RESULTS AND DISCUSSION

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1. Effects of gamma irradiation and cold storage (4±1°C) on the microbiological properties of the prepared meals:

1.1. Effects on the total bacterial count:

1.1.1. Cooked meat balls:

The total bacterial count was determined for samples of irradiated and non-irradiated cooked meat balls post treatments and during storage at 4±1°C and the results are shown in Table (1). From these results, it is clear that samples of non-irradiated meat balls had an initial total bacterial count of $7.2x10^5$ cfu/g. These results agree with those obtained by several investigators who found that cooked meat had an initial total bacterial count of more than 10^6 cfu/g ***(Aycicek et al., 2004; Fang et al., 2003; Gillespie et al., 2000 and Lee et al., 2004).***

Subjecting samples of cooked meat balls to gamma irradiation at doses of 1.5, 3 and 4.5 kGy greatly reduced their total bacterial count by 93.3, 99.7 and 99.98% as the counts reached $4.8x10^4$, $2.5x10^3$ and $1.2x10^2$ cfu/g, respectively. However, cold storage (4±1°C) induced gradual increases in the total bacterial count for both irradiated and non-irradiated cooked meat balls, but the rate of increase was much higher in control non-irradiated samples. The total bacterial count increased to $3.6x10^7$, $2.6x10^7$, $1.7x10^7$ and $2.2x10^7$ cfu/g in samples irradiated at doses of 0, 1.5, 3 and 4.5 kGy after 9, 18, 33 and 57 days of cold storage, respectively. At that time

Table (1): Effects of gamma irradiation and cold storage (4±1°C) on the total bacterial count in cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$7.2x10^5$	$4.8x10^4$	$2.5x10^3$	$1.2x10^2$
3	$3.7x10^6$	$7.6x10^4$	$6.9x10^3$	$3.5x10^2$
6	$9.8x10^6$	$1.5x10^5$	$8.7x10^3$	$7.4x10^2$
9	$3.6x10^7$ R3	$6.4x10^5$	$1.6x10^4$	$9.0x10^2$
12		$1.2x10^6$	$6.3x10^4$	$2.6x10^3$
15		$9.4x10^6$	$8.0x10^4$	$5.8x10^3$
18		$2.6x10^7$ R3	$3.6x10^5$	$7.6x10^3$
21			$7.9x10^5$	$1.2x10^4$
24			$1.4x10^6$	$3.7x10^4$
27			$5.8x10^6$	$6.8x10^4$
30			$8.9x10^6$	$1.3x10^5$
33			$1.7x10^7$ R3	$2.8x10^5$
36				$4.9x10^5$
39				$8.3x10^5$
42				$9.0x10^5$
45				$2.5x10^6$
48				$4.6x10^6$
51				$6.2x10^6$
54				$7.3x10^6$
57				$2.2x10^7$ R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

samples were rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

1.1.2. Mashed potatoes:

The results in Table (2) present the total bacterial count for irradiated and non-irradiated mashed potatoes during cold storage (4±1°C). It is obvious from the tabulated results that samples of non-irradiated mashed potatoes had an initial total bacterial count of $4.6x10^6$ cfu/g. Treatment of mashed potatoes by gamma irradiation at doses of 1.5, 3 and 4.5 kGy reduced the total bacterial count by 93.04, 99.39 and 99.96% a the count decreased to $3.2x10^5$, $2.8x10^4$ and $1.8x10^3$ cfu/g, respectively. Upon storage of samples at 4±1°C, the total bacterial count showed another gradual increase for irradiated and non-irradiated mashed potatoes but at lower rates for the irradiated samples. The count reached $7.1x10^6$, $3.5x10^6$, $1.9x10^6$ and $2.5x10^5$ cfu/g after 3, 6, 9 and 12 days of cold storage for control samples and those irradiated at doses of 1.5, 3 and 4.5 kGy, respectively.

1.1.3. Baked chicken breast meat with slices of potatoes:

Table (3) represents the total bacterial count for samples of irradiated and non-irradiated baked chicken breast meat with potatoes during storage at 4±1°C. Samples of control non-irradiated baked chicken breast meat with potatoes had an initial total bacterial count of $2.5x10^5$ cfu/g. Irradiation of baked chicken breast meat with potatoes at doses of 1.5, 3 and 4.5 kGy decreased the total bacterial count of samples by 88.8, 96.7 and 99.51% and the counts reached $2.8x10^4$, $5.9x10^3$ and

Table (2): Effects of gamma irradiation and cold storage (4±1°C) on the total bacterial count in mashed potato.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$4.6x10^6$	$3.2x10^5$	$2.8x10^4$	$1.8x10^3$
3	$7.1x10^6$	$8.9x10^5$	$8.3x10^4$	$7.6x10^3$
6	R2	$3.5x10^6$	$6.7x10^5$	$1.7x10^4$
9		R2	$1.9x10^6$	$8.7x10^4$
12			R2	$2.5x10^5$
15				R2

R2 = Rejected due to the deterioration of the odor.

Table (3): Effects of gamma irradiation and cold storage (4±1°C) on the total bacterial count in baked deboned chicken breast meat with potatoes.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$2.5x10^5$	$2.8x10^4$	$5.9x10^3$	$7.4x10^2$
3	$5.4x10^5$	$1.2x10^5$	$7.4x10^3$	$1.5x10^3$
6	$8.5x10^5$	$3.4x10^5$	$8.0x10^3$	$3.4x10^3$
9	$1.9x10^6$	$5.6x10^5$	$2.5x10^4$	$5.8x10^3$
12	R2	$8.4x10^5$	$4.9x10^4$	$7.2x10^3$
15		$1.6x10^6$	$7.5x10^4$	$9.0x10^3$
18		R2	$1.4x10^5$	$3.4x10^4$
21			R2	$7.8x10^4$
24				$1.8x10^5$
27				$4.5x10^5$
30				$7.9x10^5$
33				$1.3x10^6$
36				R2

R2 = Rejected due to the deterioration of the odor.

7.4×10^{2} cfu/g, respectively. From the same Table, it could be noticed that storage of irradiated and non-irradiated baked chicken breast meat with potatoes at 4±1°C gradually increased the total bacterial counts for samples, however, the rate of increase was higher in control samples. The total bacterial count increased to 1.9×10^{6}, 1.6×10^{6}, 1.4×10^{5} and 1.3×10^{6}

cfu/g after 9, 15, 18 and 33 days of cold storage for non-irradiated samples and those irradiated at doses of 1.5, 3 and 4.5 kGy, respectively.

1.1.4. Baked fish:

Samples of baked fish were examined for their total bacterial count post irradiation treatments and during subsequent storage at 4±1°C and the results are tabulated in Table (4). From these results, it is obvious that the initial total bacterial count for samples of non-irradiated baked fish reached 3.2×10^{6} cfu/g. Similar results were observed by ***Fang et al., (2003) and Hatha, et al., (1998)*** as they found that the initial total bacterial count exceeded 10^{5} cfu/g in samples of cooked shrimp. Exposing samples of the baked fish to gamma irradiation at doses of 1.5, 3 and 4.5 kGy decreased the total bacterial count of samples by 80, 99.44 and 99.7% as the counts reached 6.4×10^{5}, 1.8×10^{4} and 7.5×10^{3} cfu/g, respectively.

During storage of samples at 4±1°C, another gradual increase in the total bacterial count were observed for all samples under investigation, however, the rate of increase was much higher in non-irradiated samples. The total bacterial count increased to 8.7×10^{6}, 9.2×10^{6}, ٧,٦x10^{5} and 1.5×10^{6} cfu/g after storage of non-

Table (4): Effects of gamma irradiation and cold storage (4±1°C) on the total bacterial count in baked fish.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$3.2x10^6$	$6.4x10^5$	$1.8x10^4$	$7.5x10^3$
3	$8.7x10^6$	$9.6x10^5$	$4.3x10^4$	$9.7x10^3$
6	$2.4x10^7$ R3	$2.8x10^6$	$7.1x10^4$	$2.3x10^4$
9		$6.5x10^6$	$9.4x10^4$	$3.7x10^4$
12		$9.2x10^6$	$2.7x10^5$	$5.6x10^4$
15		R2	$5.3x10^5$	$8.3x10^4$
18			$7.6x10^5$	$1.9x10^5$
21			R2	$4.6x10^5$
24				$7.9x10^5$
27				$1.5x10^6$
30				R2

R2 = Rejected due to the deterioration of the odor.

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

irradiated samples and those irradiated at doses of 1.5, 3 and 4.5 kGy for 3, 12, 18 and 27 days, respectively.

1.1.5. Cooked rice:

Table (5) illustrates the effects of gamma irradiation and cold storage at 4±1°C on the total bacterial count in cooked rice. Non-irradiated cooked rice had an initial total bacterial count of $6.5x10^5$ cfu/g. These results are in accordance with those reported by ***Aycicek et al., (2004) and Nichols et al., (1999)*** as they found that the total bacterial

count in samples of cooked rice exceeded 10^6 cfu/g. The results in Table (5) further show that the application of gamma irradiation at doses of 1.5, 3 and 4.5 kGy decreased the total bacterial count in the cooked rice by 97.08, 99.41 and 99.96% as the counts reached $1.9x10^4$, $3.8x10^3$ and $2.7x10^2$ cfu/g, respectively. During storage of irradiated and non-irradiated cooked rice at 4±1°C, the total bacterial count showed another gradual increase in all samples under investigation but at higher rates for control samples. The total bacterial count reached $3.2x10^6$, $1.8x10^5$, $4.6x10^4$ and $5.4x10^4$ cfu/g after 6, 9, 12 and 15 days of cold storage for non-irradiated samples and those received 1.5, 3 and 4.5 kGy, respectively.

In all samples of ready-to-eat meals under investigation the observed high levels for the initial total bacterial count in non-irradiated samples (Tables 1-5) may be due to the presence of sporeformers in the raw materials that could survive the cooking of samples and/or the possible contamination during handling, portioning and packaging of

Table (5): Effects of gamma irradiation and cold storage ($4\pm1^{\circ}C$) on the total bacterial count in cooked rice.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$6.5x10^5$	$1.9x10^4$	$3.8x10^3$	$2.7x10^2$
3	$9.8x10^5$	$4.2x10^4$	$5.6x10^3$	$4.5x10^3$
6	$3.2x10^6$	$8.7x10^4$	$9.2x10^3$	$7.6x10^3$
9	R2	$1.8x10^5$	$2.3x10^4$	$9.7x10^3$
12		R2	$4.6x10^4$	$2.6x10^4$
15			R2	$5.4x10^4$
18				R2

R2 = Rejected due to the deterioration of the odor.

samples after cooking. Many bacterial species such as Micrococci, Streptococci, Lactobacilli, *Bacillus thermosphacta, Bacillus cereus, Bacillus coagulase, Bacillus polymyxa, Bacillus stearothermophilus, Clostridium* spp, *Lactococcus raffinolactis, Carobacterium divergens, Carnobacterium pisciola, Lactococus garvieae, Lactococcus lactis and Enterococcus faecalis* were found to be resistant to cooking ***(Barakat et al., 2000; Ingram and Simonson, 1980; Jackson et al., 2001; Potter, 1986 and Witter, 1983).***

On the other hand, the effectiveness of gamma irradiation in reducing the bacterial populations had been well documented and the observed counts in the irradiated samples may be due to the presence of bacterial cells and/or spores that could survive the applied doses ***(Anderson, 1983)***, while the increase in the total bacterial count during cold storage was also reported by other investigators ***(Lee, et al., 1999 and Lee, et al., 2004).***

1.2. Effects on the total psychrophilic bacteria:

1.2.1. Cooked meat balls:

Table (6) represents the count of total psychrophilic bacteria in cooked meat balls as affected by gamma irradiation and cold storage (4±1°C). The data in this Table reveal that the initial count of total psychrophilic bacteria was 6.9×10^5 cfu/g in samples of non-irradiated cooked meat balls. Treatment of the cooked meat balls by gamma irradiation at doses of 1.5, 3 and 4.5 kGy greatly reduced the count of total psychrophilic bacteria by 86.96, 99.92 and 99.99%, respectively. However, storage of samples at 4±1°C gradually increased the

Table (6):Effects of gamma irradiation and cold storage (4±1°C) on the total psychrophilic bacteria in cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$6.9x10^5$	$9.0x10^4$	$5.8x10^2$	$7x10^1$
3	$9.3x10^5$	$3.7x10^5$	$1.6x10^3$	$1.9x10^2$
6	$2.8x10^6$	$7.2x10^5$	$4.5x10^3$	$4.7x10^2$
9	R3	$2.8x10^6$	$2.6x10^4$	$8.6x10^2$
12		$4.7x10^6$	$6.3x10^4$	$1.3x10^3$
15		$7.5x10^6$	$8.0x10^4$	$2.7x10^3$
18		R3	$4.3x10^5$	$5.8x10^3$
21			$7.8x10^5$	$7.4x10^3$
24			$1.3x10^6$	$1.2x10^4$
27			$4.5x10^6$	$3.6x10^4$
30			$5.9x10^6$	$5.4x10^4$
33			R3	$7.6x10^4$
36				$1.7x10^5$
39				$5.2x10^5$
42				$6.9x10^5$
45				$8.0x10^5$
48				$2.8x10^6$
51				$4.9x10^6$
54				$6.7x10^6$
57				R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

counts of the total psychrophilic bacteria for both irradiated and non-irradiated cooked meat balls with higher rates for the control samples. The count of psychrophilic bacteria increased to $2.8x10^6$, $7.5x10^6$, $5.9x10^6$ and $6.7x10^6$ cfu/g in non-irradiated samples and those received 1.5, 3 and 4.5 kGy dose on day 6, 15, 30 and 54 days of storage, respectively.

1.2.2. Mashed potatoes:

The counts of total psychrophilic bacteria in cold stored samples of irradiated and non-irradiated mashed potatoes are presented in Table (7). From this Table, it is noticeable that the count of total psychrophilic bacteria in non-irradiated mashed potatoes was $5.8x10^5$ cfu/g. Subjecting samples of mashed potatoes to gamma irradiation at doses of 1.5, 3 and 4.5 kGy decreased the initial count of the total psychrophilic bacteria in mashed potatoes by 94.83, 97.93 and 99.87% as the counts of these bacteria decreased to $3x10^4$, $1.2x10^4$ and $7.5x10^2$ cfu/g, respectively.

During cold storage of samples at 4±1°C, the count of total psychrophilic bacteria showed another gradual increase being at lower rates for the irradiated samples. The count of total psychrophilic bacteria reached $2.4x10^6$, $4.7x10^6$, $7.8x10^5$ and $1.3x10^4$ cfu/g for control samples and those irradiated at1.5, 3 and 4.5 kGy doses after 3, 6, 9 and 12 days of cold storage, respectively.

1.2.3. Baked Chicken meat with slices of potatoes:

The results in Table (8) illustrate the count of total psychrophilic bacteria in baked chicken meat with potatoes as

Table (6):Effects of gamma irradiation and cold storage (4±1°C) on the total psychrophilic bacteria in cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$6.9x10^5$	$9.0x10^4$	$5.8x10^2$	$7x10^1$
3	$9.3x10^5$	$3.7x10^5$	$1.6x10^3$	$1.9x10^2$
6	$2.8x10^6$	$7.2x10^5$	$4.5x10^3$	$4.7x10^2$
9	R3	$2.8x10^6$	$2.6x10^4$	$8.6x10^2$
12		$4.7x10^6$	$6.3x10^4$	$1.3x10^3$
15		$7.5x10^6$	$8.0x10^4$	$2.7x10^3$
18		R3	$4.3x10^5$	$5.8x10^3$
21			$7.8x10^5$	$7.4x10^3$
24			$1.3x10^6$	$1.2x10^4$
27			$4.5x10^6$	$3.6x10^4$
30			$5.9x10^6$	$5.4x10^4$
33			R3	$7.6x10^4$
36				$1.7x10^5$
39				$5.2x10^5$
42				$6.9x10^5$
45				$8.0x10^5$
48				$2.8x10^6$
51				$4.9x10^6$
54				$6.7x10^6$
57				R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

counts of the total psychrophilic bacteria for both irradiated and non-irradiated cooked meat balls with higher rates for the control samples. The count of psychrophilic bacteria increased to $2.8x10^6$, $7.5x10^6$, $5.9x10^6$ and $6.7x10^6$ cfu/g in non-irradiated samples and those received 1.5, 3 and 4.5 kGy dose on day 6, 15, 30 and 54 days of storage, respectively.

1.2.2. Mashed potatoes:

The counts of total psychrophilic bacteria in cold stored samples of irradiated and non-irradiated mashed potatoes are presented in Table (7). From this Table, it is noticeable that the count of total psychrophilic bacteria in non-irradiated mashed potatoes was $5.8x10^5$ cfu/g. Subjecting samples of mashed potatoes to gamma irradiation at doses of 1.5, 3 and 4.5 kGy decreased the initial count of the total psychrophilic bacteria in mashed potatoes by 94.83, 97.93 and 99.87% as the counts of these bacteria decreased to $3x10^4$, $1.2x10^4$ and $7.5x10^2$ cfu/g, respectively.

During cold storage of samples at 4±1°C, the count of total psychrophilic bacteria showed another gradual increase being at lower rates for the irradiated samples. The count of total psychrophilic bacteria reached $2.4x10^6$, $4.7x10^6$, $7.8x10^5$ and $1.3x10^4$ cfu/g for control samples and those irradiated at1.5, 3 and 4.5 kGy doses after 3, 6, 9 and 12 days of cold storage, respectively.

1.2.3. Baked Chicken meat with slices of potatoes:

The results in Table (8) illustrate the count of total psychrophilic bacteria in baked chicken meat with potatoes as

Table (7): Effects of gamma irradiation and cold storage (4±1°C) on the total psychrophilic bacteria in mashed potato.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$5.8x10^5$	$3.0x10^4$	$1.2x10^4$	$7.5x10^2$
3	$2.4x10^6$	$8.6x10^5$	$8.3x10^4$	$9.0x10^2$
6	R2	$4.7x10^6$	$1.5x10^5$	$2.4x10^3$
9		R2	$7.8x10^5$	$8.9x10^3$
12			R2	$1.3x10^4$
15				R2

R2 = Rejected due to the deterioration of the odor.

Table (8): Effects of gamma irradiation and cold storage (4±1°C) on the total psychrophilic bacteria in baked deboned chicken breast meat with potatoes.

Storage period (day)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$2.9x10^4$	$5.7x10^3$	$5.6x10^2$	$4.0x10^1$
3	$6.8x10^4$	$8.4x10^3$	$9.2x10^2$	$2.8x10^2$
6	$7.0x10^4$	$1.6x10^4$	$1.8x10^3$	$4.5x10^2$
9	$2.5x10^5$	$5.2x10^4$	$4.4x10^3$	$7.7x10^2$
12	R2	$7.6x10^4$	$8.2x10^3$	$2.6x10^3$
15		$8.0x10^4$	$1.6x10^4$	$5.7x10^3$
18		R2	$5.2x10^4$	$7.4x10^3$
21			R2	$1.5x10^4$
24				$4.6x10^4$
27				$8.2x10^4$
30				$1.8x10^5$
33				$6.3x10^5$
36				R2

R2 = Rejected due to the deterioration of the odor.

affected by gamma irradiation and cold storage. The tabulated results indicate that non-irradiated samples of baked deboned chicken meat with potatoes had an initial count of $2.9x10^4$ cfu/g for the total psychrophilic bacteria. Application of gamma irradiation at doses of 1.5, 3 and 4.5 kGy decreased the count of the total psychrophilic bacteria by 80.34, 98.07 and 99.86% as the counts decreased to $5.7x10^3$, $5.6x10^2$ and $4x10^1$ cfu/g, respectively. The same results also reveal that cold storage of samples at 4±1°C caused gradual increase in the count of the total psychrophilic bacteria for both irradiated and non-irradiated samples, but the rate of increase was higher in the control samples. The count of total psychrophilic bacteria increased to $2.5x10^5$, $8x10^4$, $5.2x10^4$ and $6.3x10^5$ cfu/g after 9, 15, 18 and 33 days of storage for non-irradiated samples and samples irradiated at 1.5, 3 and 4.5 kGy doses, respectively.

1.2.4. Baked fish:

Table (9) shows the counts of total psychrophilic bacteria in irradiated and non-irradiated baked fish samples during storage at 4±1°C. From this Table, it is evident that the initial count of total psychrophilic bacteria in non-irradiated baked fish was $4.7x10^3$ cfu/g. Subjecting baked fish samples to gamma irradiation at doses of 1.5 and 3 kGy decreased the count of the total psychrophilic bacteria by 84.47 and 98.94% as the counts reached $7.3x10^2$ and $5x10^1$ cfu/g, respectively, while irradiation of samples at 4.5 kGy decreased the count of the total psychrophilic bacteria to the below the detection level. Upon cold storage of samples at 4±1°C, the total psychrophilic bacteria showed another gradual increase in non-irradiated samples and

Table (9): Effects of gamma irradiation and cold storage (4±1°C) on the total psychrophilic bacteria in baked fish.

Storage period (day)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$4.7x10^3$	$7.3x10^2$	$5.0x10^1$	<10
3	$7.5x10^3$	$9.5 x10^2$	$3.2x10^2$	<10
6	R3	$2.6x10^3$	$5.7x10^2$	<10
9		$5.3x10^3$	$9.2x10^2$	$7.0x10^1$
12		$7.8x10^3$	$1.6x10^3$	$2.9x10^2$
15		R2	$3.8x10^3$	$5.4x10^2$
18			$6.9x10^3$	$8.7x10^2$
21			R2	$2.4x10^3$
24				$4.5x10^3$
27				$8.6x10^3$
30				R2

R2 = Rejected due to the deterioration of the odor.

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

those irradiated at doses of 1.5 and 3 kGy and the counts reached $7.5x10^3$, $7.8x10^3$ and $6.9x10^3$cfu/g after 3, 12 and 18 days of storage, respectively. Regarding samples irradiated at dose of 4.5 kGy, the count of total psychrophilic bacteria remained below the detection level till 6 days of storage, then colony forming units of the psychrophilic bacteria started to be countable on the day 9 of storage reaching $7x10^1$ cfu/g and gradually increased during storage reaching $8.6x10^3$ cfu/g after 27 days of storage at 4±1°C.

1.2.5. Cooked rice:

The counts of total psychrophilic bacteria were determined in irradiated and non-irradiated cooked rice during storage at 4±1°C and the results are presented in Table (10). It could be seen that non irradiated samples of the cooked rice had an initial count of $1.5x10^4$ cfu/g for total psychrophilic bacteria. Exposing cooked rice samples to 1.5 and 3 kGy doses of gamma irradiation decreased the total psychrophilic bacteria by 86 and 94.47% as the counts reached $2.1x10^3$ and $2.3x10^2$ cfu/g, respectively, while no colony forming units could be detected for samples irradiated at dose of 4.5 kGy

During storage of irradiated and non-irradiated cooked rice at 4±1°C, the counts of total psychrophilic bacteria gradually increased in control samples and those irradiated at 1.5 and 3 kGy dose and reached $8.2x10^4$, $9.7x10^4$ and $2.5x10^3$cfu/g after 6, 9 and 12 days of storage, respectively. Meanwhile, no colony forming units could be detected in samples irradiated at 4.5 kGy till 3 days of storage, then the total psychrophilic

Table (10): Effects of gamma irradiation and cold storage (4±1°C) on the total psychrophilic bacteria in cooked rice.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$1.5x10^4$	$2.1x10^3$	$2.3x10^2$	<10
3	$4.7x10^4$	$3.2x10^3$	$3.9x10^2$	<10
6	$8.2x10^4$	$6.8x10^4$	$7.3x10^2$	$8.0x10^1$
9	R2	$9.7x10^4$	$9.6x10^2$	$3.4x10^2$
12		R2	$2.5x10^3$	$7.9x10^2$
15			R2	$1.6x10^3$
18				R2

R2 = Rejected due to the deterioration of the odor.

bacteria started to be countable on the day 6 of storage reaching $8x10^1$ cfu/g and showed another gradual increase during storage reaching $1.6x10^3$ cfu/g after 15 days of storage at 4±1°C.

The enumeration of psychrophilic bacteria in foods that are to be stored at refrigeration temperature is important because their presence (particularly in large numbers) indicates a high potential for spoilage during cold storage ***(Gilliland et al. 1984).*** The observed initial counts for the total psychrophilic bacteria in all non-irradiated samples of ready-to-eat meals under investigation may be due to the contamination of their raw ingredients with some bacterial strains or spores that could survive the cooking of samples and the refrigeration of samples, in addition to the possible contamination of the cooked samples during their handling and packaging. The effectiveness of gamma irradiation in reducing the counts of the total psychrophilic bacteria was also reported by several researches ***(Anderson, 1983; Badr, 1998,2004; El-Huseiny, et al.,1986 and ICMSF, 1980).***

1.3. Effects on the total yeasts and molds:

1.3.1. Cooked meat balls:

Table (11) represents the counts of yeasts and molds in the cooked meat balls as affected by gamma irradiation and cold storage (4±1°C). The data in this Table reveal that samples of non-irradiated cooked meat balls had an initial count of $2.6x10^4$ cfu/g for total yeasts and molds. Exposing cooked meat balls to gamma irradiation at doses of 1.5, 3 and 4.5 kGy decreased the count of total yeasts and molds by 89.23, 96.54

Table (11): Effects of gamma irradiation and cold storage (4±1°C) on the total yeasts and molds in cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$2.6x10^4$	$2.8x10^3$	$9.0x10^2$	$1.4x10^2$
3	$7.2x10^4$	$4.6x10^3$	$2.5x10^3$	$2.3x10^2$
6	$5.8x10^5$	$7.3x10^3$	$7.8x10^3$	$4.3x10^2$
9	R3	$1.6x10^4$	$8.0x10^3$	$6.5x10^2$
12		$6.7x10^4$	$1.9x10^4$	$7.4x10^2$
15		$2.9x10^5$	$3.8x10^4$	$8.0x10^2$
18		R3	$5.6x10^4$	$1.7x10^3$
21			$7.5x10^4$	$2.8x10^3$
24			$9.0x10^4$	$3.5x10^3$
27			$1.6x10^5$	$5.6x10^3$
30			$2.8x10^5$	$6.2x10^3$
33			R3	$7.1x10^3$
36				$9.0x10^3$
39				$1.8x10^4$
42				$2.9x10^4$
45				$4.2x10^4$
48				$5.9x10^4$
51				$7.8x10^4$
54				$1.2x10^5$
57				R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

and 99.46% as their counts decreased to $2.8x10^3$, $9x10^2$ and $1.4x10^2$ cfu/g, respectively. However, storage of the coked meat balls at 4±1°C gradually increased the counts of total yeasts and molds in both irradiated and non-irradiated samples but the rate of increase was lower in the irradiated samples. The total yeasts and molds increased to $5.8x10^5$, $2.9x10^5$, $2.8x10^5$ and $1.2x10^5$ cfu/g after storage of non-irradiated samples and those irradiated at 1.5, 3 and 4.5 kGy for 6, 15, 30 and 54 days, respectively.

1.3.2. Mashed potatoes:

The counts of total yeasts and molds in irradiated and non-irradiated mashed potatoes were determined during storage of samples at 4±1°C and the results are shown in Table(12). It is evident that the initial count of total yeasts and molds was $3.6x10^4$ cfu/g in samples of non-irradiated mashed potatoes. Irradiation of mashed potatoes at doses of 1.5, 3 and 4.5 kGy reduced this initial count by 84.44, 97.58 and 99.89% and the counts of total yeasts and molds reached $5.6x10^3$, $8.7x10^2$ and $4x10^1$ cfu/g, respectively. Upon storage of irradiated and non-irradiated samples of mashed potatoes at 4±1°C, further gradual increases in the counts of total yeasts and molds were observed for both irradiated and non-irradiated samples. The counts of total yeasts and molds increased to $7.5x10^4$, $2.8x10^4$, $9x10^3$ and $6.9x10^3$ cfu/g after storage of control samples and those irradiated at 1.5, 3 and 4.5 kGy doses for 3, 6, 9, and 12 days, respectively.

Table (12): Effects of gamma irradiation and cold storage (4±1°C) on the total yeasts and molds in mashed potato.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$3.6x10^4$	$5.6x10^3$	$8.7x10^2$	$4.0x10^1$
3	$7.5x10^4$	$8.9x10^3$	$2.3x10^3$	$2.9x10^2$
6	R2	$2.8x10^4$	$5.6x10^3$	$6.2x10^2$
9		R2	$9.0x10^3$	$1.2x10^3$
12			R2	$6.9x10^3$
15				R2

R2 = Rejected due to the deterioration of the odor.

1.3.3. Baked deboned chicken meat with potatoes:

Table (13) represents the counts of total yeasts and molds in samples of baked chicken meat with potatoes post irradiation treatments and during cold storage of samples (4±1°C). From this Table, it is obvious that samples of non-irradiated baked chicken meat with potatoes had an initial count of $1.8x10^4$ cfu/g for total yeasts and molds. Subjecting samples to gamma irradiation at doses of 1.5, 3 and 4.5 kGy decreased their counts of total yeasts and molds by 88.33, 98.22 and 99.67% as the counts decreased to $2.1x10^3$, $3.2x10^2$ and $6x10^1$ cfu/g, respectively. Cold storage at 4±1°C induced gradual increases in the counts of total yeasts and molds for irradiated and non-irradiated samples of baked chicken meat with potatoes. The counts of total yeasts and molds increased to $8.7x10^4$, $3.5x10^4$, $8.9x10^3$ and $4.3x10^4$ cfu/g in control samples and samples received 1.5, 3 and 4.5 kGy doses of gamma irradiation after 9, 15, 18 and 33 days of storage at 4±1°C, respectively.

1.3.4. Baked fish:

The changes in the counts of the total yeasts and molds during storage of irradiated and non-irradiated baked fish samples at 4±1°C are illustrated in Table (14). The results show that samples of non-irradiated baked fish had an initial count of $1.5x10^4$ cfu/g for total yeasts and molds. Treatment of baked fish samples by gamma irradiation at doses of 1.5, 3 and 4.5 kGy reduced their initial count for total yeasts and molds by 84, 95.67 and 99.87% as the counts decreased to $2.4x10^3$, $6.5x10^2$ and $2x10^1$ cfu/g, respectively. The same Table reveals that storage of

Table (13): Effects of gamma irradiation and cold storage (4±1°C) on the total yeasts and molds in baked deboned *chicken* breast meat with potatoes.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$1.8x10^4$	$2.1x10^3$	$3.2x10^2$	$6.0x10^1$
3	$4.2x10^4$	$4.7x10^3$	$5.5x10^2$	$2.5x10^2$
6	$6.6x10^4$	$6.4x10^3$	$8.6x10^2$	$4.8x10^2$
9	$8.7x10^4$	$8.2x10^3$	$1.5x10^3$	$7.2x10^2$
12	R2	$1.4x10^4$	$3.6x10^3$	$1.3x10^3$
15		$3.5x10^4$	$6.2x10^3$	$2.9x10^3$
18		R2	$8.9x10^3$	$4.2x10^3$
21			R2	$6.5x10^3$
24				$8.9x10^3$
27				$1.2x10^4$
30				$2.6x10^4$
33				$4.3x10^4$
36				R2

R2 = Rejected due to the deterioration of the odor.

Table (14): Effects of gamma irradiation and cold storage (4±1°C) on the total yeasts and molds in baked fish.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$1.5x10^4$	$2.4x10^3$	$6.5x10^2$	$2.0x10^1$
3	$4.7x10^4$	$3.9x10^3$	$7.9x10^2$	$1.3x10^2$
6	R3	$6.5x10^3$	$1.4x10^3$	$2.8x10^2$
9		$1.8x10^4$	$5.9x10^3$	$4.9x10^2$
12		$4.2x10^4$	$8.6x10^3$	$8.5x10^2$
15		R2	$2.5x10^4$	$1.2x10^3$
18			R2	$3.8x10^3$
21				$7.2x10^3$
24				$1.4x10^4$
27				$3.6x10^4$
30				R2

R2 = Rejected due to the deterioration of the odor.

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

irradiated and non-irradiated samples at 4±1°C caused gradual increases in their counts for total yeasts and molds being 4.7×10^4, 4.2×10^4, 2.5×10^4 and 3.6×10^4 cfu/g after storage of control samples and those irradiated at 1.5, 3 and 4.5 kGy doses for 3, 12, 15 and 27 days, respectively.

1.3.5. Cooked rice:

Table (15) represents the counts of total yeasts and molds in irradiated and non-irradiated cooked rice during storage at 4±1°C. The tabulated results indicate that the initial count for total yeasts and molds was 2.7×10^4 cfu/g in samples of non-irradiated cooked rice. Subjecting samples of the cooked rice to gamma irradiation at doses of 1.5, 3 and 4.5 kGy greatly reduced their initial count for total yeasts and molds by 95.18, 97.11 and 99.81% and the counts reached 1.3×10^3, 7.8×10^2 and 5×10^1 cfu/g, respectively. Storage of irradiated and non-irradiated cooked rice samples at 4±1°C induced gradual increases in their counts for the total yeasts and molds reaching 8.4×10^4, 1.7×10^4, 9.6×10^3 and 2.8×10^3 cfu/g after 6, 9, 12 and 15 days of storage for control samples and those irradiated at 1.5, 3 and 4.5 kGy, respectively.

In all non-irradiated samples of ready-to-eat meals under investigation, the observed initial counts for total yeasts and molds may be due to the contamination of the raw materials with these organisms and/or the possible contamination of the cooked samples during handling, portioning and packaging. It had been reported that molds and yeasts are widely distributed in the environment and might be found as a part of the normal flora

Table (15): Effects of gamma irradiation and cold storage (4±1°C) on the total yeasts and molds in cooked rice.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$2.7x10^4$	$1.3x10^3$	$7.8x10^2$	$5.0x10^1$
3	$5.6x10^4$	$4.2x10^3$	$1.5x10^3$	$1.8x10^2$
6	$8.4x10^4$	$7.9x10^3$	$5.7x10^3$	$3.2x10^2$
9	R2	$1.7x10^4$	$7.4x10^3$	$6.9x10^2$
12		R2	$9.6x10^3$	$9.7x10^2$
15			R2	$2.8x10^3$
18				R2

R2 = Rejected due to the deterioration of the odor.

of food or as airborne contamination. Moreover, although vegetative molds were destroyed by cooking, at least some spores remained viable ***(Koburger and Marth, 1984 and Pearson and Gillett, 1996).*** The radio-sensitivity of various yeasts and molds was determined by several investigators and the obtained results agree with those reported by ***Badr (1998), Bari et al., (2000), El-Mongy (1990), Ibrahim et al., (2004), Lescano et al., (1991) and Nketsia-Tabiri et al., (2000).***

1.4. Effects on Enterobacteriaceae:

1.4.1. Cooked meat balls:

Table (16) represents the counts of enterobacteriaceae in irradiated and non-irradiated cooked meat balls during storage at 4±1°C. It is clear that the count of enterobacteriaceae in samples of non-irradiated cooked meat balls was $8x10^2$ cfu/g. The observed count was much lower than that reported by ***Gillespie et al., (2000) and Lee et al., (2004)*** as they found that the count of enterobacteriaceae in the cooked meat exceeded 10^4 cfu/g. Irradiation of the cooked meat balls at dose of 1.5 kGy reduced the count of enterobacteriaceae by 88.06% as the count decreased to $1.2x10^1$ cfu/g, while no colony forming units were observed in samples irradiated at 3 and 4.5 kGy for the enterobacteriaceae.

During cold storage at 4±1°C for irradiated and non-irradiated samples, the counts of enterobacteriaceae gradually increased in non-irradiated samples and those irradiated at 1.5 kGy reaching $3.2x10^3$ and $3.4x10^2$ cfu/g after storage for 6 and 15 days, respectively. While, enterobacteriaceae remained

Table (16): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Enterobacteriaceae* in cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$8.0x10^2$	$1.2x10^1$	Nil	Nil
3	$1.2x10^3$	$2.7x10^1$	Nil	Nil
6	$3.2x10^3$	$5.3x10^1$	Nil	Nil
9	R3	$7.6x10^1$	Nil	Nil
12		$8.0x10^1$	Nil	Nil
15		$3.4x10^2$	Nil	Nil
18		R3	Nil	Nil
21			Nil	Nil
24			Nil	Nil
27			Nil	Nil
30			Nil	Nil
33			Nil R3	Nil
36				Nil
39				Nil
42				Nil
45				Nil
48				Nil
51				Nil
54				Nil
57				Nil R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

undetectable allover the storage of samples irradiated at 3 and 4.5 kGy doses.

1.4.2. Mashed potatoes:

The counts of enterobacteriaceae in samples of mashed potatoes were enumerated post irradiation treatments and during storage at 4±1°C and the results are shown in Table (17). Samples of non-irradiated mashed potatoes had an initial count of $1.8x10^3$ cfu/g for enterobacteriaceae. Irradiation of samples at 1.5 kGy dose decreased their counts of enterobacteriaceae by 90.56% as the count reached $1.7x10^2$ cfu/g, while enterobacteriaceae were not detected in samples irradiated at 3 and 4.5 kGy doses. Storage of mashed potatoes at 4±1°C gradually increased the counts of enterobacteriaceae in non-irradiated samples and those received 1.5 dose of irradiation and the counts reached $3.9x10^3$ and $8.3x10^3$ cfu/g after 3 and 6 days, respectively. Meanwhile, samples of mashed potatoes that irradiated at doses of 3 and 4.5 kGy showed that no colonies for enterobacteriaceae during their storage at 4±1°C.

1.4.3. Baked chicken meat with potatoes slices:

Table (18) shows the counts of enterobacteriaceae in baked chicken meat with potatoes as affected by gamma irradiation and cold storage (4±1°C). It could be noticed that the initial count of enterobacteriaceae in non-irradiated samples was $4.2x10^3$ cfu/g. Irradiation of samples at dose of 1.5 kGy reduced their count of enterobacteriaceae by 94.05% being $2.5x10^2$ cfu/g. However, cold storage at 4±1°C gradually increased the counts of enterobacteriaceae in control samples and those irradiated at

Table (17): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Enterobacteriaceae* in mashed potato.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$1.8x10^3$	$1.7x10^2$	Nil	Nil
3	$3.9x10^3$	$4.5x10^2$	Nil	Nil
6	R2	$8.3x10^3$	Nil	Nil
9		R2	Nil	Nil
12			R2	Nil
15				R2

R2 = Rejected due to the deterioration of the odor.

Table (18): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Enterobacteriaceae* in baked deboned chicken breast meat with potatoes.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$4.2x10^3$	$2.5x10^2$	Nil	Nil
3	$7.6x10^3$	$5.8x10^2$	Nil	Nil
6	$9.0x10^3$	$7.1x10^2$	Nil	Nil
9	$2.8x10^4$	$1.5x10^3$	Nil	Nil
12	R2	$3.2x10^3$	Nil	Nil
15		$6.9x10^3$	Nil	Nil
18		R2	Nil	Nil
21			R2	Nil
24				Nil
27				Nil
30				Nil
33				Nil
36				R2

R2 = Rejected due to the deterioration of the odor.

1.5 kGy to $2.8x10^4$ and $6.9x10^3$ cfu/g after 9 and 15 days of storage, respectively. Regarding samples irradiated at doses of 3 and 4.5 kGy, no colony forming units were detected for the enterobacteriaceae neither post irradiation treatments nor during storage of samples.

1.4.4. Baked fish:

The results in Table (19) illustrate the effects of gamma irradiation and cold storage on the counts of enterobacteriaceae in baked fish samples. The count of enterobacteriaceae in samples of non-irradiated baked fish was $6.4x10^3$ cfu/g. Subjecting samples of the baked fish to gamma irradiation at dose of 1.5 kGy decreased this initial count

by 98.91% as the count decreased to $7x10^1$ cfu/g, while samples irradiated at doses of 3 and 4.5 kGy showed no viable counts for enterobacteriaceae. Storage of baked fish samples at 4±1°C caused gradual increases in the counts of enterobacteriaceae for control samples and those irradiated at 1.5 kGy dose and the counts reached $7.5x10^3$ and $5.2x10^2$ cfu/g after 3 and 12 days of storage, respectively. Meanwhile, no viable counts of enterobacteriaceae could be detected during storage of samples irradiated at 3 and 4.5 kGy doses.

1.4.5. Cooked rice:

Table (20) presents the counts of enterobacteriaceae in irradiated and non-irradiated cooked rice during storage of samples at 4±1°C. From this Table, it is

Table (19): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Enterobacteriaceae* in baked fish.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$6.4x10^3$	$7.0x10^1$	Nil	Nil
3	$7.5x10^3$	$1.4x10^2$	Nil	Nil
6	R3	$2.6x10^2$	Nil	Nil
9		$3.4x10^2$	Nil	Nil
12		$5.2x10^2$	Nil	Nil
15		R2	Nil	Nil
18			Nil	Nil
21			R2	Nil
24				Nil
27				Nil
30				R2

R2 = Rejected due to the deterioration of the odor.

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

Table (20): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Enterobacteriaceae* in cooked rice.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$4.3x10^3$	$7.0x10^1$	Nil	Nil
3	$6.9x10^3$	$1.8x10^2$	Nil	Nil
6	$9.2x10^3$	$3.6x10^2$	Nil	Nil
9	R2	$8.9x10^2$	Nil	Nil
12		R2	Nil	Nil
15			R2	Nil
18				R2

R2 = Rejected due to the deterioration of the odor.

noticeable that non-irradiated cooked rice samples had an initial count of $4.3x10^3$ cfu/g for enterobacteriaceae. Gamma irradiation of cooked rice at 1.5 kGy decreased this initial count by 98.37% being $7x10^1$ cfu/g.

During storage of control samples and those irradiated at 1.5 kGy dose, the counts of enterobacteriaceae showed another gradual increases and reached $9.2x10^3$ and $8.9x10^2$ cfu/g after 6 and 9 days of storage, respectively. Samples of cooked rice that received 3 and 4.5 kGy doses showed no viable counts neither post irradiation treatments nor during cold storage of samples.

The presence of enterobacteriaceae in cooked meals is an indication of contamination after processing ***(Hatakka, 1998b)*** and the test for enterobacteriaceae has replaced the testes for coliforms that tradionally have been used as indicators of contamination after processing ***(Gillespie, et al., 2000 and Lee et al., 2004).*** The obtained results agree with those observed by ***Badr (2004)*** who found that irradiation at dose of 3 kGy was enough for the complete elimination of enterobacteriaceae.

1.5. Effects on *Staphylococcus aureus*:

1.5.1. Cooked meat balls:

The counts of *Staphylococcus aureus* in the cooked meat balls were determined during cold storage (4±1°C) of irradiated and non-irradiated samples and the results are shown in Table (21). The presented data reveal the presence of *Staphylococcus aureus* in samples of non-irradiated cooked meat balls at counts reached $6.8x10^2$ cfu/g. The observed count was

Table (21): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Staphylococcus aureus* in cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$6.8x10^2$	$5.0x10^1$	Nil	Nil
3	$8.4x10^2$	$2.8x10^2$	Nil	Nil
6	$9.0x10^2$	$6.7x10^2$	Nil	Nil
9	R3	$1.2x10^3$	Nil	Nil
12		$3.6x10^3$	Nil	Nil
15		$5.9x10^3$	Nil	Nil
18		R3	Nil	Nil
21			Nil	Nil
24			Nil	Nil
27			Nil	Nil
30			Nil	Nil
33			Nil R3	Nil
36				Nil
39				Nil
42				Nil
45				Nil
48				Nil
51				Nil
54				Nil
57				Nil R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

much lower than that observed by many investigators in the cooked meat as they found that the count of this pathogen exceeded $1x10^3$ cfu/g ***(Aycicek et al., 2004; Eleftheriadou et al., 2002 Fang et al., 2003; Gillespie et al., 2000; Hatakka, 1998b and Kanatt, 2004).*** Exposing samples of the cooked meat balls to gamma irradiation at 1.5 kGy decreased the count of *Staphylococcus aureus* by 92.65% as its count decreased to $5x10^1$ cfu/g, while samples received 3 and 4.5 kGy showed no viable counts for this pathogen.

During storage of samples at 4±1°C, the count of *Staphylococcus aureus* showed another gradual increases in non-irradiated samples and those irradiated at 1.5 kGy dose reaching $9x10^2$ and $5.9x10^3$ cfu/g after 6 and 15 days, respectively, while *Staphylococcus aureus* remained undetectable during storage of samples received 3 and 4.5 kGy doses.

1.5.2. Mashed potatoes:

Table (22) represents the counts of *Staphylococcus aureus* in samples of mashed potatoes as affected by gamma irradiation and cold storage (4±1°C). The tabulated results indicate that samples of non- irradiated mashed potatoes had an initial count of $8.6x10^2$ cfu/g for *Staphylococcus aureus*. Treatment of mashed potatoes by gamma irradiation at dose of 1.5 kGy decreased the initial count of this pathogen by 97.91% being $1.8x10^1$ cfu/g, however, *Staphylococcus aureus* was not detected in samples irradiated at 3 and 4.5 kGy doses. The tabulated results further show that cold storage (4±1°C) of non-irradiated samples of mashed potatoes and those irradiated at 1.5

Table (22): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Staphylococcus aureus* in mashed potato.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$8.6x10^{2}$	$1.8x10^{1}$	Nil	Nil
3	$1.7x10^{3}$	$6.7x10^{1}$	Nil	Nil
6	R_2	$9.6x10^{2}$	Nil	Nil
9		R_2	Nil	Nil
12			R_2	Nil
15				R_2

R_2 = Rejected due to the deterioration of the odor.

kGy gradually increased the counts of this organism reaching $1.7x10^3$ and $9.6x10^2$ cfu/g after 3 and 6 days of storage, respectively. Meanwhile, samples irradiated at doses of 3 and 4.5 kGy showed no viable counts for this organism during their cold storage.

1.5.3. Baked deboned chicken meat with potatoes:

The results in Table (23) illustrate the effects of irradiation and cold storage (4±1°C) on the counts of *Staphylococcus aureus* in baked deboned chicken meat with potatoes. It could be seen that the count of this organism reached $1.4x10^2$ cfu/g in samples of non-irradiated baked chicken meat with potatoes. Subjecting samples to gamma irradiation at dose of 1.5 kGy reduced the count of *Staphylococcus aureus* by 89.29% as its count reached $1.5x10^1$ cfu/g.

During storage of samples at 4±1°C, the count of this organism gradually increased in non-irradiated samples as well as those irradiated at dose of 1.5 kGy and reached $8.9x10^2$ and $1.6x10^2$ cfu/g after 9 and 15 days of storage, respectively. Regarding samples irradiated at doses of 3 and 4.5 kGy, *Staphylococcus aureus* was not detected in these samples neither post irradiation nor during storage of samples at 4±1°C.

1.5.4. Baked fish:

Table (24) represents the count of *Staphylococcus aureus* in irradiated and non-irradiated baked fish samples during their storage at 4±1°C. From these results, it is obvious that samples of non-irradiated baked fish had an initial count of $6.3x10^2$ cfu/g for *Staphylococcus aureus.* The observed count

Table (23): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Staphylococcus aureus* in baked deboned chicken breast meat with potatoes.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$1.4x10^2$	$1.5x10^1$	Nil	Nil
3	$3.2x10^2$	$2.6x10^1$	Nil	Nil
6	$6.4x10^2$	$4.3x10^1$	Nil	Nil
9	$8.9x10^2$	$6.5x10^1$	Nil	Nil
12	R2	$9.1x10^1$	Nil	Nil
15		$1.6x10^2$	Nil	Nil
18		R2	Nil	Nil
21			R2	Nil
24				Nil
27				Nil
30				Nil
33				Nil
36				R2

R2 = Rejected due to the deterioration of the odor.

Table (24): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Staphylococcus aureus* in baked fish.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$6.3x10^2$	$9.0x10^1$	Nil	Nil
3	$9.5x10^2$	$2.6x10^2$	Nil	Nil
6	R3	$5.2x10^2$	Nil	Nil
9		$8.3x10^2$	Nil	Nil
12		$1.7x10^3$	Nil	Nil
15		R2	Nil	Nil
18			Nil	Nil
21			R2	Nil
24				Nil
27				Nil
30				R2

R2 = Rejected due to the deterioration of the odor.

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

was lower than that reported by ***Hatakka, (1998b) and Eleftheriadou et al., (2002)*** as they found that cooked fish samples contained $4x10^3$ cfu/g of *Staphylococcus aureus.* Irradiation of baked fish samples at dose of 1.5 kGy reduced their initial count of *Staphylococcus aureus* by 85.71% being $9x10^1$ cfu/g, while samples irradiated at 3 and 4.5 kGy dose showed no viable counts for this organism.

During cold storage of samples (4±1°C), the counts of *Staphylococcus aureus* increased in non-irradiated baked fish samples and those received 1.5 kGy irradiation dose and the counts reached $9.5x10^2$ and $1.7x10^3$ cfu/g after 3 and 12 days of storage, respectively. Samples of baked fish that received 3 and 4.5 kGy doses of gamma irradiation showed no viable counts for *Staphylococcus aureus* allover the storage periods of samples.

1.5.5. Cooked rice:

Staphylococcus aureus was counted in irradiated and non-irradiated cooked rice during storage at 4±1°C and the results are shown in Table (25). Control non-irradiated cooked rice samples had an initial count of $4.7x10^2$ cfu/g for this organism. Exposing samples of the cooked rice to gamma irradiation dose of 1.5 kGy reduced this initial count by 93.62 % as the count decreased to $3x10^1$ cfu/g, while *Staphylococcus aureus* was not detected in samples irradiated at 3 and 4.5 kGy doses. Storage of the cooked rice samples at 4±1°C increased the counts of *Staphylococcus aureus* in control samples and those irradiated at 1.5 kGy dose and the counts reached $7.2x10^2$ and $3.4x10^2$ cfu/g after 6 and 9 days of storage, respectively.

Table (25): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Staphylococcus aureus* in cooked rice.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$4.7x10^2$	$3.0x10^1$	Nil	Nil
3	$5.9x10^2$	$1.4x10^2$	Nil	Nil
6	$7.2x10^2$	$2.3x10^2$	Nil	Nil
9	R2	$3.4x10^2$	Nil	Nil
12		R2	Nil	Nil
15			R2	Nil
18				R2

R2 = Rejected due to the deterioration of the odor.

However, this organism remained undetectable during storage periods of cooked rice samples irradiated at 3 and 4.5 kGy doses.

Staphylococcus aureus is one of the most important foodborne pathogen found in ready-to-eat-products and *Staphylococcus aureus* intoxication can result in debilitating illness. The presence of this organism in all ready-to-eat meals under investigation may be due to contamination of samples during handling, portioning and packaging. It had been mentioned that *Staphylococcus aureus* is destroyed by food processing and the presence of this organism is usually indicates contamination from handlers ***(Tatini et al., 1984).*** Moreover, the organism may be present in the nasal passages, throat, hair and skin of the healthy people ***(Bergdoll, 1990 and Jablonski and Boach, 1997).*** Many investigators showed that gamma irradiation is an effective mean for the elimination of *Staphylococcus aureus* from different foodstuffs ***(Badr, 1998; Badr, 2004; Hammad and El-Mongy, 1992; Hammad et al., 2000; Ibrahim et al., 2004 and Lacroix et al., 2004).***

1.6. Effects on *Streptococcus faecalis*:

1.6.1. Cooked meat balls:

The results in Table (26) show the effects of irradiation and cold storage (4±1°C) on the counts of *Streptococcus faecalis* in cooked meat balls. The tabulated results indicate that samples of non-irradiated cooked meat balls had an initial count of $6.7x10^2$ cfu/g for *Streptococcus faecalis.* Irradiation of cooked meat balls at dose of 1.5 kGy decreased the

Table (26): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Streptococcus faecalis* in cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$6.7x10^2$	$8.0x10^1$	Nil	Nil
3	$2.8x10^3$	$3.6x10^2$	Nil	Nil
6	$5.2x10^3$	$6.5x10^2$	Nil	Nil
9	R3	$1.6x10^3$	Nil	Nil
12		$3.8x10^3$	Nil	Nil
15		$5.9x10^3$	Nil	Nil
18		R3	$3.0x10^1$	Nil
21			$1.8x10^2$	Nil
24			$3.4x10^2$	Nil
27			$5.2x10^2$	Nil
30			$6.8x10^2$	Nil
33			R3	Nil
36				Nil
39				Nil
42				Nil
45				Nil
48				Nil
51				Nil
54				Nil
57				R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

count of this organism by 88.06 % being $8x10^1$ cfu/g, while it was not detected in samples irradiated at 3 and 4.5 kGy doses.

During cold storage of samples (4±1°C), the count of *Streptococcus faecalis* increased gradually in non-irradiated samples and those irradiated at 1.5 kGy dose reaching $5.2x10^3$ and $5.9x10^3$ cfu/g after 6 and 15 days of storage, respectively. In samples irradiated at 3 kGy dose, *Streptococcus faecalis* remained undetectable for 15 days of cold storage, then started to be countable on the days 18 and its count gradually increased reaching $6.8x10^2$ cfu/g after 30 days of storage at 4±1°C. Meanwhile, the organism remained undetectable allover the storage of samples irradiated at dose of 4.5 kGy.

<u>1.6.2. Mashed potatoes:</u>

Table (27) represents the counts of *Streptococcus faecalis* in samples of mashed potatoes as affected by gamma irradiation and storage at 4±1°C. From this Table, it is noticeable that the initial count of this organism reached $3.7x10^4$ cfu/g in samples of non-irradiated mashed potatoes. Treatment of mashed potatoes by gamma irradiation at doses of 1.5 and 3 kGy reduced the initial count of *Streptococcus faecalis* by 97.57 % and 99.86 % and its counts decreased to $9x10^2$ and $5x10^1$ cfu/g, respectively.

During cold storage (4±1°C) the count of this organism gradually increased and reached $8.6x10^4$, $5.3x10^3$ and $4.8x10^2$ cfu/g after 3, 6 and 9 days of storage for control samples and those irradiated at 1.5 and 3 kGy doses, respectively. Regarding samples irradiated at dose of 4.5 kGy, *Streptococcus faecalis*

Table (27): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Streptococcus faecalis* in mashed potato.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$3.7x10^4$	$9.0x10^2$	$5.0x10^1$	Nil
3	$8.6x10^4$	$2.4x10^3$	$1.8x10^2$	Nil
6	R2	$5.3x10^3$	$2.9x10^2$	Nil
9		R2	$4.8x10^2$	Nil
12			R2	$7x10^1$
15				R2

R2 = Rejected due to the deterioration of the odor.

was not detected post irradiation treatment and during storage for 6 days at 4±1°C, then started to be countable reaching $7x10^1$ cfu/g after 12 days of cold storage.

1.6.3. Baked deboned chicken meat with potatoes:

The count of *Streptococcus faecalis* was determined in samples of baked chicken meat with potatoes post irradiation treatments and during storage at 4±1°C and the results are tabulated in Table (28). It is evident that non-irradiated samples had an initial count of $9x10^2$ cfu/g for *Streptococcus faecalis.* These results agree with the findings of ***Barakat et al., (2000)*** as they isolated *Enterococcus faecalis* from refrigerated modified atmosphere packaged cooked poultry meat. Irradiation of baked chicken meat with potatoes at dose of 1.5 kGy decreased its count by 95.56 % being $4x10^1$ cfu/g.

During cold storage of samples (4±1°C), the counts of *Streptococcus faecalis* showed another gradual increases in non-irradiated samples and those irradiated at dose of 1.5 kGy and the counts reached $3.8x10^3$ and $4.8x10^2$ cfu/g after 9 and 15 days of storage, respectively. Regarding samples irradiated at doses of 3 and 4.5 kGy, *Streptococcus faecalis* was not detected neither post irradiation treatment nor during storage periods of samples.

1.6.4. Baked fish:

Table (29) illustrates the count of *Streptococcus faecalis* in samples of baked fish post irradiation treatments and during storage of samples at 4±1°C. The tabulated results indicate that the initial count of this organism reached $8x10^2$ cfu/g in control non-irradiated samples. Subjecting baked fish

Table (28): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Streptococcus faecalis* in baked deboned chicken breast meat with potatoes.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$9.0x10^2$	$4.0x10^1$	Nil	Nil
3	$1.5x10^3$	$1.2x10^2$	Nil	Nil
6	$2.4x10^3$	$1.9x10^2$	Nil	Nil
9	$3.8x10^3$	$2.7x10^2$	Nil	Nil
12	R2	$3.6x10^2$	Nil	Nil
15		$4.8x10^2$	Nil	Nil
18		R2	Nil	Nil
21			R2	Nil
24				Nil
27				Nil
30				Nil
33				Nil
36				R2

R2 = Rejected due to the deterioration of the odor.

Table (29): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Streptococcus faecalis* in baked fish.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$8.0x10^2$	$5.0x10^1$	Nil	Nil
3	$3.7x10^3$	$2.9x10^2$	Nil	Nil
6	R3	$4.5x10^2$	Nil	Nil
9		$6.8x10^2$	Nil	Nil
12		$8.5x10^2$	Nil	Nil
15		R2	Nil	Nil
18			Nil	Nil
21			R2	Nil
24				Nil
27				Nil
30				R2

R2 = Rejected due to the deterioration of the odor.

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

samples to gamma irradiation at 1.5 kGy dose decreased its count by 93.75 % reaching $5x10^1$ cfu/g, while no viable counts for this organism were detected in samples irradiated at doses of 3 and 4.5 kGy.

During cold storage of samples at (4±1°C), the count of *Streptococcus faecalis* gradually increased in non-irradiated samples and those irradiated at 1.5 kGy dose reaching $3.7x10^3$ and $8.5x10^2$ cfu/g after 3 and 12 days, respectively. Meanwhile, *Streptococcus faecalis* remained undetectable during cold storage of samples received 3 and 4.5 kGy doses of gamma irradiation.

1.6.5. Cooked rice:

The results in Table (30) show the changes in the counts of *Streptococcus faecalis* in samples of cooked rice as affected by gamma irradiation and cold storage (4±1°C). It could be seen that the initial count of *Streptococcus faecalis* reached $3.5x10^4$ cfu/g in control non-irradiated samples. Exposing samples of the cooked rice to gamma irradiation at dose of 1.5 kGy reduced the count of this organism by 95.14 % reaching 1.7x 10^3 cfu/g, while the organism was not detected in samples irradiated at doses of 3 and 4.5 kGy. Storage of cooked rice samples at 4±1°C induced gradual increases in the counts of *Streptococcus faecalis* and its counts reached $7.6x10^4$ and $6.2x10^3$ cfu/g after 6 and 9 days of storage for non-irradiated samples and those irradiated at dose of 1.5 kGy, respectively. Meanwhile, *Streptococcus faecalis* was not detected during

Table (30): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Streptococcus faecalis* in cooked rice.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$3.5x10^4$	$1.7x10^3$	Nil	Nil
3	$5.4x10^4$	$2.6x10^3$	Nil	Nil
6	$7.6x10^4$	$4.9x10^3$	Nil	Nil
9	R2	$6.2x10^3$	Nil	Nil
12		R2	Nil	Nil
15			R2	Nil
18				R2

R2 = Rejected due to the deterioration of the odor.

storage of samples received 3 and 4.5 kGy doses of gamma irradiation.

Streptococcus faecalis is another mean agent of foodborne disease, but less acute. The presence of this organism in samples of non-irradiated ready-to-eat meals under investigation may be due to contamination of the cooked samples during handling, portioning and packaging. The isolation of this organism from cooked meats was also reported by ***Badr, (1998) and Jorgensen and Schulz, (1985)*** while the radio-resistance of *Streptococcus faecalis* was also found by many investigators ***(Badr, 1998, 2004; El-Fouly et al., 1984 and Huhtanen, 1990)***

1.7. Effects on *Bacillus cereus*:

1.7.1. Cooked meat balls:

The results in Table (31) illustrate the counts of *Bacillus cereus* in samples of cooked meat balls post irradiation treatments and during cold storage at 4±1°C. The tabulated results show that non-irradiated samples of the cooked meat balls had an initial count of 6.9×10^2 cfu/g for *Bacillus cereus*. The presence of *Bacillus cereus* at counts exceeded 10^4 cfu/g in the cooked meats was also reported by ***Aycicek et al., (2004); Eleftheriadiou et al., (2002) and Hatakka, (1998b).*** Treatment of cooked meat balls by gamma irradiation at dose of 1.5 kGy decreased the initial count of this organism by 89.86 % being 7×10^1 cfu/g, while it was not detected in samples irradiated at doses of 3 and 4.5 kGy.

During cold storage at 4±1°C, the counts of *Bacillus cereus*

Table (31): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Bacillus cereus* in cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	6.9×10^2	7.0×10^1	Nil	Nil
3	9.0×10^2	3.6×10^2	Nil	Nil
6	3.4×10^3	7.4×10^2	Nil	Nil
9	R3	1.8×10^3	Nil	Nil
12		4.2×10^3	Nil	Nil
15		6.7×10^3	Nil	Nil
18		R3	Nil	Nil
21			Nil	Nil
24			Nil	Nil
27			Nil	Nil
30			Nil	Nil
33			R3	Nil
36				Nil
39				Nil
42				Nil
45				Nil
48				Nil
51				Nil
54				Nil
57				R3

R3 = Rejected due to increasing the total bacterial count to more than 1×10^7 cfu/g.

showed another gradual increase in control non-irradiated samples and these irradiated at dose of 1.5 kGy reaching 3.4×10^3 and 6.7×10^3 cfu /g after 6 and 15 days of storage , respectively . On the other hand, *Bacillus cereus* remained undetectable during storage periods of samples irradiated at doses of 3 and 4.5 kGy.

1.7.2. Mashed potatoes:

Table (32) represents the counts of *Bacillus cereus* in samples of mashed potatoes as affected by gamma irradiation and cold storage at 4±1°C. From these results, it is obvious that non-irradiated control samples had an initial count of 6.7×10^3 cfu/g for *Bacillus cereus.* The observed initial count was much lower than that reported by other investigators ***(Choma et al., 2000; Harmon and Kautter, 1991 and Hatakka, 1998b)*** as they found that the count of *Bacillus cereus* exceeded 10^5 cfu/g in mashed potatoes. Subjecting samples of mashed potatoes to gamma irradiation at dose of 1.5 kGy reduced the counts of *Bacillus cereus* by 97.91 % as the count decreased to 2.3×10^2 cfu/g. However, the organism was not detected in samples irradiated at doses of 3 and 4.5 kGy. Upon storage of control non-irradiated samples and those irradiated at 1.5 kGy, the counts of *Bacillus cereus* gradually increased reaching 1.4×10^4 and 1.5×10^3 cfu/g after 3 and 6 days of storage at 4±1°C, respectively. Regarding samples irradiated at 3 and 4.5 kGy doses, the organism was not detected in these samples allover their storage periods.

Table (32): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Bacillus cereus* in mashed potato.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$6.7x10^3$	$2.3x10^2$	Nil	Nil
3	$1.4x10^4$	$7.4x10^2$	Nil	Nil
6	R2	$1.5x10^3$	Nil	Nil
9		R2	Nil	Nil
12			R2	Nil
15				R2

R2 = Rejected due to the deterioration of the odor.

1.7.3. Baked deboned chicken meat with potatoes:

The effects of gamma irradiation and cold storage (4±1°C) on the counts of *Bacillus cereus* in samples of baked chicken meat with potatoes are shown in Table (33). The tabulated results indicate that the initial count of *Bacillus cereus* in control non-irradiated samples was $6x10^2$ cfu/g. Treatment of samples by gamma irradiation at dose of 1.5 kGy decreased the count of *Bacillus cereus* by 89.29 % and the count reached $8x10^1$ cfu/g. However, cold storage of non-irradiated samples and those irradiated at 1.5 kGy increased their counts for *Bacillus cereus* reaching $4.5x10^3$ and $5.3x10^2$ cfu/g after 9 and 15 days of storage, respectively. Meanwhile, samples of baked chicken meat with potatoes that irradiated at doses of 3 and 4.5 kGy showed no viable counts for *Bacillus cereus* neither post irradiation treatments nor during cold storage of samples.

1.7.4. Baked fish:

Table (34) represents the counts of *Bacillus cereus* in baked fish samples post irradiation and during storage at 4±1°C. The tabulated results show that non-irradiated baked fish samples had an initial count of $7.5x10^2$ cfu/g for *Bacillus cereus.* ***Eleftheriadiou et al., (2002)and Hatakka, (1998b)*** also reported the presence of *Bacillus cereus* in the cooked fish but at counts exceeded 10^4 cfu/g. The application of gamma irradiation at dose of 1.5 kGy reduced the count of *Bacillus cereus* by 92 % being $6x10^1$ cfu/g, while irradiation at 3 and 4.5 kGy reduced its count to below the detection level. Subsequent storage of sample at 4±1°C increased the count of *Bacillus cereus* in non-irradiated

Table (33): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Bacillus cereus* in baked deboned chicken breast meat with potatoes.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$6.0x10^2$	$8.0x10^1$	Nil	Nil
3	$1.8x10^3$	$1.4x10^2$	Nil	Nil
6	$2.9x10^3$	$2.3x10^2$	Nil	Nil
9	$4.5x10^3$	$3.4x10^2$	Nil	Nil
12	R_2	$4.2x10^2$	Nil	Nil
15		$5.3x10^2$	Nil	Nil
18		R_2	Nil	Nil
21			R_2	Nil
24				Nil
27				Nil
30				Nil
33				Nil
36				R_2

R_2 = Rejected due to the deterioration of the odor.

Table (34): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Bacillus cereus* in baked fish.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$7.5x10^2$	$6.0x10^1$	Nil	Nil
3	$8.7x10^2$	$2.1x10^2$	Nil	Nil
6	R3	$3.9x10^2$	Nil	Nil
9		$5.7x10^2$	Nil	Nil
12		$7.8x10^2$	Nil	Nil
15		R2	Nil	Nil
18			Nil	Nil
21			R2	Nil
24				Nil
27				Nil
30				R2

R2 = Rejected due to the deterioration of the odor.

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

samples and those irradiated at 1.5 kGy and the counts reached $8.7x10^2$ and $7.8x10^2$ cfu/g after 3 and 12 days, respectively. Meanwhile, *Bacillus cereus* remained undetectable in samples irradiated at 3 and 4.5 kGy allover their storage periods.

1.7.5. Cooked rice:

The results in Table (35) illustrated the effects of irradiation and cold storage (4±1°C) on the counts of *Bacillus cereus* in cooked rice samples. It is clear that the initial count for *Bacillus cereus* in control non-irradiated samples was $1.4x10^3$ cfu/g. Several investigators indicated the presence of *Bacillus cereus* in the cooked rice but at counts exceeded 10^4 cfu/g ***(Harmon and Kautter, 1991; Hatakka, 1998b and Nichols et al., 1999).*** The ability of spores to resist desiccation allows their survival on dried products such as cereals, these spores can survive cooking to germinate, grow and produce the emetic toxin in the cooked rice during storage ***(Adam and Moss, 1995).*** The same Table further shows that irradiation of cooked rice samples at dose 1.5 kGy decreased the count of *Bacillus cereus* by 97.86 % being $3x10^1$ cfu/g, while no viable count for *Bacillus cereus* was detected in samples irradiated at 3 and 4.5 kGy doses.

During cold storage of samples, the count of *Bacillus cereus* increased in control non-irradiated samples as well as those irradiated at 1.5 kGy dose and the counts reached $5.9x10^3$ and $4.3x10^2$ cfu/g after 6 and 9 days of storage, respectively. Meanwhile, *Bacillus cereus* was not detected in samples irradiated at 3 and 4.5 kGy during their cold storage at 4±1°C.

Table (35): Effects of gamma irradiation and cold storage (4±1°C) on the counts of *Bacillus cereus* in cooked rice.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	$1.4x10^3$	$3x10^1$	Nil	Nil
3	$3.6x10^3$	$1.2x10^2$	Nil	Nil
6	$5.9x10^3$	$2.8x10^2$	Nil	Nil
9	R2	$4.3x10^2$	Nil	Nil
12		R2	Nil	Nil
15			R2	Nil
18				R2

R2 = Rejected due to the deterioration of the odor.

The presence of *Bacillus cereus* in samples of non-irradiated ready-to-eat meals under investigation may be mainly due to the presence of its spores in the raw ingredients of these meals, in which these spores could survive the temperature of cooking and remained in the cooked products. It had been mentioned that a wide range of foods have been implicated with the diarrheal syndrome including meat products and vegetables. Moreover, dried herbs and spices used in food preparation can be an important source of *Bacillus cereus* and this has often been cited as a reason for a relatively high incidence of *Bacillus cereus* food poisoning ***(Adam and Moss, 1995).*** In addition, studies have shown that *Bacillus cereus* spores inoculated into uncooked rice were not inactivated completely during the cooking process at 100°C for 30 min. Furthermore, strains of *Bacillus cereus* isolated from foods incriminated in food poisoning outbreaks were able to grow and produce toxin at 4-7°C ***(Bennett, 2001).***

1.8. Presence of *Salmonella*:

The detection of *Salmonella* was carried out for all irradiated and non-irradiated ready-to-eat meals post treatments and the results are shown in Table (36).

From this Table, it is evident that *Salmonella* was not detected in irradiated and non-irradiated ready-to-eat meals on day zero of cold storage, therefore, samples were not further examined during their storage. These results agree with those observed by several investigators ***(Gillespie et al., 2000; Hatakka, 1998b; Hatha, et al., 1998 and Patterson, 1989).*** It is well known that

Table (36): Presence of *Salmonella* in irradiated and non irradiated prepared ready-to-eat meals.

Meals	Mean of scores / Irradiation dose (kGy)			
	0	1.5	3	4.5
Cooked meat balls	Nil	Nil	Nil	Nil
Mashed potatoes	Nil	Nil	Nil	Nil
Baked chicken breast	Nil	Nil	Nil	Nil
Baked fish	Nil	Nil	Nil	Nil
Cooked rice	Nil	Nil	Nil	Nil

Table (37): Presence of *Vibrio* spp in irradiated and non irradiated baked fish.

Meal	Irradiation dose (kGy)			
	0	1.5	3	4.5
Baked fish	Nil	Nil	Nil	Nil

cross-contamination (from raw to cooked foods) is one of the most important causes of the presence of *Salmonella* in the cooked foods. The absence of *Salmonella* in all non-irradiated ready-to-eat meals under investigation, and consequently in the irradiated samples, may be due to the care that taken to avoid cross-contamination during their preparation.

1.9. Presence of *Vibrio* spp in baked fish:

Samples of irradiated and non-irradiated baked fish were examined for to presence of *Vibrio* spp and the results are tabulated in Table (37). The tabulated results clearly indicate that non-irradiated and irradiated samples showed no viable counts for *Vibrio* spp neither post irradiation treatments (on day zero of storage), therefore, samples did not examined during storage. As with *Salmonella,* the absence of *Vibrio* spp in all samples of baked fish may be due to their absence in the raw fish samples or due to the care taken to avoid cross-contamination during preparation of samples. Moreover, *Vibrio* spp were found to be sensitive to heat as heating to an internal temperature of at least 60°C for several minutes was sufficient for the elimination of the pathogenic *Vibrio* spp ***(Oliver and Kaper, 2001).***

In terms of the microbiology of foods, quality compress **safety:** as the food must not contain levels of a pathogen likely to cause illness when the food is consumed; and **acceptability / shelf-life :** as the food must not contain levels of microorganisms sufficient to render it organoleptically spoiled in an unacceptability short time ***(Adam and Moss, 1995).***

Concerning safety of the prepared meal, the non-irradiated samples contained relatively low counts for bacteria of public health significance. Such levels for most of these bacteria are harmless, but offer sufficient inoculum for growth to hazardous levels when subsequent conditions of time-temperature abuse occur ***(Johnston and Tompkin, 1984).*** Meanwhile, the enterobacteriaceae may contain *E. coli* O157 :H7 which can introduce the risk of illness even in case of their presence at very low count (≥ 10 cells).

Generally, there no standards or specifications for such ready-to-eat meals and the published guidelines for the microbiological quality of ready-to-eat foods widely differed. For instance, the counts observed for some pathogenic bacteria in the non-irradiated samples of the prepared meals under investigation do not agree with the requirements of the European Airlines ***(AEA, 1996).***

From the results of the microbiological analyses, it is clear that an irradiation dose of 3 kGy can be the optimum for keeping the quality of ready-to-eat meals through its effectiveness in the elimination of all bacteria of public health significance that were present in the control samples, thus the resultant irradiated meals can agree with any safety requirements.

In addition, most of the published guidelines reported the count of 1×10^7 cfu/g as the maximum acceptable level for the total bacterial count in ready-to-eat foods ***(Roberts et al., 1995).*** Irradiation at 3 kGy dose decreased the initial total bacterial count and could retard their increase during storage as well as the other microbial counts, leading to the observed extension of the refrigerated shelf-life of meals under investigation.

2. Effects of gamma irradiation and cold storage (4±1°C) on the chemical properties of the prepared meals:

2.1. Effects of irradiation on the chemical composition of the meal/or its main component:

The proximate chemical composition was determined for irradiated and non-irradiated samples of the prepared meal (cooked meat balls, mashed potatoes, and cooked rice) or for the main component of the meal (chicken meat in baked chicken meat with potatoes, and baked fish in baked fish meal) and the results are shown in Tables (38-42) which present the moisture contents as well as the percentages of total lipids, crude protein, ash content and total carbohydrates (referred to dry matter) for the analyzed samples. It is apparent from these Tables that the contents of moisture, total lipids, crude protein, ash content and total carbohydrates were 50.25, 20.75, 65.62, 7.4 and 6.23 % ; 73.86, 30.58, 9.42, 6.32 and 53.68 % ; 68.93, 11.84, 80.53, 5.24 and 2.39 % ; 70.34, 9.87, 85.6, 4.41 and 0.12 % ; and 60.43, 9.97, 4.57, 2.19 and 22.27 % for samples of cooked meat balls (Table 42), mashed potatoes (Table 43), baked chicken breast meat (Table 44), baked fish (Table 45) and cooked rice (Table 46), respectively. The results in Tables (42-46) further show that the application of gamma irradiation at the different doses used in this study had no remarkable effects on the chemical composition for all ready – to - eat meals under investigation.

Table (38): Chemical composition of irradiated and non-irradiated cooked meat balls.

Components (%)	Irradiation dose (kGy)			
	0	1.5	3	4.5
Moisture	50.25	50.08	50.23	50.07
Total lipids *	20.75	20.64	20.19	20.51
Crude protein*	65.62	65.93	66.32	65.45
Ash content*	7.40	7.32	7.36	7.75
Total carbohydrates*	6.23	6.11	6.13	6.29

*= On dry weight basis

Table (39): Chemical composition of irradiated and non-irradiated mashed potato.

Components (%)	Irradiation dose (kGy)			
	0	1.5	3	4.5
Moisture	73.86	73.42	74.08	74.31
Total lipids *	30.58	30.78	30.92	30.79
Crude protein*	9.42	9.68	9.12	8.96
Ash content*	6.32	6.34	6.32	6.29
Total carbohydrates*	53.68	53.20	53.64	53.96

***= On dry weight basis**

Table (40) Chemical composition of irradiated and non-irradiated baked deboned chicken breast meat.

Components (%)	Irradiation dose (kGy)			
	0	1.5	3	4.5
Moisture	68.93	69.17	68.97	69.15
Total lipids *	11.84	11.72	11.68	11.75
Crude protein*	80.53	80.68	80.72	80.65
Ash content*	5.24	5.27	5.22	5.26
Total carbohydrates*	2.39	2.33	2.38	2.34

*= On dry weight basis

Table (41): Chemical composition of irradiated and non-irradiated baked fish.

Components (%)	Irradiation dose (kGy)			
	0	1.5	3	4.5
Moisture	70.34	70.26	70.77	70.56
Total lipids *	9.87	9.93	9.57	9.96
Crude protein*	85.60	85.59	85.87	85.57
Ash content*	4.41	4.37	4.43	4.35
Total carbohydrates*	0.12	0.11	0.13	0.12

*= On dry weight basis

Table (42): Chemical composition of irradiated and non-irradiated cooked rice.

Components (%)	Irradiation dose (kGy)			
	0	1.5	3	4.5
Moisture	60.43	60.24	60.37	60.35
Total lipids*	9.97	10.09	9.99	10.12
Crude protein*	4.57	4.66	4.63	4.64
Ash content*	2.19	2.23	2.24	2.21
Total carbohydrates*	22.27	83.02	83.14	83.03

*=On dry weight basis

These results are in well agreement with the findings of ***Anderson, (1983); Badr, (2004); Emam, (1990); Hammad and El-Mongy, (1992); Hammad et al., (1995) and Yang and Chon, (1985).***

2.2. Effects of gamma irradiation and cold storage (4±1°C) on the pH-value of meals or their main component:

2.2.1. Cooked meat balls:

Table (43) represents the changes in the pH-value during cold storage (4±1°C) of irradiated and non-irradiated cooked meat balls. As shown, samples of non-irradiated cooked meat balls had an initial pH-value of 6.29. Treatment of the cooked meat balls at the different doses of gamma irradiation caused no real changes in the initial pH-value of samples as the pH-value was 6.30, 6.32 and 6.35 for samples irradiated doses of 1.5, 3 and 4.5 kGy, respectively.

During storage of samples at 4±1°C, the pH-value showed a slight gradual decreases for control non-irradiated samples and those irradiated at dose of 1.5 kGy reaching 6.07 and 5.9 after 6 and 15 days, respectively. While the pH-value of samples irradiated at doses of 3 and 4.5 kGy showed a slight increases near the end of their storage periods reaching 6.42 and 6.53 after 30 and 54 days of storage, respectively.

2.2.2. Mashed potatoes:

The results in Table (44) illustrate the changes in the pH-value of mashed potatoes post irradiation treatments and

Table (43): pH-value of cooked meat balls as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	6.29	6.30	6.32	6.35
3	6.14	6.23	6.35	6.38
6	6.07	6.17	6.36	6.39
9	R3	6.11	6.35	6.33
12		6.02	6.38	6.35
15		5.90	6.37	6.39
18		R3	6.38	6.36
21			6.38	6.37
24			6.35	6.34
27			6.38	6.37
30			6.42	6.37
33			R3	6.39
36				6.40
39				6.43
42				6.44
45				6.48
48				6.48
51				6.50
54				6.53
57				R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

Table (45): pH-value of baked deboned chicken meat as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	6.19	6.05	6.02	5.95
3	6.07	6.05	6.02	5.95
6	5.97	6.00	6.02	5.90
9	5.94	5.94	5.96	5.87
12	R_2	5.81	5.87	5.80
15		5.73	5.79	5.78
18		R_2	5.64	5.72
21			R_2	5.66
24				5.59
27				5.54
30				5.48
33				5.40
36				R_2

R_2 = Rejected due to the deterioration of the odor.

2.2.4. Baked fish:

Table (46) represents the changes in pH-value during cold storage (4±1°C) of irradiated and non-irradiated baked fish samples. From this Table, it could be seen that the initial pH-value for non-irradiated baked fish samples was 5.75. Treatment of baked fish samples by gamma irradiation at doses of 1.5, 3 and 4.5 kGy caused no changes in their pH-value being 5.75 for all irradiated samples undertaken. Storage of baked fish samples at 4±1°C gradually decreased the pH-value for non-irradiated samples and those irradiated at 1.5, 3 and 4.5 kGy doses reaching 5.59, 5.18, 5.02 and 5.03 after storage for 3, 12, 18 and 27 days, respectively.

2.2.5. Cooked rice:

The results in Table (47) show the pH-value of cooked rice samples as affected by gamma irradiation and cold storage at 4±1°C. As shown, samples of non-irradiated cooked rice had an initial pH-value of 5.53. Irradiation of cooked rice samples at the applied ascending doses showed no effects on their pH-value as it was 5.53 for all irradiated samples.

During storage at 4±1°C, slight gradual decreases in the pH-value were observed for non-irradiated cooked rice samples as well as those irradiated at 1.5, 3 and 4.5 kGy doses and the pH-value reached 5.37, 5.35, 5.24 and 5.17 after 6, 9, 12 and 15 days, respectively.

Table (46): pH - value of baked fish as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	5.75	5.75	5.75	5.75
3	5.59	5.63	5.68	5.70
6	R_3	5.54	5.52	5.69
9		5.39	5.45	5.57
12		5.18	5.32	5.42
15		R_2	5.24	5.34
18			5.02	5.22
21			R_2	5.13
24				5.07
27				5.03
30				R_2

R_2 = Rejected due to the deterioration of the odor.

R_3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

Table (47): pH-value of cooked rice as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	5.53	5.53	5.53	5.53
3	5.42	5.47	5.50	5.52
6	5.37	5.38	5.42	5.45
9	R_2	5.35	5.33	5.38
12		R_2	5.24	5.28
15			R_2	5.17
18				R_2

R_2 = Rejected due to the deterioration of the odor.

For all samples of ready-to-eat meals undertaken, the observed results concerning the effects of irradiation on the pH-value of samples agree with those obtained by many investigators ***(Badr, 1998;Lakritz and Maerker, 1988; Lefebvre et al., 1994 and Thayer et al., 1995)*** as they found that gamma irradiation could not affect the pH-value of the irradiated foodstuffs. Furthermore, the observed slight increases in the pH-value during storage of cooked meat balls that irradiated at doses of 3 and 4.5 kGy may be due to the formation of basic compounds such as ammonia and amines which paralleled the observed increases in the total volatile basic nitrogen in samples. These results agree with those reported by ***Astiasaran et al., (1990).*** On the other hand, the observed decreases in the pH-value for non-irradiated cooked balls and those irradiated at doses of 1.5 kGy as well as irradiated and non-irradiated samples of the other meals may be due to the formation of acidic compounds which may be attributed to the activity of lactic acid bacteria. These results agree with those reported by ***Badr (1998),*** while the radioresistance of some strains of lactic acid bacteria was reported by ***ICMSF(1980).***

2.3. Effects of gamma irradiation and cold storage (4±1°C) on the thiobarbituric acid (TBA) - as optical density at 538 nm - in cooked meat balls, baked chicken and baked fish:

2.3.1. Cooked meat balls:

The effects of irradiation and cold storage (4±1°C) on the TBA (as O.D at 538 nm) in samples of cooked meat balls are illustrated in Table (48). From these results, it is obvious that the initial TBA value for samples of non-irradiated cooked meat balls was 0.044. The application of gamma irradiation at the ascending doses gradually increased the TBA values for samples reaching 0.060, 0.069 and 0.81 after the exposure of samples to 1.5, 3 and 4.5 kGy doses of gamma irradiation, respectively. The same results show that further gradual increases in the TBA value were observed upon cold storage for both irradiated and non-irradiated samples of cooked meat balls. The TBA increased to 0.076, 0.112, 0.144 and 0.183 after 6, 15, 30 and 54 days of cold storage for non-irradiated samples and those irradiated at doses of 1.5, 3 and 4.5 kGy, respectively.

2.3.2. Baked chicken meat:

Table (49) represents the effects of gamma irradiation and cold storage on the TBA (as O.D) of baked chicken meat. It is noticeable that the initial TAB for samples of non-irradiated baked chicken meat was 0.012. Upon exposure of samples to gamma irradiation, the TBA value of samples showed a gradual increase being 0.014, 0.024 and 0.029 for samples irradiated at doses of 1.5, 3 and 4.5 kGy, respectively. Furthermore, cold storage of samples at 4±1°C induced gradual increases in their TBA values which reached 0.028, 0.046, 0.060 and 0.103 after 9, 15, 18, and 33 days of storage for non-irradiated samples and those irradiated at 1.5, 3 and 4.5 kGy, respectively.

Table (48): Changes in the thiobarbituric acid (as optical density) during cold storage of irradiated and non-irradiated cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	0.044	0.060	0.069	0.81
3	0.062	0.067	0.074	0.085
6	0.076	0.078	0.081	0.092
9	R3	0.084	0.086	0.096
12		0.101	0.095	0.099
15		0.112	0.103	0.105
18		R3	0.114	0.110
21			0.119	0.117
24			0.127	0.122
27			0.137	0.126
30			0.144	0.132
33			R3	0.140
36				0.144
39				0.147
42				0.153
45				0.160
48				0.169
51				0.177
54				0.183
57				R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

Table (49): Changes in the thiobarbituric acid (as optical density) during cold storage of irradiated and non-irradiated baked deboned chicken breast meat.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	0.012	0.014	0.024	0.029
3	0.015	0.018	0.031	0.036
6	0.023	0.022	0.037	0.045
9	0.028	0.031	0.044	0.054
12	R_2	0.036	0.049	0.060
15		0.046	0.055	0.064
18		R_2	0.060	0.071
21			R_2	0.079
24				0.086
27				0.094
30				0.096
33				0.103
36				R_2

R_2 = Rejected due to the deterioration of the odor.

2.3.3. Baked fish:

The changes in TBA value (as O.D) during cold storage of irradiated and non-irradiated baked fish samples are shown in Table (50).The observed results indicate that samples of non-irradiated baked fish had an initial TBA value of 0.028. Irradiation of baked fish samples at doses of 1.5, 3 and 4.5 kGy gradually increased their TBA value reaching 0.029, 0.044 and .053, respectively.

During cold storage of samples at 4±1°C, the values of TBA showed another gradual increases for non-irradiated samples and those irradiated at 1.5, 3 and 4.5 kGy doses and reached 0.035, 0.049, 0.067 and 0.098 after 3, 12, 18 and 27 days of cold storage, respectively.

The determination of thiobarbituric acid (TBA) in the most widely used test for measuring the extent of oxidation of muscle foods due to its speed and simplicity ***(Raharjo and Sofos, 1993 and Shahidi, 1997).*** From the results of TBA value for all analyzed samples is this study, it is evident that irradiation treatments and cold storage of samples (4±1°C) markedly increased their TBA as compared to the initial values for control non-irradiated samples. These results agree with those obtained by many investigators ***(Badr, 1998; Hammad et al., 2000; Lacroix et al., 2004; Lee et al., 1999 and Nam and Ahn, 2002).*** The increase in TBA values may be mainly due to the indirect effect of gamma radiation through the liberation of free radicals upon radiolysis of water which enhances lipid oxidation ***(Nawar, 1972 and Snauwaert et al., 1977).*** Moreover, cooked meat in

Table (50): Changes in the thiobarbituric acid (as optical density) during cold storage of irradiated and non-irradiated baked fish.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	0.028	0.029	0.044	0.053
3	0.035	0.033	0.048	0.056
6	R_3	0.038	0.052	0.060
9		0.045	0.056	0.066
12		0.049	0.060	0.071
15		R_2	0.063	0.075
18			0.067	0.082
21			R_2	0.086
24				0.092
27				0.098
30				R_2

R_2 = Rejected due to the deterioration of the odor.

R_3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

highly susceptible to lipid oxidation because the cooking process denatures antioxidant component, damages cell structure, and exposes membrane lipids to the environment ***(Ahn et al., 1999).***

2.4. Effects of irradiation and cold storage (4±1°C) on the contents of total volatile basic nitrogen (TVBN) in cooked meat balls, baked chicken meat and baked fish:

2.4.1. Cooked meat balls:

The contents of TVBN in irradiated and non-irradiated cooked meat balls were determined post irradiation treatments and during storage at 4±1°C and the results are shown in Table (51). From this Table, it is clear that samples of non-irradiated cooked meat balls had an initial content of 39.15 mg N/100g dry matter for TVBN. The application of gamma irradiation at doses of 1.5, 3 and 4.5 kGy had no remarkable effects on the contents of TVBN in samples of the cooked meat balls as their contents amounted to 39.28, 39.47 and 39.78 mg N/100g dry matter, respectively. The same Table further shows that cold storage of the cooked meat balls at 4±1°C induced gradual increase in the contents of TVBN for non-irradiated samples and those irradiated at doses of 1.5, 3 and 4.5 kGy, while was at higher rates for the control samples, and the amounts of TVBN reached 53.62, 58.47, 63.72 and 83.26 mg N/100g dry matter after 6, 15, 30 and 54 days of storage, respectively.

Table (51): Effects of gamma irradiation and cold storage (4±1°C) on the total volatile basic nitrogen (TVBN mg N/100g dry matter) in cooked meat balls.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	39.15	39.28	39.47	39.78
3	46.87	42.93	40.65	40.87
6	53.62	45.86	43.25	42.36
9	R3	49.28	44.09	43.79
12		53.64	47.28	45.12
15		58.47	49.35	46.85
18		R3	52.27	48.34
21			55.18	50.07
24			58.32	53.79
27			60.25	57.48
30			63.72	60.09
33			R3	62.76
36				64.12
39				67.38
42				69.87
45				73.05
48				76.64
51				79.52
54				83.26
57				R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

2.4.2. Baked chicken breast meat:

Table (52) represents the effects of irradiation and cold storage (4±1°C) on the contents of TVBN in baked chicken meat samples. The data in this Table clearly show that the initial content of TVBN in samples of non-irradiated baked chicken meat was 35.78 mg N/100g dry matter. Irradiation of samples at doses applied in this study caused no real changes in their contents of TVBN which amounted to 36.02, 35.85 and 36.07 mg N/100g dry matter for samples irradiated at doses of 1.5, 3 and 4.5 kGy, respectively. On the other hand, it is noticeable that cold storage of samples at 4±1°C induced gradual increase in the contents of TVBN for non-irradiated samples and those irradiated at doses of 1.5, 3 and 4.5 kGy and the amounts reached 62.09, 58.72, 57.46 and 59.48 mg N/100g dry matter after 9, 15, 18 and 33 days of storage, respectively.

2.4.3. Baked fish:

The results in Table (53) illustrate the contents of TVBN in samples of baked fish as affected by gamma irradiation and cold storage (4±1°C). The results reveal that the initial content of TVBN in non-irradiated samples was 37.92 mg N/100g dry matter. This initial content showed no observable changes due to irradiation of samples at all doses applied in this study as their content of TVBN was also 37.92 mg N/100g dry matter. During storage of samples at 4±1°C, a gradual increase in the contents of TVBN was observed for non-irradiated baked fish samples and those irradiated at 1.5, 3 and 4.5 kGy doses and the amounts of TVBN reached 45.32, 65.47, 59.84 and 67.38

Table (52): Effects of gamma irradiation and cold storage (4±1°C) on the total volatile basic nitrogen (TVBN mg N/100g dry matter) in baked deboned chicken breast meat.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	35.78	36.02	35.85	36.07
3	40.17	39.77	38.12	37.2
6	49.53	44.83	41.89	39.18
9	62.09	49.15	44.35	40.69
12	R_2	53.26	50.02	42.36
15		58.72	54.17	43.89
18		R_2	57.46	44.76
21			R_2	47.05
24				49.63
27				52.14
30				56.27
33				59.48
36				R_2

R_2 = Rejected due to the deterioration of the odor.

Table (53): Effects of gamma irradiation and cold storage (4±1°C) on the total volatile basic nitrogen (TVBN mg N/100g dry matter) in baked fish.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	37.92	37.92	37.92	37.92
3	45.32	40.25	39.18	38.65
6	R_3	46.89	42.33	40.28
9		52.36	46.78	43.17
12		65.47	50.22	47.53
15		R_2	54.63	52.64
18			59.84	55.76
21			R_2	59.48
24				62.15
27				67.38
30				R_2

R_2 = Rejected due to the deterioration of the odor.

R_3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

mg N/100g dry matter after storage for 3, 12, 18 and 27 days of storage, respectively.

In all samples analyzed for their contents of TVBN, the observed results for the effects of irradiated on the formation of TVBN agree with those obtained by many investigators who found that gamma irradiation had no remarkable effects on the contents of TVBN ***(Badr, 1998, 2004 and Hammad et al., 2000).*** Moreover, the application of gamma irradiation lowered the rate of formation for TVBN, proportionally to the applied dose, during cold storage of irradiated samples as compared with non-irradiated ones. This may be due to the inhibition of microorganisms capable of producing those compounds through the application of irradiation treatments. It has been illustrated that the increase in TVBN is caused by the microbiological deamination of amino acids as well as the complete microbial reduction of TMAO to TMA ***(Truelstrup et al., 1996).***

2.5. Effects of irradiation and cold storage (4±1°C) on the contents of trimethylamine (TMA) in baked fish samples:

The changes in TMA contents in baked fish as affected by gamma irradiation and old storage (4±1°C) are shown in Table (54). As shown in this Table, irradiation of baked fish samples at doses used in this study had no detectable effects on their initial TMA contents which amounted to 9.37 mg N/100g dry matter in both non-irradiated samples and those irradiated at all applied doses. Similar findings were reported by ***El-Fouly et al., (1986)*** who found that gamma irradiation had no

Table (54): Changes in trimethylamnie contents (TMA mg N/100g dry matter) during cold storage (4±1°C) of irradiated and non-irradiated baked fish.

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	9.37	9.37	9.37	9.37
3	12.05	10.24	9.86	9.54
6	R_3	11.18	10.32	9.93
9		13.07	10.79	10.18
12		16.24	11.57	10.67
15		R_2	12.08	11.09
18			12.84	11.43
21			R_2	12.25
24				12.87
27				14.36
30				R_2

R_2 = Rejected due to the deterioration of the odor.

R_3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

effects on the contents of TMA in fish fillets. The results in the same Table further show that storage of baked fish samples at 4±1°C caused gradual increase in their TMA contents which increased to 12.05, 16.24, 12.84 and 14.36 mg N/100g dry matter in non-irradiated samples and those irradiated at 1.5, 3 and 4.5 kGy after 3, 12, 18 and 27 days of storage, respectively. However, the rate of increase in TMA contents was lower in irradiated samples, proportionally to the applied dose, than in non-irradiated samples and paralleled the reduced rate of increase for microbial counts in irradiated samples as compared with the controls. However, all the observed values appeared to be within the acceptable level which reported to be 10 mg N/100g in raw fish (on wet weight basis) according to the Egyptian Standards No. 2760 ***(1994). Dondero et al., (2004)*** mentioned that the formation of TMA correlated well with storage time and total viable count for aerobic and non aerobic bacteria.

3. Effect of gamma irradiation and cold storage (4±1°C) on the sensory properties of the prepared ready-to-eat meals:

3.1. Effects on the appearance of the prepared ready-to-eat meals:

The most important of the sensory properties is the product visual appearance and it could be concluded that the appearance of the food constitutes the first sensory impression of the product. Samples of the prepared ready-to-eat meals under investigation were subjected to sensory evaluation for their

Table (55): Sensory attributes for the appearance of cooked meat balls as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	8.3	8.2	8.2	8.3
3	7.8	7.8	8.2	8.2
6	7.5	7.5	7.8	7.8
9	7.3 R3	7.2	7.5	7.8
12		6.7	7.5	7.6
15		6.5	7.5	7.6
18		6.3 R3	7.5	7.6
21			7.5	7.5
24			7.3	7.5
27			7.3	7.5
30			7.2	7.5
33			7.2 R3	7.5
36				7.5
39				7.3
42				7.3
45				7.3
48				7.2
51				7.2
54				7.2
57				7.2 R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

Table (56): Sensory attributes for the appearance of mashed potatoes as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	8.9	8.4	8.3	8.3
3	8.6	8.4	8.3	8.3
6	8.2 R_2	8.3	8.2	8.3
9		8.2 R_2	8.2	8.3
12			8.1 R_2	8.3
15				8.2 R_2

R_2 = Rejected due to the deterioration of the odor.

Table (57): Sensory attributes for the appearance of baked deboned chicken breast meat as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	8.4	8.3	8.3	8.3
3	8.4	8.3	8.3	8.3
6	8.2	8.3	8.3	8.3
9	7.8	8.2	8.2	8.3
12	7.5 R_2	8.2	8.2	8.3
15		7.9	7.8	8.2
18		7.3 R_2	7.6	8.2
21			7.2 R_2	8.2
24				8.2
27				7.8
30				7.8
33				7.6
36				7.4 R_2

R_2 = Rejected due to the deterioration of the odor.

Table (58): Sensory attributes for the appearance of baked fish as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	8.7	8.5	8.5	7.9
3	8.7	8.5	8.5	7.7
6	8.5 R_3	8.5	8.5	7.6
9		8.2	8.5	7.6
12		7.9	8.2	7.4
15		7.5 R_2	8.2	7.4
18			7.8	7.3
21			7.6 R_2	7.3
24				7.6
27				7.6
30				7.3 R_2

R_2 = Rejected due to the deterioration of the odor.

R_3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

Table (59): Sensory attributes for the appearance of cooked rice as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	8.9	8.3	7.9	7.9
3	8.9	8.3	7.9	7.9
6	8.7.	8.3	7.9	7.9
9	8.5 R2	7.8	7.6	7.9
12		7.3 R2	7.5	7.6
15			7.2 R2	7.6
18				7.4 R2

R2 = Rejected due to the deterioration of the odor.

appearance post irradiation treatments and during storage (4±1°C) and the mean of scores are shown in Tables (54-59). The tabulated results reveal that the application of gamma irradiation at the different doses used in this study did not affect the appearance of samples as all irradiated and non-irradiated ready-to-eat meals had a very good scores for their appearance. These results agree with those reported by many investigators ***(Anon, 1995; Stevenson et al., 1995; Badr, 1998 and Du and Ahn, 2002).***

On the other hand, samples of all irradiated and non-irradiated ready-to-eat meals showed a high scores for their appearance during cold storage at 4±1°C including samples that rejected due to either the deterioration of odor or increasing their total bacterial count to more than $1x10^7$ cfu/g as illustrated in the same Tables (59-63).

3.2. Effects on the odor of the prepared ready-to-eat meals:

3.2.1. Cooked meat balls:

Table (60) represents the mean of scores recorded for the odor of cooked meat balls post irradiation treatments and during storage at 4±1°C. It is evident that treatment of cooked meat balls by gamma irradiation at doses of 1.5, 3 and 4.5 kGy induced no changes in the odor of samples and both irradiated and non-irradiated samples had a very good scores as recorded by the panelists. Similar results were observed by ***Badr (1998) and Hammad et al., (2000).*** During storage at 4±1°C, non-irradiated cooked meat balls as well as those irradiated at 1.5 and 3 kGy doses showed a high scores for their odor including samples that rejected due to increasing their total bacterial count to more than $1x10^7$cfu/g. Regarding samples irradiated at dose of 4.5 kGy, samples showed a high scores for their odor till the day 39 of cold storage, then lower scores were recorded for samples when the panelists detected the odor of oxidation, however, scores indicated an acceptable samples including those rejected when their total bacterial count exceeded $1x10^7$cfu/g.

3.2.2. Mashed potatoes:

Irradiated and non-irradiated samples of mashed potatoes were sensory evaluated for their odor post irradiation treatments and during storage at 4±1°C and the mean of scores are tabulated in Table (61). The results clearly show that gamma irradiation at the different applied doses had no adverse effects on the odor of samples as all irradiated samples showed a high scores for odor similar to non-irradiated samples. During storage of samples at 4±1°C, an objectionable sour off-odor was detected in non-irradiated samples on the day 6 of storage and samples were scored as a poor samples and rejected. Similar results were observed by ***Patterson et al., (1998)*** who found that mashed potatoes has a short shelf life and spoiled rapidly. The same Table shows that irradiation of mashed potatoes at doses of 1.5, 3 and 4.5 kGy could retard the detection of the sour odor which detected in these samples on day 9, 12 and 15 of cold storage, respectively, in which samples were rejected.

Table (60): Sensory attributes for the odor of cooked meat balls as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	7.8	7.6	7.8	7.6
3	7.5	7.5	7.8	7.6
6	7.2	7.3	7.6	7.6
9	7.1 R3	6.7	7.6	7.5
12		6.5	7.5	7.5
15		6.5	7.4	7.4
18		6.3 R3	7.3	7.4
21			7.2	7.2
24			7.1	7.2
27			6.8	7.1
30			6.7	6.9
33			6.7 R3	6.9
36				5.8
39				5.1
42				4.7
45				4.5
48				4.5
51				4.6
54				4.3
57				4.3 R3

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

Table (61): Sensory attributes for the odor of mashed potatoes as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	8.9	8.5	8.3	8.2
3	8.1	8.4	8.1	8.2
6	3.1 R_2	7.5	7.6	8.1
9		3.2 R_2	7.4	7.6
12			3.2 R_2	7.4
15				3.3 R_2

R_2 = Rejected due to the deterioration of the odor.

3.2.3. Baked deboned chicken meat with potatoes:

Table (62) illustrates the mean of scores for the odor of baked chicken meat with potatoes as affected by gamma irradiation and cold storage (4±1°C). It could be seen that both irradiated and non-irradiated samples showed a similar acceptability for their odor and scored as a very good samples. This indicates that gamma irradiation at the different applied doses could not adversely affect the odor of samples. On day 12 of cold storage (4±1°C), non-irradiated samples were rejected due to the detection of the sour off-odor. Meanwhile, samples irradiated at doses of 1.5, 3 and 4.5 kGy were rejected for the same reason on day 18, 21 and 36 of storage, respectively.

3.2.4. Baked fish:

Samples of irradiated and non-irradiated baked fish were subjected to sensory evaluation for their odor post treatments and during storage at 4±1°C and the mean of scores are shown in Table (63). The tabulated results indicate that the odor of baked fish was not affected due to irradiation of samples at the different applied doses and both irradiated and non-irradiated samples had a similar high scores for odor acceptability. On day 6 of cold storage, the total bacterial count exceeded 10^7 cfu/g in non-irradiated samples leading to their rejection, however, they still showed the same high scores for their odor. Regarding samples irradiated at doses of 1.5, 3 and 4.5 kGy, these samples showed a sour off-odor and rejected on day 15, 21 and 30 of cold storage, respectively.

Table (62): Sensory attributes for the odor of baked deboned chicken breast meat as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	8.3	8.3	7.8	7.9
3	7.5	8.2	7.8	7.8
6	6.8	8.2	7.8	7.8
9	6.5	7.6	7.6	7.6
12	3.2 R_2	7.5	7.6	7.6
15		6.7	6.9	7.6
18		3.1 R_2	6.8	7.5
21			3.3 R_2	7.5
24				7.3
27				6.9
30				6.8
33				6.5
36				3.2 R_2

R_2 = Rejected due to the deterioration of the odor.

Table (63): Sensory attributes for the odor of baked fish as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	8.9	8.7	7.8	7.6
3	8.7	8.7	7.8	7.5
6	8.5 R3	8.5	7.5	7.5
9		8.5	7.5	7.3
12		7.6	7.5	7.3
15		3.1 R2	7.3	7.3
18			6.5	7.3
21			3.2 R2	7.2
24				7.2
27				7.2
30				3.2 R2

R2 = Rejected due to the deterioration of the odor.

R3 = Rejected due to increasing the total bacterial count to more than $1x10^7$ cfu/g.

3.2.5. Cooked rice:

Table (64) represents the mean of scores for samples of irradiated and non-irradiated cooked rice post treatments and during storage at 4±1°C. The results show that the panelists recorded similar high scores for the odor of both non-irradiated and irradiated cooked rice samples. This reveals that irradiation treatments at the different applied doses had no adverse effects on the odor of cooked rice. On the other hand, samples of non-irradiated cooked rice showed a sour off-odor and rejected on day 9 of cold storage at 4±1°C. Irradiation of samples at doses of 1.5, 3 and 4.5 kGy could retard their rejection as the sour off-odor was observed in these samples on day 12, 15 and 18 of storage, respectively.

3.3. Effects of irradiation on the taste of the prepared ready-to-eat meals:

Samples of the prepared ready-to-eat meals under investigation were sensory evaluated for their taste post irradiation treatments and the mean of scores are presented in Table (65). It is obvious that the application of gamma irradiation for all prepared ready-to-eat meals at the different doses used had no adverse effects on the taste of meals as all irradiated samples (within each of the prepared meals) showed a high scores of acceptability for the taste similar to those of non-irradiated samples.

Sensory evaluation is still the best means in determining the acceptability of any food product and it is the final guide to assure the product quality. The results of sensory evaluation

Table (64): Sensory attributes for the odor of cooked rice as affected by gamma irradiation and cold storage (4±1°C).

Storage period (days)	Irradiation dose (kGy)			
	0	1.5	3	4.5
0	8.7	7.9	7.8	7.8
3	8.7	7.6	7.5	7.6
6	8.5	7.5	7.4	7.6
9	3.2 R_2	7.5	7.3	7.4
12		3.4 R_2	7.3	7.4
15			3.2 R_2	7.2
18				3.2 R_2

R_2 = Rejected due to the deterioration of the odor.

Table (65): Effects of irradiation on the taste of the prepared ready-to-eat meals (on day zero).

Meals	Mean of scores / Irradiation dose (kGy)			
	0	1.5	3	4.5
Cooked meat balls	7.2	7.2	7.5	7.1
Mashed potatoes	8.9	8.3	8.3	8.2
Baked chicken breast	8.7	8.5	8.4	8.3
Baked fish	8.8	8.6	8.5	8.5
Cooked rice	8.6	8.3	8.1	7.9

reveled the high sensory acceptability of all irradiated samples as compared with the control non-irradiated ones.

The obtained results for the effects of irradiation on the sensory attributes are similar to those obtained by ***Kim et al., (2002)*** who reported that there were no significant differences in sensory scores between irradiation and non-irradiated meats although irradiated meats produced new volatiles and higher TBARs.

On the other hand, except for samples that rejected due to their bacterial count (> $1x10^7$ cfu/g), the sour off-odor was the main factor determined the refrigerated storage life for the prepared meals. The observed sour odor may be attributed to the activity of Micrococcus, Lactobacillus and Microbacterium species as reported by ***Banwart, (1981).***