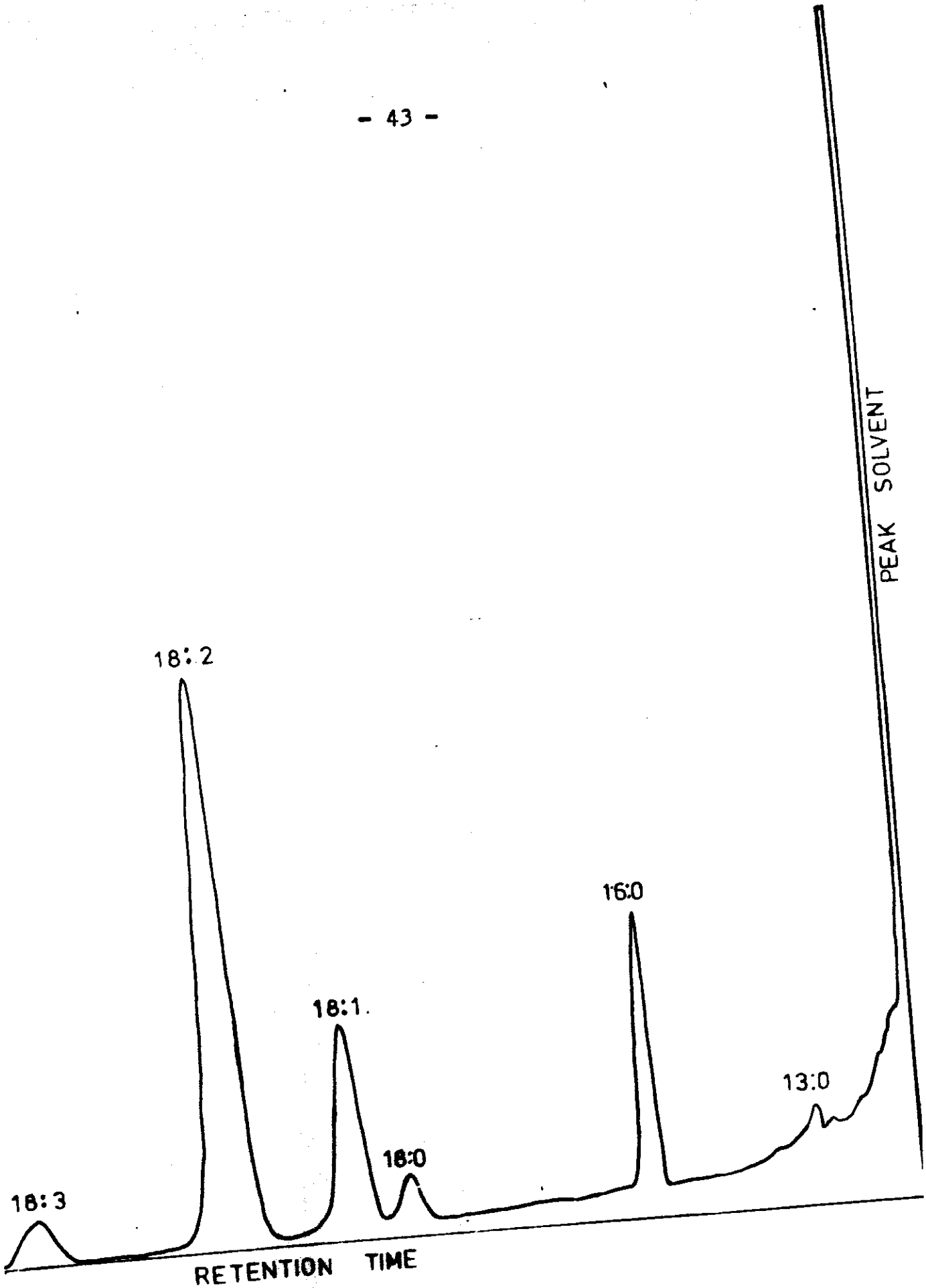

Fig.(1): Chromatographic analysis of fatty acids components of unirradiated soybean seeds oil.

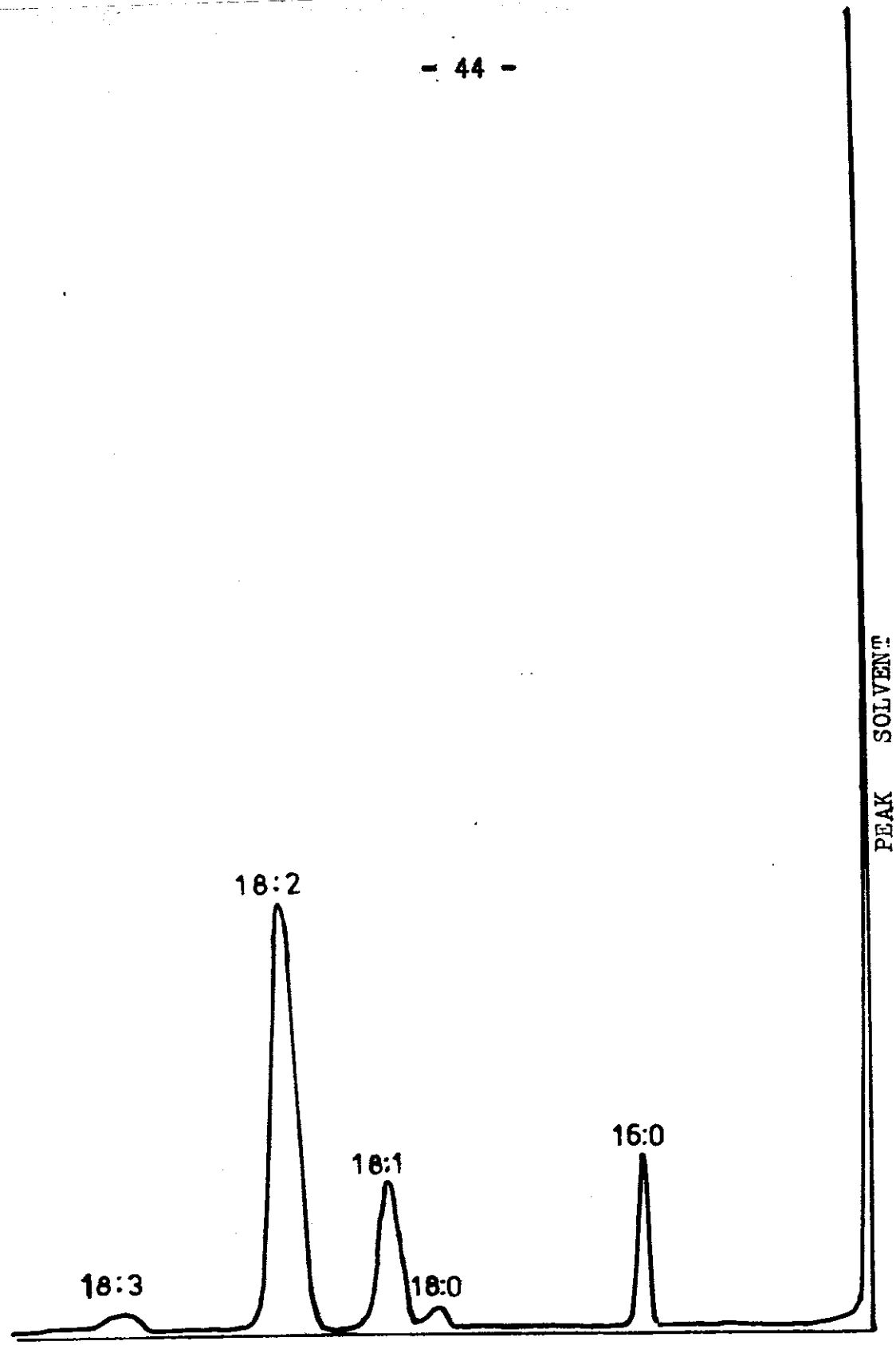

Fig.(2): Effect of 100 K.rad of gamma irradiation on fatty acids composition of soybean oil .

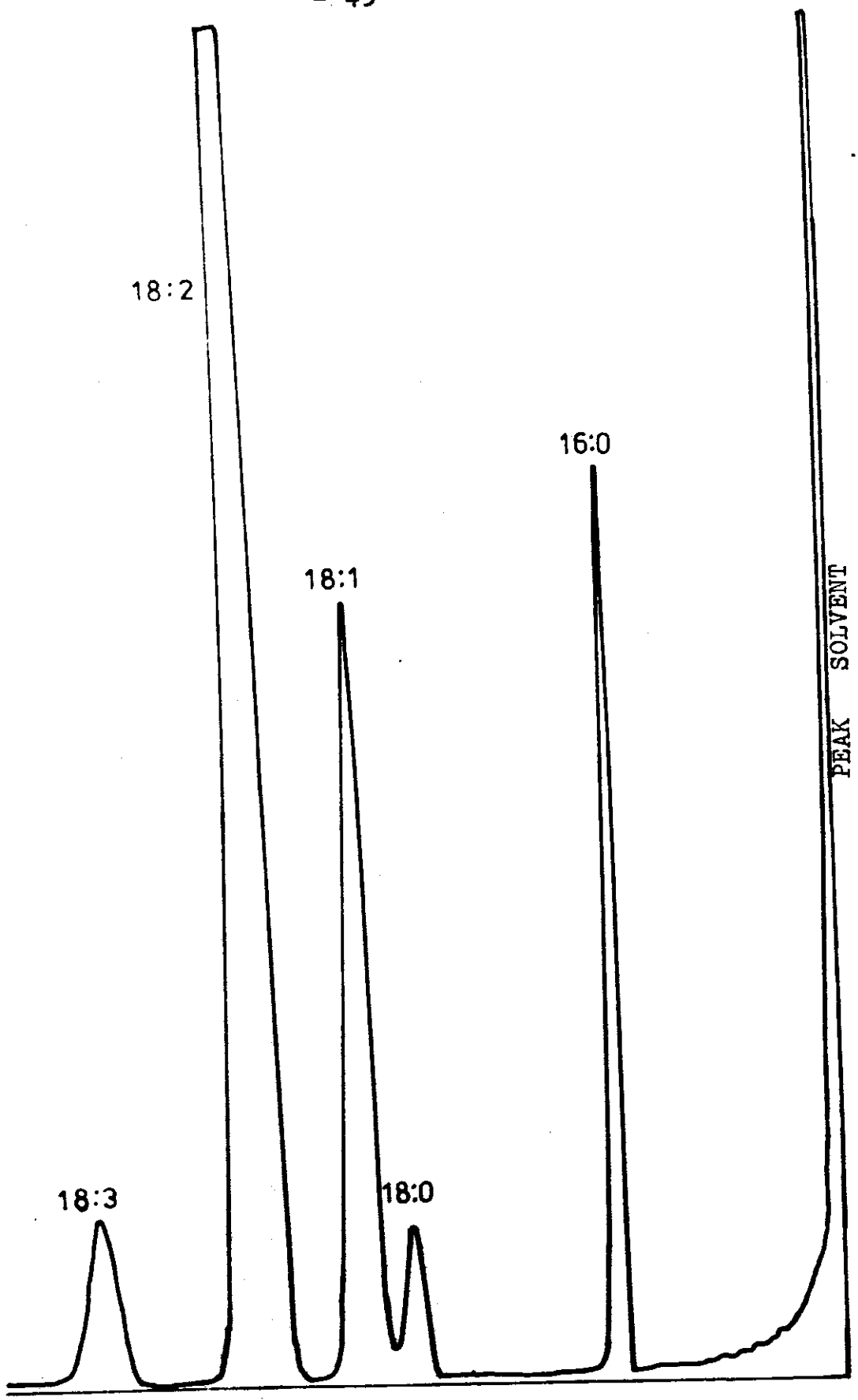

Fig.(3): Effect of 250 K.rad of gamma irradiation on fatty acids composition of soybean oil .

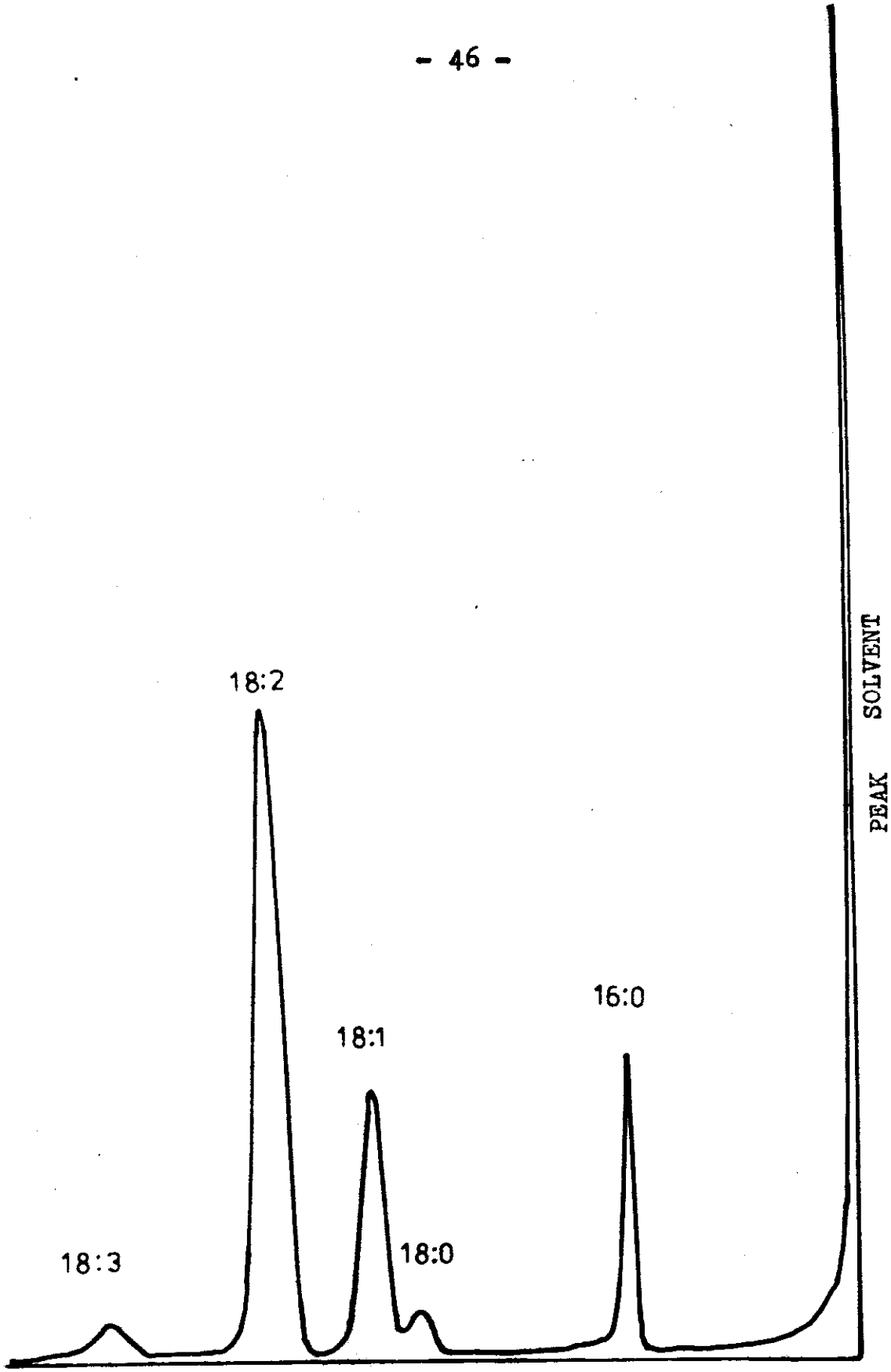

Fig.(4): Effect of 500 K.rad of gamma irradiation on fatty acids composition of soybean oil .

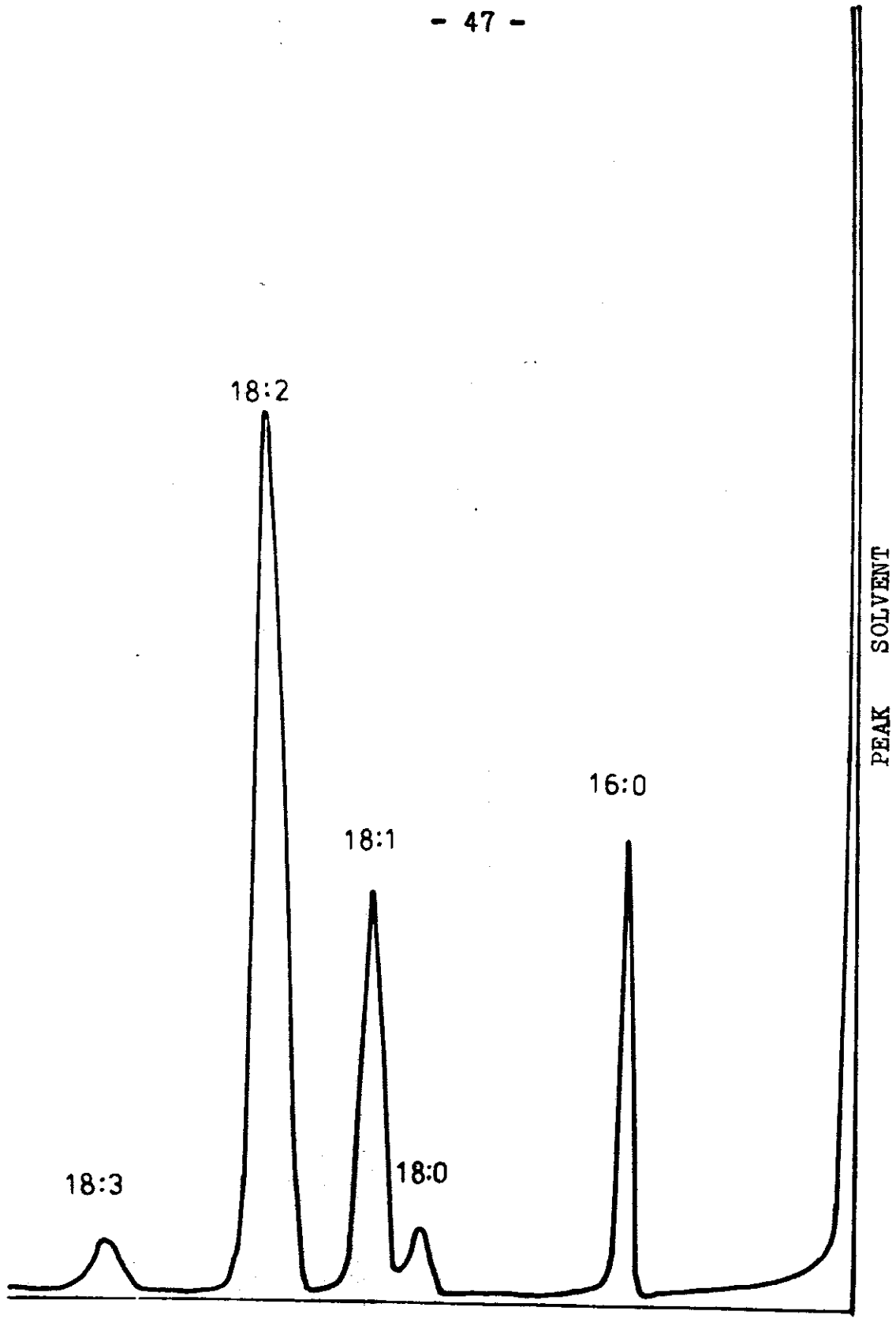

Fig.(5): Effect of 1000 K.rad of gamma irradiation on fatty acids composition of soybean oil .

Effect of storage on the fatty acids composition of oils extracted from un-irradiated and irradiated soybean seeds:

Relative percentage of fatty acids in control and irradiated soybean seeds oils after three months of storage were determined by Gas-liquid Chromatography technique. The obtained results are shown in Table (6) and illustrated in Figures (6-10).

Results obtained in Table (5) and table (6) revealed that storage induced a remarkable changes in fatty acid composition of oils of both irradiated and unirradiated soybean seeds, Storage increased total saturated fatty acids from 19.55%, 13.01%, 11.69m, 11.46% and 15.38% to 20.54%, 14.35%, 16.45%, 17.05% and 17.25% after storage for un-irradiated and irradiated samples with 100, 250, 500 and 1000 K.rad. gamma irradiation doses. As for saturated acids the relative percentage of palmitic acid showed a noticable increase when all samples stored for three months. It increased from 15.52%, 11.52%, 9.50%, 9.92% and 13.62% before storage to 16.16%, 12.16%, 14.43% 16.23% and 15.62% at the end of storage for control and irradiated samples with ascendant doses respectively. The same picte occurred in stearic acid as it increased from 3.3% and 1.49% before storage to 4.13% and 2.19% after storage for un-irradiated and irradiated samples with 100

Table (6): Effect of storage* on fatty acids components of control and irradiatcd soybean seeds oils.

Fatty acids		R.R.T.	Gamma irradiation doses (K. rad.)				
			0	100	250	500	1000
	14:0	0.20	0.25	-	-	-	-
Palmitic	16:0	0.47	16.16	12.16	14.43	16.23	15.62
Stearic	18:0	0.99	4.13	2.19	2.02	0.82	1.63
Oleic	18:1	1.00	17.22	19.89	20.88	18.75	20.08
Linoleic	18:2	1.21	57.98	51.89	58.12	62.31	58.22
Linolenic	18:3	1.55	4.25	3.86	4.54	1.88	4.44
Total saturated F.A.			20.54	14.35	16.45	17.05	17.25
Total unsaturated F.A.			79.45	85.64	83.54	82.94	82.74

* Storage for three months .

100 K.rad respectively, Meanwhile storage of oils extracted from samples irradiated with high doses (250, 500 and 1000 K. rad) occurred a slight decreas in the relative percentage of the same acid as it decreased from 2.19%, 1.54% and 1.76% at the begining of the storage to 2.02%, 0.82% and 1.63% after storage for the corresponding samples respectively.

Increase in total saturated fatty acids after three months storage may be due to the formation of peroxide compound and saturation of double bonds. It is obvious from the same results obtained in Tables(5) and (6) that the storage treatment led to a noticeable decrease in total unsaturated fatty acids of all treatments under investigation. Total unsaturated fatty acids decreased from 80.44%, 86.98%, 88.30%, 88.53% and 84.61% before storage to 79.45%, 85.64%, 83.54%, 82.94% and 82.74% after storage period for control and irradiated samples with the mentioned doses of gamma irradiation respectively. Among unsaturated fatty acids oleic acid showed a slight decrease in control sample, while it showed a pronounced increase in all irradiated samples that had been stored for three months. The relative percentage of oleic acid increased from 17.59 , 15.89 ., 15.62 and 15.90% at the intial of storage to

19.89 , 20.88 , 18.75 and 20.08% at the end of storage for samples subjected to the above mentioned ascendant doses of gamm irradiation respectively. Furthermore, di-unsaturated fatty acid (lenoleic) showed a slight decrease in control sample due to storage. Meanwhile, storage caused remarkable decrease in the relative percentage of lenoleic acid for oils extracted from all irradiated soybean seeds. As it decreased from 67.27 , 67.01 , 70.56 and 65.83% before storage to 51.89 , 58.12 , 62.31 and 58.22% after storage for the oils of samples irradiated with 100, 250, 500 and 1000 K.rad. respectively. As for lenolenic acid, storage for three months induced a fluctuation in its relative percentage, this acid changed from 5.38%, 2.12%, 5.40%, 2.35% and 2.88% at the intial of storage to 4.25%, 3.86%, 4.54%, 1.88% and 4.44% at the end of storage for control, 100, 250, 500 and 1000 K. rad.

It could be concluded that storage of oils of un-irradiated and irradiated soybean seeds caused a noticeable increase and decrease in saturated and unsaturated fatty acids respectively. This may be due to partial oxidation of unsaturated fatty acids and saturation of some double pounds, especially the peroxide value of all samples under investigation increased after storage for three months. Also from these results it

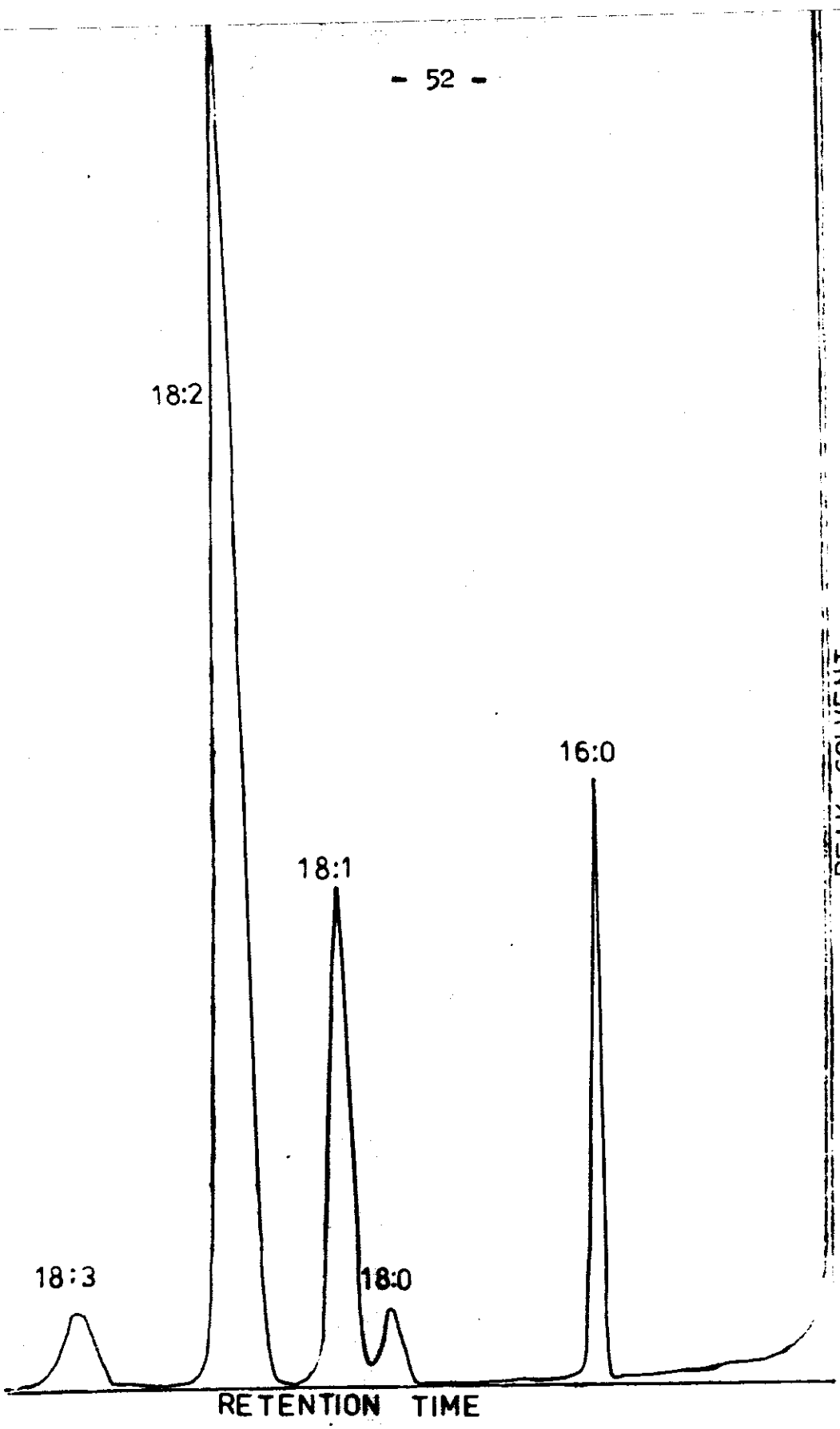

Fig.(6): Effect of storage on fatty acids components of unirradiated soybean seeds oil.

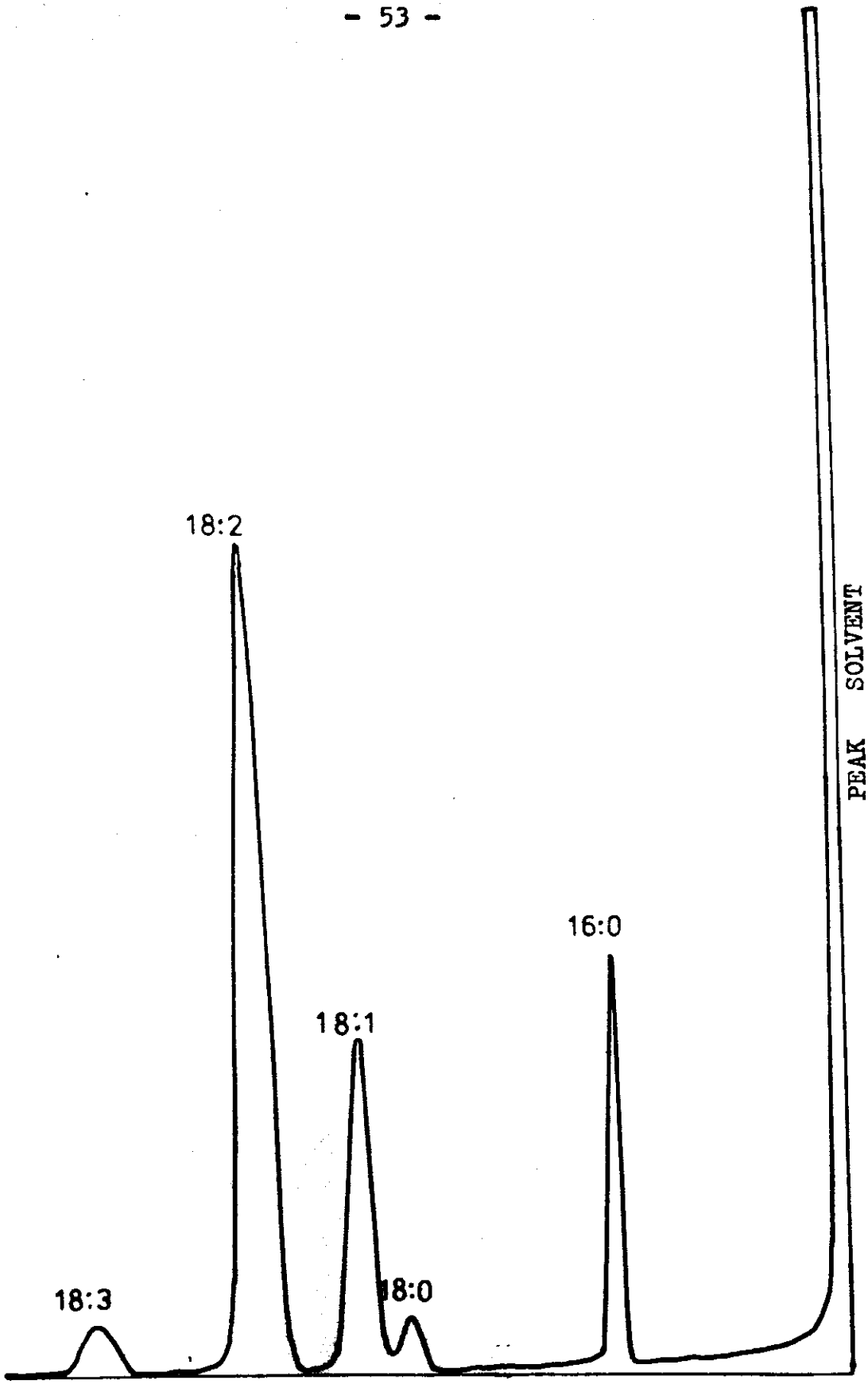

Fig.(7): Effect of storage on fatty acids components of soybean oil after irradiation of seeds with gamma rays at 100 k.rad.

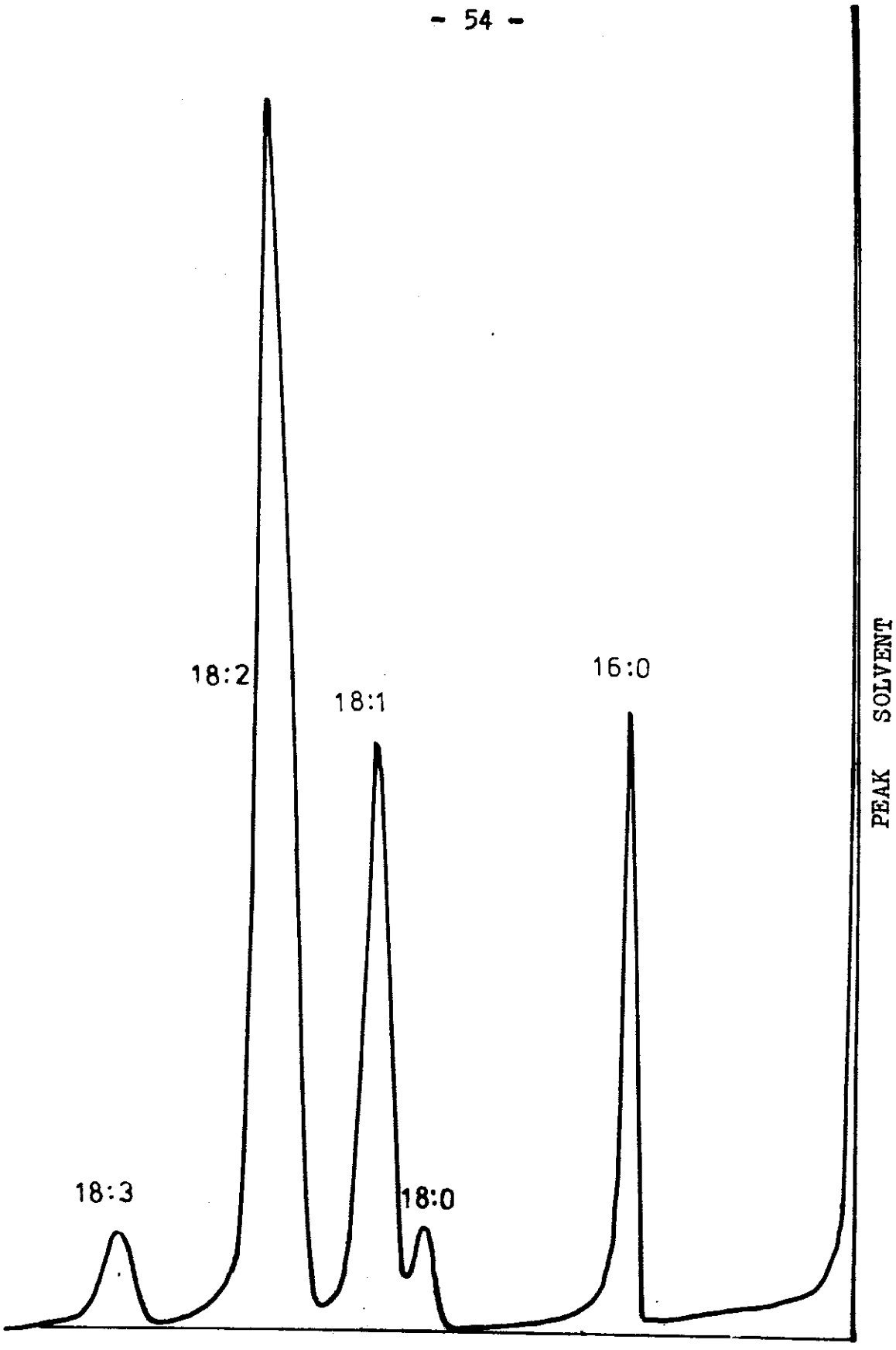

Fig.(8): Effect of storage on fatty acids components of soybean oil after irradiation of seeds gamma rays at 250 K.rad.

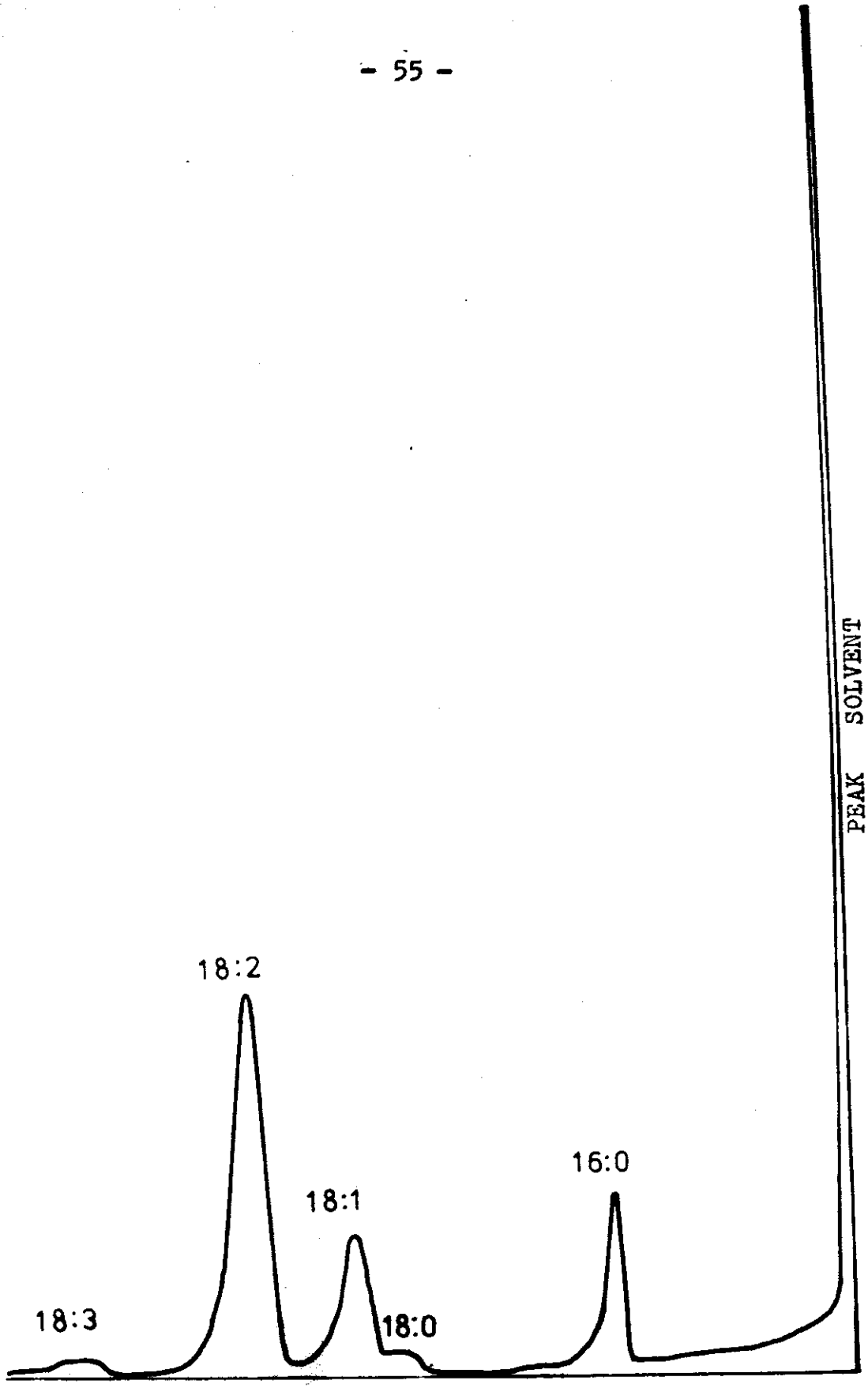

Fig.(9): Effect of storage on fatty acids components of soybean oil after irradiation of seeds with gamma rays at 500 K.rad.

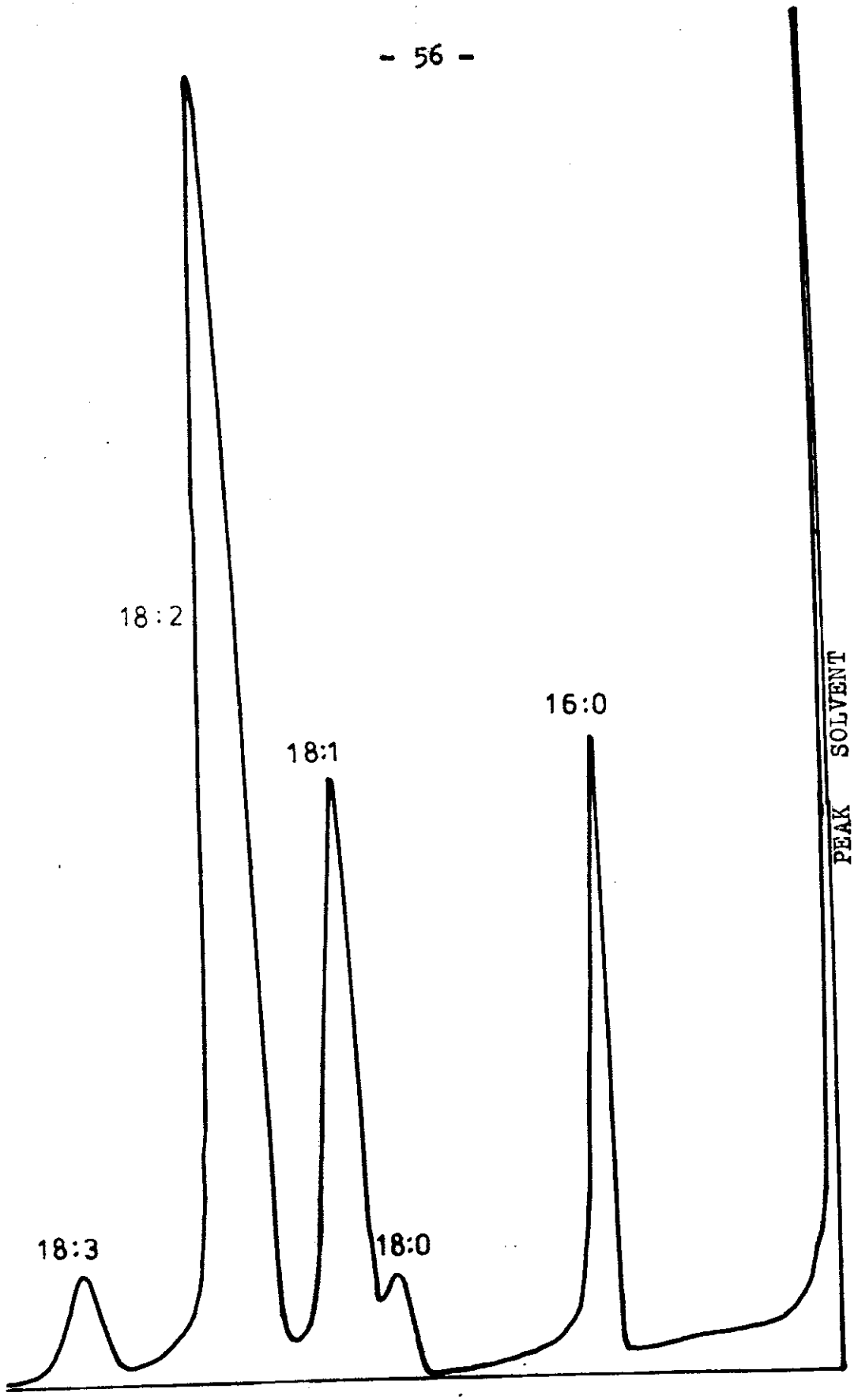

Fig.(10): Effect of storage on fatty acids components of soybean oil after irradiation of seeds with gamma rays at 1000 K.rad.

could be noticed that lenoleic acid decrease while oleic acid increased due to storage treatment. This means that storage treatment partially converted 18:2 to 18:1 by saturation some double bonds of 18:2 and produced oleic acid and peroxide compounds.

Effect of gamma irradiation on the unsaponifiable matter components of soybean oils:

Crude unsaponifiable matter separated from the oils of both irradiated and unirradiated soybean seeds were fractionated and identified by Gas-Liquid Chromatography against outhentic compounds. The obtained results are shown in Table(7) & Figures(11-15). From these results and figures it could be observed that crude unsaponifiable matter of soybean oil (control sample) contained 43.61% hydrocarbons, 3.27% γ-tocopherol and 53.11% sterols.

By fractionation of the unsaponifiable matter of soybean oil, it consisted of eight hydrocarbons compounds namely C_{23}, C_{25}, C_{27}, C_{28}, Squalene, C_{31} and C_{32}. C_{27} compound represented the major hydrocarbon compound in the unsaponifiable matter of soybean oil, as it amounted to 25.52%. Moreover, squalene was present in moderate concentration of 8.42%. While other hydrocarbon compounds were present in minor concentration.

Table (7): Effect of gamma irradiation on the constituents of unsaponifiable matter of soybean Oils.

Components		R.R.T	Gamma rays doses (K. rad)				
			0*	100	250	500	1000
1- - - - - - -	C_{20}	0.012	-	3.24	3.20	6.43	4.26
2-n-hencosane	21	0.02	-	1.18	1.98	4.17	3.12
3-n-docosane	22	0.03	-	3.67	3.97	4.32	5.20
4-n-tricosane	23	0.04	1.66	9.41	11.13	19.26	12.33
5-n-tetracosane	24	0.07	1.68	0.54	0.08	0.79	0.21
6-n-pentacosane	25	0.12	1.91	0.08	0.06	0.39	0.12
7-n-heptacosane	27	0.15	25.52	7.13	6.65	9.47	3.65
8-n-octacosane	28	0.18	2.01	0.81,	1.02	0.76	0.69
9- Squalene		0.22	8.42	8.51	7.92	2.95	4.82
10- Unknown	31	0.30	1.66	-	-	-	1.87
11-n-dotriacontane	32	0.42	0.75	1.58	1.62	1.68	3.84
12-Y-tocopherol		0.51	3.27	4.50	4.82	4.90	2.60
13- Cholesterol		0.62	0.45	-	-	-	-
14- Compsterol		0.81	8.30	6.77	7.76	6.13	8.52
15- Stigmasterol		0.86	4.83	5.00	4.45	3.93	5.97
16-B-sitosterol		1.00	34.40	44.47	41.28	30.86	39.27
17- Fucosterol		1.13	2.11	1.89	1.80	1.40	1.47
18-Δ-7 stigmasterol		1.20	-	1.21	2.25	-	-
19-Δ-7 Avenasterol		1.30	3.02	-	-	2.55	1.40
20- - - - - - -		1.45	-	-	-	-	0.65
Total hydrocarbons			43.61	36.15	37.63	50.22	40.11
Y-tocopherol			3.27	4.50	4.82	4.90	2.60
Total sterols			53.11	59.34	57.54	44.87	57.28

*= Unirradiated sample (control). (-) = not-detected.

R.R.T= Relative retention time of compounds compared with that of B-sitosterol which is used as reference.

These results agreed with those mentioned by Itoh et al., (1973); Bastic and Jovanovic (1979) and El-Nikeety(1981).

It is obvious from the results obtained in Table (7)& Figures(11-15), that gamma irradiation induced a drastic change in hydrocarbon compounds of the unsaponifiable matter of soybean oil. Total hydrocarbons decreased from 43.61% in control sample to 36.15 , 37.63 and 40.11% in samples exposed to 100, 250 and 1000 K. rad gamma rays doses respectively. Meanwhile, 500 K. rad gamma rays dose caused a minor change in total hydrocarbons of soybean oil.

The decrease in total hydrocarbons due to gamma irradiation agreed with the results obtained by Rady (1981), who studied the effect of gamma irradiation on total hydrocarbons of rice bran oil. Gas Chromatographic analysis revealed that the short chain hydrocarbon compounds (C_{20}, C_{21} and C_{22}) appeared, when soybean seeds subjected to gamma rays doses under investigation. These hydrocarbon compounds appeared in comparatively higher concentration when soybean seed treated with high doses (500 and 1000 k. rad), on the other hand, C_{23} hydrocarbon compound showed a pronounced increase, as it increased from 1.66% in control to

9.41 , 11.13 , 19.27 and 12.33% for samples exposed to 100, 250, 500 and 1000 K. rad gamma irradiation doses respectively. Moreover, C_{27} which represented the predominant hydrocarbon compound in the unsaponifiable matter of soybean oil showed a noticeable decrease as it decreased from 25.52% in control to 7.13 , 6.65 , 9.47 and 3.65% for samples irradiated with above mentioned doses respectively. Similar trend was also observed in squalene when soybean seeds subjected to high doses of gamma rays, as it decrease from 8.42% in untreated sample to 7.92 , 2.95 and 4.82% in samples treated with 250, 500 and 1000 K. rad gamma irradiation doses respectively. Furthermore, C_{32} showed gradual increase in its relative percentage with exposure of seeds to ascendant doses of gamma irradiation mentioned before.

The same table indicate also that crude soybean oil contained 3.27% γ-tocopherol, which was identical with that reported by El-Nikeety (1981). These results revealed also that gamma irradiation increased γ-tocopherol as it increased from 3.27% in control to 4.50 , 4.82 and 4.90% in samples exposed to 100, 250 and 500 K. rad gamma rays respectively. Meanwhile, high dose (1000 K.rad) decreased it to 2.60%.

It is clearly observed from Table (7) and Figures (11-15) that unsaponifiable matter of crude soybean oil (control) contained 53.11% sterols compounds. By fractionation, the unsaponifiable matter consisted of six sterol compounds namely cholesterol 0.45%, campsterol 8.30 % stigmasterol 4.83%, B-sitosterol 34.40%, fucosterol 2.11% and $\Delta 7$ avenasterol 3.02%. These results indicated also that B-sitosterol was the main sterol compound followed by campsterol, These results are partially in agreement with Hoffmann et al., (1962); Itoh et al., (1973) and Bastic and Jovanovic (1979).

The same Table and Figures revealed also that gamma irradiation induced remarkable changes in the relative percentage of some sterol compounds. Total sterols increased from 53.11 in control to 59.34 , 57.54 and 57.28% in samples exposed to 100, 250 and 1000 K. rad gamma rays doses respectively. The same findings were previously observed by Rady (1981) who studied the effect of gamma irradiation on total sterols of rice bran oil. On the other hand, B-sitosterol increased from 34.40% in control to 44.47%, 41.28% and 39.27% in samples irradiated with 100, 250 and 1000 K. rad gamma irradiation doses respectively. While 500 K. rad gamma rays dose caused a decrease to 30.86% . The application of gamma irradiation led to a decrease in the relative percentages of both

compsterol and fucosterol compounds. In addition, $\Delta 7$ stigmasterol was identified only when soybean seed irradiated with 100 and 250 K. rad gamma rays doses, while unknown sterol compound (with R.R.T. 1.45) was appeared in unsaponifiable matter of sample irradiated with 1000 K. rad gamma-rays dose . Moreover, cholesterol compound disappeared when soybean seeds subjected to all gamma irradiation doses under taken. On the other hand, Δ-7 avenasterol disappeared only when soybean seed irradiated with 100 and 250 K. rad gamma rays doses.

Generally it could be concluded that gamma-irradiation induced remarkable changes in both hydrocarbon and sterol compounds. As the application of gamma-irradiation produced short chain hydrocarbon compounds, which showed a pronounced increased in their relative percentages, especially with high doses (500 and 1000 K. rad).

Gamma-irradiation decreased the long chain hydrocarbon compounds (C_{25}, C_{27}, C_{29} and squalene compounds). This means that gamma irradiation induced a degradation in long chain hydrocarbon compounds and produced short chain hydrocarbon compounds. Besides, gamma irradiation altered the structure of some sterols and led to changes in the relative percentage of some sterols. These results agreed with those obtained by Merritt et al., (1966) and Rady (1981).

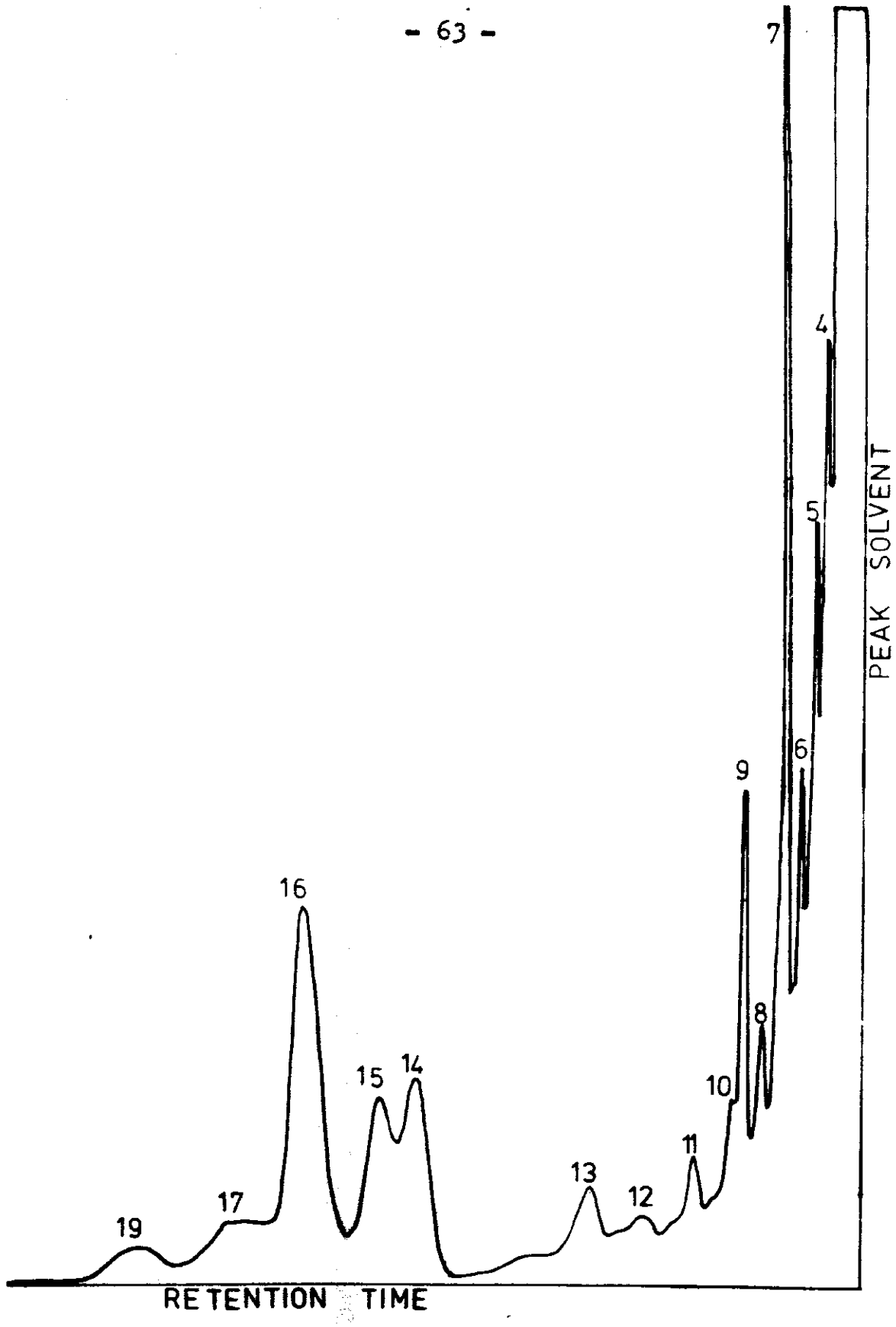

Fig.(11): Chromatographic analysis of unsaponifiable matter components of unirradiated sample of soybean seeds oil .

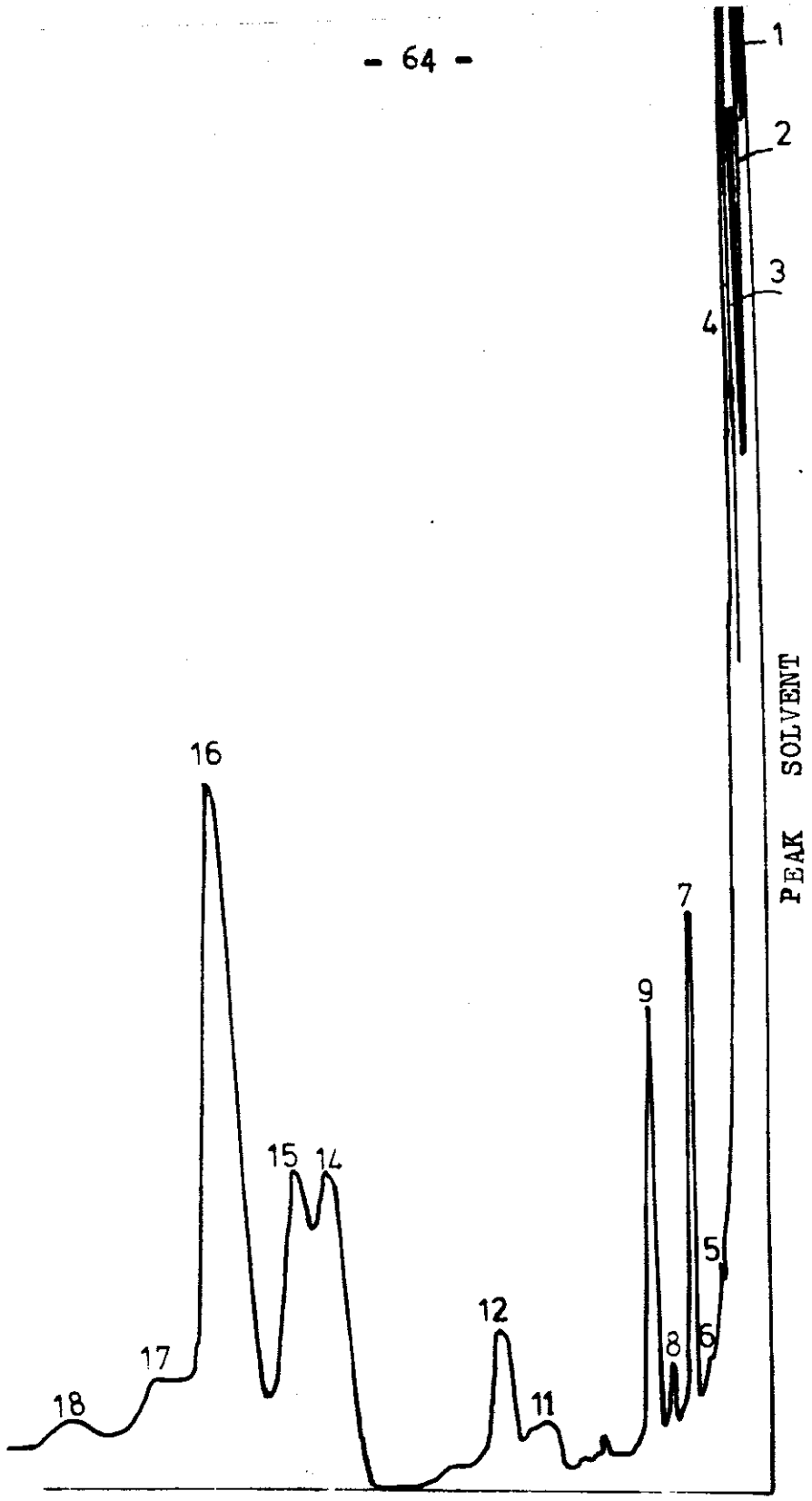

Fig.(12): Effect of 100 K.rad of gamma irradiation on unsaponifiable matter components of soybean oil .

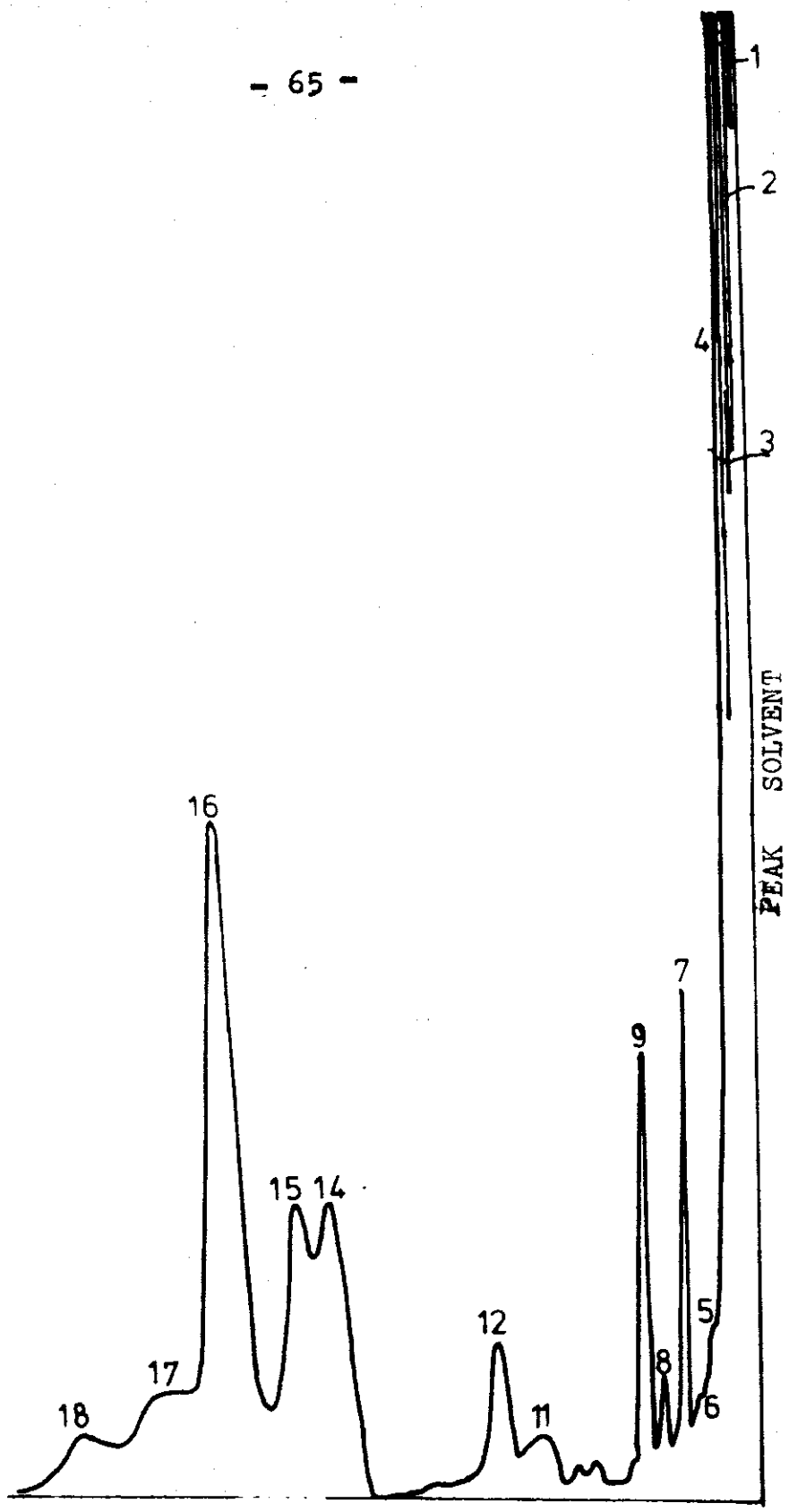

Fig.(13): Effect of 250 K.rad of gamma irradiation on unsaponifiable matter components of soybean oil .

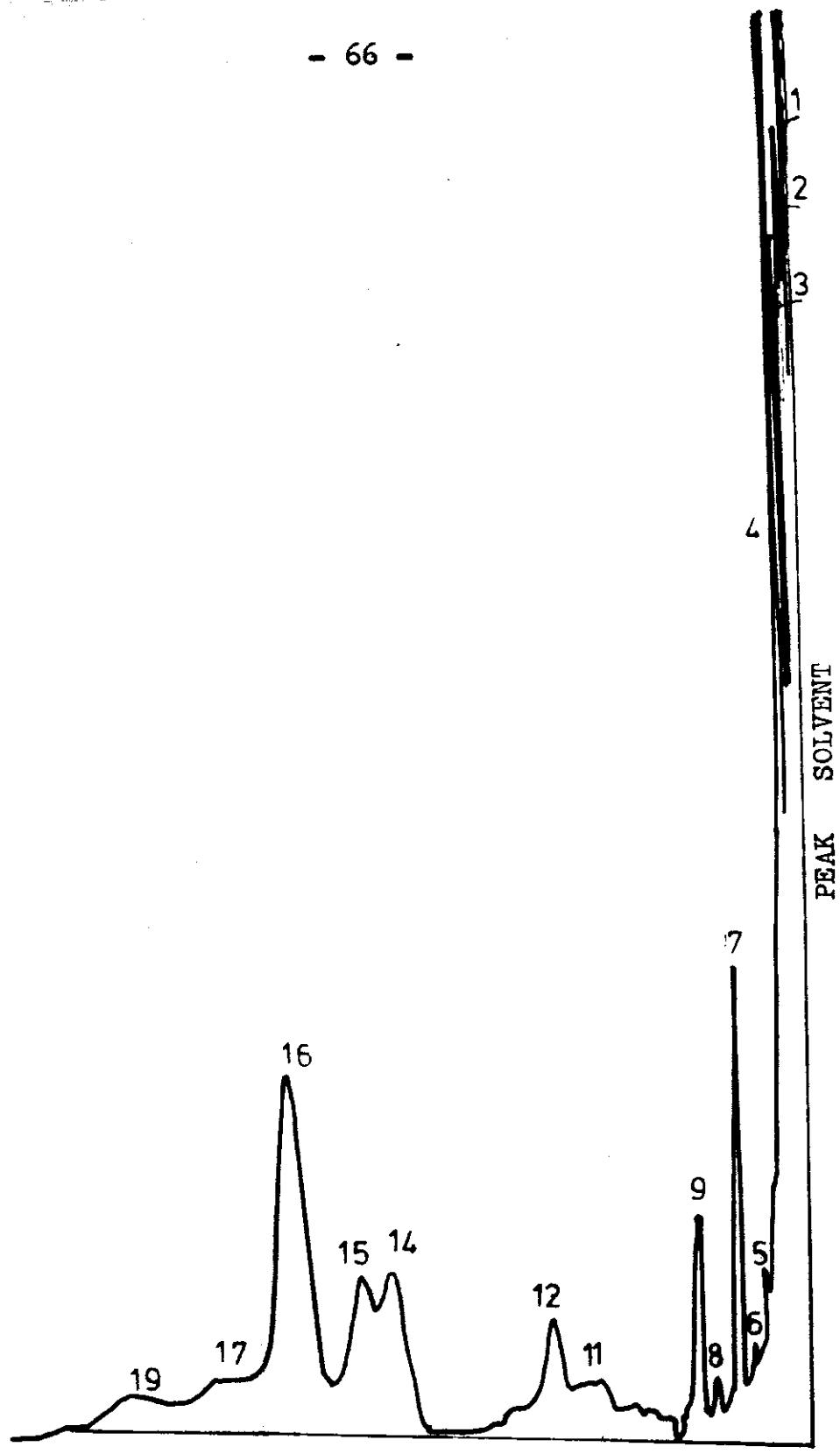

Fig.(14): Effect of 500 K.rad of gamma irradiation on unsaponifiable matter components of soybean oil.

Effect of storage on unsaponifiable matter components of soybean oils :

Crude unsaponifiable matter of oils extracted from un-irradiated (t_1) and irradiated seeds with 100(t_2) , 250(t_3). 500 (t_4) and 1000 K. rad (t_5) gamma irradiation doses after storage for three months at room temperature were fractionated and identified using Gas-Liquid Chromatography technique. Both relative percentage and relative retention time of each compound were calculated . The obtained results are shown in Table (8) and are graphically represented in Figures (16 - 20).

From these results it could be noticed that storage of oils of both irradiated and unirradiated soybean seeds for three months occurred a drastic change in the relative percentages of some hydrocarbon and sterol compounds. Total hydrocarbons showed a pronounced decrease when soybean oils of irradiated and unirradiated samples were stored for three months. They decreased from 43.61 , 36.15 , 37.63 , 50.22 and 40.11%before storage table(7) to 29.97 , 19.42 , 21.73 , 30.51 and 27.77% after stored T.(8) for three months for control, t_2, t_3, t_4 and t_5 respectively.

By fractionation of hydrocarbon compounds, it was proved that short chain hydrocarbon compounds namely C_{21},

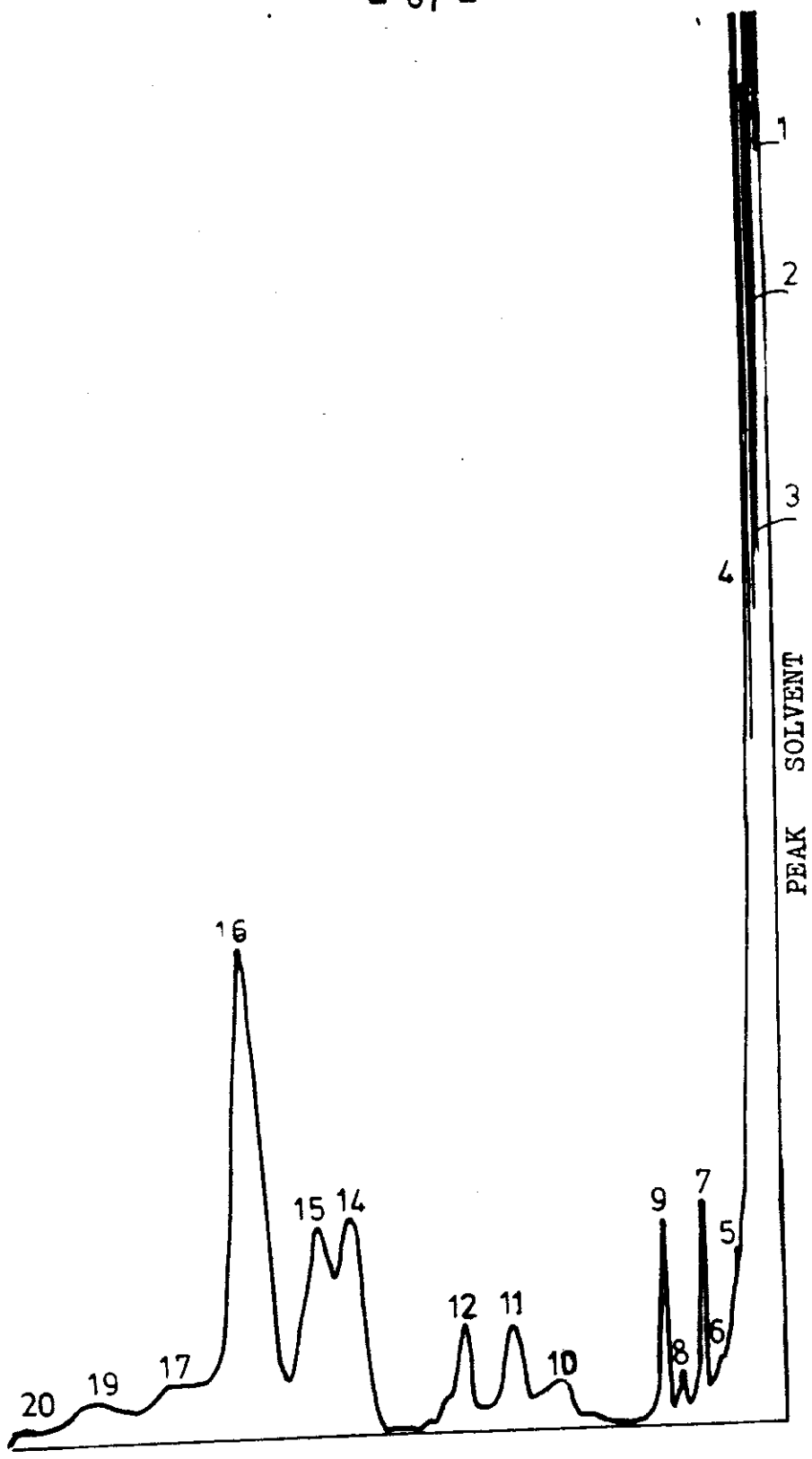

Fig.(15): Effect of 1000 K.rad of gamma irradiation on unsaponifiable matter components of soybean oil .

Table (8): Effect of storage on the unsaponifiable matter component

Components		R.R.T.	Gamma rays doses (K. rad.)				
			0	100	250	500	1000
1-n-hencosane	C_{21}	0.02	1.41	-	-	-	-
2-n-docosane	22	0.03	3.10	-	-	3.38	-
3-n-tricosane	23	0.04	10.74	-	-	3.24	-
4-n-tetracosane	24	0.07	0.20	-	1.50	0.89	0.32
5-n-pentacosane	25	0.12	0.20	0.19	1.52	0.50	0.15
6-n-heptacosane	27	0.15	4.68	7.15	8.13	12.16	14.90
7-n-octacosane	28	0.18	0.75	0.74	0.15	1.26	1.93
8- Squalene	30	0.22	7.71	10.43	8.63	7.74	9.16
9- Unknown	31	0.30	0.37	0.53	0.97	0.77	1.06
10-n-dotriacontane	32	0.42	0.81	0.38	0.83	0.57	0.25
11-Y-tocopherol		0.51	2.26	3.32	3.21	7.53	2.85
12- Cholesterol		0.62	0.32	0.50	0.50	0.19	0.52
13- Campsterol		0.81	6.79	11.47	10.93	7.24	11.28
14- Stigmasterol		0.86	7.54	6.35	9.74	7.10	5.89
15-B-sitosterol		1.00	49.37	56.03	52.06	45.30	49.38
16- Fucosterol		1.13	0.99	0.69	-	0.32	-
17-Δ-7 stigmasterol		1.20	-	2.21	1.82	1.80	0.76
18-Δ-7 avenasterol		1.30	2.75	-	-	-	1.54
Total hydrocarbons			29.97	19.42	21.73	30.51	27.77
Y-tocopherol			2.26	3.32	3.21	7.53	2.85
Total sterols			67.76	77.25	75.05	61.95	69.37

C_{22} and C_{23} were detected only in control sample. While, these compounds disappeared in t_2, t_3 and t_5 after three months of storage. Moreover, the former compound C 21 disappeared also in (t_4), but the other two-compounds decreased only as a result of storage. Furthermore, the main hydrocarbon compound (C_{27}) showed a drastic decrease in the unsaponifiable matter of un-irradiated soybean sample, as it decreased from 25.52% to 4.68% after storage. On the other hand, storage increased the same compound from 6.65 , 9.47 and 3.65% before storage to 8.13 ,12.16 and 14.90% for oils irradiated with 250, 500 and 1000 K. rad respectively.

In addition, storage led to a slight decrease in the relative percentage of squalene compound in unsaponifiable matter of contol sample. Storage induced a noticeable increase in squalene compound, as it increased from 8.51 , 7.92 , 2.95 and 4.82% before storage to 10.43 , 8.63 , 7.74 and 9.16% after the storage of irradiated samples at the ascendant doses undertaken respectively. On the other hand, other hydrocarbon compounds showed a minor change in the oils of both unirradiated and irradiated soybean seeds. It is obvious from the same results obtained in Table (7) and (8) that storage decreased the relative percentages of δ-tocopherol compounds

in t_1, t_2 and t_3 as they decreased from 3.27 , 4.5 and 4.82% before storage to 2.26 , 3.32 and 3.21% after storage for the above mentioned treatments respectively.

The relative percentage of γ-tocopherol increased from 4.90 and 2.60% before storage to 7.53 and 2.85% after the oils of t_4 and t_5 stored for three months.

Table (8) declared that storage caused a remarkable increase in total sterols in the oils of both irradiated and un-irradiated samples. Total sterols increased from 53.11 , 59.34 , 57.54 , 44.87 and 57.28% before storage to 67.76 , 77.25 , 75.05 , 61.95 and 69.37% after storage for un-irradiated and irradiated samples with the above mentioned doses respectively. Gas Chromatographic analysis illustrated that storage decreased camp sterol compound in control sample, as it decreased from 8.30% to 6.79% after storage, while an opposite trend occurred in the same sterol compound for all irradiated samples, as its percentage increased from 6.77, 7.76, 6.13 and 8.52 to 11.47, 10.93, 7.24 and 11.28%after storage of oils extracted from samples irradiated with ascendant doses mentioned before. Stigmasterol compound storage caused a marked increase in percentages of for t_1, t_2, t_3 and t_4. They increased from 4.83 , 5.00 , 4.45 and 3.93% to 7.54 , 6.35 , 9.74 and 7.10% after storage for the corresponding treatments.

Meanwhile, storage caused a minor decreased in this compound for t_5.

It is clearly observed from the same results that the predominant sterol compound (B-sitosterol) showed a progressive increase in the oils of both irradiated and un-irradiated samples which were stored for three months. This compound increased from 34.4 , 44.47 , 41.28 , 30.86 and 39.27% to 49.37 , 56.03 , 52.06 , 45.30 , and 49.38% after storage for un-irradiated and irradiated samples at the ascendant doses under investigation respectively. Although cholesterol compound disappeared by irradiation it was detected in the irradiated samples after storage. Besids, other sterol compounds showed a slight change in both oils of irradiated and un-irradiated soybean seeds due to storage.

Generally it could be concluded that storage induced a pronounced change in both hydrocarbon and sterol compounds in all samples under investigation. Total hydrocarbons showed a progressive decrease while total sterol showed a remarkable increase.

It could be stated that storage caused a noticeable changes in short chain hydrocarbon compounds in all sample under investigation. Also, the major hydrocarbon compound (C_{27}) of unsaponifiable matter of all samples showed a progressive decrease, while the reverse trend occurred in the predominant sterol compound (B-sitosterol) for the same samples.

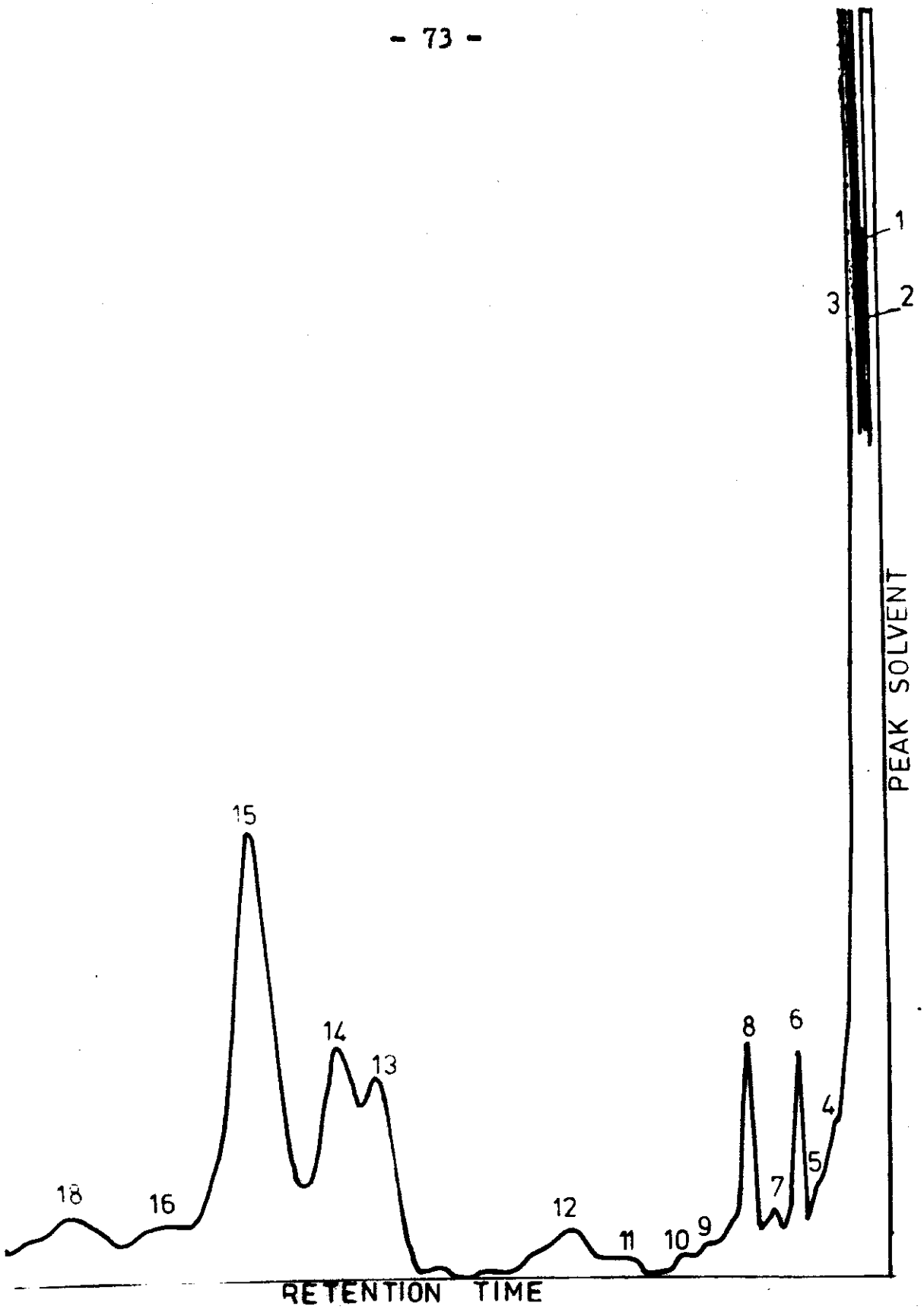

Fig.(16): Effect of storage on unsaponifiable matter components of unirradiated sample of soybean seeds oil.

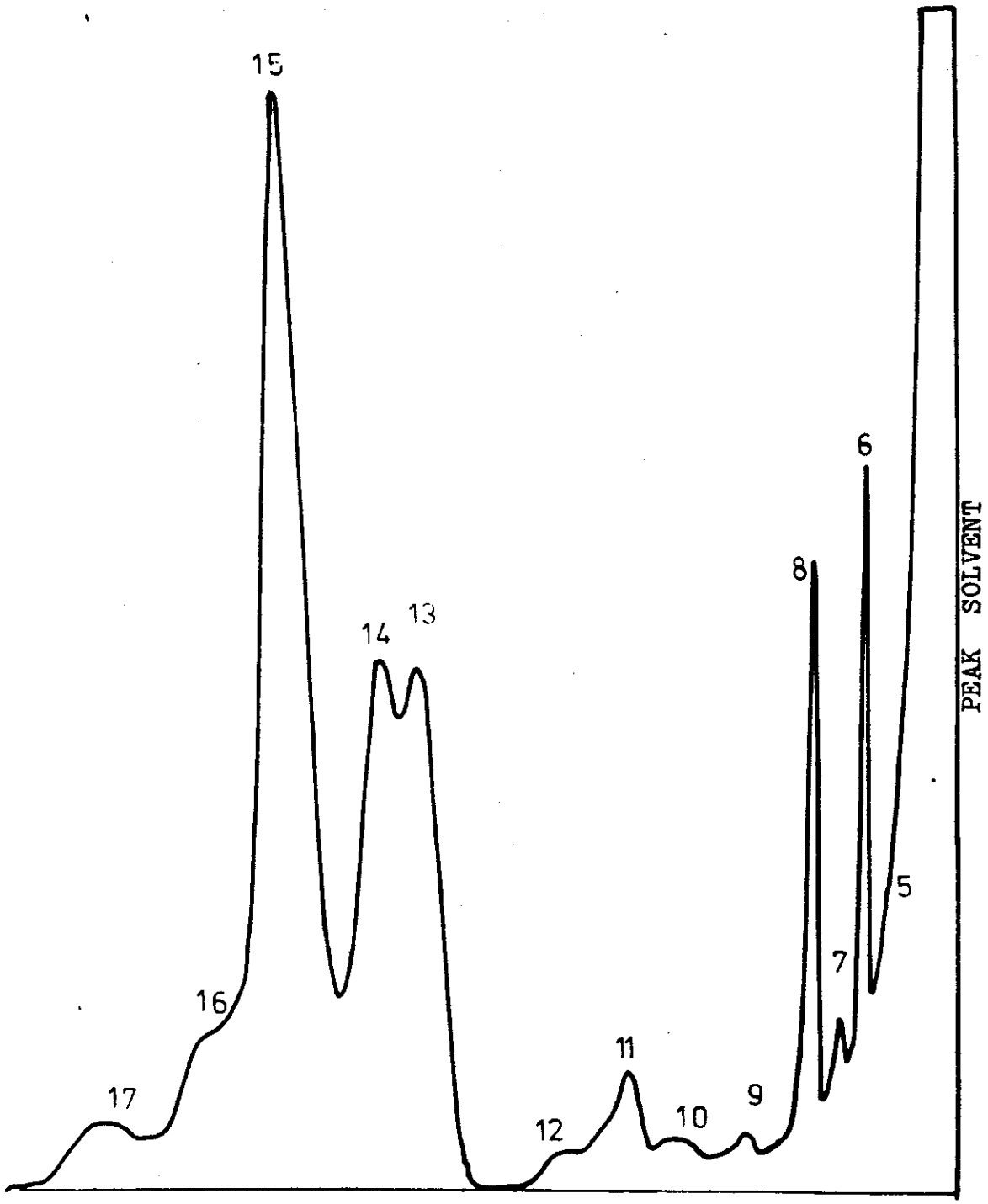

Fig.(17): Effect of storage on unsaponifiable matter components of soybean oil after irradiation with gamma rays at 100 K.rad.

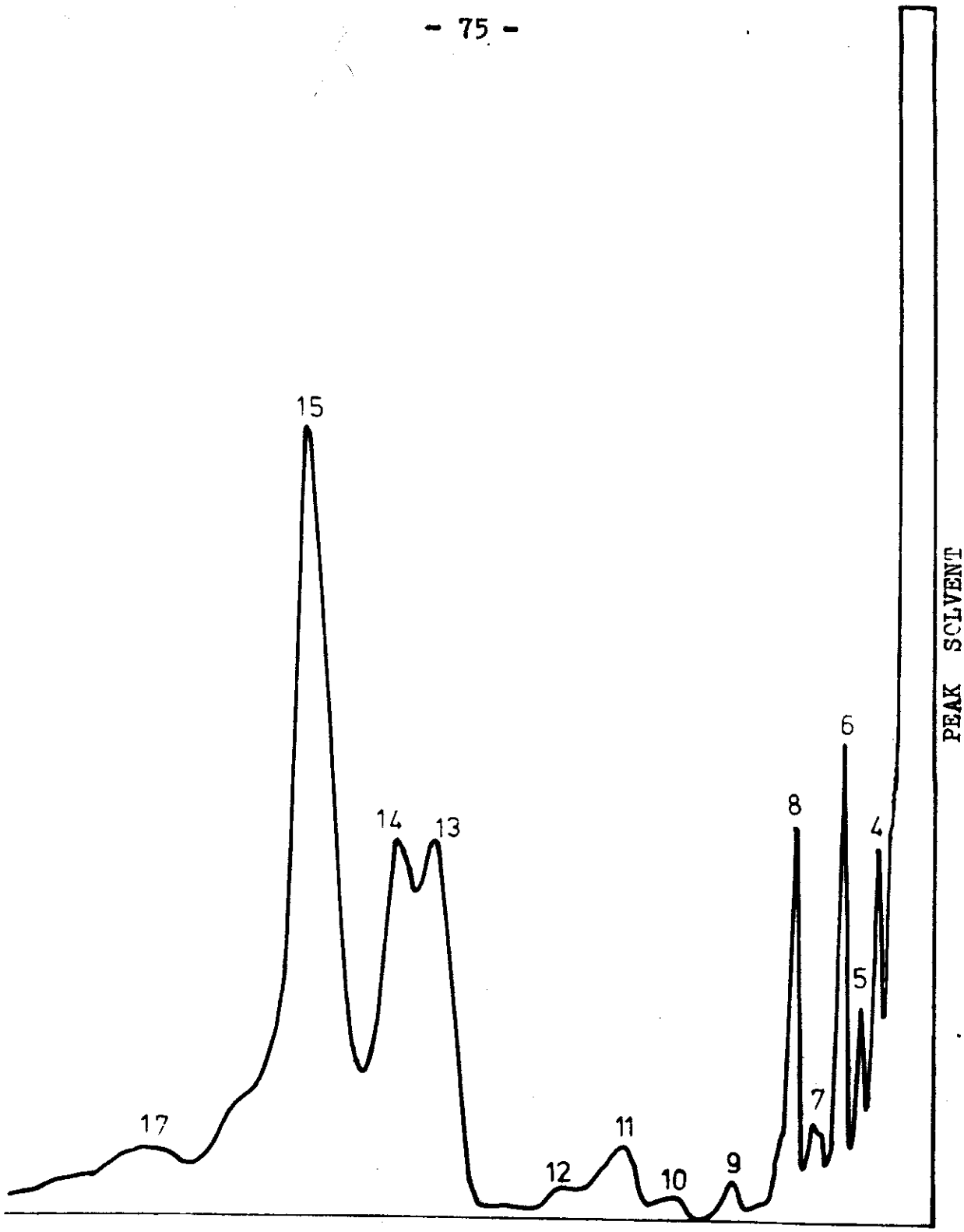

Fig.(18): Effect of storage on unsaponifiable matter components of soybean oil after irradiation with gamma rays at 250 K.rad.

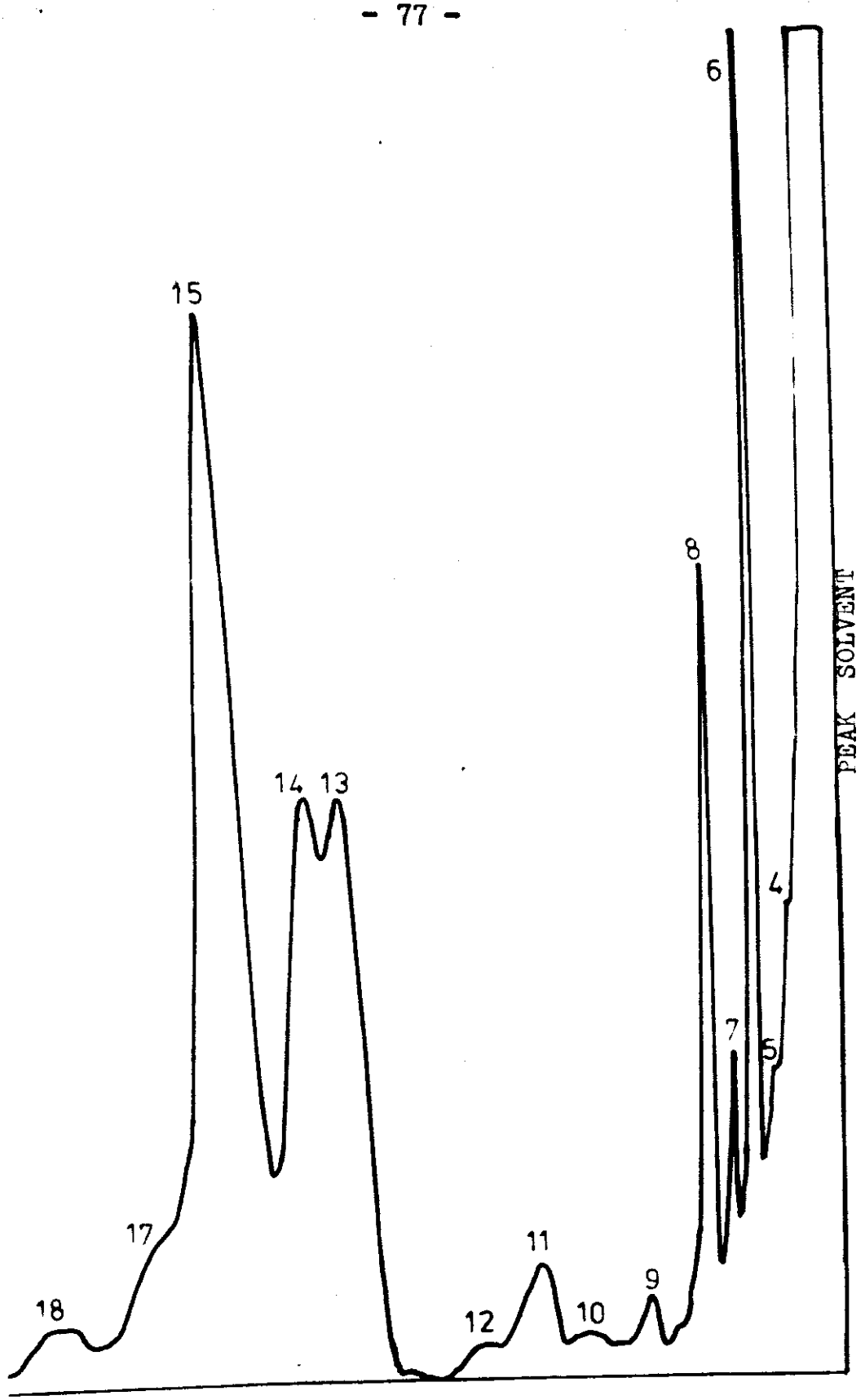

Fig.(20): Effect of storage on unsaponifiable matter components of soybean oil after irradiation with gamma rays at 1000 K.rad.

Effect of gamma irradiation on polar and non-polar fractions content of unsaponifiable matter of soybean oils

Total hydrocarbons (non-polar fraction), total unsaturated hydrocarbons and total sterols (polar fraction) were determined in unsaponifiable matter of oils extracted from non-irradiated and irradiated soybean seeds and the obtained results are shown in Table (9) .

From the results obtained in Table (9), it could be noticed that total hydrocarbon (non-polar fraction) of crude soybean oil (control) was 28.08% of total unsaponifiable matter. This value was in range of 15-30% as reported by Hoffman et al., (1962). It is evident from the same results that exposure of soybean seeds to 100, 250 and 1000 K. rad led to a remarkable decrease in the total non-polar fraction of unsaponifiable matter in soybean oil. The corresponding decrease was 22.58 , 21.98 and 24.26% respectively. Meanwhile, 500 K. rad gamma rays dose increased total hydrocarbonsto 35.12%.

The same data indicated that non-polar fraction of the unsaponifiable matter of soybean oil contained 7.93% unsaturated hydrocarbons. These results revealed also that gamma irradiation induced a gradual increase in total unsaturated hydrocarbons, as it increased from 7.93% in

Table (9): Polar and non-polar fractions of oils of un-irradiated and irradiated soybean oil.

Constituents	Gamma rays doses (K. rad)				
	0	100	250	500	1000
Unsaponifiable matter (gm/100 gm oil).	0.73	0.70	0.76	0.78	0.79
Total hydrocarbon (non-polar fraction). (gm/100 gm unsap. m.)	28.08	22.58	21.98	35.12	24.26
Total hydrocarbon (gm/ 100 gm oil).	0.205	0.158	0.167	0.274	0.192
Total unsaturated hydro-carbon) (gm/100 gm total hydrocarbons).	7.93	9.83	12.58	12.91	13.02
Total unsaturated hydro-carbon. (gm/100 gm un-saponifiable m.).	2.23	2.22	2.77	4.53	3.16
Total unsaturated hydro-carbon.(mg/100 gm oil).	16.26	15.54	21.05	35.33	24.96
Total sterols (polar fraction).(gm/100 gm un-saponifiable).	71.98	77.42	78.02	64.88	75.74
Total sterol (gm/100 gm. oil).	0.525	0.542	0.593	0.506	0.598

control to 9.83 , 12.58 , 12.91 and 13.02% in non-polar fraction of samples irradiated with 100, 250, 500 and 1000 K. rad gamma rays respectively.

Similarly high doses (500 and 1000 K. rad) led to a pronounced increase in total unsaturated hydrocarbons of unsaponifiable matter of irradiated samples as it increased from 2.23% in control to 4.53 and 3.16% in unsaponifiable matter of samples exposed to 500 and 1000 K. rad respectively. Moreover, the same phenomena , also occurred in oils irradiated with 500 and 1000 K. rad as it increased from 16.26 (mg/100 gm oil) to 35.33 and 24.96 (mg/100 gm oil) in the oils at the corresponding samples respectively. The increase in total unsaturated hydrocarbons in non-polar fraction may be due to the dehydrogenation effect of different doses of gamma irradiation on the hydrocarbons of unsaponifiable matter of soybean oil. This results agreed with the report of FAO/WHO/IAEA (1962) and Rady (1981) .

It is clearly observed from the same data that soybean oil contained 71.98% total sterols (polar fraction). The application of gamma irradiation induced on opposite trend in total sterols as compared with that occured in total hydrocarbons by radiation. Total sterols increased from 71.98 in unsaponifiable matter of control to 77.42 ,

78.02 and 75.74% in unsaponifiable matter of samples irradiated with 100, 250 and 1000 K. rad, while 500 K. rad decreased total sterols to 64.8%; Total sterols (polar fraction) in oils were 0.525, 0.542, 0.593, 0.506 and 0.598 gm/100 gm. of oil for control and samples subjected to the above mentioned ascendant doses respectively.

It could be concluded that determination of total hydrocarbons and sterols in both unirradiated and irradiated samples agreed with those results obtained for the same samples by using gas chromatographic technique.