RESULTS

Fungal isolation:

Fifty three fungal isolates of *Curvularia* spp., *Alternaria* spp. and *Fusarium* spp. were isolated from different sources, i.e. wheat (5), potato (6), tomato (11), mandarin (2), fenugreek (1), bread (1), orange (1), lupine (4), chicken feed (13), soil (7) and air (2) as shown in Table (1).

From Table (1), five isolates were selected from each genus according to the difference in their morphological characters and the source of food. The five isolates of *Fusarium* were taken from wheat, potato, tomato, chicken feed and soil; the five isolates of *Alternaria* were taken from tomato, mandarin, fenugreek, bread and chicken feed; while one *Curvularia* sp. was selected from each of orange, soil, air and two isolates from lupine.

Table (1): Fungal genera isolated from different collected sources.

Sources	Genera	Total isolates	No. of selected isolates
Wheat (w)	*Fusarium*	5	1 (Fw)
Potato (p)	*Fusarium*	6	1 (Fp)
Tomato (t)	*Fusarium*	7	1 (Ft)
	Alternara	4	1 (At)
Mandarin (m)	*Alternaria*	2	1 (Am)
Fenugreek (f)	*Alternaria*	1	1 (Af)
Bread (b)	*Alternaria*	1	1 (Ab)
Orange (o)	*Curvularia*	1	1 (Co)
Lupine (*l*)	*Curvularia*	4	2 (C*l*)
Chicken feed (c)	*Fusarium*	7	1 (Fc)
	Alternaria	6	1 (Ac)
Soil (s)	*Fusarium*	5	1 (Fs)
	Curvularia	2	1 (Cs)
Air (a)	*Curvularia*	2	1 (Ca)
Total	53		15

F: *Fusarium*

C: *Curvularia*

A: *Alternaria*

w: Wheat, p: Potato, t: Tomato, m: Mandarin, f: Fenugreek, b: Bread, o: Orange, *l*: Lupine, c: Chicken feed, s: Soil and a: Air,

Effect of gamma irradiation on the linear growth of the selected fungal isolates:

The fifteen fungal isolates which were selected from the previous experiment were individually grown on Czapek's-yeast extract agar medium in petri-dishes at 25-28 °C for 10 days, then exposed to different increasing dose levels of gamma irradiation (0.0, 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0 kGy). Discs, measure 5mm in diameter, were taken from the different treatments and transferred to Czapek;s-yeast extract agar medium in petri-dishes (three dishes for each treatment).

All the dishes were then incubated at 25-28 °C the mycelial growth were measured daily till the mycelium of unirradiated isolate reached the edge of the dish (9.0 cm).

It is clear from the data given in Table (2) and Fig. (1) that all the radiation doses used affected the mycelium growth of the experimental five isolates of *Curvularia* but at different degrees, as the dose level increased the growth diameter decreased. The unirradiated isolates reached the petri-dishes edges before any of the treated one. Un-irradiated *Curvularia* sp. which was isolated from lupine (Cl_1) was the faster one in its growth comparing with other isolates of *Curvularia*, since its mycelium reached the edges of the petri-dishes after 6 days followed by Cl_2, Co (isolated from lupine and orange, respectively) and Ca (isolated from air) where they reached the petri edges after 7 days. *Curvularia* sp. isolated from soil (Cs) was the slower one in its growth and reached the petri edge after 8 days.

The results recorded in Table (2) also revealed that the selected *Curvularia* isolates differ in their resistance to gamma radiation. Cl_1 sp. showed the highest resistance to gamma radiation, since up to 2.0 kGy, the mycelia growth were slightly different from the control (8.7 cm) and gradual decrease occurred thereafter.

Table (2): Effect of gamma irradiation on linear growth (cm) of selected isolates of *Curvularia* spp. collected from different sources.

Irradiation dose levels (kGy) / *Curvularia* isolates	0.0	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
C*l*₁	9.0	8.9	8.8	8.7	8.0	7.8	7.7	7.5	7.3	7.2	7.1	7.0
Co	9.0	8.0	8.0	7.9	7.9	7.7	7.2	6.8	5.6	5.1	4.8	4.0
Cs	9.0	8.5	8.2	8.0	7.9	7.6	7.5	4.2	4.0	3.5	0	0
Ca	9.0	6.7	6.5	5.7	4.8	4.5	3.7	3.2	2.0	0	0	0
C*l*₂	9.0	7.2	6.7	6.2	6.0	4.7	3.0	0	0	0	0	0

C: *Curvularia* spp.

l: Lupine, o: Orange, s: Soil, a: Air.

Maximum growth of Cl_1 at 6 days.

Maximum growth of Cs at 8 days.

Maximum growth of C*a*, Co and Cl_2 at 7 days.

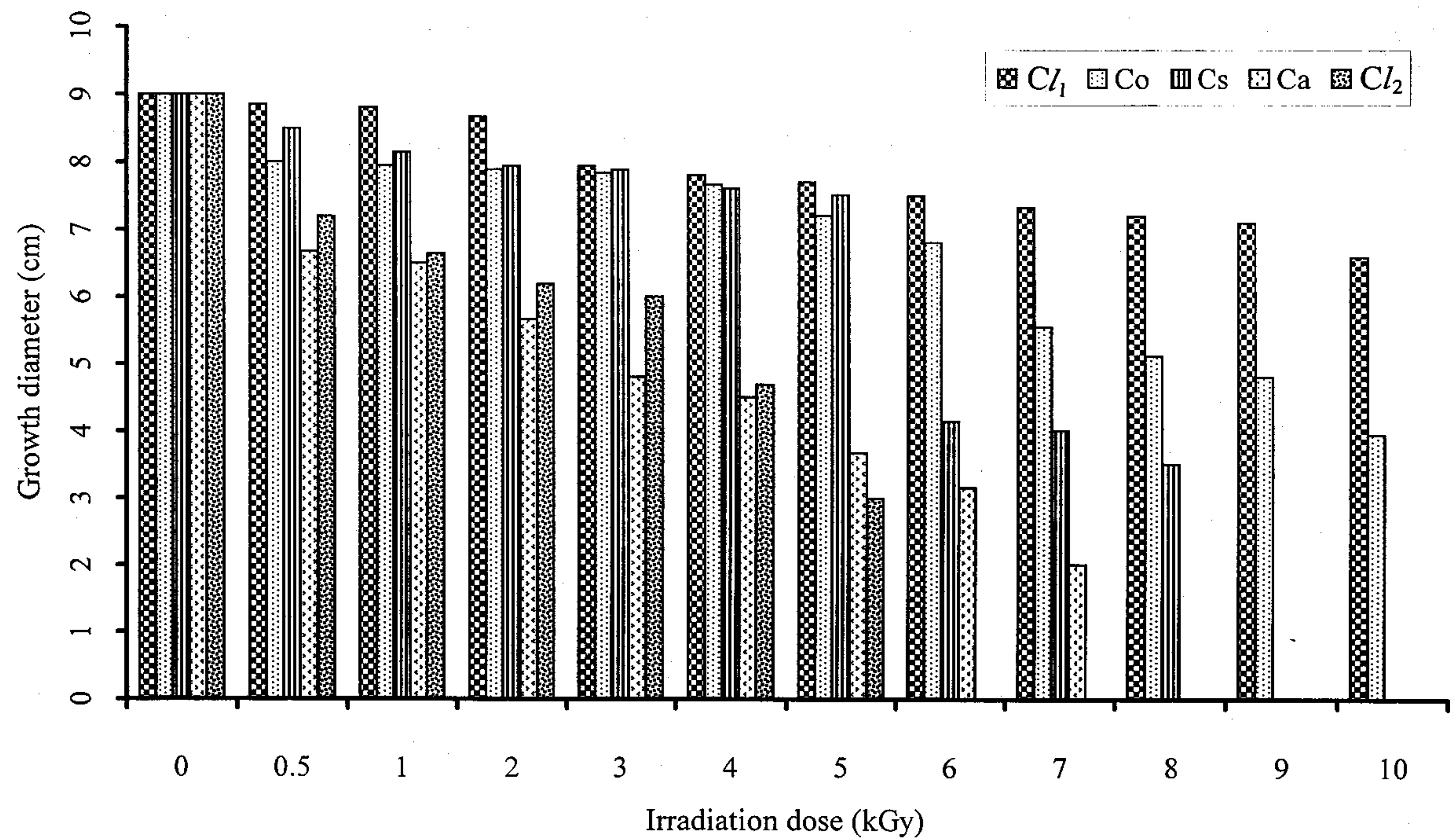


Fig. (1): Effect of gamma irradiation on growth diameter (cm) of the selected isolates of ***Curvularia*** spp.

The growth diameter recorded was 7.0cm after exposure to dose level of 10.0 kGy. Meanwhile, Cl_2 sample (isolated from lupine seeds) showed the highest sensitivity to gamma radiation and its growth completely inhibited after exposure to dose level of 6.0 kGy. The mycelial growth of Cs and Ca isolates inhibited after exposure to dose levels of 9.0 and 8.0 kGy, respectively, while Co isolate continued to grow even after exposed to dose level of 10 kGy but its growth diameter recorded only 4.0 cm. Thus, the resistance of the selected *Curvularia* isolates to gamma radiation was as follows: Cl_1 > Co > Cs > Ca > Cl_2.

Growth diameter of the selected *Alternaria* isolates as affected by gamma radiation are recorded in Table (3) and illustrated by Fig. (2). It is clear that the highest rate of growth was observed with Ac isolate and the lowest rate of growth was noticed with At isolate. Also, it is evident that Ac isolate was the highest resistant to gamma radiation among the *Alternaria* studied isolates. While Ab and At isolates had the lowest resistant to gamma radiation. Dose level of 5 kGy inhibited the growth of the two strains of *Alternaria* (A_b and A_t) while the other three strains resist gamma rays up to dose 8.0 kGy and Ac strain remained alive after exposure to dose 9.0 kGy.

The results recorded in Table (4) and illustrated by Fig. (3) showed the effect of gamma irradiation on the growth diameter of the selected *Fusarium* spp.. From the data, it could be noticed that *Fusarium* isolate (Fw) isolated from wheat was the faster in its growth than the other *Fusarium* isolates, since the mycelial growth of the unirradiated (control) reached the petri dishes edge after only 5 days of incubation while the other four isolates reached the edges after 7 days. Exposuring the five isolates to gamma radiation greatly decreased the mycelial growth and their decrease was proportional with irradiation dose.

Table (3): Effect of gamma irradiation on linear growth (cm) of selected isolates of *Alternaria* spp. collected from different sources.

Irradiation dose levels (kGy) / *Alternaria* Isolates	0.0	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
Ac	9.0	7.0	6.9	6.8	6.6	6.3	6.2	5.8	5.2	4.3	2.9	0
Am	9.0	7.8	6.9	5.2	4.6	4.2	3.5	2.6	2.0	1.6	0	0
Af	9.0	7.0	6.1	5.9	4.4	3.7	3.1	2.6	2.1	1.9	0	0
Ab	9.0	6.7	5.1	4.4	4.0	3.2	0	0	0	0	0	0
At	9.0	7.2	5.9	5.1	4.2	3.0	0	0	0	0	0	0

A: *Alternaria* spp.

c: Chicken feed, m: Mandarin, f: Fenugreek, b: Bread, t: Tomato.

Maximum growth of Ac at 7 days.

Maximum growth of Am and Af at 8 days.

Maximum growth of Ap at 10 days.

Maximum growth of At at 11 days.

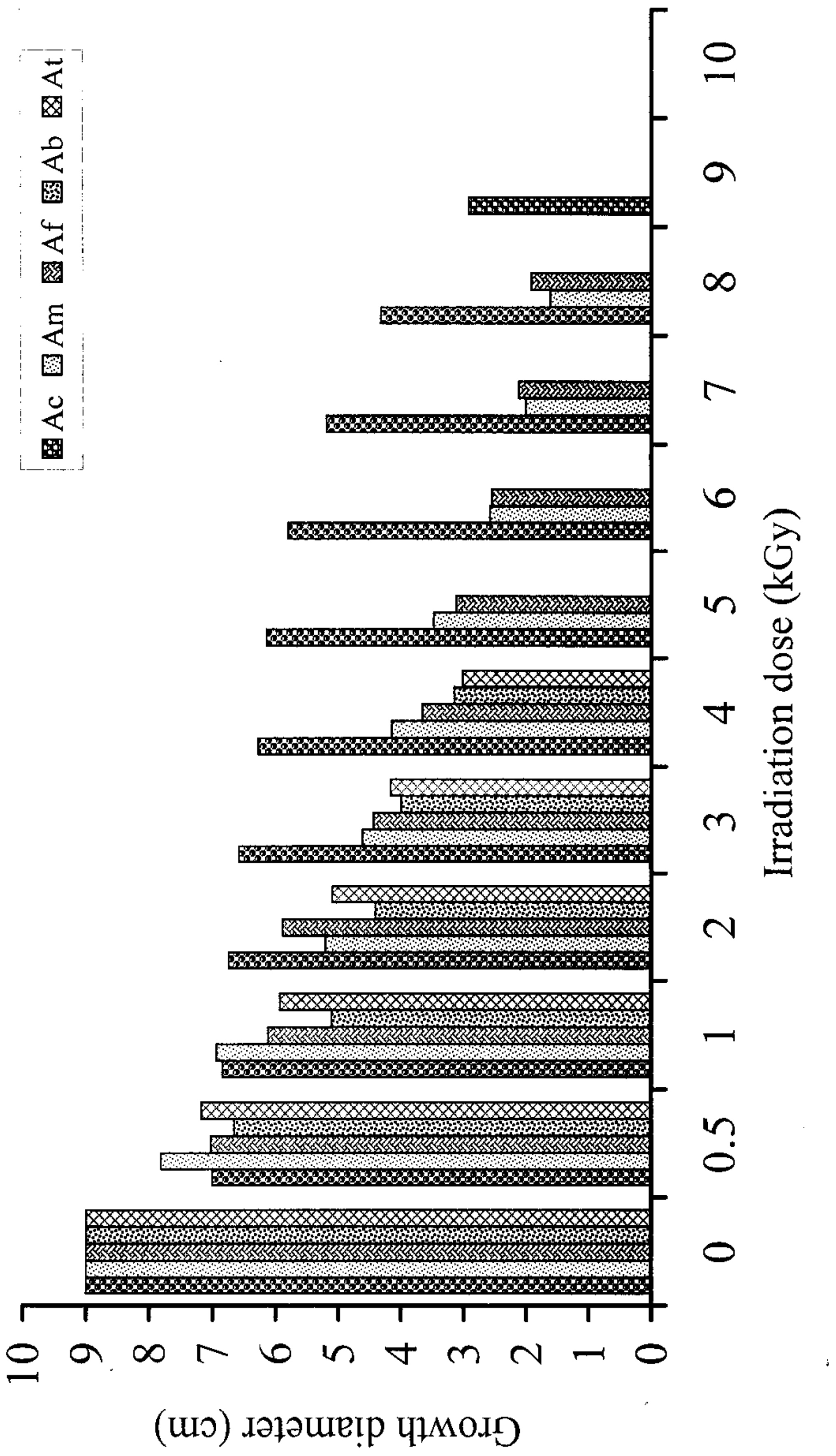


Fig. (2): Effect of gamma irradiation on growth diameter (cm) of the selected isolates of ***Alternaria*** spp.

After exposure to 4.0 kGy, the growth of *Fusarium* sp. (Fp) isolated from potatoes completely inhibited, while the growth diameter of other four samples of *Fusarium* were 5.8, 4.4, 4.1 and 5.0 cm for Fc, Fs, Fw and Ft isolates, respectively. Dose level of 6.0 kGy inhibited the growth of Fw sample while Ft isolate stopped growing after exposure to 7.0 kGy and Fs isolate after exposure to 8.0 kGy. These results revealed that the highest resistance to gamma radiation was observed with Fc isolate as its growth was inhibited at 9.0 kGy.

Referring to data in Tables (2, 3 and 4) and Figs. (1, 2 and 3), it could be noticed that the growth rate of most selected isolates of *Alternaria* spp. were relatively slower than that of *Fusarium* and *Curvularia* spp., since they reached the edge of Petri dishes between 7-11 days comparing by 6-8 days in *Curvularia* strains and 5-7 days in case of *Fusarium* strains. Also, the resistance of the selected fungal genera spp. were in the order: *Curvularia* spp. > *Alternaria* spp. > *Fusarium* spp..

It could be concluded that *Curvularia* isolates (Cl_1) and (Co) approved to be the highest radiation resistance, since they tolerated irradiation doses up to 10.0 kGy, followed by Ac isolates which tolerated irradiation doses up to 9.0 kGy, then Fc which tolerated irradiation doses up to 8.0 kGy.

Table (4): Effect of gamma irradiation on linear growth (cm) of selected isolates of *Fusarium* spp. collected from different sources.

Irradiation dose levels (kGy) / *Fusarium* isolates	0.0	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
Fc	9.0	8.1	7.5	6.9	6.2	5.8	5.2	4.5	4.0	2.9	0	0
Fs	9.0	7.9	6.7	6.0	5.2	4.4	3.7	3.0	2.5	0	0	0
Ft	9.0	8.1	7.4	6.6	5.9	5.0	4.3	2.9	0	0	0	0
Fw	9.0	8.5	7.9	6.5	5.6	4.1	3.3	0	0	0	0	0
Fp	9.0	8.0	6.2	5.1	4.1	0	0	0	0	0	0	0

F: *Fusarium* spp.

c : Chicken feed, s: Soil, t: Tomato, w: Wheat, p: Potato

Maximum growth of Fc, Fs, Ft and Fp at 7 days.

Maximum growth of Fw at 5 days.

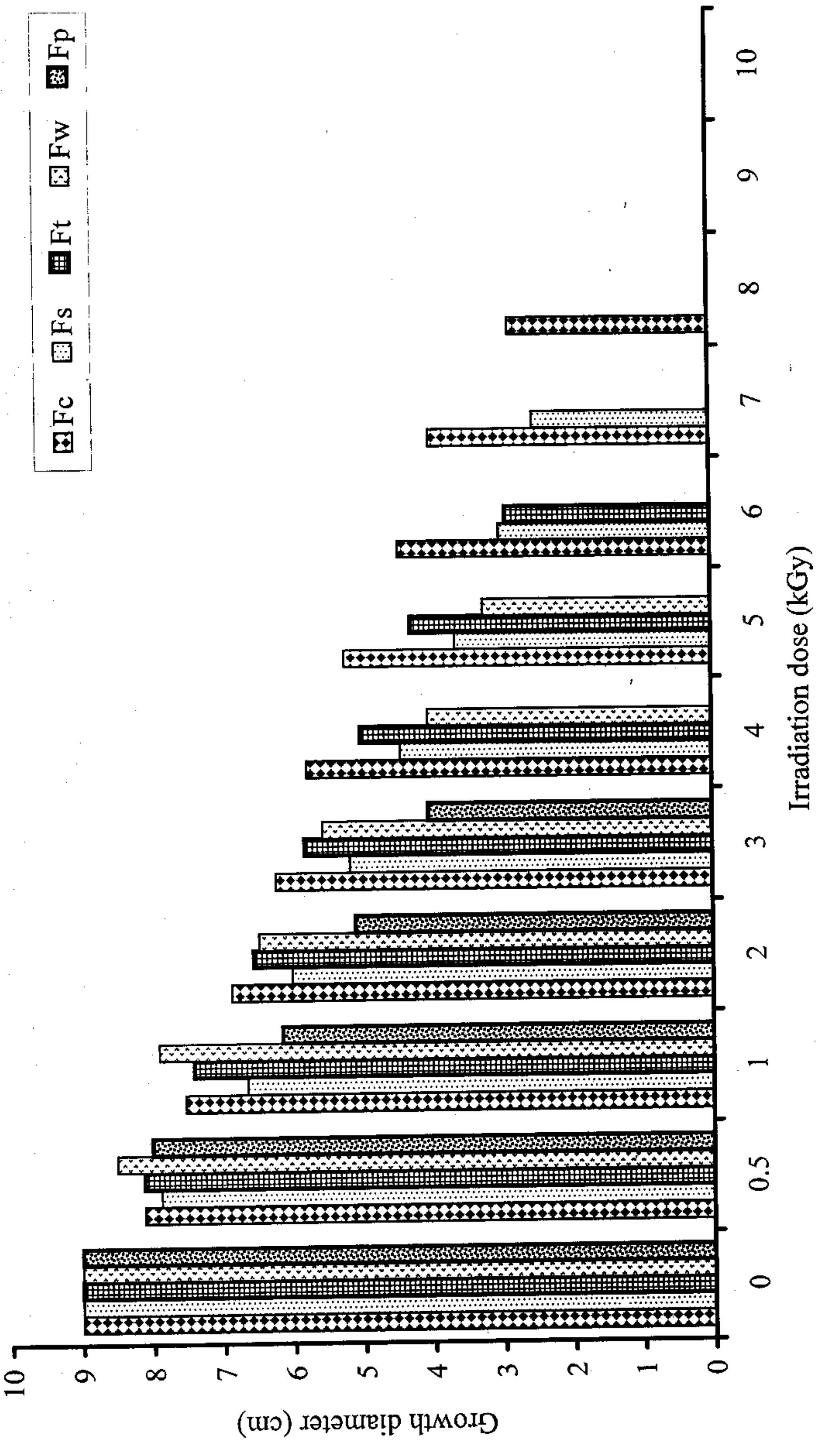


Fig. (3): Effect of gamma irradiation on growth diameter (cm) of the selected isolates of *Fusarium* spp.

Identification of the selected fungal isolates

From the previous experiments, the highest and the lowest radiation resistance isolates of each genus were identified and selected for further studies. The three radiation resistant isolates were identified as *Curvularia lunata* (Cl_1) isolated from lupine, *Alternaria alternata* (Ac) isolated from chicken feed and *Fusarium oxysporum* (Fc) isolated from chicken feed, while the three radiation sensitive isolates were identified as *Curvularia tuberculata* (Cl_2) isolated from lupine, *Alternaria tenuissima* (At) isolated from tomato and *Fusarium semitectum* (Fp) isolated from potato.

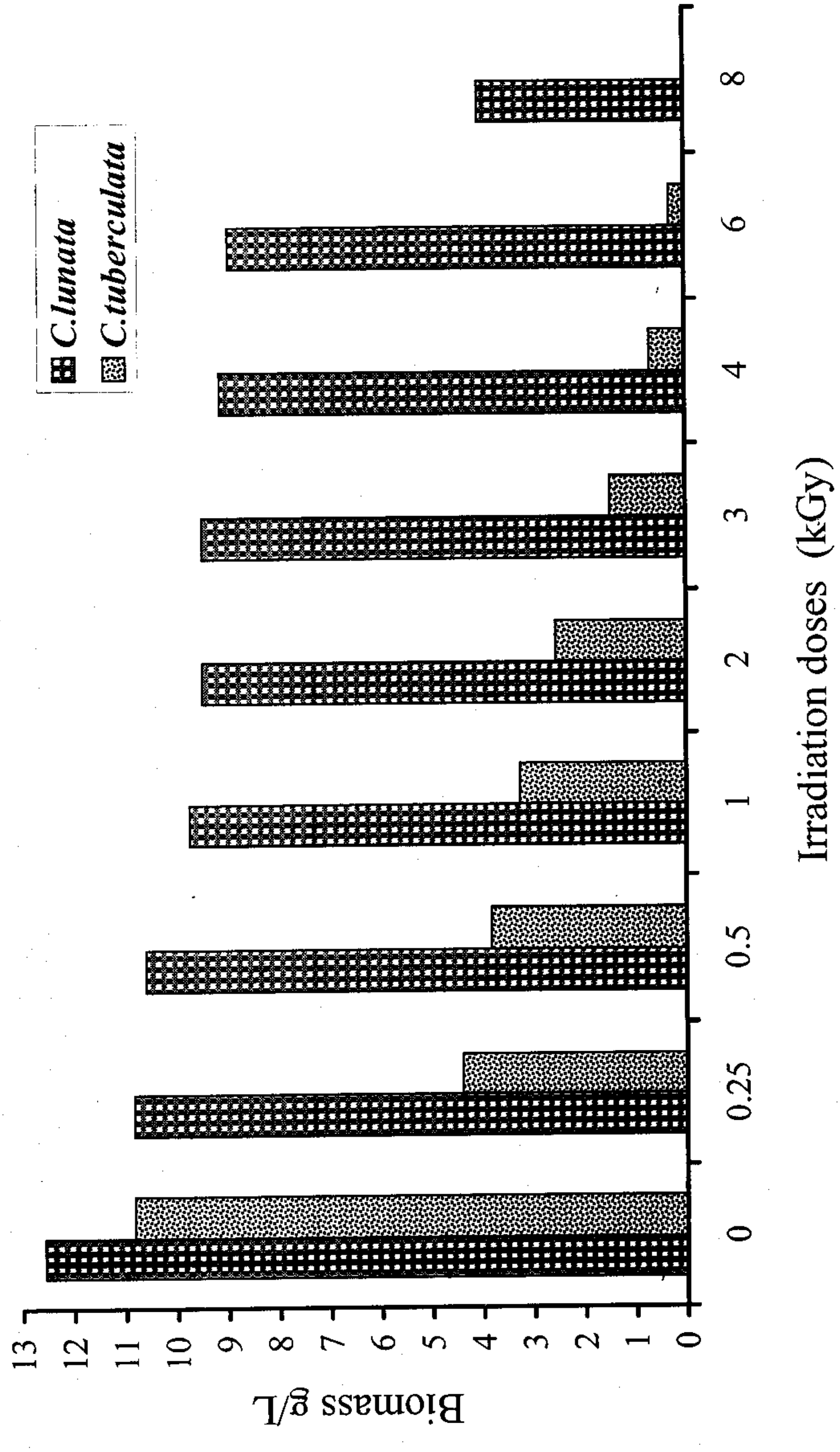
Effect of gamma irradiation on the biomass of the selected strains:

This experiment was carried out to investigate the effect of increasing dose levels of gamma radiation (0.0-8.0 kGy) on the biomass of the six selected fungal species.

Table (5) and Fig. (4) showed the effect of gamma rays on the biomass of the radiation resistance and sensitive strains of *Curvularia,* i.e. *C. lunata* and *C. tuberculata.* It is clear from the data that the growth of unirradiated *C. lunata* was more intensified (12.56 g/L) than that of unirradiated *C. tuberculata* (10.82 g/L). The biomass dry weight of both *C. lunata* and *C. tuberculata* decreased by increasing the dose levels of radiation, but at different levels. The rate of decrease was much lower with *C. lunata* indicating the resistance of this fungus to gamma radiation. The biomass of *C. lunata* decreased by only 15.6 % at dose level of 0.5 kGy compared with 64.6% in case of *C. tuberculata* at the same dose. At dose level of 6.0 kGy the biomass of *C. lunata* decreased by 28.8 % compared with 97.3 % in case of *C. tuberculata.* Dose level of 8.0 kGy almost inhibited the growth of *C. tuberculata* while the dry mass of *C. lunata* decreased by only 67.8 %.

Table (5): Effect of gamma irradiation on the biomass of the resistant and sensitive *Curvularia* species.

Irradiation dose (kGy)	***Curvularia lunata***		***Curvularia tuberculata***	
	Biomass g/L	Increase or decrease %	Biomass g/L	Increase or decrease %
0.00	12.56	0.00	10.82	0.00
0.25	10.83	-13.8	4.40	-59.3
0.50	10.60	-15.6	3.83	-64.6
1.00	9.74	-22.5	3.26	-69.9
2.00	9.49	-24.4	2.56	-76.3
3.00	9.48	-24.5	1.48	-86.3
4.00	9.12	-27.4	0.69	-93.6
6.00	8.94	-28.8	0.29	-97.3
8.00	4.04	-67.8	0.02	-99.8



Fig(4): Effect of gamma irradiation on the biomass of the resistant and sensitive ***Curvularia*** species.

The mycelium dry weight (biomass) of the two *Alternaria* species (the resistant and sensitive) as affected by gamma radiation was tabulated in Table (6) and illustrated in Fig. (5). It is clear that, the lowest irradiation dose used, i.e. 0.25 kGy increased the biomass of *Alternaria alternata* by 3.6 %. Thereafter, a gradual decrease was observed up to 8.0 kGy as the percentage of decrease reached 47.8 % at that dose. Meanwhile, exposure the radiation sensitive *Alternaria tenuissima* to dose level of 0.25 kGy decreased its biomass by 23.1% and a sharp decrease was occurred thereafter by increasing the dose levels of gamma radiation recording 72.1 % decreases at dose level of 6.0 kGy and at dose level of 8.0 kGy the decreases reached 92.0% compared by 47.8 % in case of *Alternaria alternata*.

The effect of different dose levels of gamma radiation on *Fusarium oxysporum* (resistant) and *F. semitectum* (sensitive) is shown in Table (7) and illustrated by Fig. (6). It is clear that the growth rates of the two untreated *Fusarium* species were less than that occurred in the two *Curvularia* species, especially *Fusarium semitectum* (sensitive), where its biomass recorded only 5.9 g/L compared with 12.56 g/L and 10.82 g/L in case of *C. lunata* and *C. tuberculata*, respectively. Gradual decreases in the dry weight biomass of *F. oxysporum* were occurred by increasing the dose levels of gamma ray recording 58.5% at 6.0 kGy. Meanwhile, exposure the sensitive *F. semitectum* to low dose devel of gamma rays, i.e. 0.25 kGy caused slight increase (1.2 %) in its dry weight biomass followed by gradual decreases by increasing the dose levels of gamma radiation up to 2.0 kGy. Thereafter, a sharp decrease of the biomass of *F. semitectum* was observed and almost the growth inhibited at dose level of 8.0 kGy compared by 61.2 % decreases in the dry biomass of *F. oxysporum*.

Table (6): Effect of gamma irradiation on the biomass of the resistant and sensitive *Alternaria* species.

Irradiation Jose (kGy)	*Alternaria alternata*		*Alternaria tenuissima*	
	Biomass g/L	Increase or decrease %	Biomass g/L	Increase or decrease %
0.00	9.67	0.00	9.26	0.00
0.25	10.02	+3.60	7.12	-23.1
0.50	8.89	-8.10	6.04	-34.8
1.00	7.78	-19.5	5.99	-35.3
2.00	7.23	-25.2	5.87	-36.6
3.00	7.16	-26.0	5.19	-44.0
4.00	6.68	-30.9	3.59	-61.2
6.00	5.90	-39.0	2.58	-72.1
8.00	5.05	-47.8	0.74	-92.0

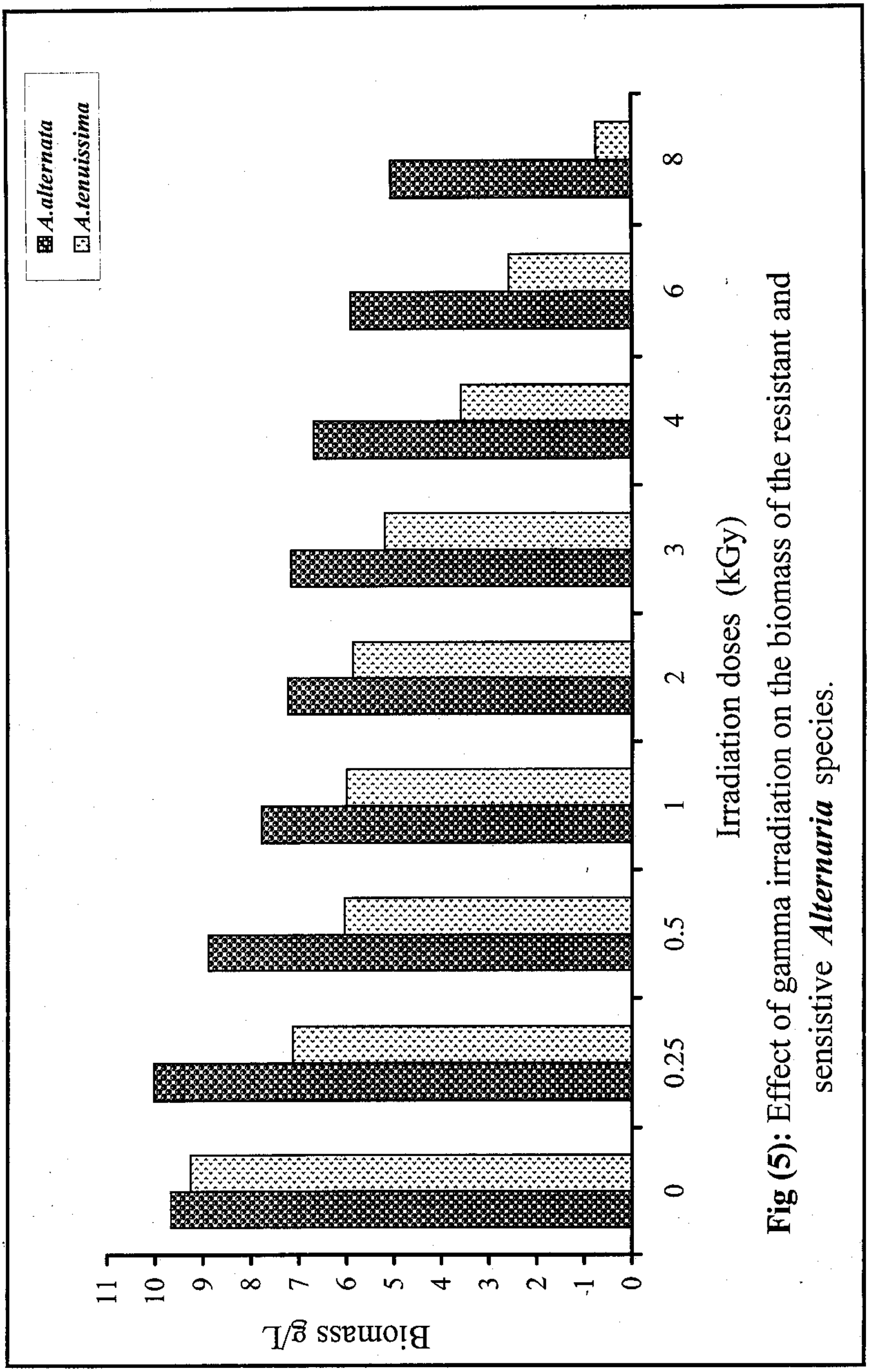


Fig (5): Effect of gamma irradiation on the biomass of the resistant and sensitive ***Alternaria*** species.

Table (7): Effect of gamma irradiation on the biomass of the resistant and sensitive *Fusarium* species.

Irradiation dose (kGy)	***Fusarium oxysporum***		***Fusarium semitectum***	
	Biomass g/L	Increase or decrease %	Biomass g/L	Increase or decrease %
0.00	8.02	0.00	5.90	0.00
0.25	7.08	-11.7	5.97	+1.2
0.50	6.56	-18.2	4.91	-16.8
1.00	5.78	-27.9	4.33	-26.6
2.00	5.57	-30.5	3.77	-36.1
3.00	5.24	-34.7	2.70	-54.2
4.00	4.48	-44.1	2.17	-63.2
6.00	3.33	-58.5	1.34	-77.3
8.00	3.11	-61.2	0.01	-99.8

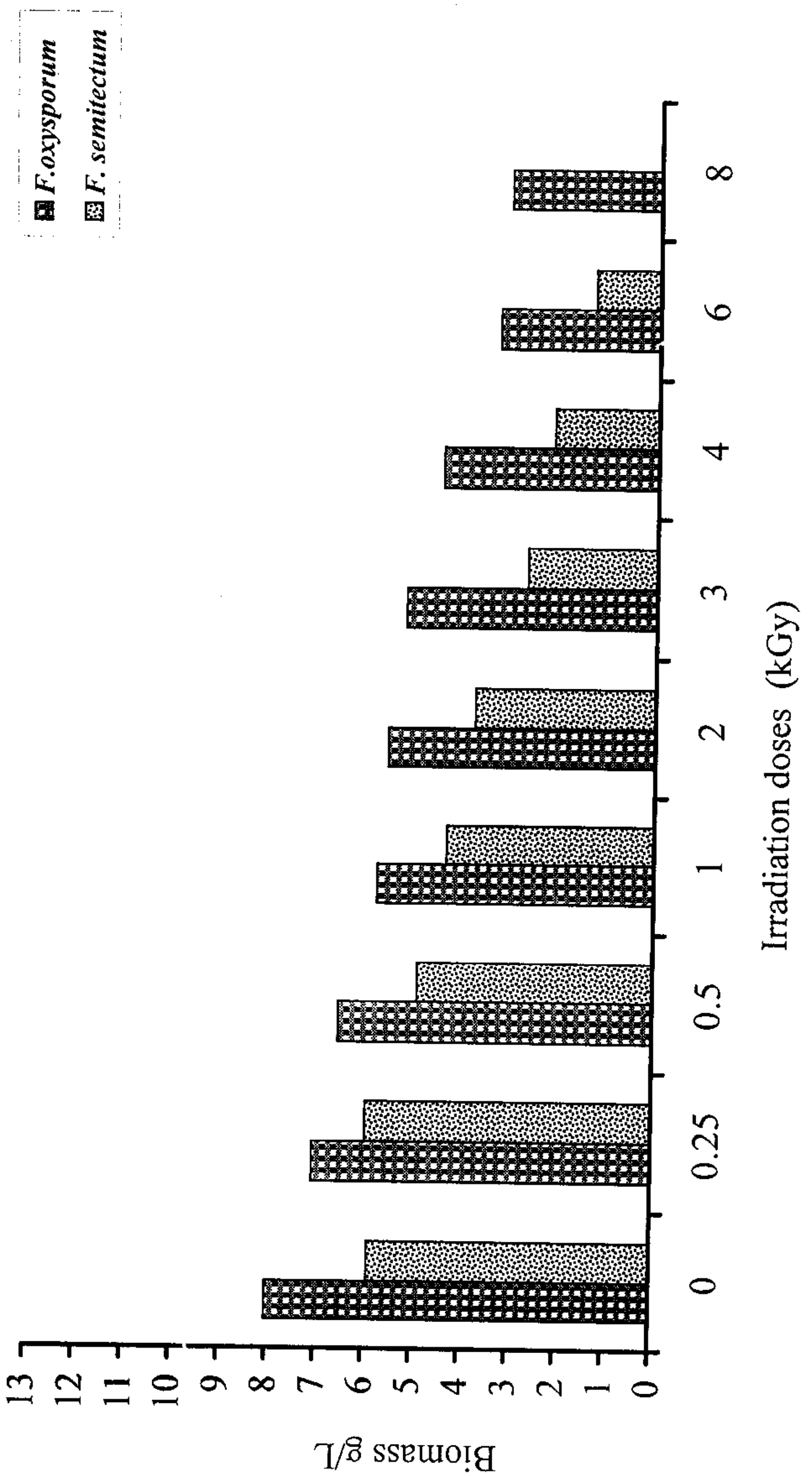


Fig (6): Effect of gamma irradiation on the biomass of the resistant and sensitive ***Fusarium*** species.

It is obvious from the results that the three strains, i.e *Curvularia lunata*, *Alternaria alternata* and *Fusarium oxysporum* showed high resistance to the harmful effect of gamma radiation and have the ability to remain alive and multiply even at high dose level of gamma radiation (8.0 kGy). The decreases in their biomass were 67.8%, 47.8% and 61.2% as a result of irradiation at this dose, respectively. Meanwhile the same dose level inhibited the growth of the sensitive strains of *Curvularia tuberculata, Alternaria tenuissima* and *Fusarium semitectum*

Determination of the decimal reduction dose (D_{10}-value) of the selected strains:

Spores, germinating spores, mycelia, sclerotia and other morphological structures of fungus colonies might exhibit somewhat different sensitivities toward gamma radiation. This experiment was done to investigate the sensitivity of the selected fungal specie spores to gamma radiation and to determine their D_{10}-values.

The D_{10}-values of *Curvularia lunata* and *Curvularia tuberculata* were determined in physiological saline solution and in lupine seeds (source of isolation), while the D_{10}-values of *Alternaria alternata*, *Alternaria tenuissima*, *Fusarium oxysporum* and *Fusarium semitectum* were determined in physiological saline solution and in chicken feed because of their high frequency in this substrate.

The results were recorded in Tables (8-10) and illustrated by Figs. (7-18). Generally the results showed that the viable counts of all fungal spores decreased as irradiation doses increased, but at different levels, indicating that these six fungi differ in their sensitivity to gamma irradiation. The initial count of *C. lunata* spores was 1.38×10^8 cfu / ml in saline solution and 2.07×10^8 cfu / g in lupine seeds before irradiation (Table 8 and Figs. 7,8).

Table (8): Effect of gamma irradiation on the survival count of *Curvularia lunata* and *Curvularia tuberculata* in saline solution and lupine seeds.

Irradiation doses (kGy)	*C. lunata*				*C. tuberculata*			
	In physiological saline solution		In lupine seeds		In physiological saline solution		In lupine seeds	
	No. of survivors	Log N/N°	No. of survivors	Log N/N°	No. of survivors	Log N/N°	No. of survivors	Log N/N°
0.00	1.38×10^8	0.00	2.07×10^8	0.00	9.56×10^6	0.00	1.40×10^8	0.00
0.25	8.27×10^7	-0.22	1.57×10^8	-0.12	2.88×10^5	-1.52	1.88×10^6	-1.87
0.50	8.90×10^6	-1.19	1.14×10^7	-1.26	2.23×10^5	-1.63	3.00×10^5	-2.67
1.00	5.26×10^5	-2.42	1.90×10^6	-2.04	2.30×10^4	-2.62	1.19×10^5	-3.07
2.00	9.87×10^4	-3.15	1.59×10^5	-3.12	1.60×10^4	-2.78	3.02×10^4	-3.67
3.00	2.32×10^4	-3.77	3.06×10^4	-3.83	1.90×10^3	-3.70	3.16×10^3	-4.65
4.00	7.34×10^3	-4.27	9.77×10^3	-4.33	2.5×10^2	-4.58	7.47×10^2	-5.27
6.00	1.25×10^3	-5.04	2.12×10^3	-4.99	NC	0.00	90	-6.19
8.00	4.65×10^2	-5.47	9.94×10^2	-5.32	NC	0.00	NC	0.00
D_{10}-values	1.92		2.25		1.25		1.56	

NC = no colonies were observed. N° = Number of initial count. N = Number of survivors count

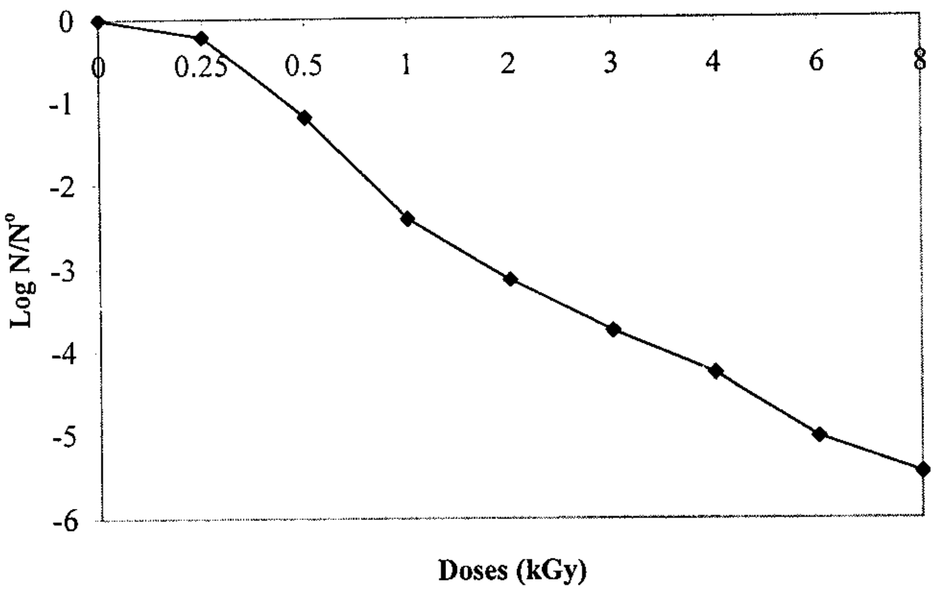


Fig. (7): Radiation dose response curve of ***Curvularia lunata*** in a saline solution

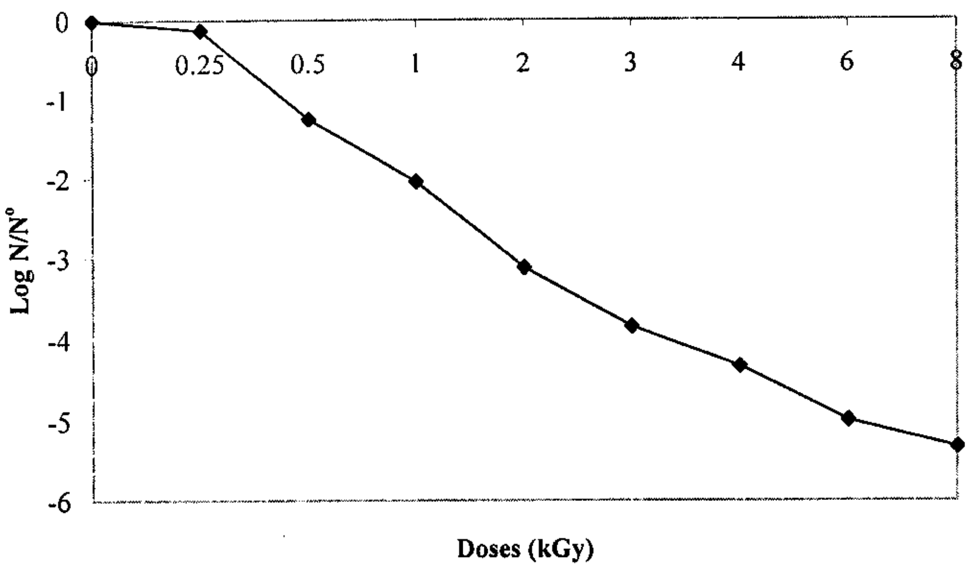


Fig. (8): Radiation dose response curve of ***Curvularia lunata*** in lupine seeds.

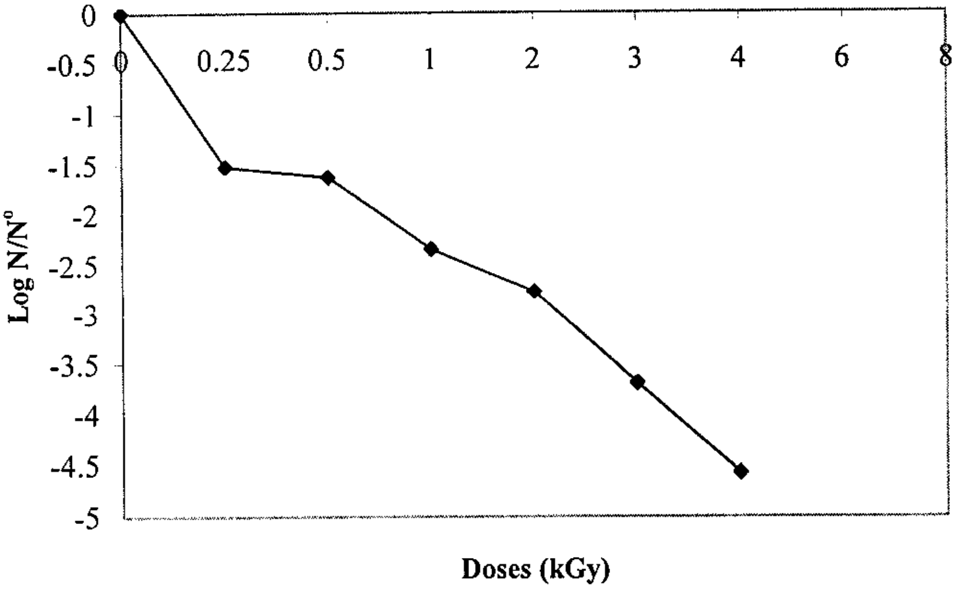


Fig. (9): Radiation dose response curve of ***Curvularia tuberculata*** in saline solution.

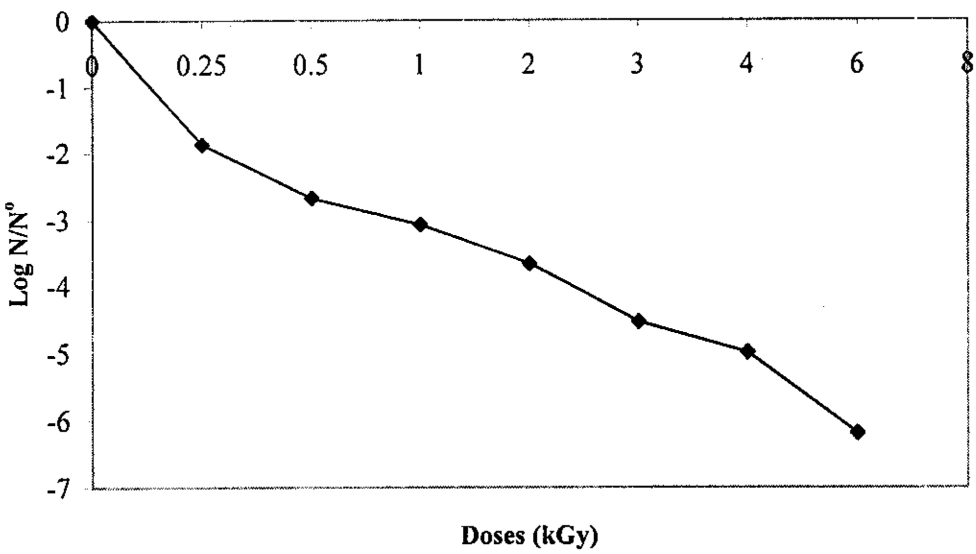


Fig. (10): Radiation dose response curve of ***Curvularia tuberculata*** in lupine seeds.

These counts continuously decreased as irradiation dose increased reaching 4.65 x 10^2 cfu / ml and 9.94 x 10^2 cfu / g at 8.0 kGy. The D_{10}-value of this fungus was 1.92 kGy in saline solution and 2.25 kGy in lupine seeds. Table (8) and Figs. (9, 10) also show that the initial count of *C. tuberculata* spores was 9.56 x 10^6 cfu / ml in saline solution and 1.40 x 10^8 cfu / g in lupine before irradiation. Irradiation doses of 4.0 and 6.0 kGy decreased these counts to 2.5 x 10^2 cfu / ml and 9.0 x 10 cfu/g in saline solution and lupine seeds, respectively. Irradiation dose of 8.0 kGy completely inactivated the spores of this fungus. The D_{10}-value of *C. tuberculata* was 1.25 kGy in saline solution and 1.56 kGy in lupine seeds.

The results obtained from Table (9) and Figs. (11, 12) show that the initial count of *A. alternata* spores was 1.11 x 10^8 cfu / ml in saline solution and 1.76 x 10^8 cfu /g in chicken feed before irradiation, respectively. These counts continuously decreased as irradiation dose increased reaching 2.15 x 10^2 cfu / ml and 7.3 x 10^2 cfu /g at 8.0 kGy. The D_{10}-value for this fungus was 1.47 kGy in saline solution and 1.7 kGy in chicken feed. On the other hand, the results given in Table (9) and Figs. (13, 14) indicate that the initial count of *A. tenuissima* in saline solution was 1.34 x 10^7 cfu / ml and 2.34 x 10^7 cfu /g in chicken feed and 4.0 kGy decreased these counts to 1.60 x 10^2 cfu / ml and 1.19 x 10^3 cfu/g in saline solution and chicken feed, respectively. Irradiation dose of 6.0 kGy decreased the counts of this fungus to 1.3 x 10^2 cfu /g in chicken feed, while completely inactivated its spores in saline solution. The D_{10}-value was 0.47 kGy in saline solution and 1.3 kGy in chicken feed.

Table (9): Effect of gamma irradiation on the survival count of *Alternaria alternata* and *Alternaria tenuissima* in saline solution and chicken feed.

Irradiation doses (kGy)	*A. alternata*				*A. tenuissima*			
	In physiological saline solution		In chicken feed		In physiological saline solution		In chicken feed	
	No. of survivors	Log N/N°	No. of survivors	Log N/N°	No. of survivors	Log N/N°	No. of survivors	Log N/N°
0.00	1.11×10^8	0.00	1.76×10^8	0.00	1.34×10^7	0.00	2.34×10^7	0.00
0.25	1.51×10^7	-0.87	2.59×10^7	-0.83	7.53×10^6	-0.25	1.32×10^7	-0.25
0.50	2.46×10^6	-1.65	1.11×10^7	-1.20	2.09×10^6	-0.81	3.05×10^6	-0.89
1.00	2.14×10^6	-1.71	3.05×10^6	-1.76	5.76×10^4	-2.37	2.13×10^5	-2.04
2.00	3.04×10^5	-2.56	1.61×10^6	-2.04	1.53×10^3	-3.94	5.41×10^3	-3.64
3.00	1.89×10^5	-2.77	3.62×10^5	-2.69	6.23×10^2	-4.33	6.50×10^3	-3.56
4.00	2.47×10^4	-3.65	5.33×10^4	-3.52	1.60×10^2	-4.92	1.19×10^3	-4.29
6.00	6.67×10^2	-5.22	2.29×10^3	-4.89	NC	0.00	1.3×10^2	-5.26
8.00	2.15×10^2	-5.71	7.3×10^2	-5.38	NC	0.00	NC	0.00
D_{10}-values	1.47		1.70		0.47		1.30	

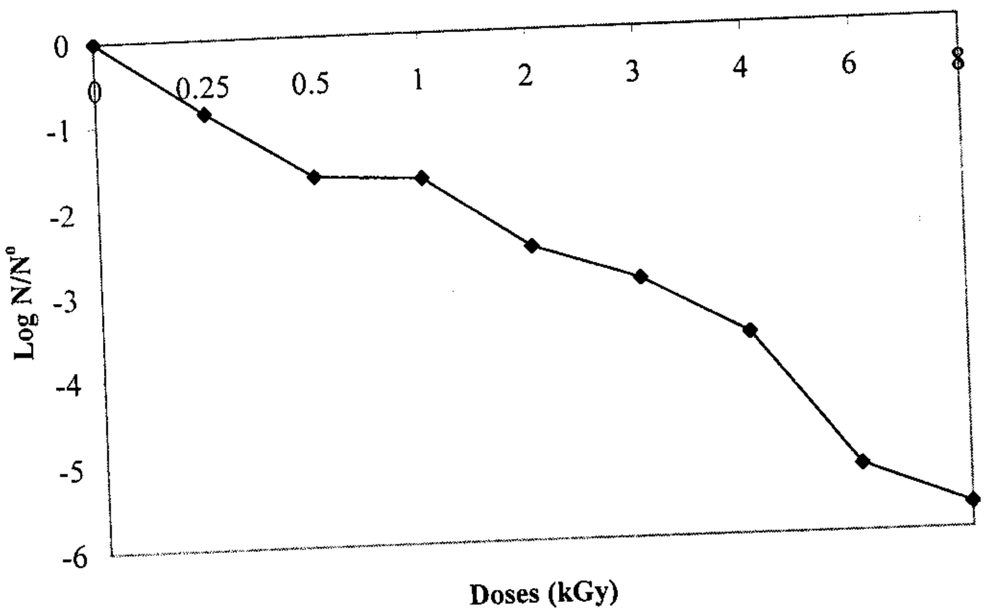


Fig. (11): Radiation dose response curve of ***Alternaria alternata*** in saline solution.

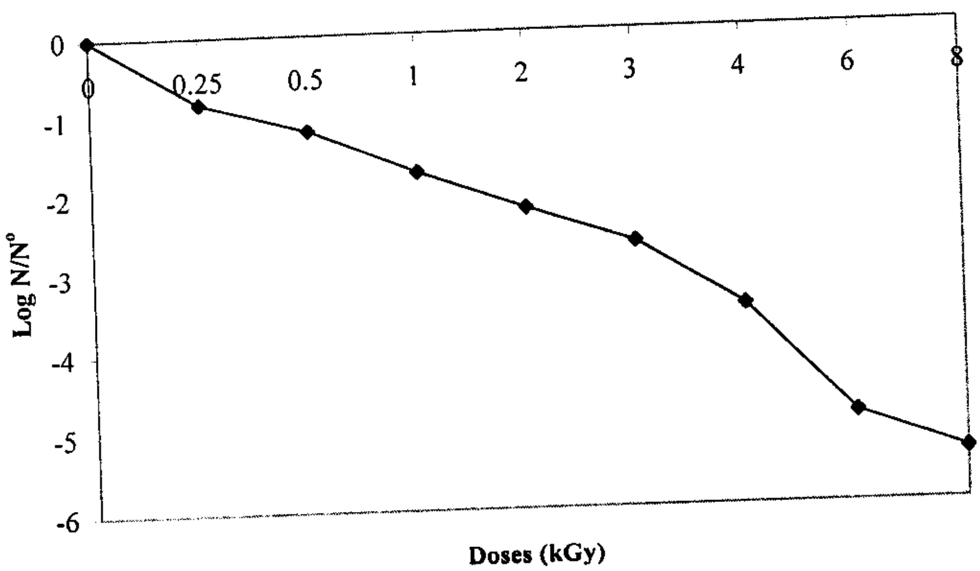


Fig. (12): Radiation dose response curve of ***Alternaria alternata*** in chicken feed..

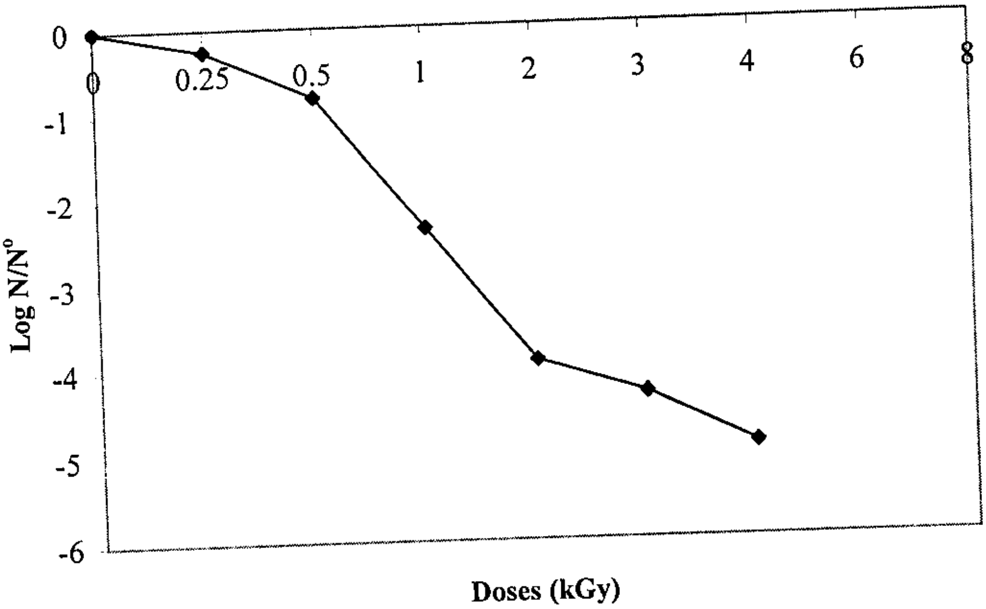


Fig. (13): Radiation dose response curve of ***Alternaria tenuissima*** in saline solution.

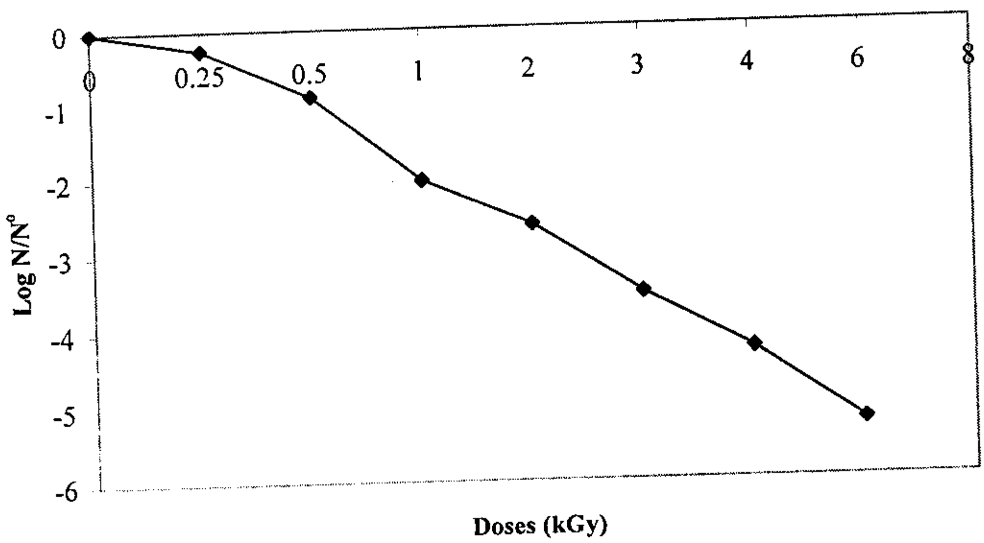


Fig. (14): Radiation dose response curve of ***Alternaria tenuissima*** in chicken feed.

The initial count of *Fusarium oxysporum* was 1.14 x 10^8 cfu / ml in saline solution and 2.31 x 10^8 cfu / g in chicken feed before irradiation (Table 10 and Figs. 15, 16). These counts continuously decreased as irradiation dose increased reaching 6.67 x 10 cfu / ml and 1.70 x 10^2 cfu / g at 8.0 kGy in saline solution and chicken feed, respectively. The D_{10}-value of *F. oxysporum* was 1.31 kGy in saline solution and 1.83 kGy in chicken feed. Table (10) and Figs. (17, 18) show that the radiation dose of 6.0 kGy caused complete inactivation of *F. semitectum* spores in saline solution, therefore its D_{10}-value was 0.7 kGy in saline solution and 1.23 kGy in chicken feed.

It is clear from the data in Table (11) that the substrate either the lupine seeds or chicken feed assist all the isolated fungi to resist the harmful effects of gamma rays since the D_{10}-values of all studied fungi were higher in the substrates than in saline solution. Also, it is obvious that *C. lunata* proved to be the most resistant fungus to radiation of the selected fungi recording the highest D_{10} values (1.92 and 2.25 kGy in saline and substrate, respectively). Meanwhile, *A. tenuissima* had the lowest D_{10}-value (0.47 kGy) in saline solution and *F. semitectum* had the lowest D_{10}-value (1.23 kGy) in chicken feed indicating their relative sensitivity to gamma radiation.

Table (10): Effect of gamma irradiation on the survival count of *Fusarium oxysporum* and *Fusarium semitectum* in saline solution and chicken feed.

Irradiation doses (kGy)	*F. oxysporum*				*F. semitectum*			
	In physiological saline solution		In chicken feed		In physiological saline solution		In chicken feed	
	No. of survivors	Log N/N°	No. of survivors	Log N/N°	No. of survivors	Log N/N°	No. of survivors	Log N/N°
0.00	1.14×10^{8}	0.00	2.31×10^{8}	0.00	3.28×10^{7}	0.00	5.67×10^{7}	0.00
0.25	1.11×10^{7}	-1.01	7.54×10^{7}	-0.49	2.19×10^{6}	-1.18	1.21×10^{7}	-0.67
0.50	1.21×10^{7}	-0.98	2.07×10^{7}	-1.05	1.60×10^{5}	-2.31	2.02×10^{6}	-1.45
1.00	2.86×10^{6}	-1.60	4.57×10^{6}	-1.70	1.48×10^{4}	-3.35	6.56×10^{4}	-2.94
2.00	2.72×10^{5}	-2.62	3.29×10^{5}	-2.85	3.29×10^{3}	-4.00	1.34×10^{4}	-3.63
3.00	1.50×10^{4}	-3.88	5.52×10^{4}	-3.62	9.60×10^{2}	-4.53	1.88×10^{3}	-4.48
4.00	1.47×10^{3}	-4.89	2.85×10^{3}	-4.91	2.23×10^{2}	-5.17	8.57×10^{2}	-4.82
6.00	4.00×10^{2}	-5.46	1.05×10^{3}	-5.34	NC	0.00	1.45×10^{2}	-5.59
8.00	6.67×10	-6.23	1.70×10^{2}	-6.13	NC	0.00	NC	0.00
D_{10}-values	1.31		1.83		0.70		1.23	

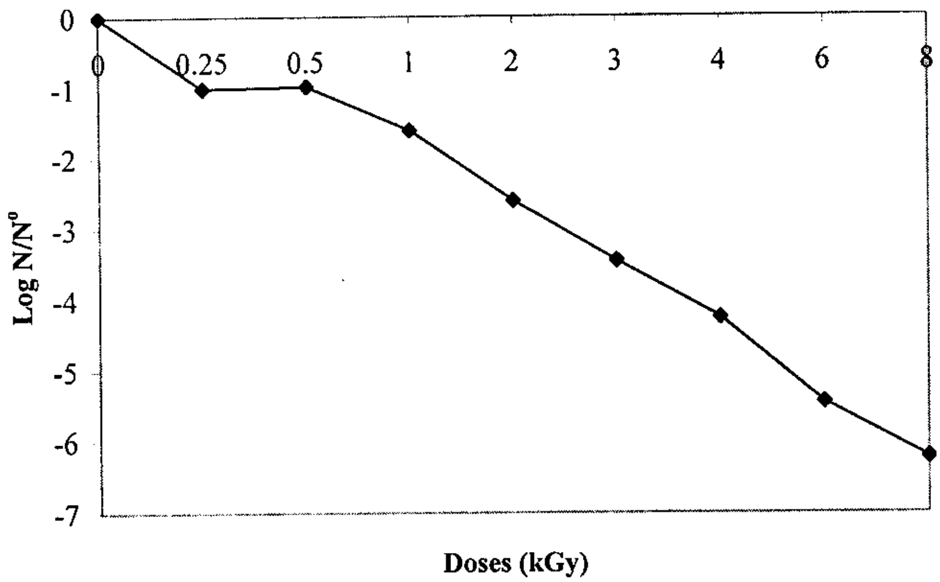


Fig. (15): Radiation dose response curve of ***Fusarium oxysporum*** in saline solution.

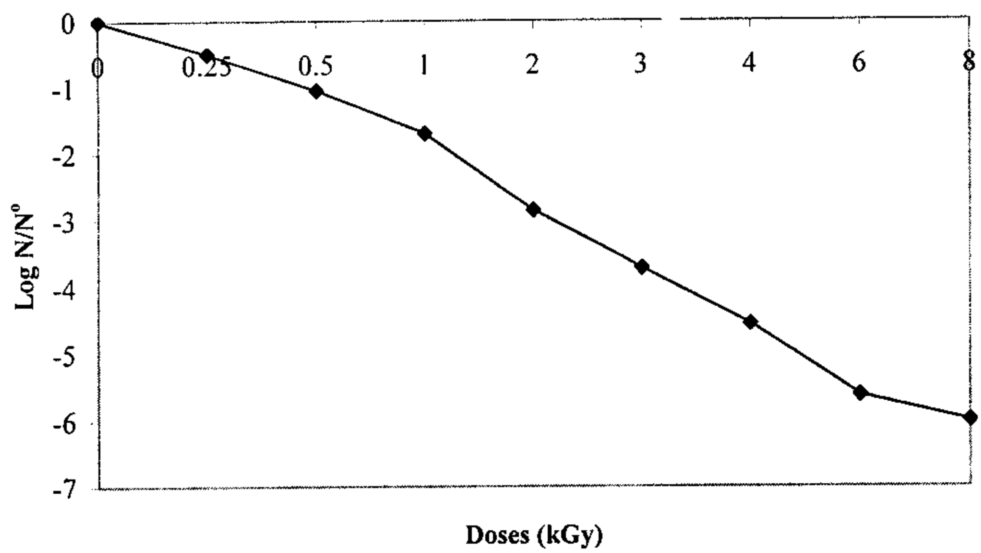


Fig. (16): Radiation dose response curve of ***Fusarium oxysporum*** in chicken feed.

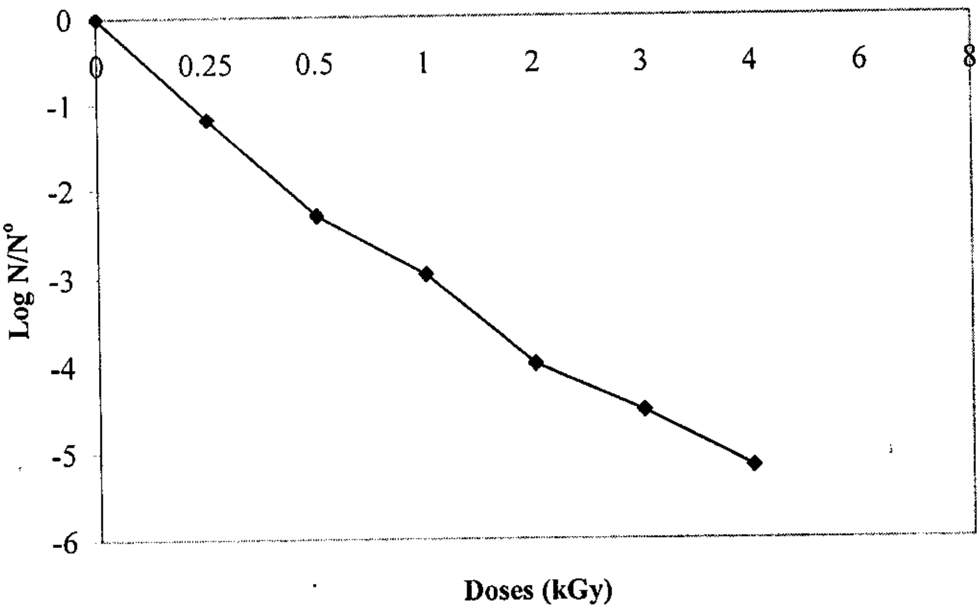


Fig. (17): Radiation dose response curve of ***Fusarium semitectum*** in saline solution.

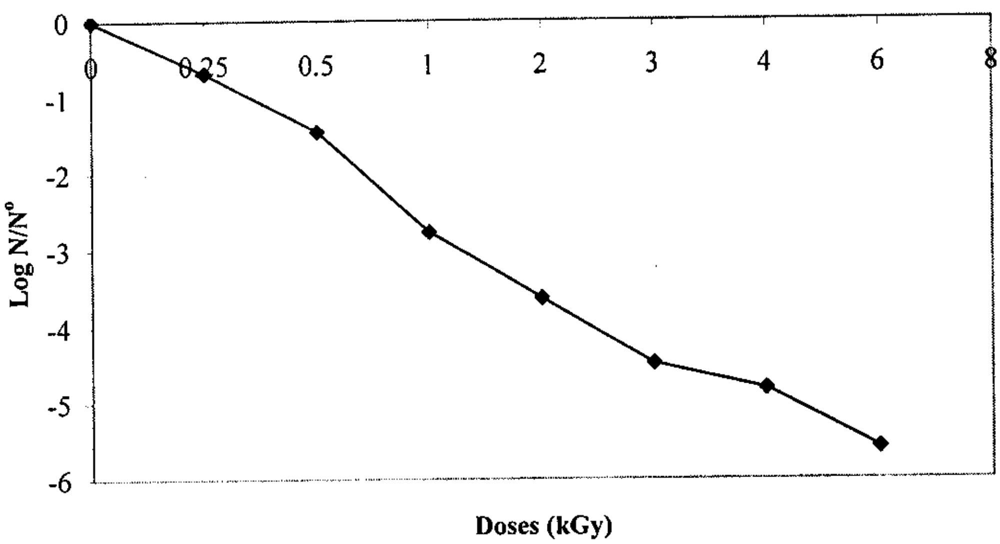


Fig. (18): Radiation dose response curve of ***Fusarium semitectum*** in chicken feed.

Table (11): D_{10}-values of the studied experimental fungal species in saline solution and substrate.

Fungal species	**D_{10}-value (kGy)**	
	In saline solution	**In substrate**
Curvularia lunata	1.92	2.25
C. tuberculata	1.25	1.56
Alternaria alternata	1.47	1.70
A. tenuissima	0.47	1.30
Fusarium oxysporum	1.31	1.83
F. semitectum	0.70	1.23

Cellular composition of radiation resistant and sensitive fungal species:

Total protein:

Total protein content in the selected fungi were determined and recorded in Table (12) and illustrated in Fig. (19). The data represented the percentage of total nitrogen (T_N) and subsequently percentage of total protein (Tp), in the untreated fungal strains. The total protein of the three radiation resistant species (*Curvularia lunata*, *Alternaria alternata* and *Fusarium oxysporum*) were 76.88 %, 72.69% and 69.83 %, respectively, while in the three relative sensitive species, i.e. *Curvularia tuberculata*, *Alternaria tenuissima* and *Fusarium semitectum* were less, since they recorded 70.13%, 64.06% and 46.88 %, respectively. So, it was found interesting to determine different amino acids contents of these fungal species.

Amino acids:

The total amino acids of the fungi were analysed using high performance amino acid analyzer. The results revealed that 17 amino acids were detected in studied fungi. Data in Table (13) and Fig. (20) showed that glutamic acid was the predominant amino acids (16.2 mg/g) in *Curvularia lunata* followed by proline (13.2 mg/g). Aspartic acid was 12.4 mg/g, leucine was 10.4mg/g and lysine was 9.8 mg/g, while cysteine was only found in trace amount (0.4 mg/g). The total amino acids content of *C. lunata* was 129.2 mg/g dry wt.. Also, data in Table (13) and Fig. (21) illustrated that the predominant amino acids in *Curvularia tuberculata* was glutamic acid (13.2 mg/g) followed by proline (11.4 mg/g) and aspartic (9.8 mg/g) but they less in their values than *Curvularia lunata*, also cysteine was the lowest amino acids in its value, the total amino acids content was 101.0 mg/g dry wt.

Table (12): Total protein content (%) of the selected fungal species.

Fungal species	**Total nitrogen (T_N) %**	**Total protein (Tp)%**
Curvularia lunata	12.30	76.88
C. tuberculata	11.22	70.13
Alternaria alternata	11.63	72.69
A. tenuissima	10.25	64.06
Fusarium oxysporum	11.17	69.83
F. semitectum	7.50	46.88

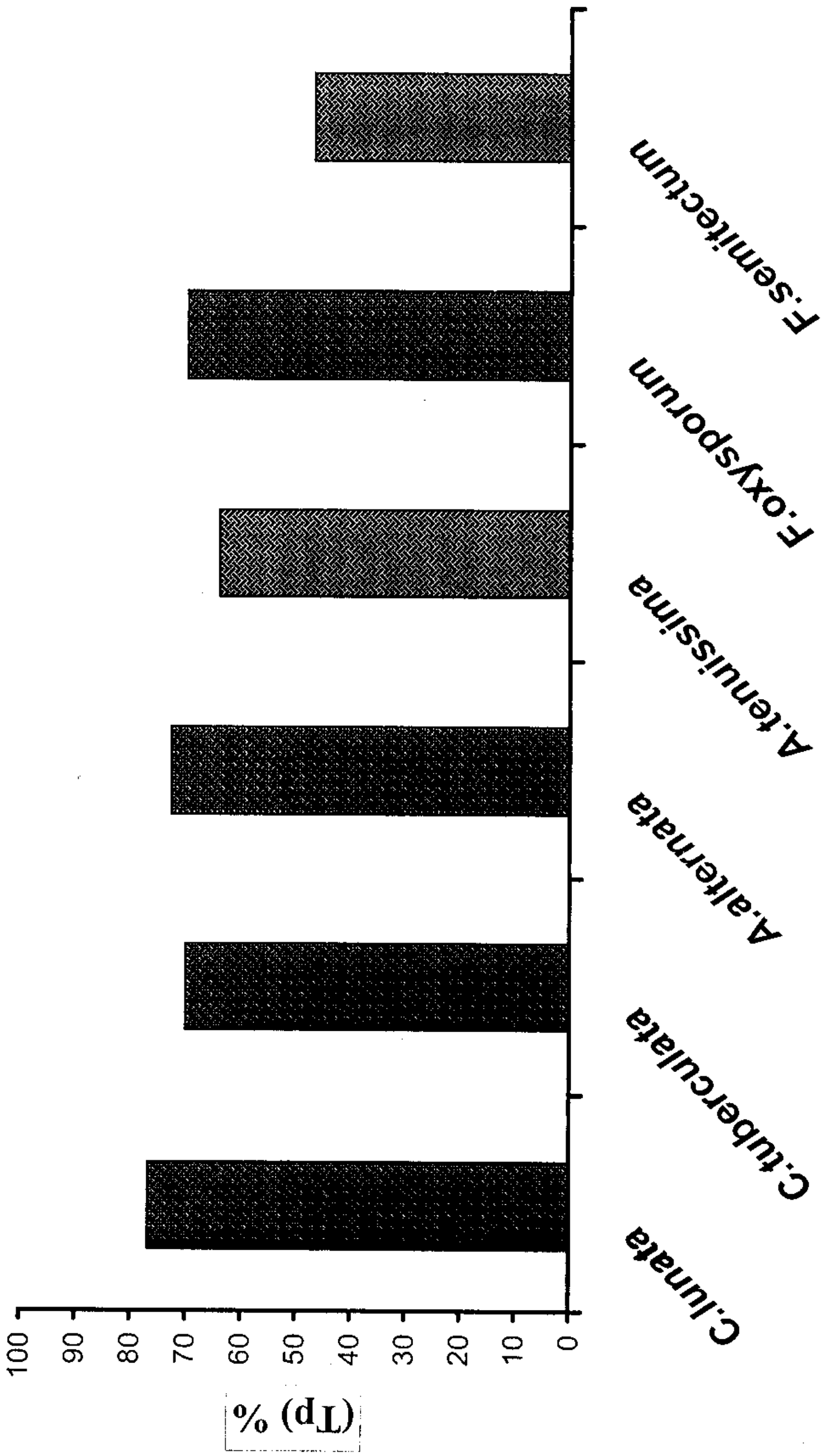


Fig. (19): Total protein content of the selected fungal species.

For *Alternaria alternata*, the results in Table (13) and Fig. (22) showed that the total amino acids content was 114.4 mg/g dry wt. and glutamic acid had the highest value (15.2mg/g) followed by proline (11.4 mg/g) aspartic (9.8 mg/g) and leucine (9.8 mg/g), methionine hadn't appear in the results. Meanwhile, amino acids composition of *Alternaria tenuissima* Table (13) and Fig. (23) showed that glutamic acid also was the highest value (10.2 mg/g) followed by aspartic acid (7.8 mg/g) but methionine and cysteine were absent. The total amino acids content was 74.0 mg/g dry wt.

Table (13) and Figs. (24, 25) indicated that in *Fusarium oxysporum* and *Fusarium semitectum* glutamic acid was the predominant (7.6 and 8.8 mg/g, respectively) followed by aspartic acid (6.4 and 7.6 mg/g), leucine (3.8 and 5.6 mg/g) and proline (2.4 and 5.2 mg/g), while methionine hadn't appear in the results of the two strains. The total amino acids content was 49.2 and 63.2 mg/g dry wt., respectively.

Table (13): Amino acids composition (mg/g) of the selected fungal species.

Fungal species / Amino acids (mg/g)	*C.lunata*	*C.tuberculata*	*A.alternata*	*A.tenuissima*	*F.oxysporum*	*F.semitectum*
Aspartic	12.4	9.8	9.8	7.8	6.4	7.6
Threonine	8.2	6.4	7.4	5.4	3.4	4.0
Serine	7.2	5.4	6.6	5.0	2.8	4.6
Glutamic acid	16.2	13.2	15.2	10.2	7.6	8.8
Proline	13.2	11.4	11.4	6.6	2.4	5.2
Glysine	6.2	5.0	5.8	3.8	3.4	3.8
Alanine	9.2	7.8	8.6	5.8	3.4	4.6
Cysteine	0.4	0.4	0.6	0.0	0.6	0.0
Valine	6.6	5.2	6.0	4.2	2.8	3.6
Methionine	1.2	0.8	0.0	0.0	0.0	0.0
Isoleucine	5.8	4.4	5.0	3.6	2.2	2.6
Leucine	10.4	7.8	9.8	5.6	3.8	5.6
Tyrosine	4.2	2.8	4.0	1.8	1.2	1.6
Phenylalanine	6.0	4.2	5.0	3.0	2.2	2.4
Histidine	3.8	3.0	3.0	1.8	2.0	1.6
Lysine	9.8	7.2	8.6	5.2	3.2	4.0
Arginine	8.4	6.2	7.6	4.2	1.8	3.2
Total	129.2	101.0	114.4	74.0	49.2	63.2

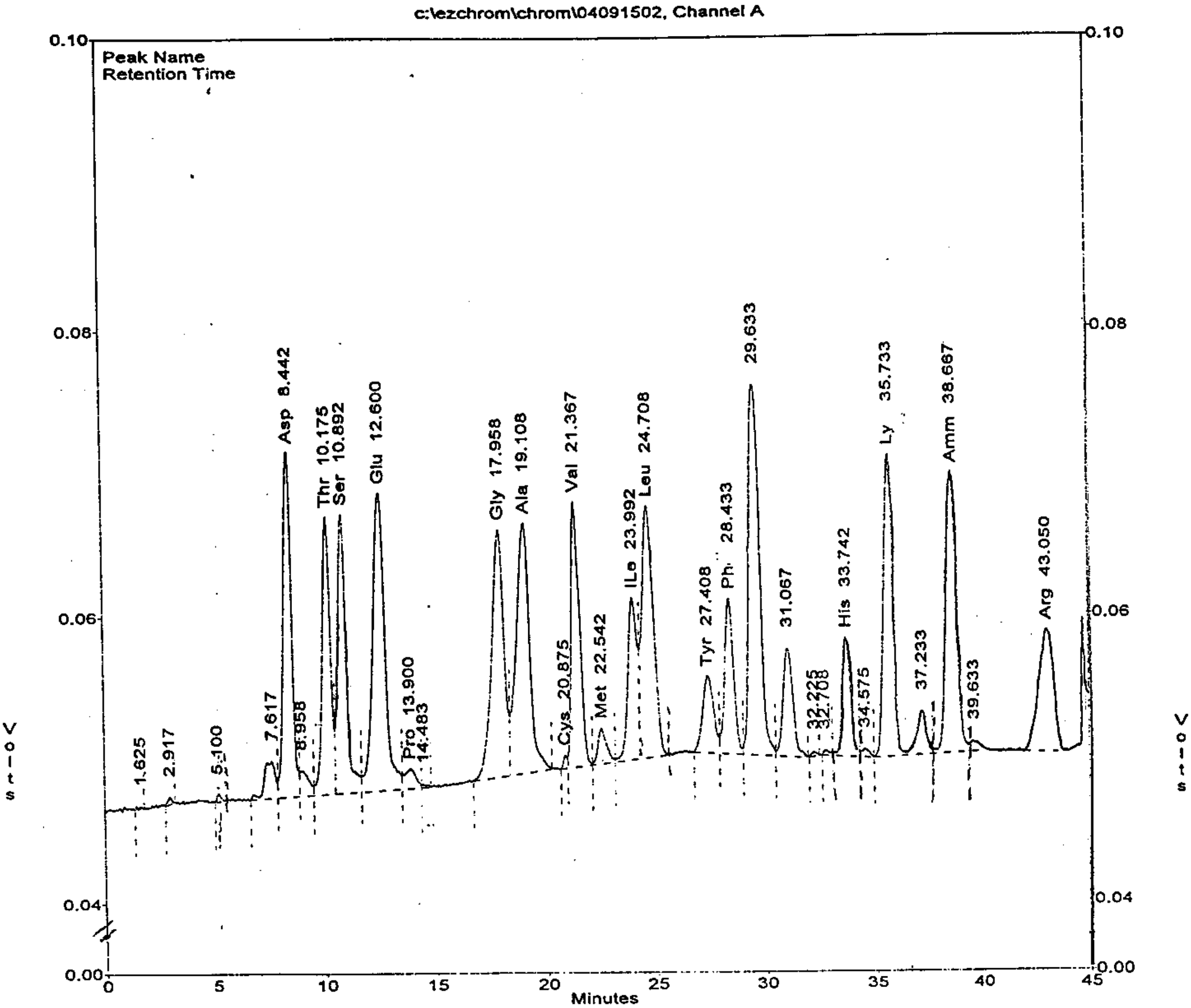


Fig. (20): Amino acid chromatographs of *Curvularia lunata*

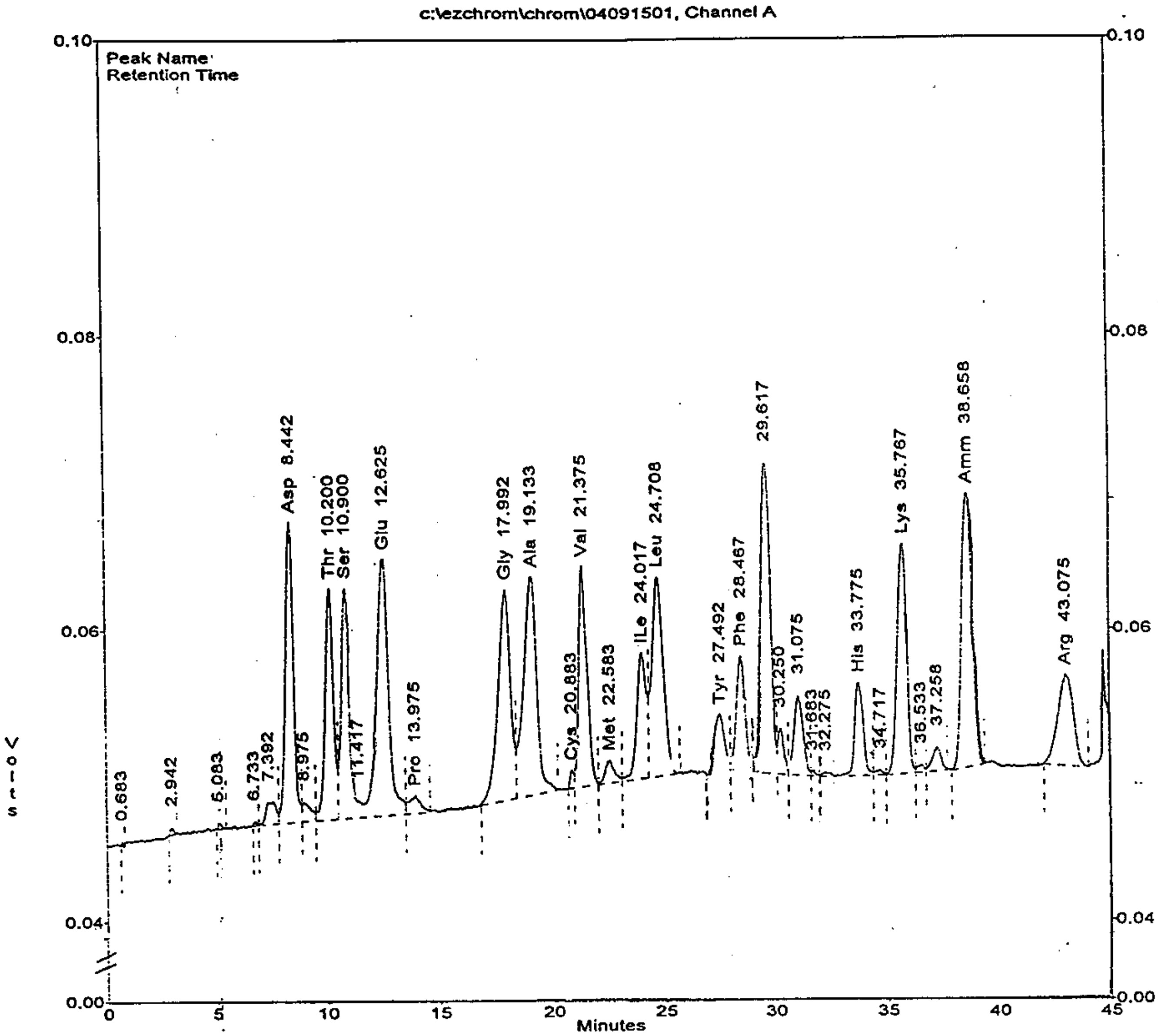


Fig. (21): Amino acid chromatographs of *Curvularia tuberculata*

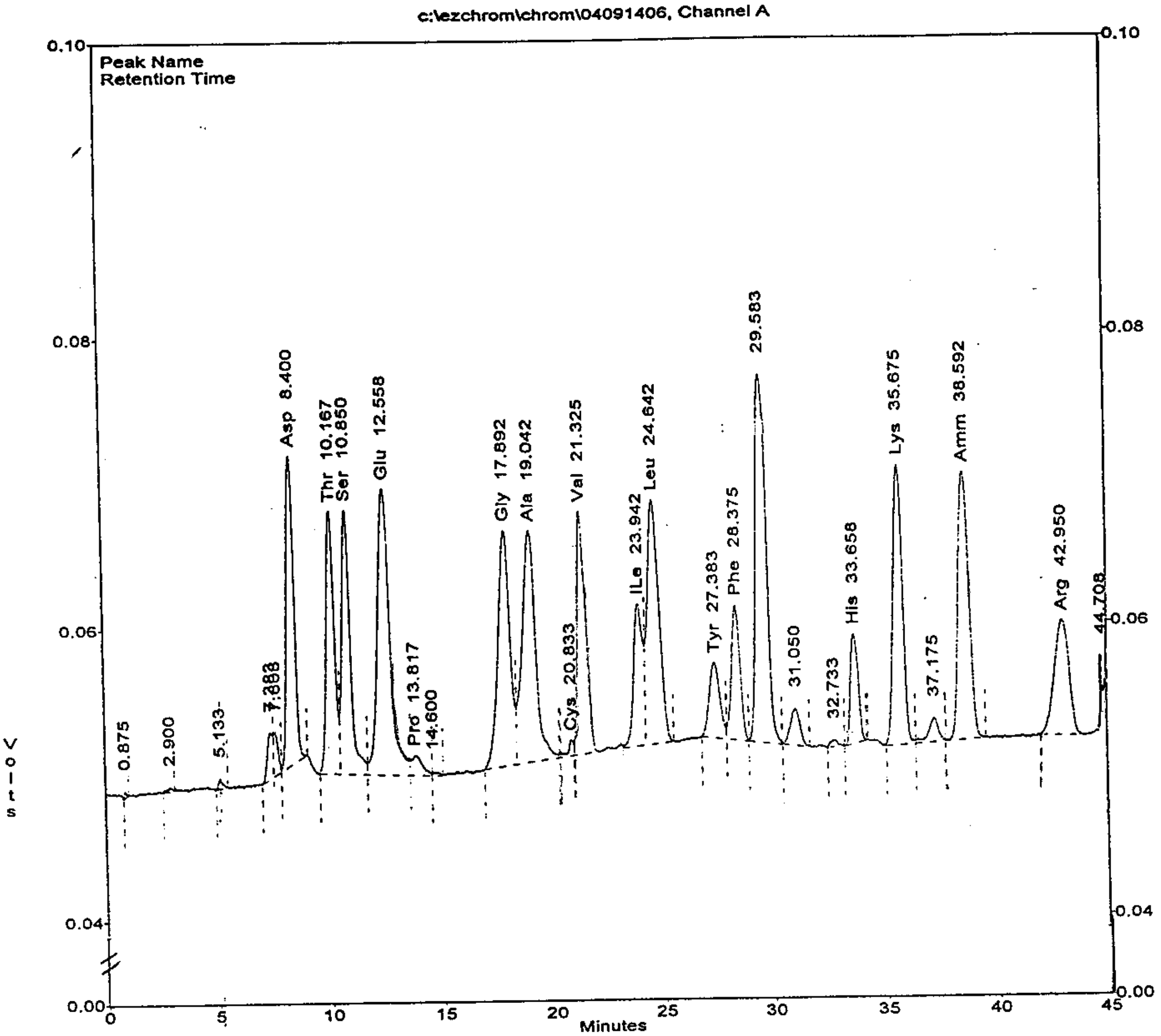


Fig. (22): Amino acid chromatographs of *Alternaria alternata*

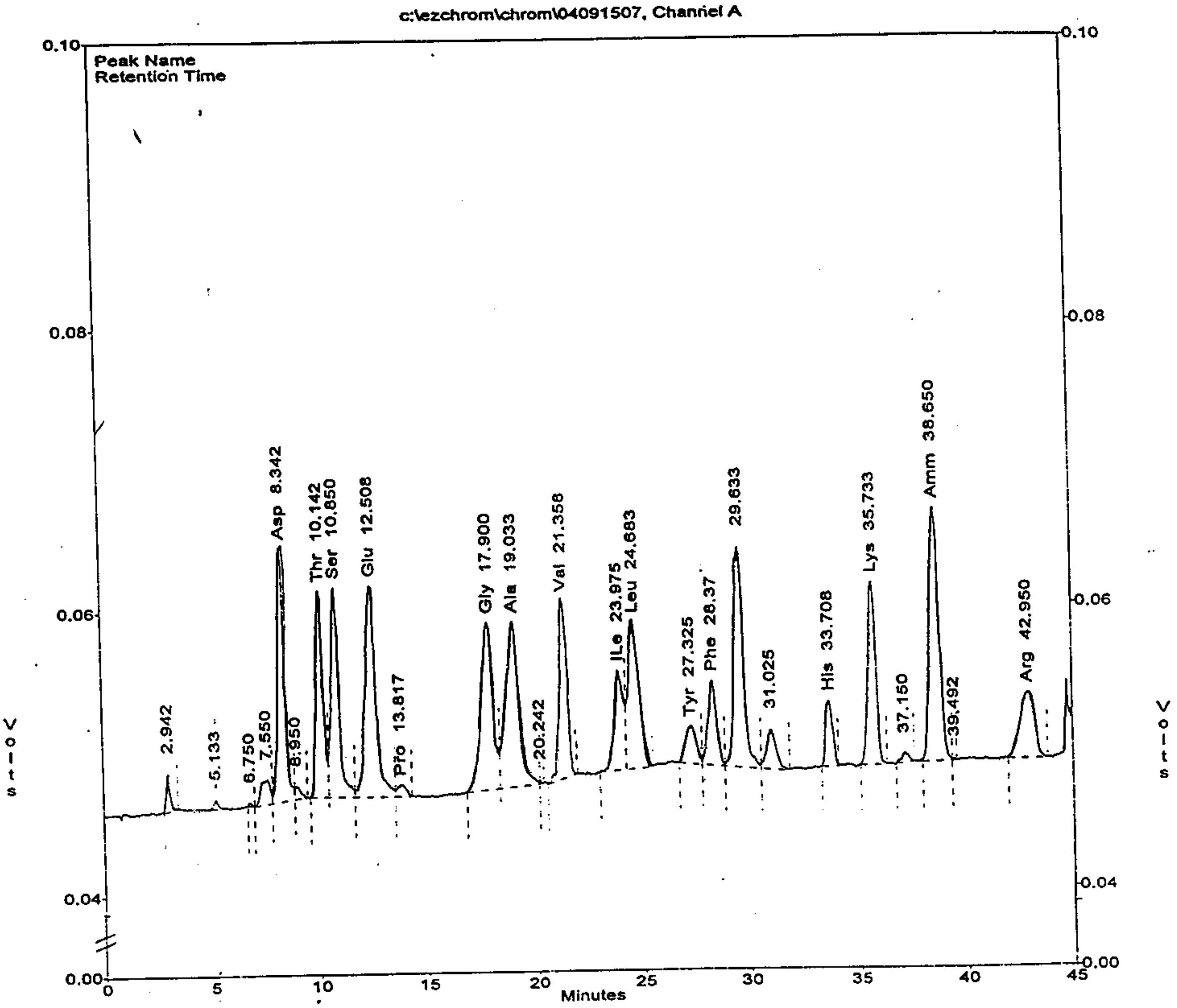


Fig. (23): Amino acid chromatographs of *Alternaria tenuissima*

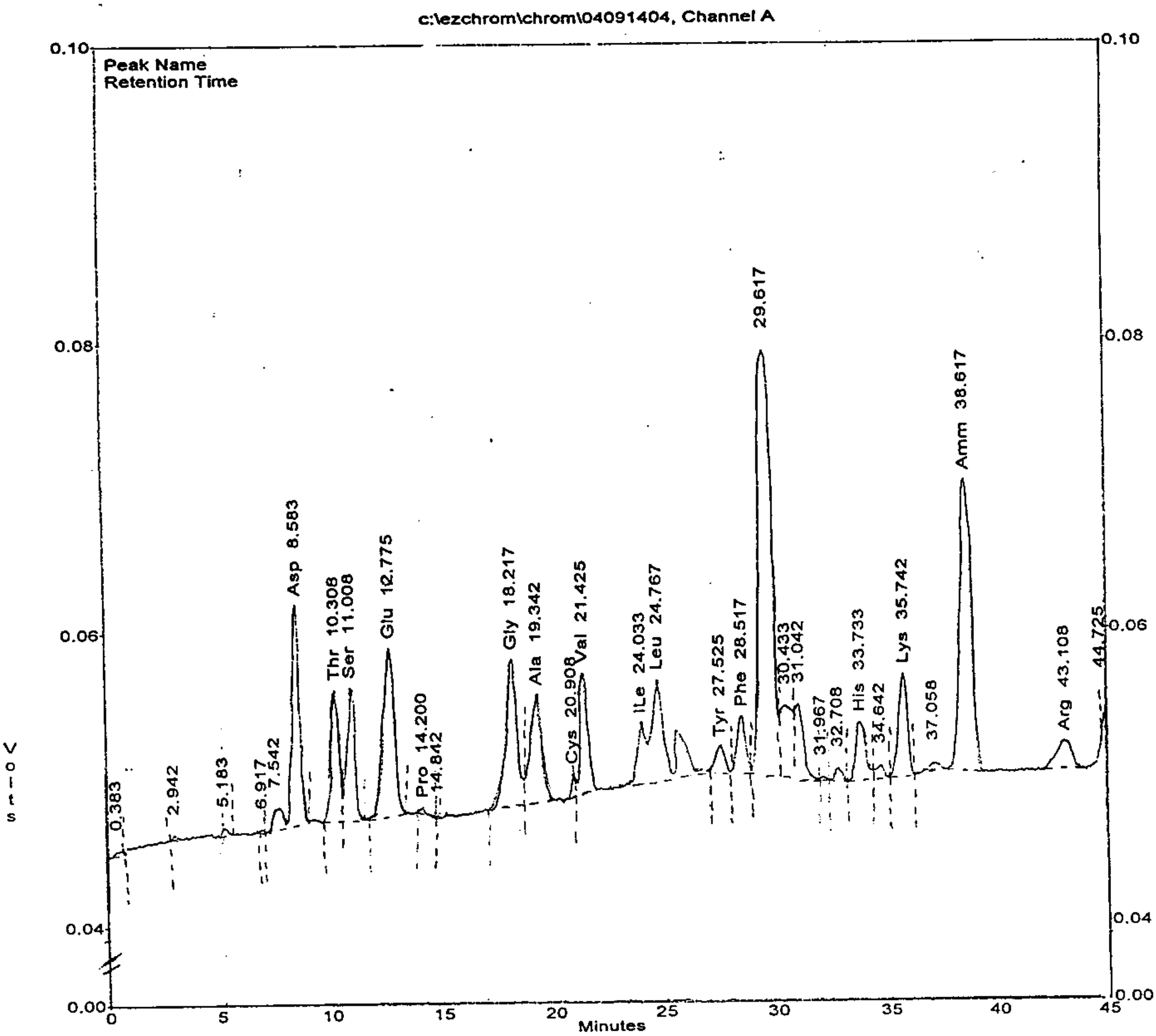


Fig. (24): Amino acid chromatographs of *Fusarium oxysporum*

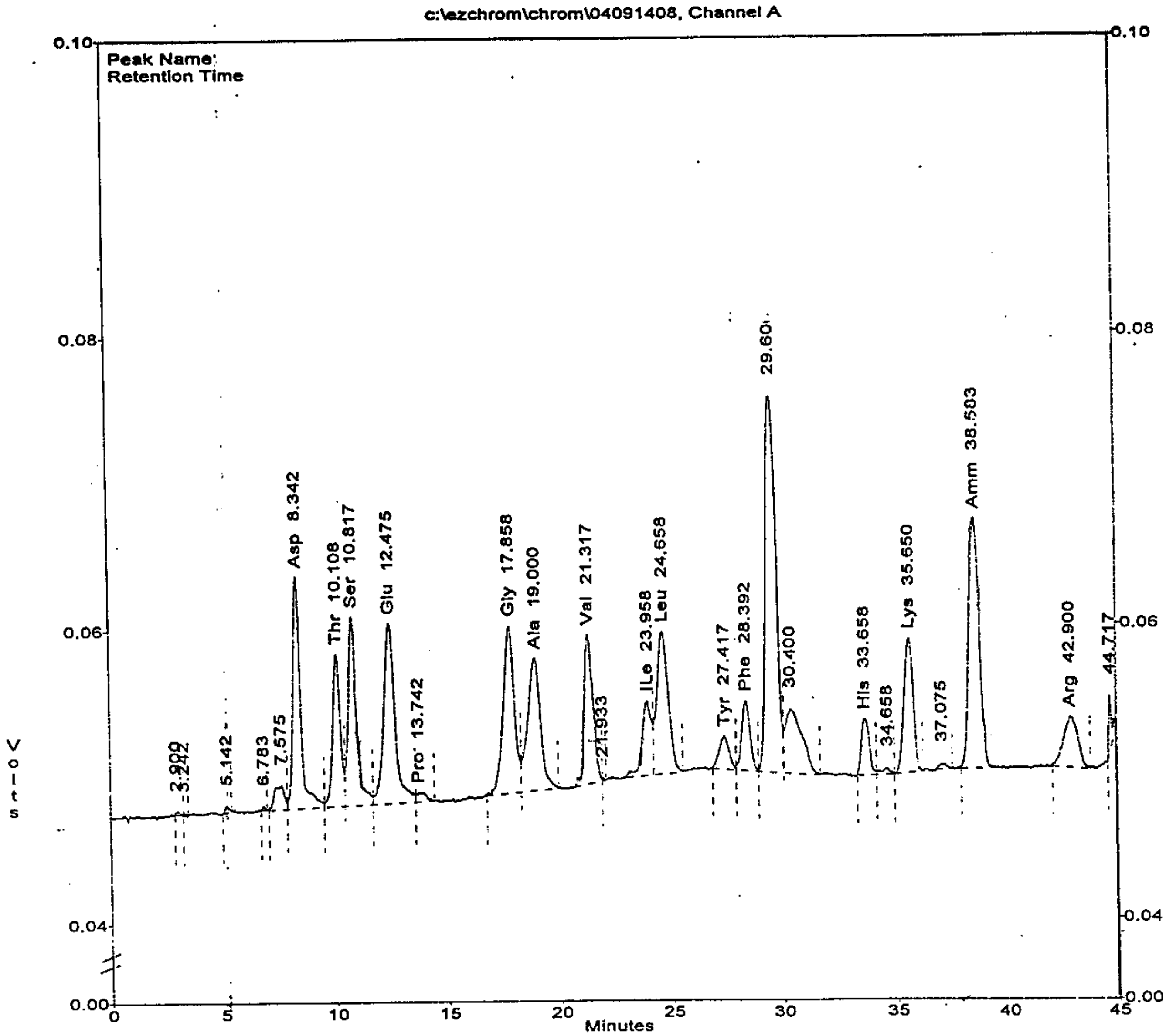


Fig. (25): Amino acid chromatographs of *Fusarium semitectum*

Total lipids:

Data in Table (14) and Fig. (26) showed the total lipids content of the studied fungal species, the data indicated that the total lipids content of *Curvularia lunata* was the highest (16.26 %) followed by *Alternaria alternata* (12.57 %) and *Fusarium oxysporum* (8.16) and the lowest lipids content was observed in *Alternaria tenuissima*. The results showed that *Curvularia lunata*, *Alternaria alternata* and *Fusarium oxysporum* (the highly radio-resistant isolates) contain more lipids compared with the less radio-resistant isolates of the same genus: *Curvularia tuberculata, Fusarium semitectum* and *Alternaria tenuissima*, (6.99 %), (5.67%) and (3.91 %), respectively.

Fatty acids:

Fatty acid methyl esters of lipids extracted from the tested fungi were analyzed by using GC-MS analysis Table (15) represented the relative percentage of the main fatty acids composition of tested fungal strains. The results showed that the identified fatty acids of *Curvularia lunata* were myristic (14:0), palmitic (16:0), stearic (18:0), oleic (18:1) and linoleic (18:2). The same fatty acids were found in *Curvularia tuberculata* except myristic. *Alternaria alternata* contained myristic (14:0), palmitic (16:0), stearic (18:0), oleic (18:1) and linoleic (18:2), but lauric, linolenic and erucic were also found in *Alternaria tenuissima*. Meanwhile fatty acids in *Fusarium oxysporum* were lauric (12:0), myristic (14:0), palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2) and erucic (22:1) but myristic was not found in *Fusarium semitectum*.

Table (14): Total lipids content (%) of the selected fungal species.

Fungal species	Lipid %
Curvularia lunata	16.26
C. tuberculata	6.99
Alternaria alternata	12.57
A. tenuissima	3.91
Fusarium oxysporum	8.16
F. semitectum	5.67

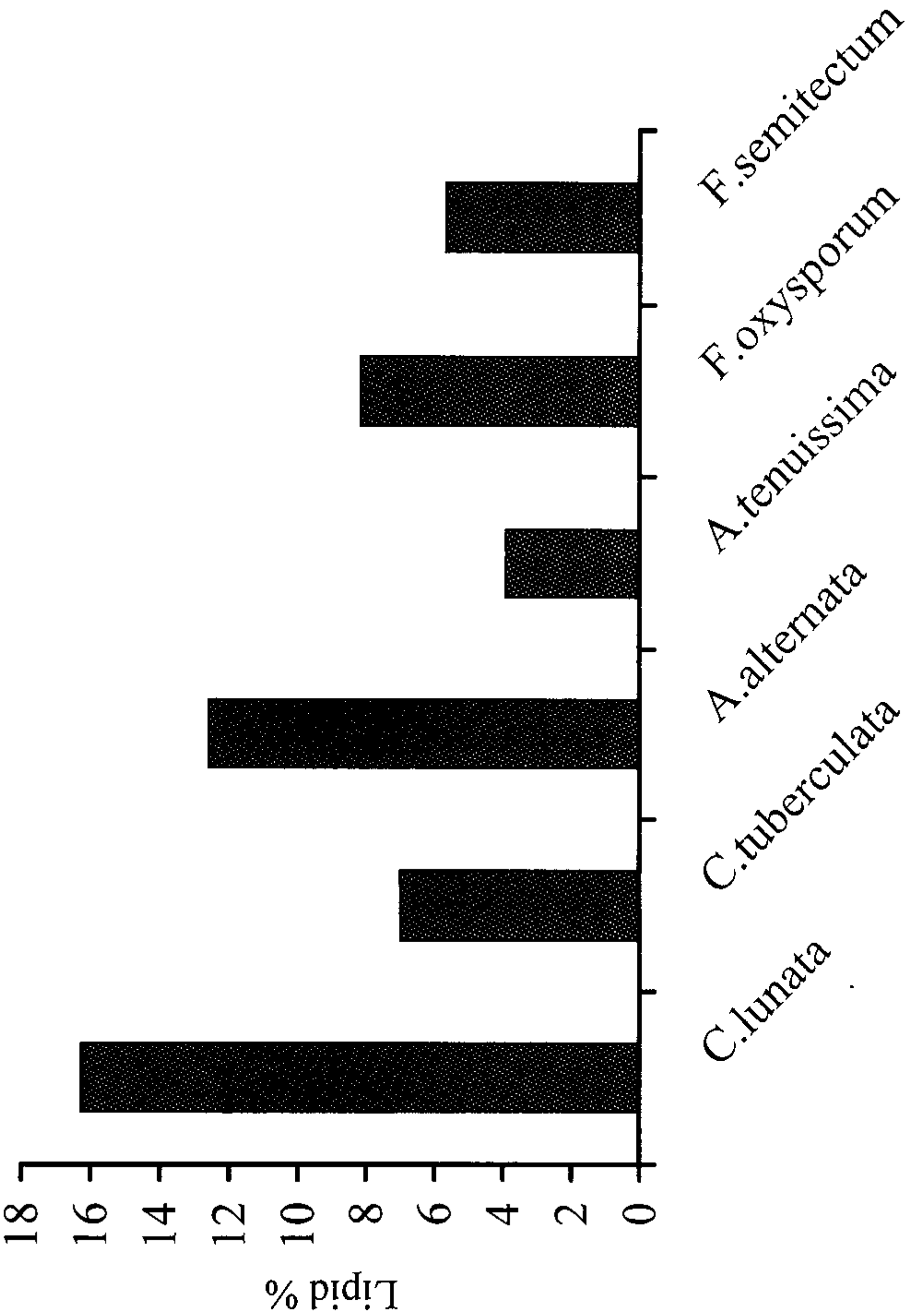


Fig. (26): Total lipid content of the selected fungal species.

The results also showed that the most predominant fatty acids in *Curvularia lunata* were oleic acid and linoleic followed by palmitic acid. The total saturated (Ts) and unsaturated (Tus) fatty acids were 26.52% and 73.48 %, respectively. Also, in *C. tuberculata* oleic acid and linoleic acid were found at high percentage followed by palmitic acid. The (Ts) were 30.89 % and the (Tus) were 69.11 %. The most predominant fatty acids in *Alternaria alternata* was linoleic acid followed by oleic and palmitic acid and the (Ts) were 28.33% while (Tus) were 71.68 %. But in case of *A. tenuissima* the (Ts) were 31.33 % and the (Tus) were 68.67 %. *Fusarium oxysporum* had also high values of linoleic and oleic acids. The (Ts) and (Tus) were 29.9% and 70.11 %, respectively. *F. semitectum* had total saturated fatty acids of 46.63 % and total unsaturated fatty acids of 53.38 %.

From these results, it is clearly observed that *Curvularia lunata* contained the highest percentage of (Tus) 73.48 % and lowest percentage of (Ts) (26.52%) followed by *Alternaria alternata* (71.68 %, 28.33 %) and *Fusarium oxysporum* (70.11 %, 29.9 %) while the lowest percentage of (Tus) was found in *F. semitectum* (53.38%) followed by *A. tenuissima* (68.67 %) and *C. tuberculata* (69.11 %), respectively.

Table (15): The relative percentage of the main fatty acids composition of the selected fungal species.

Fatty acid (%)		Fungi					
Chain length	**Common name**	***C.lunata***	***C.tuberculata***	***A.alternata***	***A.tenuissima***	***F.oxysporum***	***F.semitectum***
12 : 0	Lauric	ND	ND	ND	1.53	1.35	1.68
14 : 0	Myristic	1.29	ND	1.44	2.72	2.30	ND
16 : 0	Palmitic	20.11	25.66	21.84	21.54	20.83	37.70
18 : 0	Stearic	5.12	5.23	5.05	5.54	5.42	7.25
18 : 1	Oleic	38.12	38.34	33.29	30.48	31.28	27.26
18 : 2	Linoleic	35.36	30.77	38.39	33.01	34.10	22.34
18 : 3	Linolenic	ND	ND	ND	1.86	ND	1.70
22 : 1	Erucic	ND	ND	ND	3.32	4.73	2.08
Ts		26.52	30.89	28.33	31.33	29.9	46.63
Tus		73.48	69.11	71.68	68.67	70.11	53.38

ND = Not detected Ts = Total saturated fatty acids Tus = Total unsaturated fatty acids

Nucleic acids:

This experiment has done to determine the nucleic acids content of the radiation resistant and sensitive studied fungi. The total amounts of DNA and RNA for the six fungal species were measured and the data were recorded in Table (16) and Fig. (27). The results showed that, the total nucleic acids content of *Curvularia lunata* was 36.63 mg/g, while in *Curvularia tuberculata* the total nucleic acids content was 29.60 mg/g.

With regard to *Alternaria alternata*, the total nucleic acids content was 35.13 mg/g, while with *Alternaria tenuissima*, the total nucleic acids content was 28.17 mg/g.

In case of *Fusarium oxysporum*, the total nucleic acids content was 33.41 mg/g, while in *Fusarium semitectum*, the total nucleic acids content was 28.46 mg/g.

From the previous results, it was found that *C. lunata* contained the highest content of total nucleic acids (36.63 mg/g) followed by *A. alternata* (35.13 mg/g), *F. oxysporum* (33.41 mg/g), *C. tuberculata* (29.60 mg/g), *F. semitectum* (28.46 mg/g) and *A. tenuissima* (28.17 mg/g).

Table (16): Nucleic acids content (mg/g) of the selected fungal species.

Fungal species	RNA (mg/g)	DNA (mg/g)	Total nucleic (mg/g)
Curvularia lunata	24.5	12.13	36.63
C. tuberculata	19.88	9.72	29.60
Alternaria alternata	23.63	11.50	35.13
A. tenuissima	18.75	9.42	28.17
Fusarium oxysporum	22.81	10.60	33.41
F. semitectum	20.13	8.33	28.46

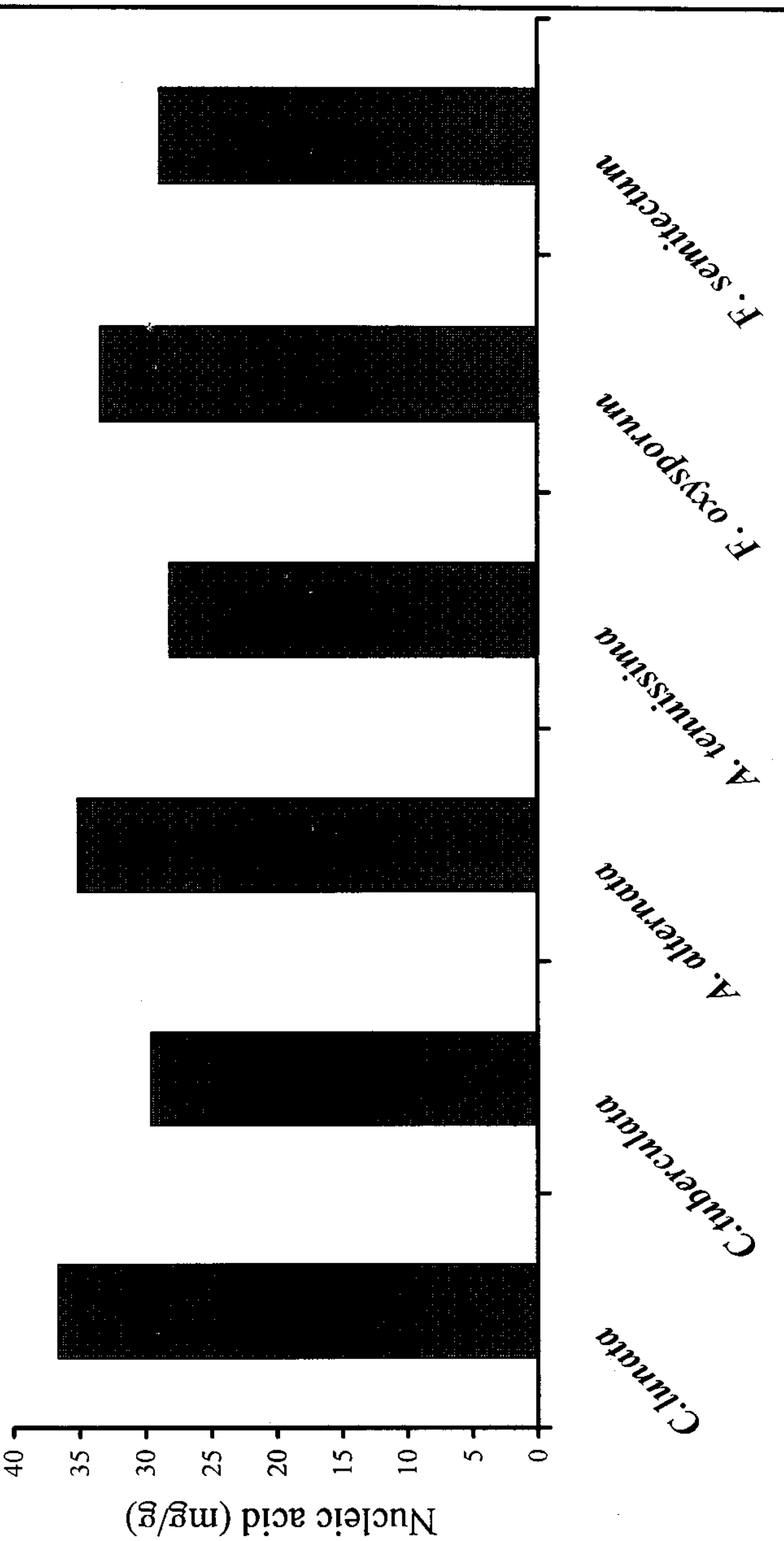


Fig. (27): Nucleic acids content (mg/g) of the selected fungal species

Effect of gamma irradiation on some cellular composition of resistant and sensitive species:

Total protein:

This experiment was carried out to study the effect of gamma radiation on protein content of the studied fungi. The spore suspension of the tested fungi were exposed to dose level of 4.0 kGy. Thereafter the irradiated spores were inoculated in Czapek's-yeast extract liquid media and the mats were harvested after 10 days. The protein content of the dry unirradiated and irradiated mats were determined and the data recorded in Table (17).

It was found that T_p % of unirradiated *Curvularia lunata*, *C. tuberculata, Alternaria alternata*, *A. tenuissima*, *Fusarium oxysporum* and *F. semitectum* were 76.88%, 70.13 %, 72.69%, 64.06 %, 69.83 % and 46.88%, respectively. The T_p of the above irradiated species decreased after exposure to 4.0 kGy and were found to be 71.88%, 63.50 %, 66.50%, 54.10%, 63.25 % and 40.21 %, respectively. In the radiation resistant fungal species, i.e. *C. lunata, A. alternata* and *F. oxysporum* the percentage of decreasing reached 6.50%, 8.52% and 9.42%, respectively, while the decreasing percentage in the radiation sensitive fungal species, i.e. *C. tuberculata, A. tenuissima* and *F. semitectum* reached 9.45 %, 15.55 % and 14.23 %, respectively. It is obvious that the decreasing in the total protein of the most radiation resistant fungus (*C. lunata*) was only 6.5 % while it reached 15.55% in the most radiation sensitive one (*A. tenuissima*).

Table (17): Effect of gamma irradiation on the total protein content of the selected fungal species.

Fungal species	Radiation doses (kGy)	Total nitrogen (T_N) %	Total protein (Tp)%	Increase or decrease %
Curvularia lunata	0.0	12.30	76.88	—
	4.0	11.50	71.88	-6.50
C.tuberculata	0.0	11.22	70.13	—
	4.0	10.16	63.50	-9.45
Alternaria alternata	0.0	11.63	72.69	—
	4.0	10.64	66.50	-8.52
A.tenuissima	0.0	10.25	64.06	—
	4.0	8.66	54.10	-15.55
Fusarium oxysporum	0.0	11.17	69.83	—
	4.0	10.12	63.25	-9.42
F.semitectum	0.0	7.50	46.88	—
	4.0	6.43	40.21	-14.23

Amino acids:

From the previous experiment, the results clearly showed the decreasing in total protein content by exposed the studied fungal species to gamma radiation at dose level of 4.0 kGy. It was found interesting to determine the effect of this dose level on the quantitative amount of different amino acids in these species.

The total amino acids of the fungi were analysed using high performance amino acid analyzer. The results revealed that 17 amino acids were detected in studied fungi. Results given in Table (18) and Figs. (28-39) showed that gamma radiation decreased the total amino acids content of the experimental fungi. After irradiation by 4.0 kGy the contents of all amino acids of *C. lunata* were decreased except cysteine with different percentage. The highly percentage of decreasing were observed in lysine (28.6%), histidine (26.3%) and proline (24.2%). The total amino acids content decreased by 15.2 %.

The results obtained from Table (18) illustrated by Figs. (30, 31) showed that the total amino acids content in *Curvularia tuberculata* was found to be 101.0 mg/g dry wt. and decreased to 62.0 mg/g dry wt. (38.6%) after exposuring to 4.0 kGy. Also, all the amino acids content were decreased, the highly percentages of decreasing were observed in methionine (75.0 %), arginine (51.6 %) and cysteine (50.0%).

Table (18): Effect of gamma irradiation on the amino acids composition (mg/g) of the selected fungal species.

Fungal species	*C. lunata*		*C. tuberculata*		*A. alternata*		*A. tenuissima*		*F. oxysporum*		*F. semitectum*	
Radiation doses (kGy) / Amino acids (mg/g)	0.0	4.0	0.0	4.0	0.0	4.0	0.0	4.0	0.0	4.0	0.0	4.0
Aspartic	12.4	11.2	9.8	6.8	9.8	6.8	7.8	6.2	6.4	4.6	7.6	6.8
Threonine	8.2	7.2	6.4	5.0	7.4	4.2	5.4	4.8	3.4	3.0	4.0	3.6
Serine	7.2	6.6	5.4	3.6	6.6	4.6	5.0	3.8	2.8	3.0	4.6	4.0
Glutamic acid	16.2	14.8	13.2	7.6	15.2	8.4	10.2	7.4	7.6	4.4	8.8	8.4
Proline	13.2	10.0	11.4	5.8	11.4	5.2	6.6	4.8	2.4	0.0	5.2	0.0
Glysine	6.2	5.6	5.0	3.2	5.8	3.6	3.8	3.2	3.4	3.6	3.8	3.6
Alanine	9.2	8.6	7.8	4.6	8.6	5.0	5.8	5.0	3.4	3.4	4.6	4.0
Cysteine	0.4	0.4	0.4	0.2	0.6	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Valine	6.6	5.8	5.2	3.6	6.0	3.8	4.2	3.8	2.8	3.0	3.6	3.6
Methionine	1.2	1.0	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isoleucine	5.8	5.0	4.4	2.6	5.0	2.6	3.6	3.2	2.2	1.4	2.6	2.4
Leucine	10.4	8.6	7.8	4.8	9.8	5.0	5.6	4.6	3.8	3.2	5.6	4.8
Tyrosine	4.2	3.4	2.8	2.0	4.0	2.0	1.8	1.2	1.2	0.8	1.6	2.0
Phenylalanine	6.0	4.8	4.2	2.6	5.0	2.8	3.0	2.6	2.2	1.4	2.4	2.4
Histidine	3.8	2.8	3.0	2.0	3.0	1.8	1.8	1.4	2.0	0.8	1.6	1.6
Lysine	9.8	7.0	7.2	4.4	8.6	3.2	5.2	4.4	3.2	2.4	4.0	4.0
Arginine	8.4	6.8	6.2	3.0	7.6	3.6	4.2	3.2	1.8	1.6	3.2	3.6
Total	129.2	109.6	101.0	62.0	114.4	62.6	74.0	59.6	49.2	36.6	63.2	54.8

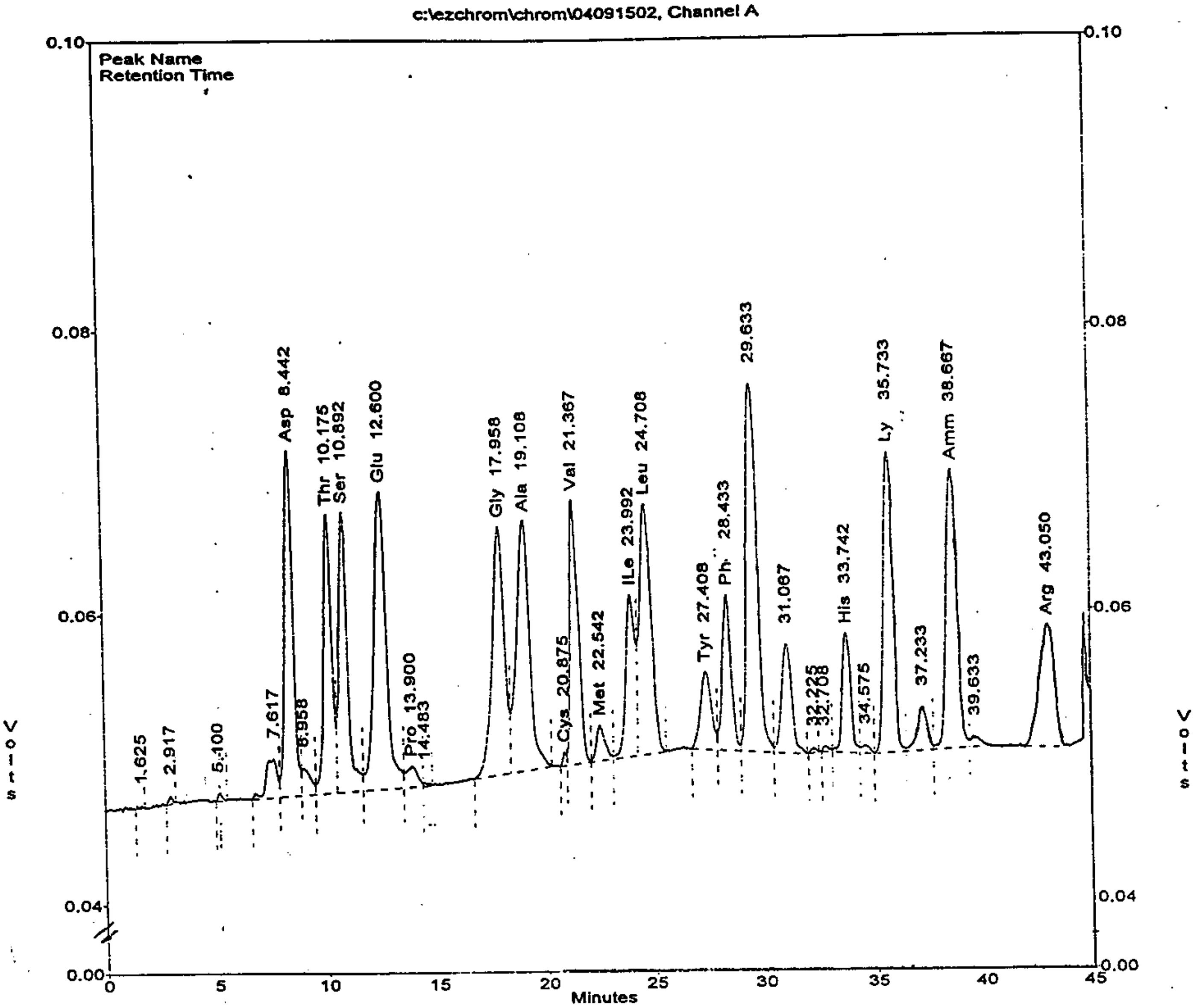


Fig. (28): Amino acid chromatographs of *Curvularia lunata* at 0.0 kGy.

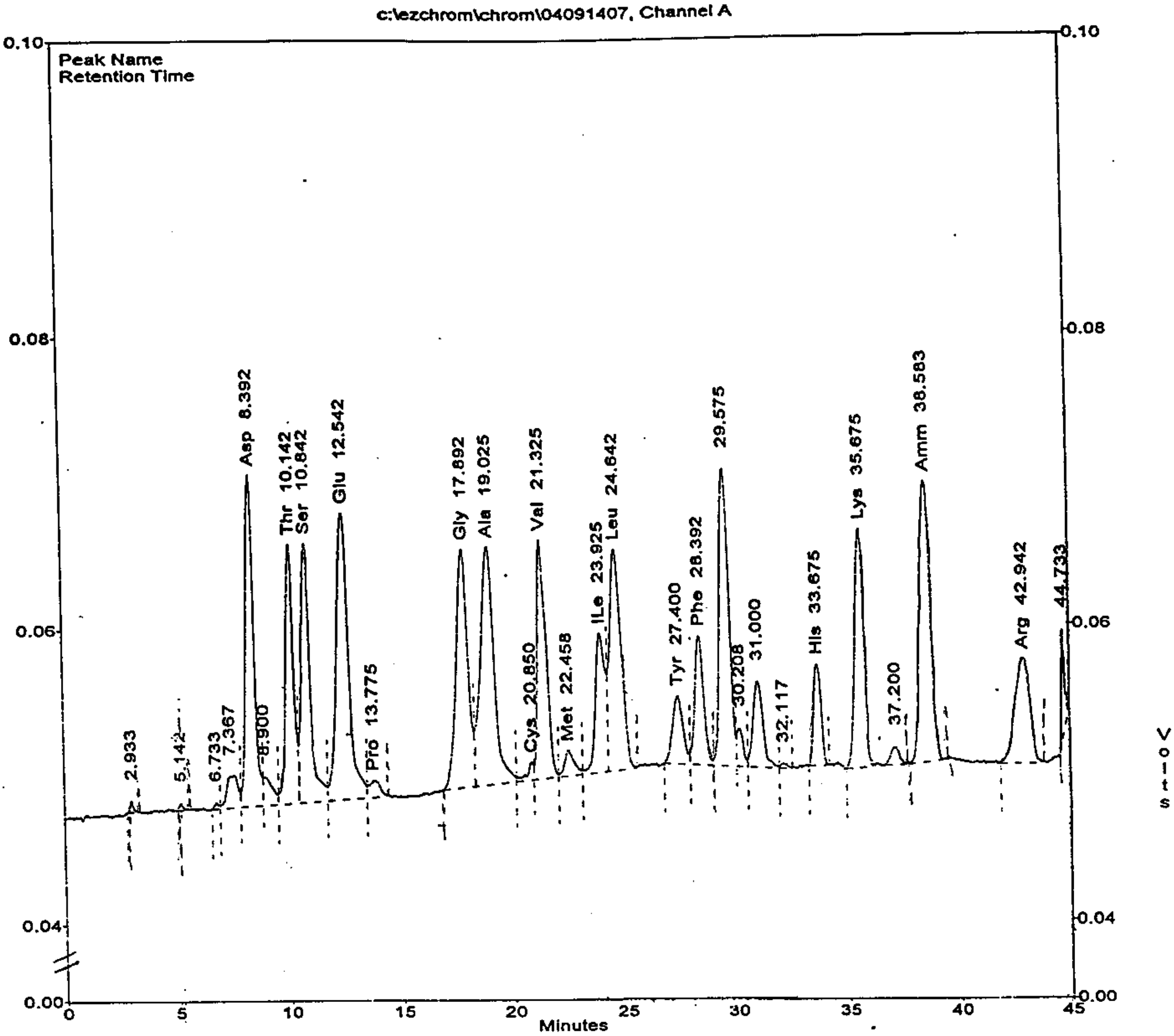


Fig. (29): Amino acid chromatographs of *Curvularia lunata* at 4.0 kGy.

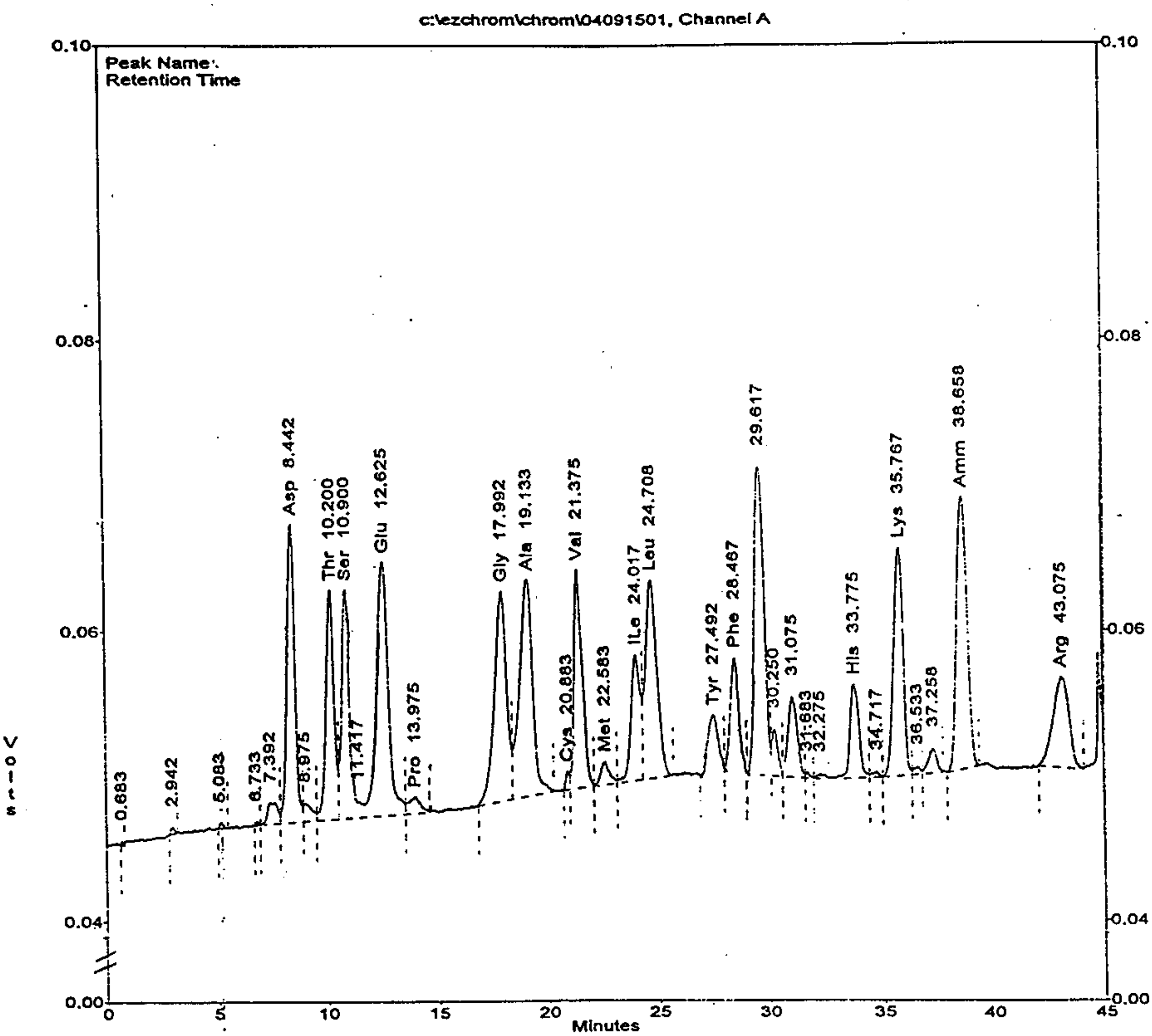


Fig. (30): Amino acid chromatographs of *Curvularia tuberculata* at 0.0 kGy.

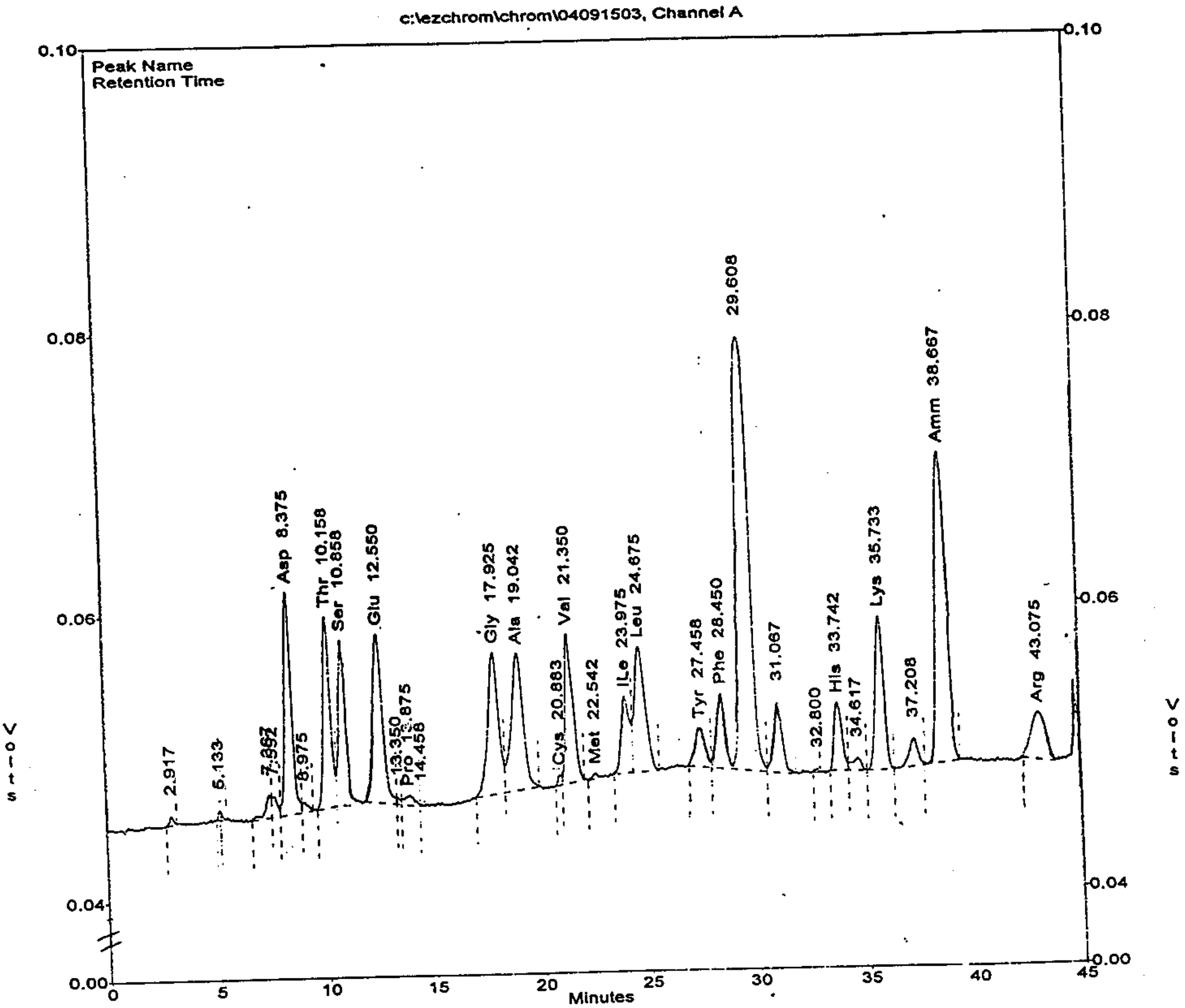


Fig. (31): Amino acid chromatographs of *Curvularia tuberculata* at 4.0 kGy.

With regard to *Alternaria alternata*, the results in Table (18) and Figs. (32, 33) showed that the total amino acids content was 114.4 mg/g dry wt. After exposing to 4.0 kGy all the amino acids content decreased. Cysteine was completely destroyed after irradiation, while lysine decreased by 62.8 %, proline by 54.4 % and the total amino acids content decreased by 45.3 %.

Amino acids composition of *Alternaria tenuissima* as shown in Table (18) and Figs. (34, 35) revealed that the total amino acids contents were 74.0 mg/g dry wt. and after irradiating by 4.0 kGy were decreased to 59.6 mg/mg dry wt. (19.5%) and all the individual amino acids decreased at different levels. Tyrosine decreased by 33.3 %, glutamic acid by 27.5% and proline by 27.3 %.

The data recorded in Table (18) and Figs. (36, 37) indicated that the total amino acids content in *F. oxysporum* was 49.2 mg/g dry wt. and decreased to 36.6 mg/g dry wt. (25.6%) after exposure to 4.0 kGy. Cysteine and proline were completely destroyed after irradiation. On the other hand, serine, glysine and valine were increased by percentages of 7.1%, 5.9 %, and 7.1 %, respectively.

In Table (18) and Figs. (38 and 39) the results showed that the total amino acids content in *F. semitectum* was 63.2 mg/g dry wt. and decreased to 54 .8 mg/g (12.0 %) after exposure to 4.0 kGy. Proline was completely concealed after the irradiation process, while the percentage of tyrosine and arginine increased by 25.0 % and 12.5 %, respectively.

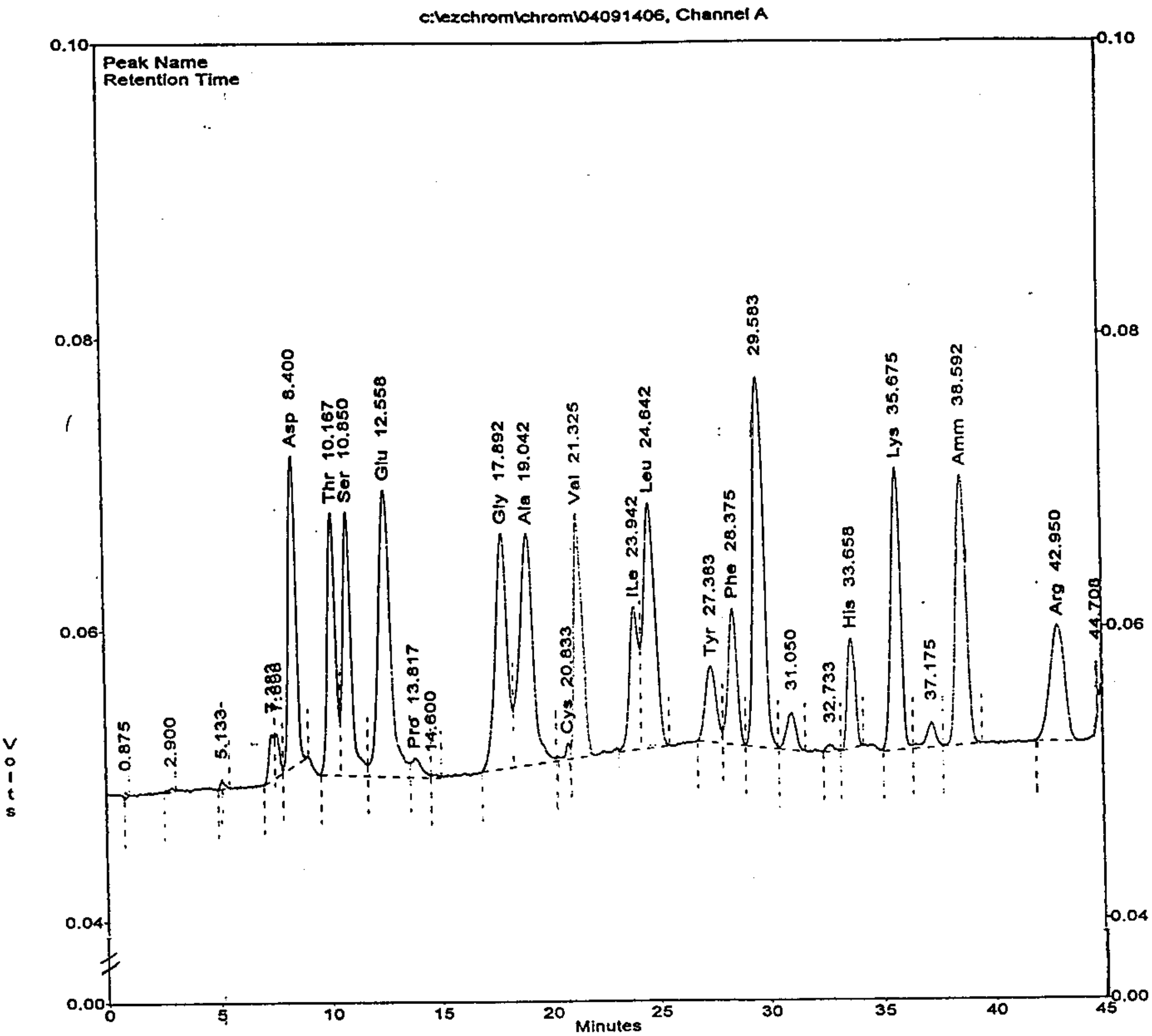


Fig. (32): Amino acid chromatographs of *Alternaria alternata* at 0.0 kGy.

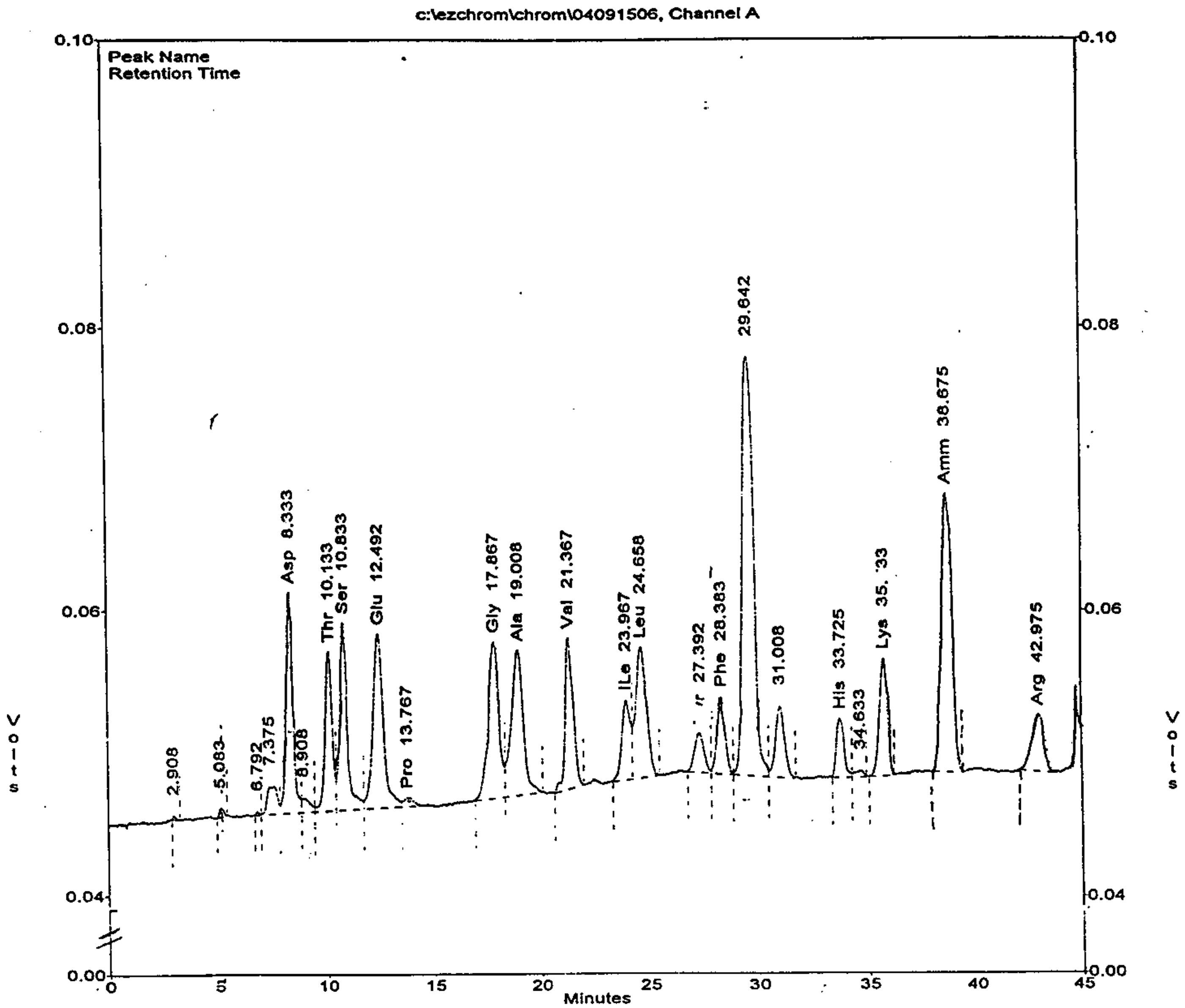


Fig. (33): Amino acid chromatographs of *Alternaria alternata* at 4.0 kGy.

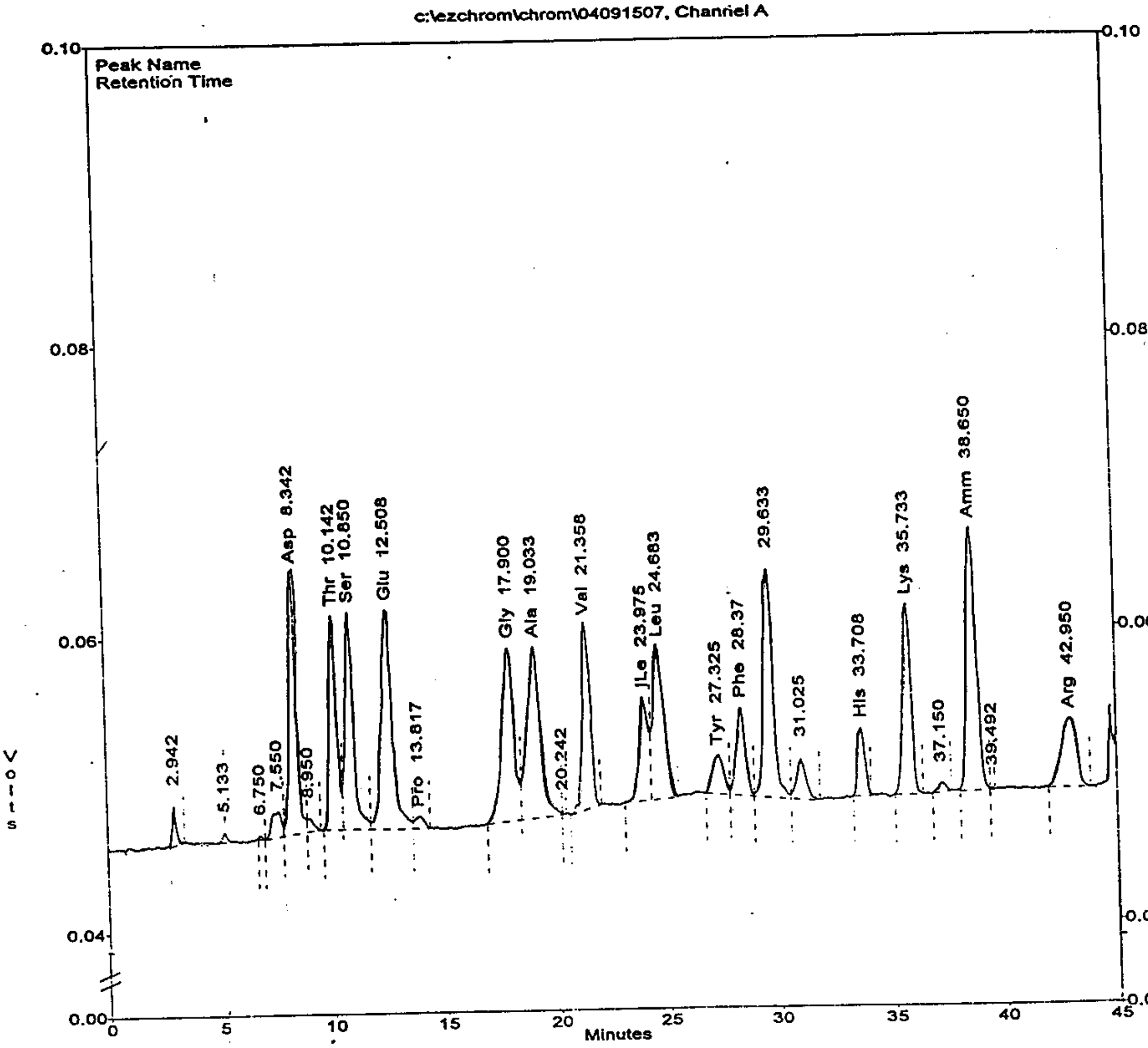


Fig. (34): Amino acid chromatographs of *Alternaria tenuissima* at 0.0 kGy.

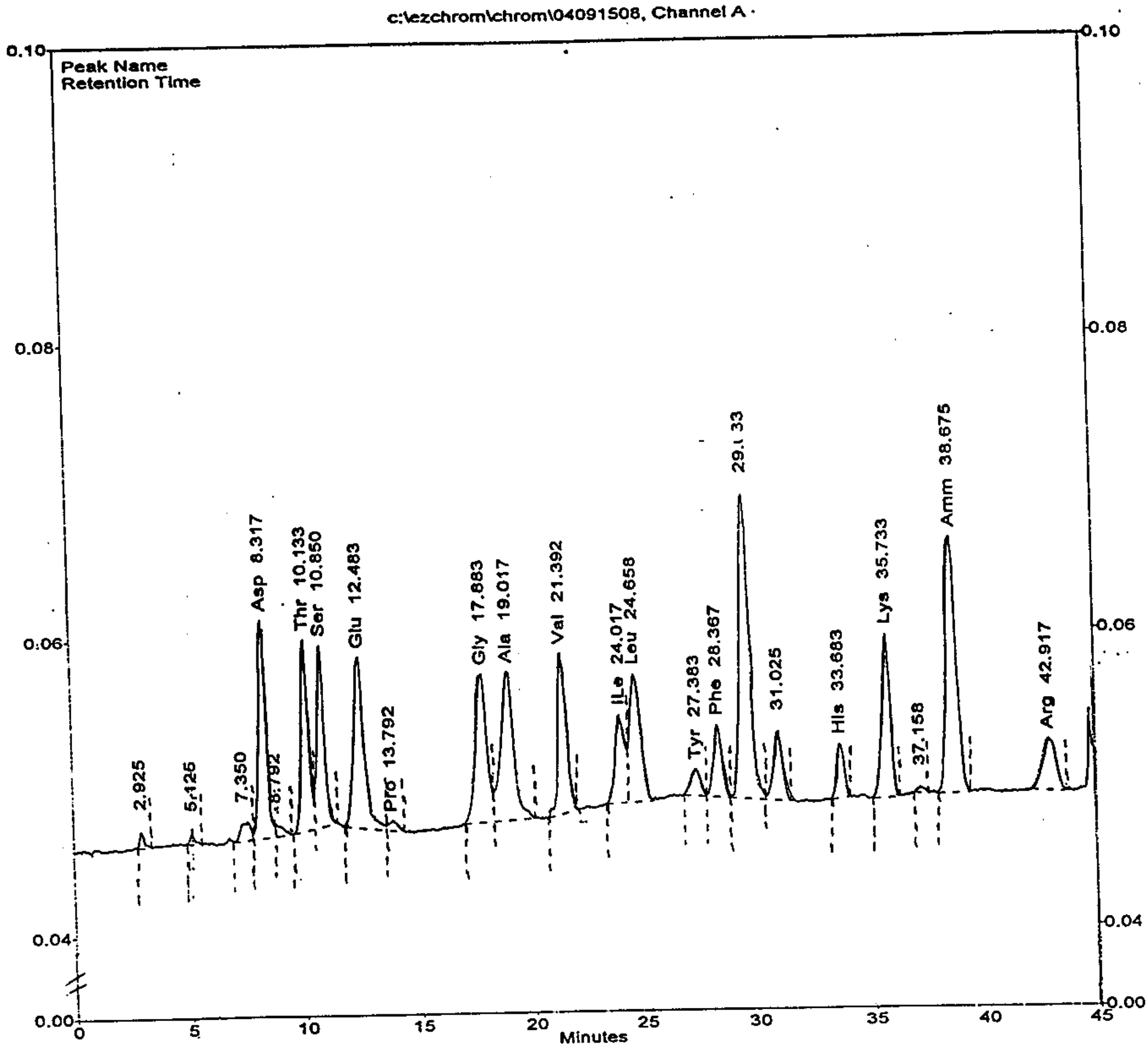


Fig. (35): Amino acid chromatographs of *Alternaria tenuissima* at 4.0 kGy.

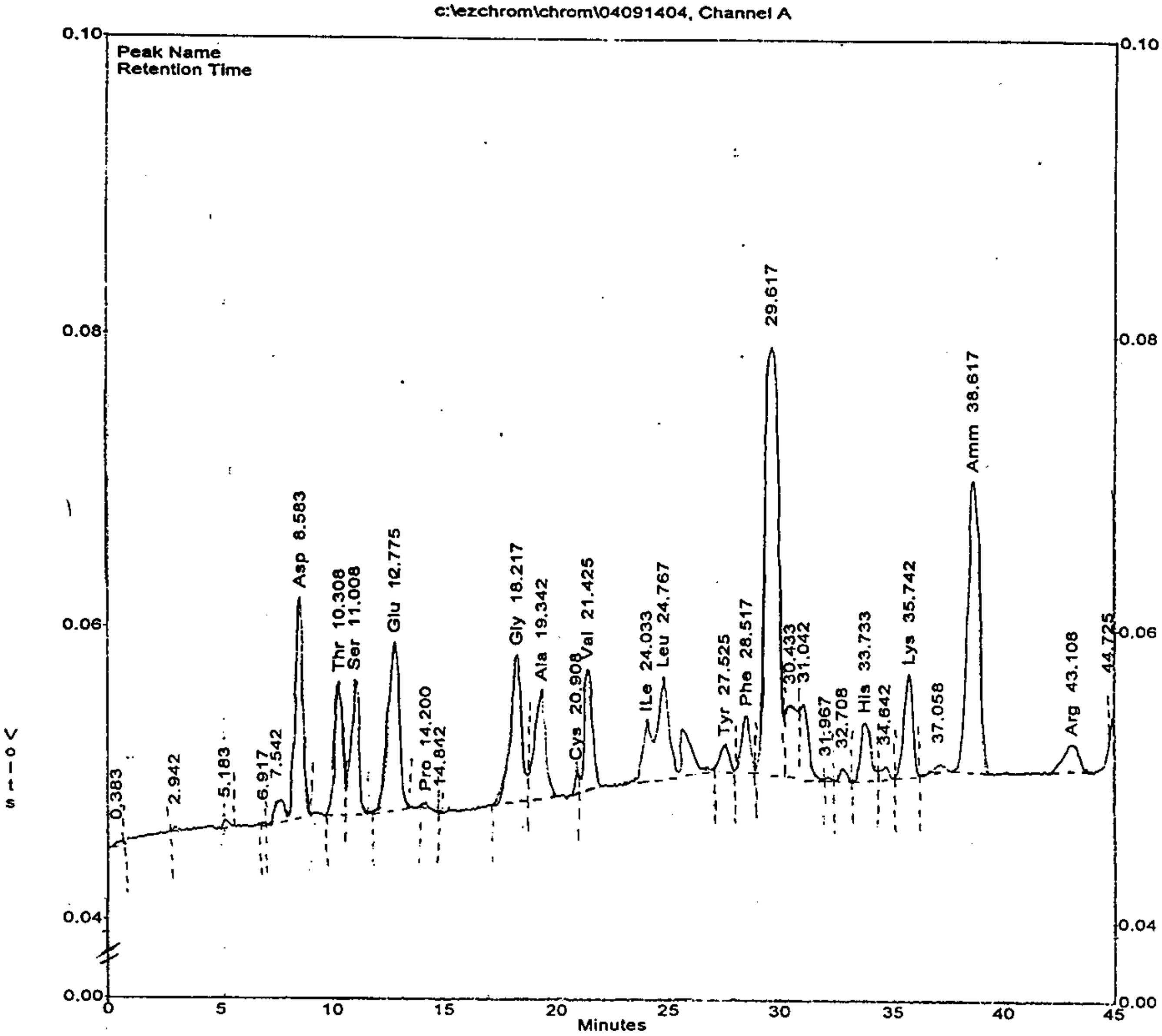


Fig. (36): Amino acid chromatographs of *Fusarium oxysporum* at 0.0 kGy.

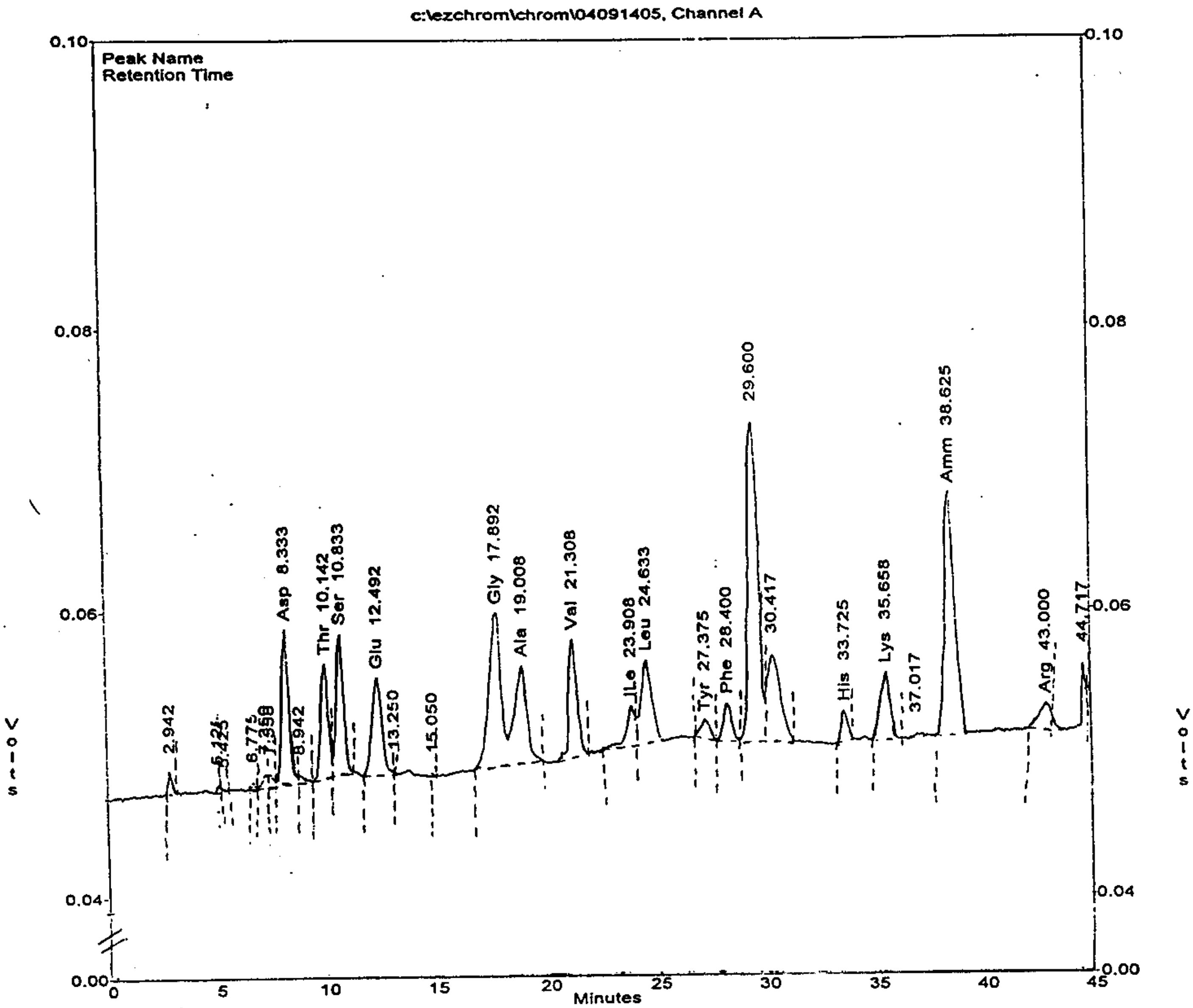


Fig. (37): Amino acid chromatographs of *Fusarium oxysporum* at 4.0 kGy.

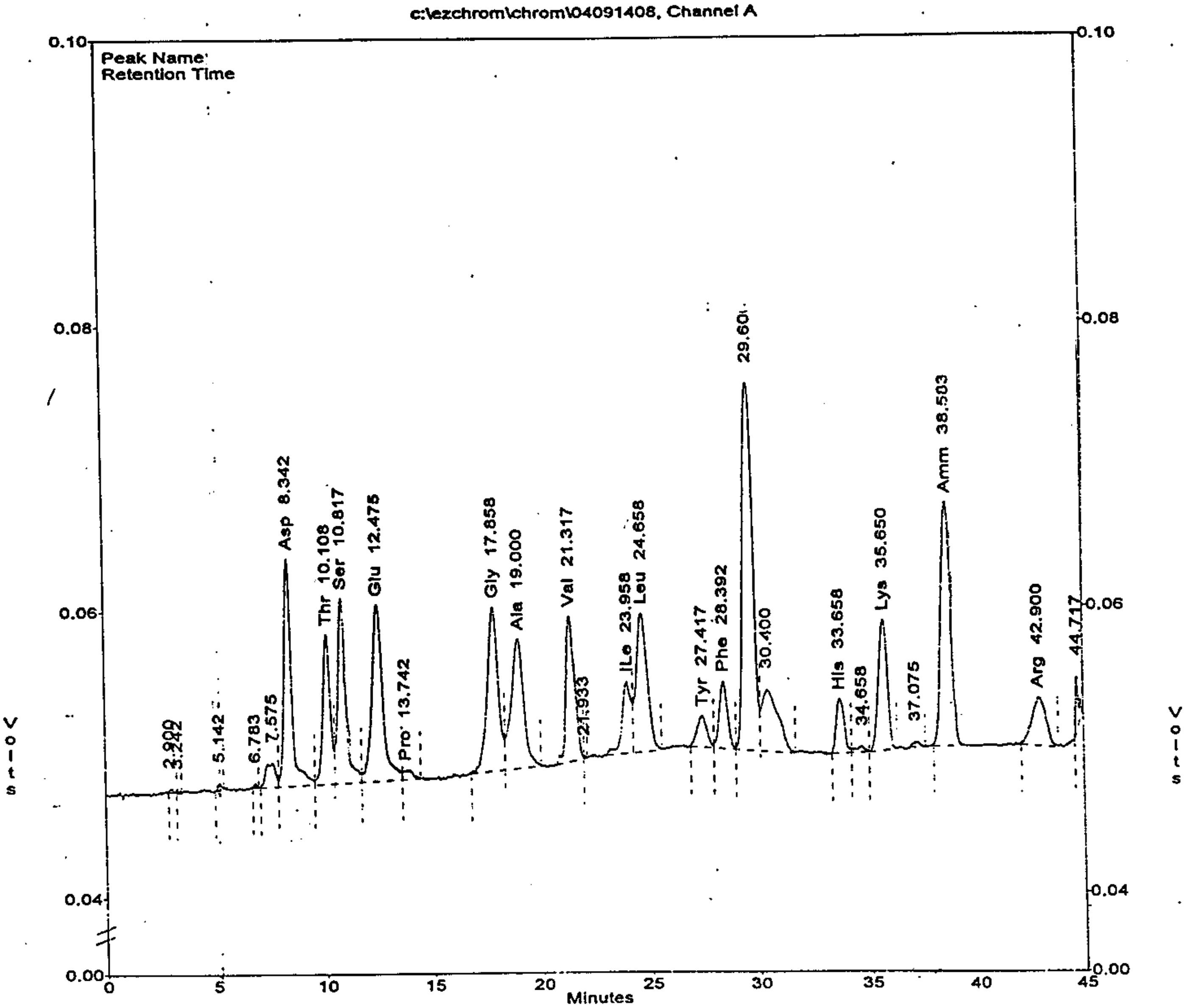


Fig. (38): Amino acid chromatographs of *Fusarium semitectum* at 0.0 kGy.

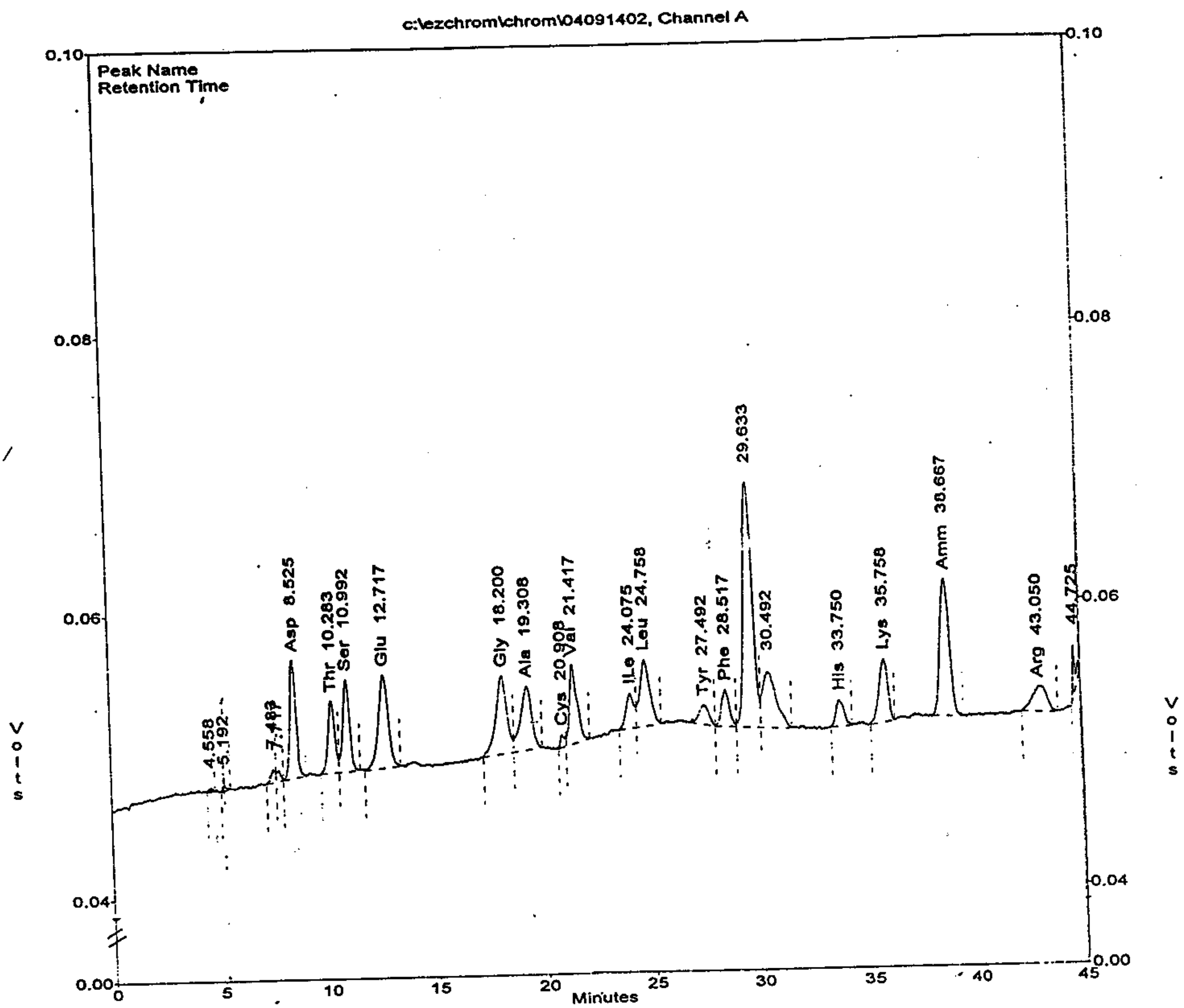


Fig. (39): Amino acid chromatographs of *Fusarium semitectum* at 4.0 kGy.

Nucleic acids:

This experiment has done to clear the effect of gamma irradiation on the nucleic acids content of the resistant and radiation sensitive studied fungi.

The total amounts of DNA and RNA for the six fungal species were measured and the data were recorded in Table (19). The data showed that, the total nucleic acids content of *Curvularia lunata* was 36.63 mg/g before irradiation and decreased to 29.20 mg/g (20.28 %) after exposure to 4.0 kGy. In *Curvularia tuberculata* the total nucleic acids content was 29.60 mg/g and decreased by 30.7 % after the irradiation process.

With regard to the unirradiated *Alternaria alternata*, the total nucleic acids content was 35.13 mg/g and decreased by 21.72% at 4.0 kGy, while with unirradiated *Alternaria tenuissima*, the total nucleic acids content was 28.17 mg/g and decreased by 46.75% at 4.0 kGy.

In case of *Fusarium oxysporum*, the total nucleic acids content was 33.41 mg/g and the value decreased after exposuring to gamma irradiation by 27.18 %, while with *Fusarium semitectum*, the total nucleic acids content was 28.46 mg/g and decreased to 18.70 mg/g at 4.0 kGy recording decreasing percentage 34.29 %.

From the previous results, it could be stated that the radiation resistant fungal species, i.e. *Curvularia lunata*, *Alternaria alternata* and *Fusarium oxysporum* contained higher total nucleic acids content than radiation sensitive species, i.e. *C. tuberculata, A. tenuissima* and *F. semitectum*. Although both of the values of RNA and DNA decreased by exposure the tested fungal strains to 4.0 kGy, the percentage of decreasing due to the irradiation process were higher in DNA than RNA as clearly observed from the data of Table (19). Also, the percentage of decreasing in the RNA of the radiation sensitive species, i.e. *C. tuberculata*, *A. tenuissima* and *F. semitectum* were more than that occurred in the radiation resistant ones, i.e. *C. lunata*, *A. alternata* and *F. oxysporum*. The percentages of decreasing in DNA recorded 32.8 %, 33.7 % and 29.7 % in the radiation resistance species, i.e. *C. lunata* , *A. alternata* and *F. oxysparum* compared with 40.6 %, 59.4 %, 55.0 % in the radiation sensitive corresponding species, i.e. *C. tuberculata, A. tenuissima* and *F. semitectum*, respectively.

Table (19): Effect of gamma irradiation on the nucleic acids content of the selected fungal species.

Fungal species	Radiation doses (kGy)	RNA (mg/g)	Change %	DNA (mg/g)	Change %	Total nucleic acids (mg/g)	Change %
C. lunata	0.0	24.50	—	12.13	—	36.63	—
	4.0	21.05	-14.0	8.15	-32.8	29.20	-20.28
C.tuberculata	0.0	19.88	—	9.72	—	29.60	—
	4.0	14.75	-25.8	5.77	-40.6	20.52	-30.70
A. alternata	0.0	23.63	—	11.50	—	35.13	—
	4.0	19.88	-15.9	7.62	-33.7	27.50	-21.72
A. tenuissima	0.0	18.75	—	9.42	—	28.17	—
	4.0	11.18	-40.4	3.82	-59.4	15.00	-46.75
F. oxysporum	0.0	22.81	—	10.60	—	33.41	—
	4.0	16.88	-26.0	7.45	-29.7	24.33	-27.18
F.semitectum	0.0	20.13	—	8.33	—	28.46	—
	4.0	14.95	-25.7	3.75	-55.0	18.70	-34.29

Effect of gamma irradiation on the survival count of the tested resistant fungal species artificially inoculated into lupine seeds or chicken feed during storage:

This experiment was carried out to confirm the fact that the effect of "gamma irradiation is an effective method in controlling fungi contaminated foods". Sterile lupine seeds were artificially contaminated with spores of the highest radiation resistant fungus, i.e. *Curvularia lunata* while sterile chicken feed was separately contaminated with *Alternaria alternata* and *Fusarium oxysporum.* The dose levels used were 0.0, 2.5, 5.0, 7.5, 10.0 and 12.5 kGy. The samples tested for total fungal count immediately after irradiation (zero time) and periodically every one month of storage period (3 months). The results are recorded in Tables 20, 21 and 22 and illustrated by Figs. 40, 41 and 42. The given results in Table (20) and Fig. (40) showed that the total count of *Curvularia lunata* unirradiated lupine seeds were 2.85 x 10^7 cells /g at the zero time of storage. These counts ranged between 1.39 x 10^7 and 2.53 x 10^8 cells /g during storage. Meanwhile, the counts of *Curvularia lunata* decreased after exposure the contaminated lupine seeds to increasing dose levels of gamma rays. The survival counts decreased by about 2.0, 4.0 and 5.0 log cycles from the initial count at irradiation doses of 5.0, 7.5 and 10.0 kGy, respectively, and completely destroyed after dose level of 12.5 kGy. During storage, the fungus count slightly increased after one month of storage in all unirradiated and irradiated samples, except that exposed to 12.5 kGy which proved to be sufficient to freedom the samples from this fungus all over the storage period. It is worth to mention that dose level of 10 kGy was enough to keep the counts of *Curvularia lunata* less in the range of 10^3-10^2 cfu/g during all the storage periods.

Table (20): Effect of gamma irradiation on the survival counts of ***Curvularia lunata*** inoculated into lupine seeds during storage periods.

Storage period (months)	Irradiation dose (kGy)											
	0.0		2.5		5.0		7.5		10.0		12.5	
	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N
0	2.85×10^7	7.45	1.51×10^7	7.18	7.2×10^5	5.86	1.13×10^3	4.05	4.05×10^2	2.61	NC	0.00
1	2.53×10^8	8.40	5.46×10^7	7.74	6.15×10^6	6.79	2.88×10^4	4.46	1.04×10^2	3.02	NC	0.00
2	2.29×10^7	7.35	2.58×10^6	6.41	3.87×10^5	5.59	4.87×10^3	3.69	8.83×10	1.95	NC	0.00
3	1.39×10^7	7.14	2.23×10^6	6.35	2.14×10^5	5.33	6.69×10^2	2.83	5.83×10	1.77	NC	0.00

NC = No colonies were observed.

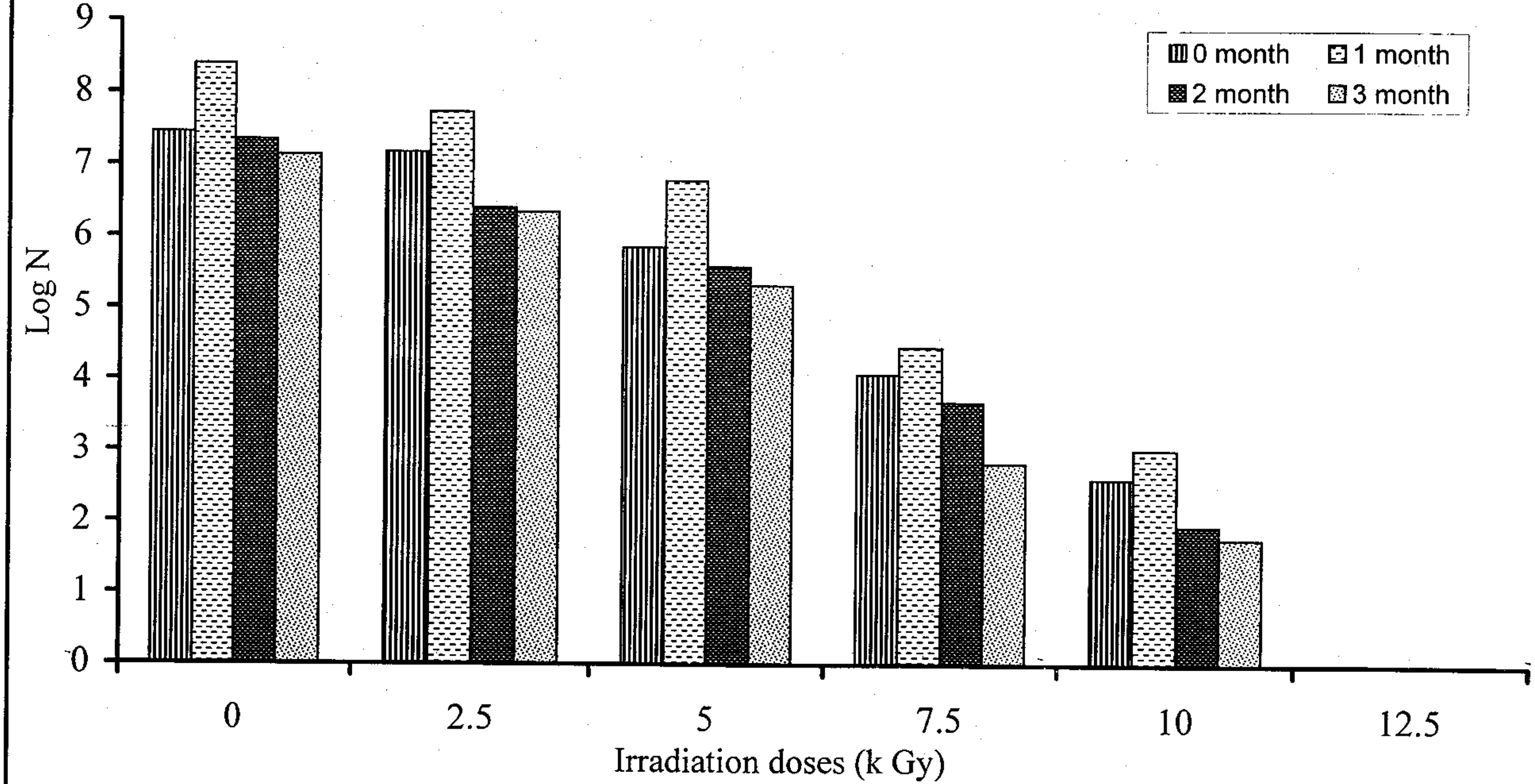


Fig. (40): Effect of gamma irradiation on the survival counts of ***Curvularia lunata*** inoculated into lupine seeds during storage periods.

As occurred in case of *Curvularia lunata*, data in tables (21 and 22) illustrated by Figs. (41 and 42) showed that the survival counts of *Alternaria alternata* and *Fusarium oxysporum* artificially contaminated the chicken feed fluctuated between 10^7 and 10^8 cells/g during the storage period. Exposure the contaminated samples to increasing doses of gamma rays greatly decreased the survival counts of both tested fungi. Dose level of 12.5 kGy was quite sufficient for complete elimination of *Alternaria alternata* from chicken feed either immediately after irradiation or during the storage period. Meanwhile, the spores of *Fusarium oxysporum* showed less resistance than *Curvularia lunata* and *Alternaria alternata* where its spores completely inhibited from chicken feed at dose level of 10 kGy during the storage period.

It could be concluded that dose level of 10 kGy consider enough for treating the highly contaminated food or feed with fungi, even radiation resistant fungi, since it either freedom the food from their spores or keep their counts under the safety limit (< 10^3 cfu/g).

Table (21): Effect of gamma irradiation on the survival counts of ***Alternaria alternata*** inoculated into chicken feed during storage periods.

Storage period (months)	Irradiation dose (kGy)											
	0.0		2.5		5.0		7.5		10.0		12.5	
	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N
0	6.73×10^7	7.83	1.38×10^7	7.14	5.98×10^5	5.78	1.04×10^4	4.02	1.13×10^2	2.05	NC	0.00
1	9.52×10^7	7.98	1.11×10^8	8.05	1.02×10^8	6.01	1.56×10^4	4.19	2.03×10^2	2.31	NC	0.00
2	6.28×10^7	7.80	5.67×10^6	6.75	6.11×10^5	5.79	1.15×10^4	4.06	1.28×10^2	2.11	NC	0.00
3	1.12×10^7	7.05	1.56×10^6	6.19	1.72×10^5	5.24	9.64×10^3	3.98	1.13×10^2	2.05	NC	0.00

NC = No colonies were observed.

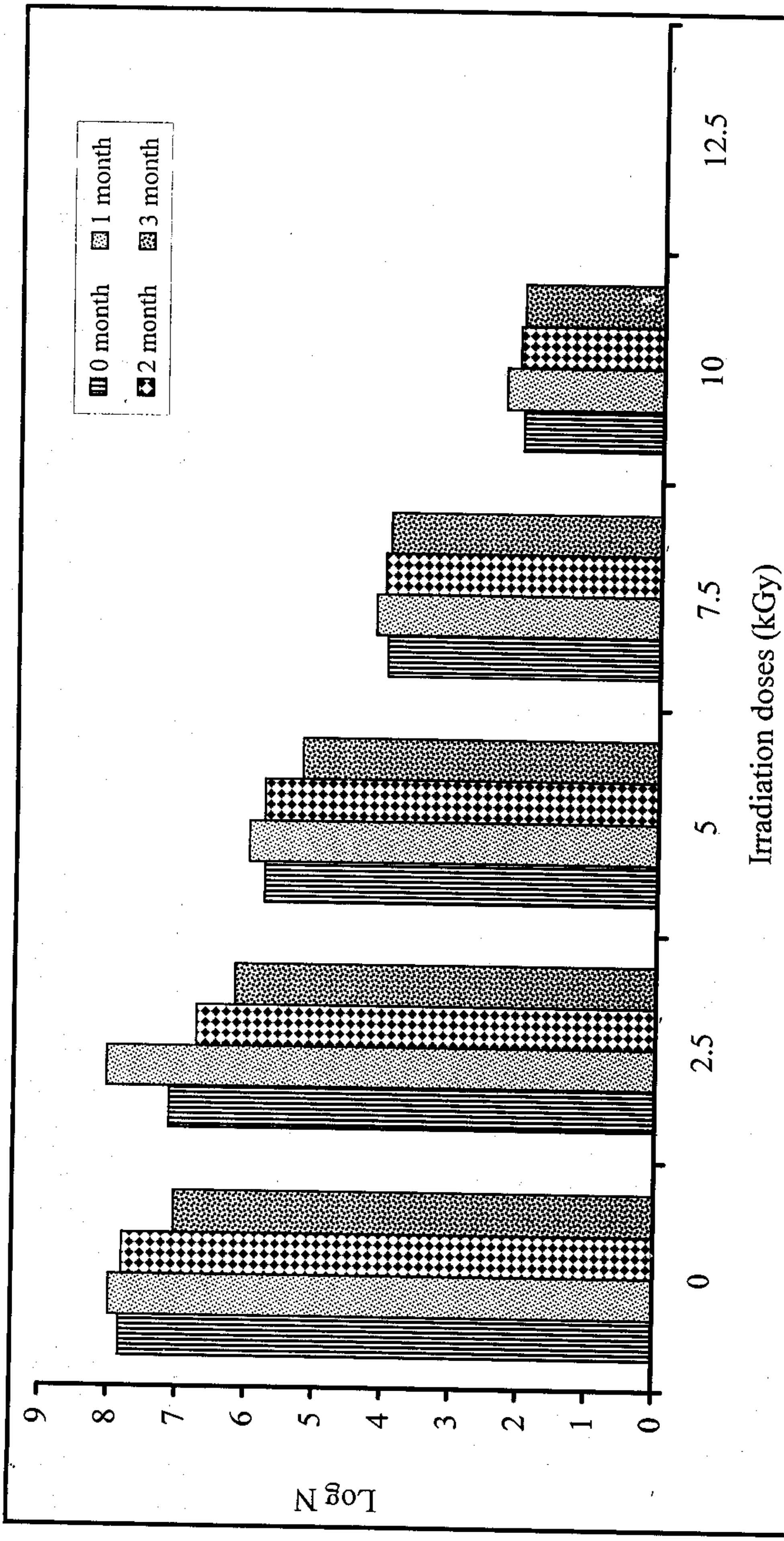


Fig. (41): Effect of gamma irradiation on the survival counts of ***Alternaria alternata*** inoculated into chicken feed during storage periods.

Table (22): Effect of gamma irradiation on the survival counts of ***Fusarium oxysporum*** inoculated into chicken feed during storage periods.

Storage period (months)	Irradiation dose (kGy)											
	0.0		2.5		5.0		7.5		10.0		12.5	
	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N	No. of survivor	Log N
0	5.35×10^7	7.73	1.35×10^7	7.13	6.92×10^5	5.84	8.99×10^3	3.95	NC	0.00	NC	0.00
1	2.44×10^8	8.39	6.62×10^7	7.82	8.15×10^5	5.91	1.77×10^4	4.25	NC	0.00	NC	0.00
2	4.68×10^7	7.67	1.19×10^7	7.08	6.66×10^4	4.82	1.03×10^3	3.01	NC	0.00	NC	0.00
3	1.88×10^7	7.28	6.52×10^6	6.81	4.96×10^3	3.70	4.94×10^2	2.69	NC	0.00	NC	0.00

NC = No colonies were observed.

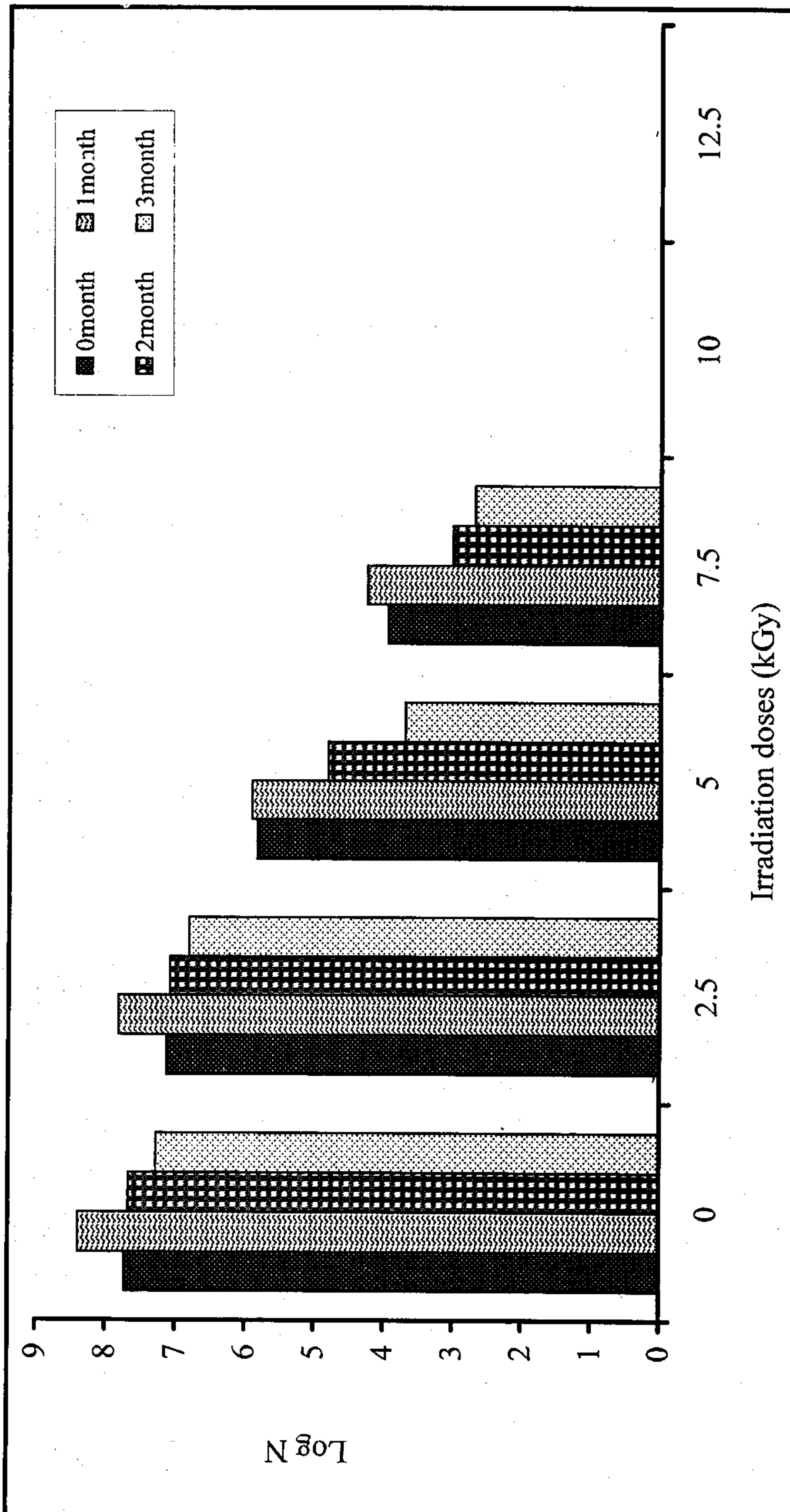


Fig. (42): Effect of gamma irradiation on the survival counts of ***Fusarium oxysporum*** inoculated into chicken feed during storage periods.