RESULTS AND DISCUSSION

4.RESULTS AND DISCUSSION

Fillets yield and waste of bolti fish:

Filleting of the fish (Dressing) can be influence on both the quality and quantity of minced fish such as; the head cut during filleting is very important. If the position of the head cut is too far forward, the gills and heart remain and the product quality will decrease. If the position of the cut is too far to the rear, the yield will be decreased and also, the viscera must be removed completely. If even a small protein of the viscera remains, the gel forming properties of the surimi will decrease due to the high content of proteolytic enzymes and the number of spoilage microorganisms present will increase **(Toyoda, *et al.*, 1992).**

For studying the relationship between the weight of whole fish and flesh yield (Dressing percentage) twenty whole fish were individually weighted and the obtained results are present in Table (1).

It could be noticed that the weight of whole fish ranged from 800 to 3200 gm., also the obtained results from the same Table indicated that the flesh fish yield or dressing percentage increased by increasing whole fish weight, where the highest flesh fish yield (1370 gm.) was obtained from the largest weight of whole fish (3200 gm.) corresponding 42.8% as dressing percentage, while the lowest yield of flesh fish yield (248 gm.) was obtained from the smallest fish weight (800 gm.) corresponding 31% as dressing percentage. These results are in agreement with those obtained by **Abd El Aal, *et al.*, (2000)** who

Table (1): Technological characterization of individual live Bolti fish used for preparing different imitated fish products.

Sample No.	Whole fish Weight (gm)	Yield		Waste	
		Wt. Flesh (gm)	Dressing %	Wt. Waste (gm)	Losses %
1	1200	400	33.33	791	65.91
2	880	302	34.31	575	65.34
3	1400	479	34.21	915	65.35
4	800	248	31	550	68.75
5	830	290.5	35	537	64.69
6	1000	335	33.5	665	66.50
7	1200	420	35	778	64.83
8	1050	342.3	32.6	705	67.14
9	950	218.5	23	730	76.84
10	1030	339.9	35.77	690	66.99
11	1480	500	33.78	980	66.21
12	3200	1370	42.8	1825	57.03
13	930	353.4	38	575	61.82
14	1020	335	32.84	680	66.66
15	1000	320	32	677	67.70
16	2000	781	39.05	1219	60.95
17	2755	988	35.86	1730	62.79
18	3000	1186	39.53	1790	59.66
19	2500	890	35.60	1590	63.60
20	1995	760	38.09	1195	59.89
Average	1511	537.9	34.60	959.85	64.93

found that the fillets yield percentage of bolti fish was 30.72% for fish having weight 651 gm.

The yield increased from 248 gm. for smallest fish weighted (800 gm.) to 335, 479, 781 and 890 gm., which were obtained from whole fish having 1000, 1400, 2000, and 2500 gm., respectively.

Effect of different washing steps on chemical composition of minced fish: -

Efficient washing or leaching is the most important step in surimi fish processing, where the purpose of washing or leaching is the removal of water soluble matter, lipids and blood from the minced meat to improve the colour and flavour as well as to increase the gel strength of the surimi **(Toyoda, *et al.*, 1992 and Park and Lanier, 2000).**

Data showed in Table (2) and Fig (1) indicated that the chemical composition of minced bolti fish meat as follow: 77.52% moisture, 16.98 % protein; 3.97% fat; 1.18% ash and 0.35% carbohydrates on wet weight basis. These results are in agreement with those obtained by **Kongpun, (1999); Moghazy; *et al.*, (2002) and Yasin, *et al.*, (2002)** they found that the moisture content of fresh bolti fish meat ranged from 77.4 to 78.33 % and contained 84.4; 10.70 and 4.9% (on dry weight basis) for protein, fat and ash, respectively.

The effects of washing processes on minced fish with sodium bicarbonate (0.2 %), distilled water and saline solution (0.15%) on its chemical composition were determined after each washing step and the obtained results are presented in Table (2) Fig (1) as following: -

Moisture content: -

Data in Table (2) Fig (1) indicate that the washing steps caused a slight increment in moisture content of minced flesh fish which increased from 77.52% for unwashed minced flesh to 79.12% after washing by sodium bicarbonate (0.2%) while, reached to 80.02 and 81.10% after washing by distilled water and saline solution (0.15% sodium chloride solution), respectively. These results are in agreement with those obtained by **Lin and Park, (1996) and El-shourbagy, *et al.*, (2003)** they found that washing steps caused a slight increase in moisture content of minced flesh fish.

Crude protein:-

Date cited in Table (2) Fig (1) also indicate that the protein content of minced fish slight decreased by washing process. It decreased from 16.98% for unwashed minced flesh fish to 16.87; 16.72 and 16.68% after washing the minced fish by sodium bicarbonate; distilled water and saline solution, respectively. This decrease in protein content due to progressive removal of all the non protein nitrogen and a large part of the sarcoplasmic proteins (myoglobin, enzymes, et.) by washing steps. These results agreed with those obtained by **Roussel and cheftel, (1988); Lee, *et al.*, (1990),** as they found that the washing process decreased protein content below 17% for the final surimi.

In contrast, on dry weight basis, a noticeable increase in protein content of washed minced fish was observed by washing process. The protein content increased from 75.53% for unwashed minced fish to 80.79; 83.68 and 88.25% after washing steps by $NaHCO_3$; distilled water and saline solution, respectively. This increase in protein content on dry weight basis due to the concentration of myofibril protein in dry matter resulting the losing of fat and other ingredient by washing process. These findings agreed with those reported by **Roussel and Cheftel, (1988); Howe, *et al.*, (1994); Kim, *et al.*, (1996) and El-Shourbagy, *et al.*, (2003),** they concluded that washing and dewatering steps concentrated the protein (myofibrilla protein).

Crude fat: -

It is clear from the same results in Table (2) Fig (1) that the fat content clearly decreased by washing process, where, it decreased from 17.66 % (on dry weight basis) for unwashed minced fish sample to 12.93; 11.06 and 8.25 % after washing operation by sodium bicarbonate; distilled water and saline solution, respectively. These results are in agreement with those reported by **Adu, *et al.*, (1983); kim, *et al.*, (1996).** They reported that the large amounts of fat for minced flesh fish were removed by washing process and this removal due to separation of fat during washing treatment, due to the differences in density and polarity between fat and aqueous solution.

Ash content: -

From the aforementioned results in Table (2) Fig (1) it is clear that ash content decreased from 5.25% (on dry weight basis) for unwashed minced flesh fish to 4.79; 4.05 and 3.12 % after washing the minced fish by sodium bicarbonate; distilled water and saline solution, respectively. Similar observations were showed by **Adu, *et al.*, (1983); Lee, *et al.*, (1996);**

Table (2): Effect of different washing steps on chemical composition of minced fish.

Component \ Process		Raw mince	Washing steps: Solution (1)	Washing steps: Solution (2)	Washing steps: Solution (3)
Moisture		77.52	79.12	80.02	81.10
% Protein	Wet	16.98	16.87	16.72	16.68
	Dry	75.53	80.79	83.68	88.25
% Fat	Wet	3.97	2.70	2.21	1.56
	Dry	17.66	12.93	11.06	8.25
% Ash	Wet	1.18	1.00	0.81	0.59
	Dry	5.25	4.79	4.05	3.12
%Carbohydrate*	Wet	0.35	0.31	0.24	0.06
	Dry	1.55	1.48	1.20	0.32

(1) Washed by 0.2 % $NaHCO_3$
(2) Washed by distilled water
(3) Washed by 0.15 % NaCl
* Calculated by difference

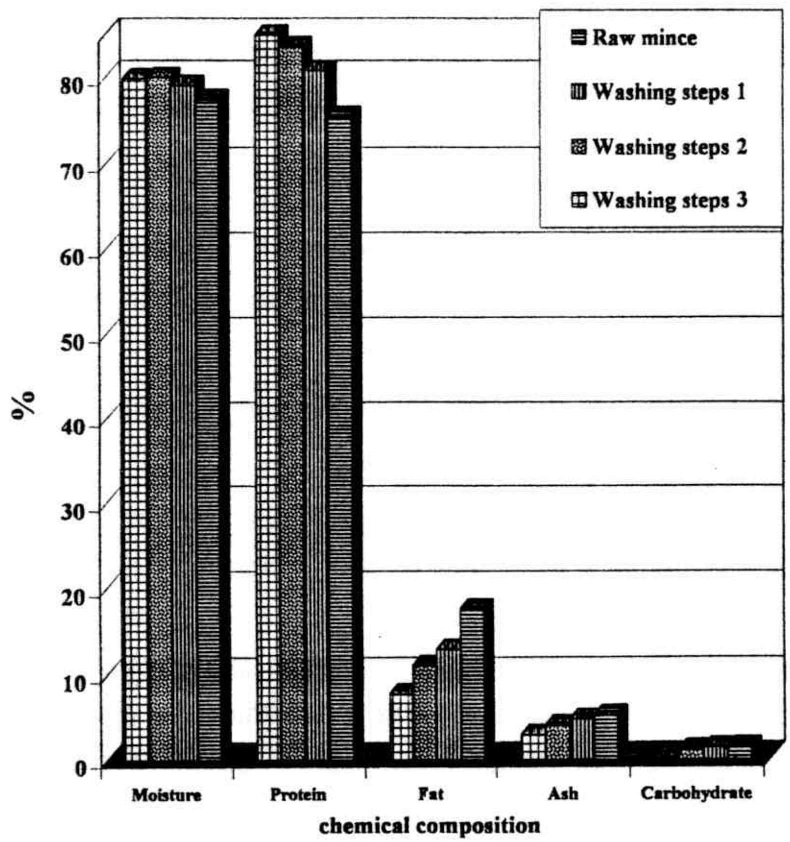


Fig (1): Effect of different washing steps on chemical composition of minced fish

El-Hanafy, (2001) and El-Shourbagy ***et al.*****, (2003)** as they found that 77.4% of the original ash was removed from minced fish after washing steps.

Carbohydrate content:

The previously tabulated data in Table (2) Fig (1) illustrated that the total carbohydrate was slightly decrease by washing process, it decreased from 1.55% (on dry weight basis) for unwashed mince to 1.48; 1.20 and 0.32 % after washing solution by sodium bicarbonate; distilled water and saline solution, respectively. The decrement of carbohydrate may be attributed to removal of fat and ash from mince by washing steps.

Effect of washing steps by different solution on yield percentage of minced bolti fish: -

Influence of washing process using sodium bicarbonate solution; distilled water and saline solution on yield percentage of minced bolti fish are shown in Table (3). Data in the same Table also showed the yield percentage after washing steps. It could be noticed that there was a decrement in yield after the first washing with sodium bicarbonate solution to reach 26.11%. In contrast, an increase in the yield after the second washing with distilled water observed as the yield percentage reached 40.88%. This increment may be attributed to water absorbed by the minced protein **(Amin, 1997).** Where as, the yield was reduced after the third washing step by 0.15% NaCl reach to 32.28 %. This reduction in yield percentage may be due to the salt solution remove a great part of water absorbed by the minced protein.

Solution salt (0.1-0.3%) in the final washing step reduced the moisture content of washed minced **(Lin and Park, 1996).**

Generally, the yield was decreased during washing steps. This decrement in the yield was due to removal of water-soluble substances, fat and small minced meat particles during washing and dewatering process. Similar observation was noticed by **Iso, *et al.*, (1985)** who mentioned that the most of the minced washing losses resulted during dewatering as a result of passing the small meat particles through the perforation of dewatering filter. These results are in agreement with those reported by **Lee, (1986); Pigott, (1986); Roussel and cheftel, (1988); Lee, (1990) and Park, *et al.*, (1997)** as they found the yield percentage after washing and dewatering ranged between (18-33%).

Effect of washing process solution on physical and chemical properties of minced bolti fish: -

The results summarized in Table (4) indicate the effect of washing steps on the physical and chemical properties of minced bolti fish such as salt extractable protein (SEP %), total volatile nitrogen (TVN), thiobarbituric acid (TBA), pH values and water holding capacity (WHC %).

Salt extractable protein (SEP %):-

From the results in Table (4) it is obvious that the SEP % was 45.26 % for unwashed minced fish and increased reached to 69.31, 73.5 and 88 % after washing steps by sodium bicarbonate, distilled water and saline solution, respectively.

These results are in close agreement with those reported by **Lee, (1992)** who found that the SEP % increased with additional washing cycle from 76 to 96.2 % after four steps of washing. Moreover, **Howe, *et al.*, (1994)** noticed that washing and dewatering steps led to concentrate the protein and increased of SEP %.

Total volatile nitrogen (TVN): -

Total volatile nitrogen is a mixture of many volatile nitrogenous compounds such as trimethylamine, dimethylamine, monomethylamine and ammonia, which considered an index of the degree of protein decomposition by microorganisms.

Table (4) indicate also that TVN of unwashed mince fish was 9.93 mg N / 100g sample. From the same results, it could be noticed that washing step led to a noticeable decrease in TVN, as it decrease from 9.93 to 8.41, 5.94, and 3.12 mg N / 100g sample after washing with sodium bicarbonate, distilled water and saline solution, respectively.

This decrease of TVN due to washing steps progressively remove all of the non protein nitrogen as mentioned by **Roussel and Cheftel, (1988) and Lee *et al.*, (1990)**.

Thiobarbituric acid (TBA): -

TBA value is a measure of the amount of reaction products of oxidation of lipids. It is based on measurment of the amount of malonaldehyde, a major oxidation product.

It is seen from Table (4) that the TBA value of unwashed minced fish was 0.88 mg malonaldehyde / kg. It is obvious from these results that washing steps caused a remarkable decrease in

Effect of washing steps by different solution on microbiological load of minced bolti fish: -

Effect of washing process using sodium bicarbonate, distilled water and NaCl solution on microbiological load of minced bolti fish are shown in Table (5) and Fig (2)

The results summarized in Table (5) Fig (2) indicated that the total bacterial count of unwashed minced bolti fish was $2.3x10^5$ cfu / g and there was a gradual decrease in total bacterial counts reached to 2.6×10^4; 2.5×10^4 and 2.1×10^4 cfu / g for first , second and third washing steps, respectively.

The same trends were also observed in psychrophilic and yeast counts which were 1.7×10^3 and 2.7×10^2 cfu / g for unwashed minced fish, respectively which showed a gradual decreased reached to 1.1×10^3 and < 100 cfu / g after third washing steps, respectively.

These results are in agreement with those obtained by **Licciardello and Hill, (1978) and Ingham, (1991)** who mentioned that the washing with water significantly removes the numbers of bacterial cells from the minced fish just as washing of fillets reduces aerobic plate count. In addition, **El-Hanafy, (2001) and El-Shourbagy, *et al.*, (2003)** found that washing of minced fish three times using sodium bicarbonate solution at the first wash; distilled water (second wash) and sodium chloride solution at the third reduced the numbers of total bacterial count, psychrophilic bacteria; yeast and mould.

Table (5): Effect of washing steps by different solutions on microbiological load of minced Bolti fish (cfu / g).

Process / Microbial	Raw mince	Washing steps		
		Solution (1)	Solution (2)	Solution (3)
Total bacterial count (TBC)	$2.3x10^5$	$2.6x10^4$	$2.5x10^4$	$2.1x10^4$
Psychrophilic	$1.7x10^3$	$1.6x10^3$	$1.4x10^3$	$1.1x10^3$
Yeast	$2.7x10^2$	$2x10^2$	$1.6x10^2$	<100
Mould	<10	<10	<10	<10

(1) Washed by 0.2 % $NaHCO_3$
(2) Washed by distilled water
(3) Washed by 0.15 % NaCl

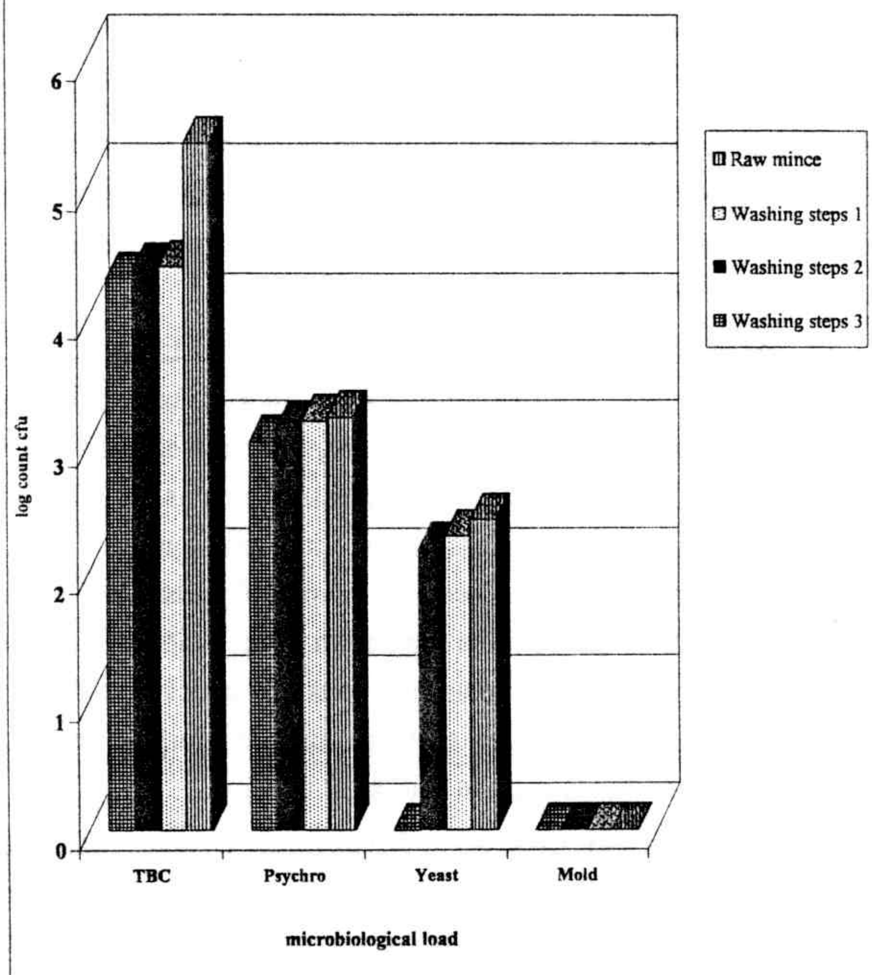


Fig (2): Effect of washing steps by different solution on microbiological load of minced Bolti fish (cfu/g)

Effect of washing steps by different solutions on elements (calcium; phosphorus; sodium; potassium and lead) of minced fish:

Calcium is responsible for about 2% of total body weight, with 99% of these found in bones and teeth. In addition to providing hardness to bone, much of the calcium in this structure is in storage available for other body functions, the parathyroid hormone and calcitonin regulate the blood level of calcium. **(Pigott and Tucker, 1990).**

Phosphorus is an integral part of bone and tooth mineral as well as part of the structure of every cell and, in addition is involved in most all metabolic reactions, although sodium has a role in a number of physiological processes, such as transport of substances across cell membranes, transmission of nerve impulses and metabolism of protein and carbohydrate, the major dietary concern is related to its regulation of the amount of water retained by the body but potassium ions are concentrated with cells, like sodium ions they to help maintain normal osmotic pressure of body fluids and the acid-base balance.

Potassium activates several enzymes systems, such as those involved in muscle contraction and nerve impulse transmission. Seafoods are relatively reach in potassium with fish providing 300-400 mg / 100g and shellfish 200-300 mg / g. **(Pigott and Tucker, 1990).**

Effect of washing process using sodium bicarbonate, distilled water and NaCl solution on elements (calcium; phosphorus; sodium; potassium and lead) of minced bolti fish are shown in Table (6) and Fig (3).

The obtained results in Table (6) and Fig (3) showed that the element contents (mg / g) of unwashed minced fish were 8.75; 6.10; 0.74; 8.62 and 3.88 for Ca; P; Na; K and Pb, respectively.

From the tabulated data, it could be noticed that the elements contents were gradually decreased after washing steps and reached to 3.30; 2.86; 0.48; 4.09 and 0.27 mg/gm. for Ca; P; Na; K and Pb, respectively.

These results are in agreement with those obtained by **(El-Shourbagy, *et al.*, 2003)**.

Table (6): Effect of washing steps by different solutions on minerals content (Ca, P, Na, K, Pb) of minced Bolti fish.

Process	Elements mg/gm.				
	Ca	P	Na	K	Pb
Minced fish	8.75	6.10	0.74	8.62	3.88
Washing (1)	9.50	8.83	0.89	8.97	0.34
Washing (2)	4.70	1.27	0.95	9.59	3.40
Washing (3)	3.30	2.86	0.48	4.09	0.27

(1) Washed by 0.2 % $NaHCO_3$
(2) Washed by distilled water
(3) Washed by 0.15 % NaCl

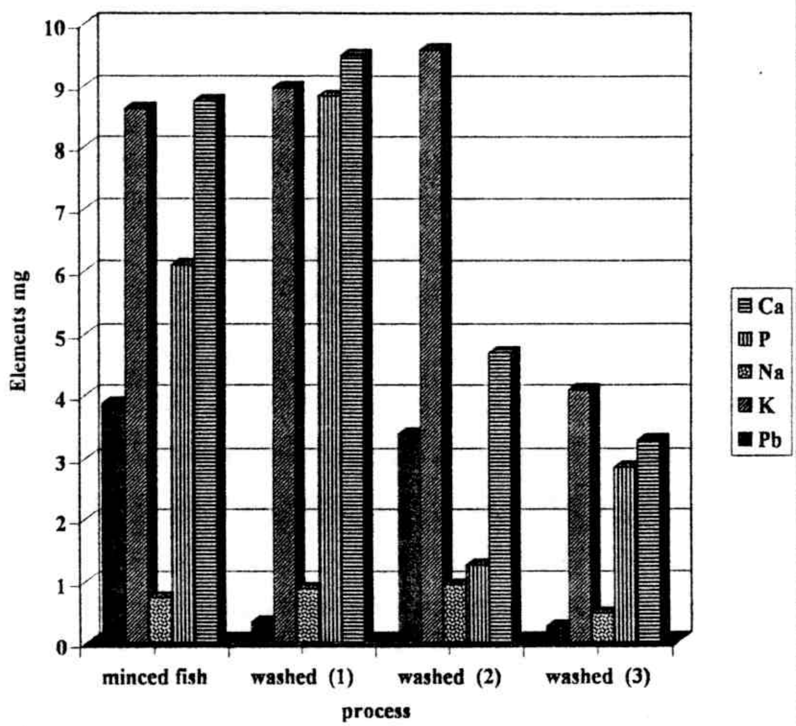


Fig (3): Effect of washing steps by different solutions on elements (Ca, p, Na, K, Pb) of minced Bolti fish

Choose the optimum of imitated shrimp and crab:

Flavor is one of the critical components of the imitated fish product, because of the acceptance of final product by consumers greatly depends on the flavor.

The flavor sensation of shellfish usually begins with its visual assessment, but the main components of it include volatile compounds (Aroma), non volatile compounds (Taste) and that are perceived in the mouth as mouth feel **(Taylor and Liforth, 1996).**The flavor contains aroma chemical precursors that require heat to be converted to the desired final product. Therefore, that the surimi seafood flavor be added boiling water to permit the necessary chemical conversions to occur.

Fresh fish flavor are very delicate and can be easily destroyed or masked by deteriorative odors, also they are often unstable thought process or during manufacture. Therefore, the synthetic flavor which adding to imitated fish product must be evaluated during manufacture.

There are two ways to evaluate seafood flavor, the first is in a hot water solution and the second a prototype product. An effective way to evaluate a flavor system is in a prototype-finished product because this gives a more complete picture of the flavor profile of the product. For adopting the optimum concentration from synthetic shrimp and crab (Aspin and American) utilize in final product, and studying the stability these flavors after cooking (steaming or frying) process.

A number from prototype finished product were manufactured at different concentration (0.5, 0.75, 1, 1.5,and 2 ml/kg final product) of shrimp and crab flavor and sensory evaluated for odouring, tasting.

The obtained results were presented in Table (7) for Aspain flavor and Table (8), (9) for American flavor.

Data in Table (7) show that the raw natural shrimp having 24 degree while the processed natural shrimp (steaming and frying) recorded 25 and 23 for odor and taste, and 23 and 24 degree for frying samples.

It is clear that from the same table the concentration of 1g/kg was the optimum concentration from Aspin flavor (shrimp) were it having the high scores for odor and taste compared another concentration where its odor having 21, 23.5 and 23 degrees for raw, steaming and frying, respectively, while the taste degree were 24 and 23 for steaming and frying product.

It is clear that the odor degrees either natural or imitated product were increased by steaming and frying process, and this increase due to the chemical conversion for aroma by heating process to the desired final product.

The same observation in the odor and taste of American flavor was noticed in Tables (8) and (9) But the optimum concentration of shrimp and crab was 2g / kg final product.

From these results it could be concluded that the optimum concentration of Aspin flavor (shrimp) was1g/kg final product and which was stabilized during heating process (steaming and frying). Therefore it utilized in manufacturing the imitated fish product under investigation while the 2 g / kg concentration from American flavor was the optimum concentration for manufacturing imitated shrimp and crab.

Table (7): Evaluation of taste, color and odor of imitated shrimp manufactured with different concentration of Aspin flavor

Product / Parameter	Natural shrimp			Imitated shrimp (Aspin)														
				Concentration gm/Kg final product.														
				0.5			0.75			1			1.5			2		
	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry
Color (15)	14	15	15	10.8	11	10	10	11	11	10	11	11	11	12	10	11	12	11
Odor (25)	24	25	23	18	17.2	16.1	20	20	19	21.5	23.5	23.0	21	20	20	21	20	21
Taste (25)	-	25	24	-	18	18	-	18.3	18.4	-	24.0	23.0	-	21	20	-	21	20

Table (8): Evaluation of taste, color and odor of imitated shrimp manufactured with different concentration of American flavor

Product / parameter	Natural shrimp			Imitated shrimp (American)														
				Concentration gm/Kg final product.														
				0.5			0.75			1			1.5			2		
	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry
Color (15)	14	15	15	10.7	11	10	10.8	11	11	10.8	11.3	10.4	11	11.2	11	11	12	11.3
Odor (25)	24	25	23	12	11	10	16	14	13.8	18	14.8	14.3	22	18	18.5	23	21.2	21.0
Taste (25)	-	25	24	-	9.3	8.4	-	14	13	-	15	13.8	-	17.0	18.0	-	20.2	21

Table (9): Evaluation of taste, color and odor of imitated crab manufactured with different concentration of American flavour

product / parameter	Natural crab			Imitated crab														
				Concentration gm/Kg final product.														
				0.5			0.75			1			1.5			2		
	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry	Raw	Steam	Fry
Color (15)	13.5	14	14	10	9.7	8.7	10.1	10	9.8	10.1	10.2	10.4	11	11.1	11.1	12	12	13
Odor (25)	22	23	22	9	7.8	7.5	11.0	10.7	10.6	13.8	13.1	12.75	18.3	18.1	18	21.7	20.4	20
Taste (25)	-	24	23	-	8.1	7.9	-	11.4	11.0	-	13.8	12.7	-	17.6	17.8	-	20.3	19.3

Chemical composition of natural and imitated shrimp and crab:

Shrimps are marketed soon after catch as: live, fresh with shell, with or without head, cooked in brine, or cooked without shell. They have very short shelf lives. Shrimps are also sold canned, deep-frozen or as an extract or a salad ingredient.

Shrimps are heated (pasteurized) at just 80-90 ° C so as not to affect their flavor, hence, they are semi preserves with a limited shelf life. In addition, crabs are marketed as "extra choice soft ". The forms sold are live, fresh, frozen and canned. Crab paste, soup and crab cakes similar to deep fried fish cakes are delicatessen seafood. In the trade, the term crabmeat means white muscle meat, colored red only in leg muscles and chelae, and is distinguished from brown crabmeat obtained from crab liver and gonads. The latter are usually processed into crab paste. All crab products are of limited shelf life **(Belitz and Grosch, 1999).**

The chemical composition of natural and imitated shrimp and crab were determined and the obtained results are presented in Table (10) and Fig (4), (5), (6) and (7) the obtained results show that the natural shrimp contain 74.86% moisture, 21.31 % protein, 2.13 % fat, 1.19 % ash and 0.51 % carbohydrate.

These results are in agreement with those obtained by **Ghaly, (1995)** found that Suez shrimp had 75.63 % moisture, 18.85 % protein and 1.64 % fat (on wet weight basis). Moreover, the same results indicated that the imitated shrimp having 77.86 % moisture, 10.58 % protein, 1.70 % fat, 1.36 % ash and 8.55 % carbohydrate (on wet weight basis).

Data in same table indicate also that the natural crab contains 78.02 % moisture, 19.06 % protein, 1.03 % fat, 1.83 % ash and 0.06 % carbohydrate. These results are in agreement with those mentioned by **Silva and Chamul,(2000)** as they found that the blue crab contained 79.02 % moisture, 18.06 % protein, 1.08 % fat, 0.04 % carbohydrate and 1.8 % ash.

Moreover, Table (10) and Fig (7) showed also that the imitated crab have 79.33 % moisture, 11.5 % protein, 1.01 % fat, 4.89 % ash and 5.84 % carbohydrate.

The results agreed with those mentioned by **Lee, (1986) and El-sharnouby and Moharram, (1994)** who reported that the chemical formula of surimi – based products was ranged from 72 to 78 %.

It could be noticed that these products were varied in their composition according to the ingredients of imitated fish products used during the processing.

Table (10): Chemical composition of fresh shrimp (Natural and Imitated) and Crab (Natural and imitated).

Products		%Moisture	%Protein		%Fat		%Ash		%Carbohydrate	
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Shrimp	Natural	74.86	21.31	84.76	2.13	8.47	1.19	4.73	0.51	2.03
	Imitated	77.81	10.58	47.68	1.70	7.66	1.36	6.13	8.55	38.53
Crab	Natural	78.02	19.06	86.71	1.03	4.69	1.83	8.32	0.06	0.27
	Imitated	79.33	11.50	55.64	1.01	4.89	2.32	11.22	5.84	28.25

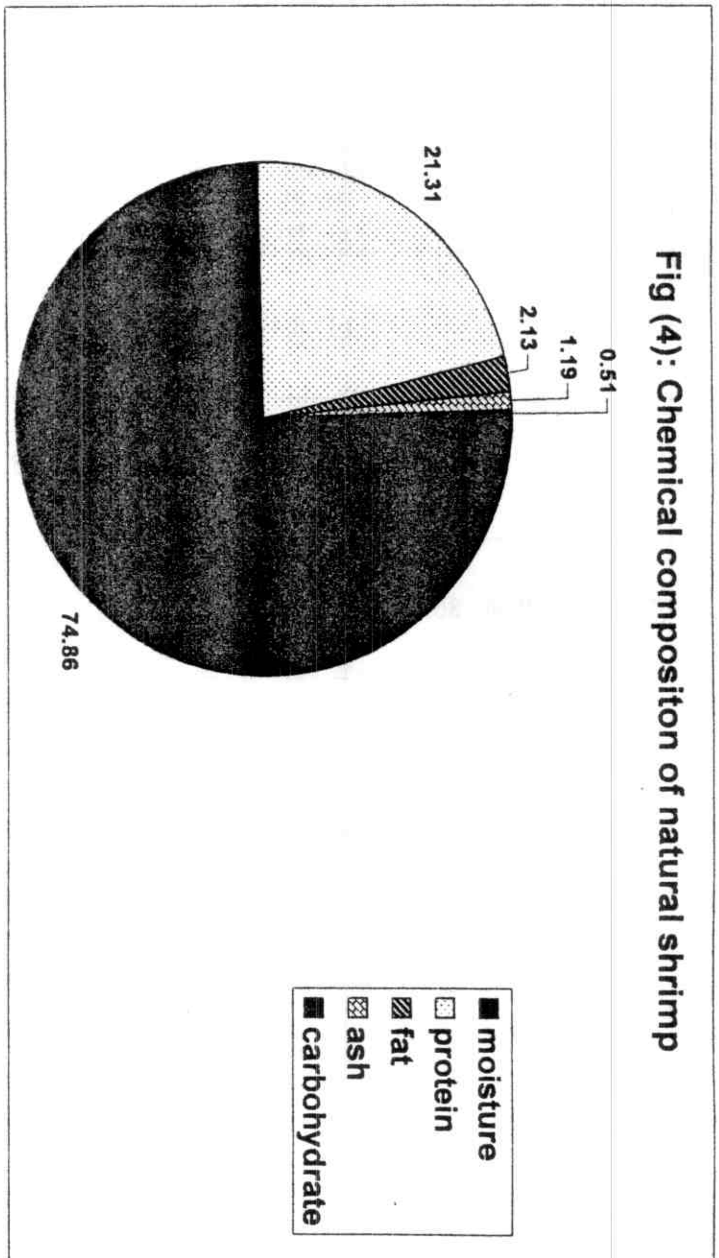


Fig (4): Chemical compositon of natural shrimp

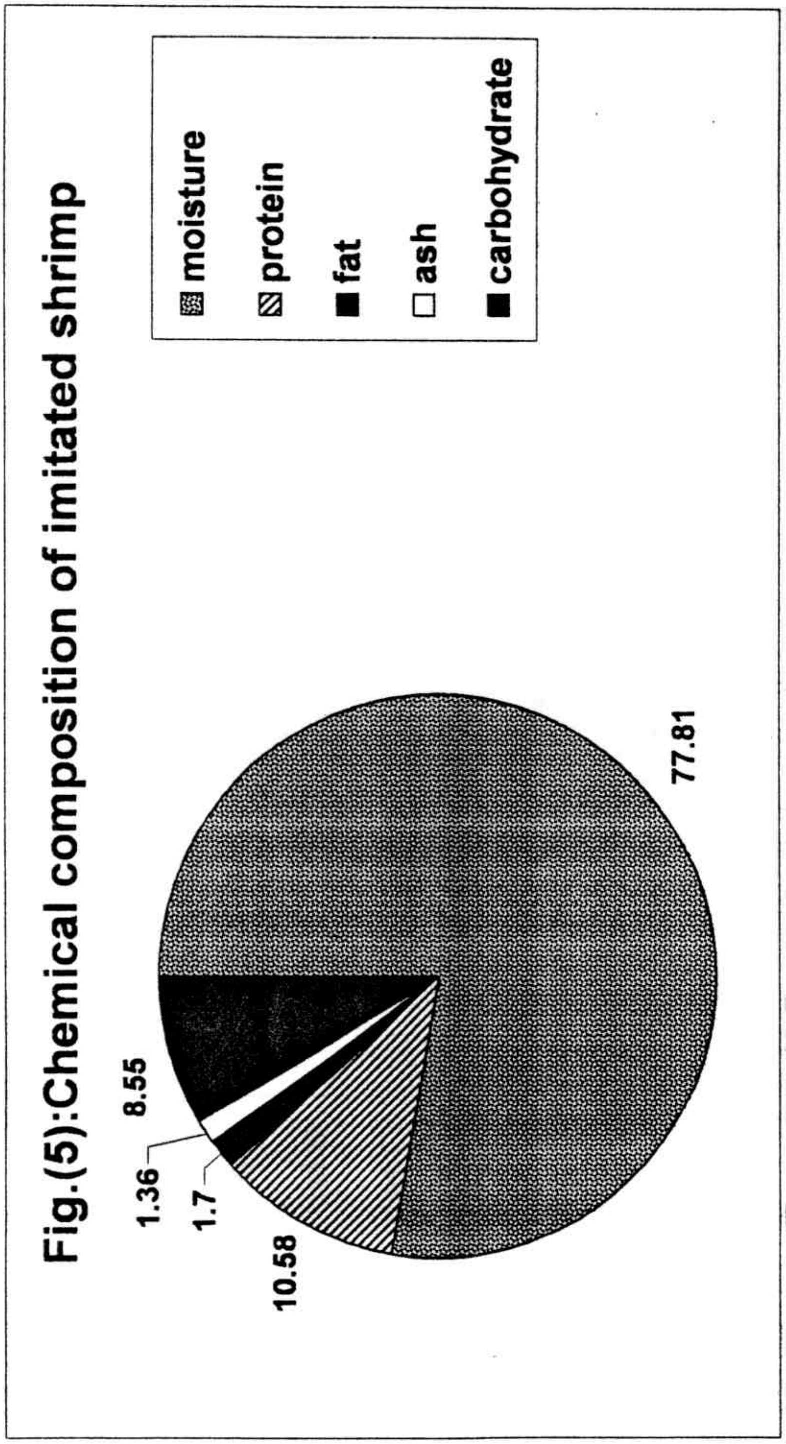


Fig.(5):Chemical composition of imitated shrimp

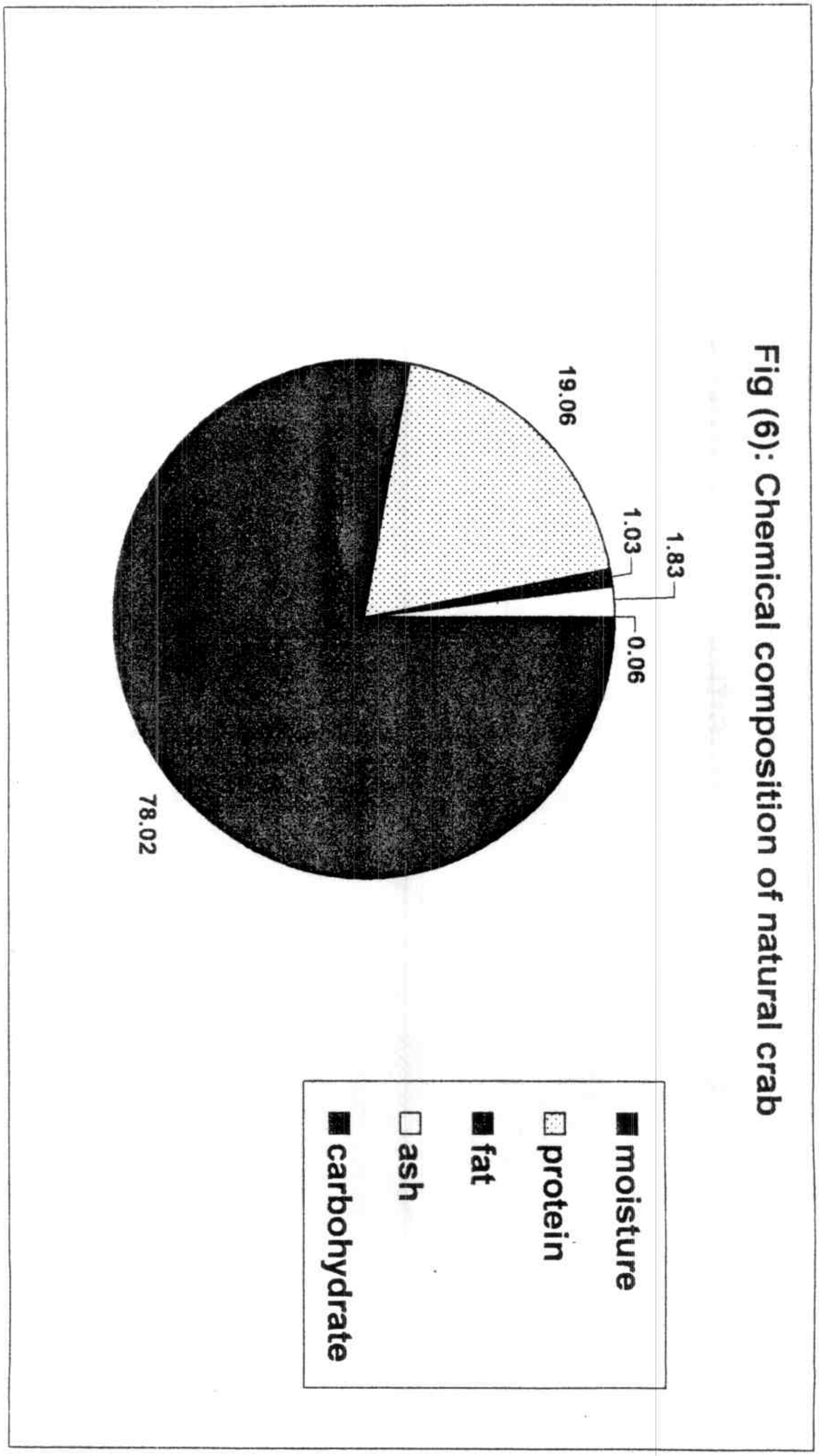


Fig (6): Chemical composition of natural crab

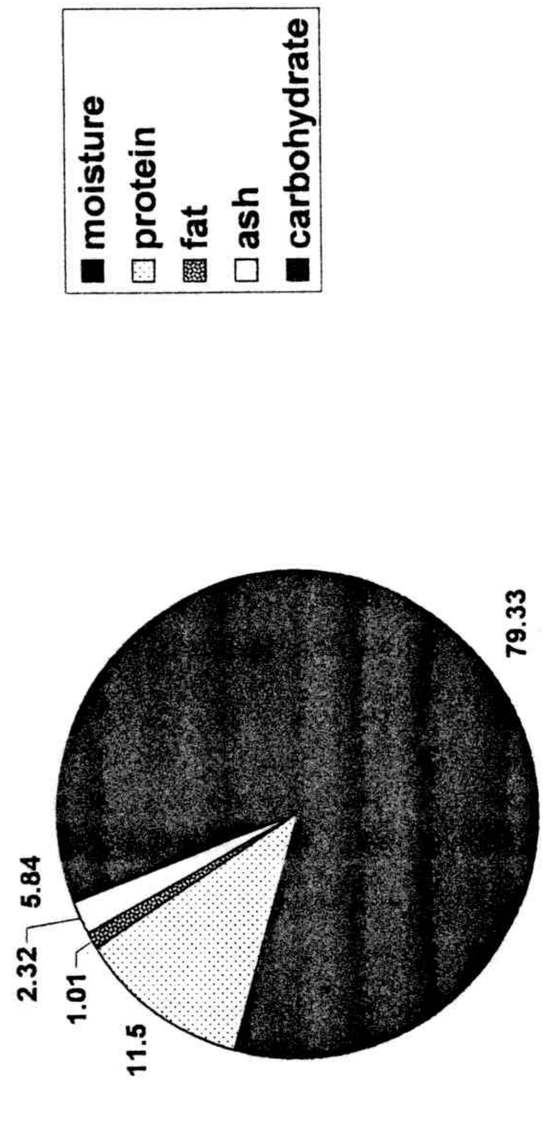


Fig (7): Chemical composition of imitated crab

Effect of cooking process on chemical attributes of natural and imitated of shrimp and crab:-

Heat is added to foods for three primary reasons:

To cook or "make a food taste good", to pasteurize a food, which eliminates microorganisms that cause public health problems and prolongs the refrigerated shelf life. Often this factor is combined with item (1) above and to sterilize a food that is to be hermetically sealed to give it indefinite shelf life.

In addition, not only the aim of cooking process from the gel type in imitated products but also the heating (cooking process) with regard to enzymes is generally to rapidly inactivate the endogenous and bacterial enzymes to avoid deterioration in the quality of products.Cooking easily destroys the enzyme activity in fish (**Pigott and Tucker, 1990 & Sikorski and Pan, 1994).**

Table (11) shows the effect of cooking process on some chemical attributes (salt extractable protein, total volatile nitrogen, thiobarbituric acid, pH value and water holding capacity) of natural and imitated of shrimp and crab.

Salt extractable protein (SEP): -

Data in Table (11) indicate that the SEP of natural and imitated shrimp samples before cooking process were 32.7 and 53.4 %, respectively. It is clear that the cooking process caused a decrease in SEP % of natural and imitated shrimp and reached to 25.8 and 47.4 % after heat treatment, respectively. This decrease in SEP % may be due to denaturation and aggregation of protein by heating.

These results are in agreement with those obtained by **Holmquist, *et al.*, (1984) and Park, *et al.* , (1996).**

Total volatile nitrogen: -

Results in Table (11) indicate that TVN of natural and imitated shrimp slightly decreased after cooking process from 24.6 and 2.11 mg/100g sample to 24.2 and 1.69 mg/100g, respectively. These results are in agreement with those obtained by **Ghaly, (1995)** who found that the cooking process decreased the TVN of Suez shrimp.

This decrement may be due to the water-soluble nitrogen fraction such as mono methylamine, dimethylamine, etc., **(Amin, 1997)**.

Similarly, the TVN of natural and imitated crab showed a slight decrease by cooking process as it decrease from 22.3 and 1.83 mg N / 100g sample before heating to 22 and 1.45 mg N / 100 g, respectively.

These results are in agreement with those obtained by **Yoon, *et al.*, (1988) and Gillman and Skonberg , (2002).**

Generally, it could be noticed that process of either natural or imitated shrimp and crab caused a slight reduction in total volatile nitrogen.

Thiobarbituric acid value:-

The same Table indicate also that the thiobarbituric acid (TBA) values of natural and imitated shrimp were 0.11 and 0.49 mg malonaldehyde / kg sample before cooking process and reached to 0.19 and 0.58 mg malonaldehyde / kg after cooking process, respectively.

These results are in agreement with those obtained by **Ghaly, (1995)** who found that the TBA values of fresh and cooked shrimp were 0.101 and 0.125 mg malonaldehyde / kg., respectively.

The same pattern was also observed the TBA values of natural and imitated crab after cooking process as the TBA values were slightly increased from 0.15 and 0.39 mg malonaldehyde / kg Before cooking to 0.21 and 0.44 mg malonaldehyde / kg by exposing to heating process, respectively. These results are in agreement with those obtained by **Gillman and Skonberg, (2002)**.

This increment in TBA value for natural and imitated shrimp and crab may be due to the drastic responses to cooking temperature > 60 $^{\circ}$C. The increase in cell disintegration and the changes in hemoprotein which acting as a pro-oxidative forms **Undeland, *et al.* , (1998).**

Water holding capacity (WHC)

From Table (11) it could be noticed that the cooking process lead to a decrease of WHC % for imitated shrimp and crab.

The WHC % was decreased from 90.1 and 89.7 % before cooking to 86.3 and 83.1 % after cooking process for shrimp and crab respectively. These results are in agreement with those obtained by **Alvarez, *et al.* , (1992).**

This decrement of WHC % for imitated fish under taken may be attributed to heating process which cause the denaturation of protein, as well as aggregation and interaction between protein – protein molecules to form the gel network structure which responsible of the final texture of imitated fish.

In addition, **Suzuki, (1981)** reported that raw surimi had a higher WHC % than frozen and cooked surimi. The water binding was linked to the formation of a stable gel network and its ability to entrap water inside this structure (**Honikel and Hamm, 1994).**

pH value:

pH value is the most important factor governing texture in cooked fish, pH apparently exerts its effect on the texture of fish muscle by influencing the contractile elements since, fish collagen is disrupted by normal cooking. (**Hultin, 1985).**

The same Table illustrates also, that the pH values of natural and imitated shrimp were 6.83 and 6.77 before cooking process and slightly increase after cooking reached to 6.88 and 6.88, respectively.

It could be noticed that there was a slightly increase in pH of natural and imitated crab after cooking which were 6.74 and 6.86 before cooking process and reached to 6.84 and 6.91 after cooking process.

This results are in agreement with those obtained by **Yoon *et al.*, (1988)** who reported that the pH value of imitated crab was 7.1.

Table (11): Effect of cooking process on physical and chemical attributes of shrimp and crab.

Products / Parameters	Shrimp				Crab			
	Natural		Imitated		Natural		Imitated	
	A	B*	A	B*	A	B*	A	B*
% SEP	32.70	25.80	53.40	47.40	34.50	29.10	46.80	39.49
TVN	24.60	24.20	2.11	1.69	22.30	22.00	1.83	1.45
TBA	0.11	0.19	0.49	0.58	0.15	0.21	0.39	0.44
pH	6.83	6.88	6.77	6.83	6.74	6.84	6.86	6.91
%WHC	53.3	49.1	90.10	86.30	48.6	44.2	89.70	83.10

A (before heating).
B* (After heating , Blanching for 20 min at 90 c°).
SEP (% Sal Extractable Protein).
TVN (Total Volatile Nitrogen mg /100g).
TBA (Thiobarbituric acid mg / kg).
WHC (%Water Holding Capacity).

Effect of cooking process on microbiological load of natural and imitated of shrimp and crab: -

Variations in numbers of total bacterial count; psychrophilic bacteria, yeast and mold are shown in Table (12) after heating process of natural and imitated shrimp and crab.

It could be noticed that the microbiological load sharply reduced after heating process of imitated and natural shrimp and crab.

From the results in Table (12) the total bacterial count, psychrophilic, yeast and mold of natural shrimp were 4.3×10^5, 7.3×10^3, 4.3×10^2 and < 10 cfu / g. before thermal process and reached to 3.2×10^2, 3.0×10^2, < 100 and < 10 cfu / g., respectively.

This results are in agreement with those obtained by **El-Fouly, *et al.*, (1987)** who found that the blanching process when applied alone was effective to reduce at least one log cycle of psychrophilic.

On the other hand, these reduction in the bacterial numbers increased the shrimp shelf – life for about 3 days than the untreated when stored at 3 °C.

From the same Table the total bacterial count, psychrophilic bacteria, yeast and mold of imitated shrimp were 2.6×10^5, 4.2×10^4, 3.2×10^2 and <100 cfu / g. before heating process and reached to 2×10^2, 1×10^2, < 10 and < 10 cfu / g. after heating process, respectively.

Those results are in agreement with those obtained by **Ingham, (1991)** who found that the native microbial load of surimi varies depending on the length of time that fish held before processing and surimi made on board ship had a mean Aerobic plate count of 10^4 cfu / g while, surimi produced on shore had a mean aerobic plate count of 10^6 cfu / g.

Table (12) indicate that the total bacterial count, psychrophilic, yeast and mold of natural crab were 7.1 x 10^4, 6.9 x 10^4, < 100 and < 100 cfu / g., before heating process and reached to 8 x 10^2, 2.1 x 10^2, <10 and < 10 cfu / g., after heating process, respectively.

From the same table the total bacterial count, psychrophilic, yeast and mold of imitated crab were 8.1 x 10^5, 3.9 x 10^4, 2.1 x 10^2 and < 100 cfu / g before thermal process and reached to 1.1 x 10^2 , 5.3 x 10 , <10 and <10 cfu / g., respectively.

Table (12): Effect of cooking process on microbiological load of shrimp and crab (Natural and Imitated).

Products / Microbial counts	Shrimp				Crab			
	Natural		Imitated		Natural		Imitated	
	A	B*	A	B*	A	B*	A	B*
Total bacterial	$4.3x10^5$	$3.2x10^2$	$2.6x10^5$	$2x10^2$	$7.1x10^4$	$8x10^2$	$8.1x10^5$	$1.1x10^2$
Psychrophilic	$7.3x10^3$	$3x10^2$	$4.2x10^4$	$1x10^2$	$6.9x10^4$	$2.1x10^2$	$3.9x10^4$	5.3x10
Yeast	$4.3x10^2$	<100	$3.2x10^2$	<10	<100	<10	$2.1x10^2$	<10
Mould	<10	<10	<100	<10	<100	<10	<100	<10

A (before heating).
B* (After heating , Blanching for 20 min at 90 c°).

Effect of gamma irradiation and cold storage on the sensory properties as well as shelf-life of imitated shrimp:-

Physical and chemical analyses are useful as a wide indicator of food quality, but it cannot be accurately used to predict it sensory quality. Moreover, sensory tests are the final guide to assure the product quality.

All imitated shrimp under investigation were submitted to panelists to evaluate the changes in the sensory properties i.e. color, odor, taste, texture and overall acceptability percentages and the degrees of panelists are recorded in Table (13). The results indicate that no changes in the sensory properties were observed by treated samples with gamma irradiation doses.

Similar observations were noticed by many investigators **Picoini, *et al.*, (1986) El-Fouly, *et al.*, (1987); Poole, *et al.*, (1990); Al-Kahtani, *et al.*, (1996) and Bassiouny, *et al.*, (2002)** as they found that no changes in the organoleptic properties of irradiated seafood and their products post irradiation.

The same table showed also that the control imitated shrimp samples that stored at 4±1 °C remained fresh and acceptable during the first 7 weeks of storage, while the samples were rejected by the panelists after 8 weeks of storage at 4±1 °C.

The samples were rejected due to the visible mold growth and softening of the texture.

Moreover, irradiated imitated shrimp samples at doses of 1, 3 and 5 kGy were rejected after 13,17 and 25 weeks of cold storage, respectively. Obviously, an existed relationship between the increase in the sensory scores and those of the bacterial counts. Thus , it can be noticed that the delayed spoilage in irradiated samples were mainly due to radiation survivors (mostly Gram positive organisms) which are not as active growers as radiation sensitive (Gram negative organisms) **(Barnes, 1960).**

Generally, it could be concluded that application of gamma irradiation at doses of 1, 3 and 5 KGy could be used to prolong the shelf-life of imitated shrimp samples under cold storage for 12, 16 and 24 weeks respectively, without the alteration of their sensory properties.

Table (13):Effect of cold storage on sensory evaluation of irradiated imitated shrimp

Storage Period (weeks)	Control				Radiation Dose (kGy)											
					1				3				5			
	color	odor	taste	texture	color	odor	Taste	texture	color	odor	taste	texture	color	odor	taste	texture
0	11.0	23.5	24.0	19.85	10.5	23.3	23.5	19.5	10.6	23.2	23.4	19.4	10.4	23	23.2	19.3
1	11.0	23.3	23.5	19.5	10.7	23.2	23.5	19.4	10.5	23.1	23.3	19.3	10.3	22.4	23	19.2
2	10.8	23.0	23.3	19.3	10.7	23.0	23.3	19.3	10.3	23.1	23.3	19.2	10.2	22.0	23	19.0
3	10.5	22.3	23.0	19.0	10.6	23.0	23.1	19.0	10.0	23.0	23.0	19.0	10.0	22.0	22.3	18.8
4	10.3	22.4	22.8	18.5	10.5	22.7	22.6	19.0	9.7	22.7	23.0	18.7	10.0	22.0	22.1	18.6
5	10.0	22.0	22.5	18.0	10.5	22.5	22	18.5	9.5	22.5	23.0	18.5	9.8	21.8	22.0	18.4
6	9.8	22.0	22.0	17.2	10.3	22.2	22	18.4	9.3	22.3	22.7	18.3	9.7	21.5	21.7	18.0
7	9.0	21.0	21.0	17.0	10.2	22.0	21.5	18.3	9.0	21.8	22.0	18.0	9.7	21.4	21.4	18.0
8	8.0	15.0	10.0	9.0	10.0	21.5	21.2	18.0	8.8	21.0	21.7	17.9	9.6	21.3	21.3	17.7
9	R	R	R	R	9.0	21.0	21.0	18.1	8.7	20.6	21.3	17.7	9.5	21.2	21.1	17.3
10	-	-	-	-	8.5	21.0	20.0	17.8	8.5	20.0	21.0	17.6	9.4	21.0	21.0	17.0
11					8.0	18.0	19.0	17.5	8.4	18.7	20.7	17.5	9.3	21.0	20.7	16.8
12					7.0	15.0	18.0	17.0	8.2	18.0	20.2	17.3	9.2	20.7	20.5	16.5
13					5.0	10	9.0	10	8.0	17.0	20.0	17.0	9.0	20.5	20.3	16.2
14					R	R	R	R	7.9	16.2	19.0	16.0	8.8	20.4	20.2	16.0
15					-	-	-	-	7.5	16.0	18.0	15.5	8.6	20.3	20.0	15.8
16									7.3	12.0	15.0	14.0	8.5	20.2	19.7	15.4
17									7.0	10.0	13.0	11.0	8.4	20.0	19.2	15.2
18									R	R	R	R	8.2	19.2	19.0	15.0
19									-	-	-	-	8.0	19.0	18.7	14.9
20													7.5	18.3	18.4	14.1
21													7.0	16.8	18.0	14.0
22													6.4	13.2	17.6	13.2
23													6.0	12.0	17.4	12.4
24													5.5	11.1	15.0	11.1
25													4.8	10.0	12.0	10.0

R= Rejected

- (experiment did not continued because of mould growth) .

Effect of gamma irradiation on the microbiological quality of imitated shrimp during cold storage

Total bacterial count:

The total mesophilic plate count is widely used as an indication of the microbiological quality of foods unless they are known to contain large numbers of bacteria as a natural consequence of their preparation such as chilled fish and fish products (**Adams and Mass, 1995).** Total bacterial counts of control and irradiated imitated shrimp under investigation were determined during cold storage (4 ± 1 °C) and the results are tabulated in Table (14) and Fig (8).

From these results it is clear that the mean of the initial total bacterial counts of the control samples was $2x10^2$ cfu / g. The results a greed with those obtained by **Yoon, *et al.*, (1988) and Ingham, (1991),** they found that the Aerobic plate count of freshly processed crab leg and flaked crab leg analogs had very low initial microbial counts (10^2 – 10^3 cells / g.).The low initial Aerobic plate count of control sample due to lethal effect of heat treatment on the microbial load of samples during cooking process at 88 °C for 15 min. **(Matches, 1982 and Layrisse and Matches, 1984).**

Subjecting imitated shrimp samples to gamma irradiation caused a great reduction in total bacterial counts, and this reduction was proportional with radiation dose. The total bacterial counts of irradiated imitated shrimp at doses of 1 KGy was reduced by 55% as the counts reached $1.1x10^2$ cfu / g.

Moreover, no viable counts could be detected in samples irradiated at 3 and 5 kGy doses. The great reduction in the bacterial load is mainly due to the direct and indirect effects of gamma irradiation on the microorganisms as reported by **Hammad, (1985) Poole, *et al.*, (1990), Shawki, (1998).**

During cold storage of sample undertaken the total bacterial counts generally increased as storage period increased and these increases were much higher in control samples than irradiated one. The total bacterial counts reached 7.3×10^7;2.1×10^7; 7.1×10^6 and 8×10^6 cfu / g. after 8; 13; 17 and 25 weeks of cold storage for control sample and those irradiated at doses of 1; 3 and 5 kGy, respectively. While no counts could be detected in irradiated samples at doses 3 and 5 kGy after 6 and 12 weeks, then counts were increased and reached $7.1x10^6$ and $8x10^6$ cfu / g after 17 and 25 weeks of cold storage for these samples, respectively. From these results, it is clear that gamma irradiation samples of imitated shrimp had a total bacterial counts lower than those of control ones. The total counts observed in the irradiated samples may be due to the presence of a few numbers of aerobic bacterial cells and / or spores that could survive even upon exposure to the high doses used and grow at low temperatures **(Anderson, 1983).**

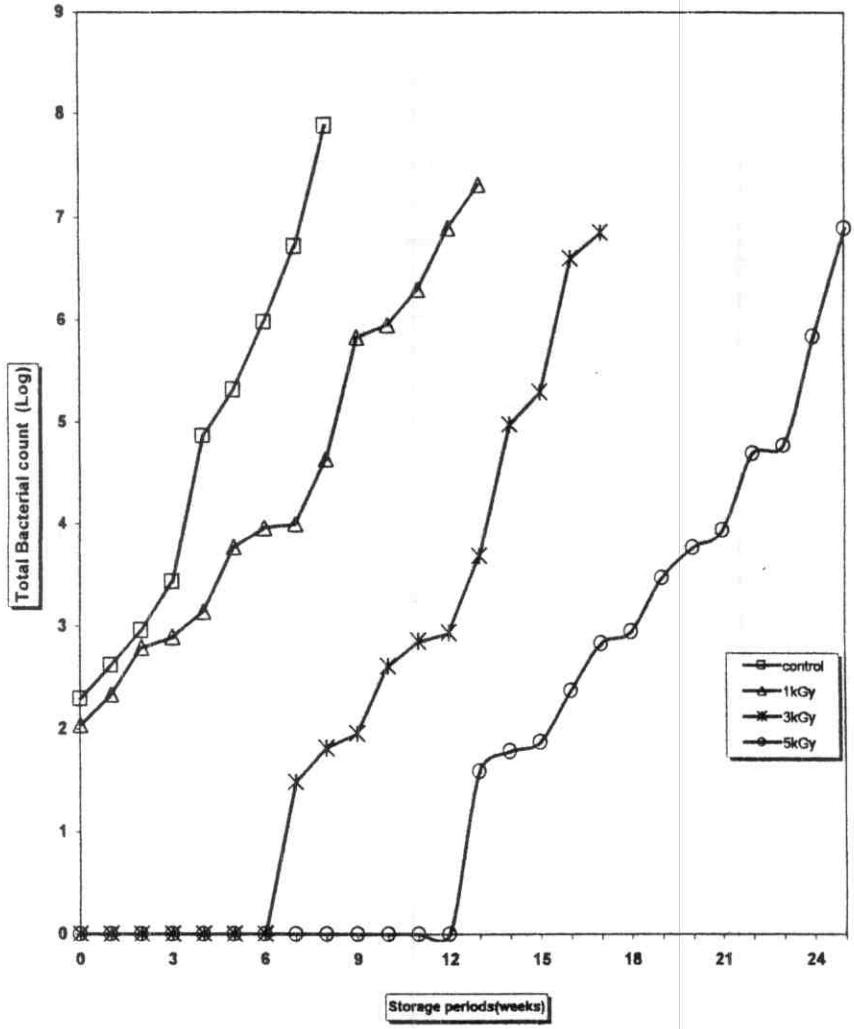
These findings are in agreement with those obtained by **El-Fouly, *et al.*, (1987); Poole, *et al.*, (1990) and Bassiouny, *et al.*, (2002).**

Generally, it could be concluded that the applied doses of gamma irradiation were more effective in reducing the total bacterial counts of imitated shrimp samples under investigation.

Table (14): Effect of gamma irradiation on the Total bacterial count (cfu / g) of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	$2x10^2$	$1.1x10^2$	ND	ND
1	$4.3x10^2$	$2.2x10^2$	ND	ND
2	$9.2x10^2$	$6.4x10^2$	ND	ND
3	$2.7x10^3$	$8.2x10^2$	ND	ND
4	$7.4x10^4$	$1.4x10^3$	ND	ND
5	$2.1x10^5$	$6x10^3$	ND	ND
6	$9.7x10^5$	$9.2x10^3$	ND	ND
7	$5.3x10^6$	$1x10^4$	$3.1x10^1$	ND
8	$7.3x10^7$®	$4.3x10^4$	$6.7x10^1$	ND
9		$6.8x10^5$	$9.3x10^1$	ND
10		$9x10^5$	$4.2x10^2$	ND
11		$2x10^6$	$7.3x10^2$	ND
12		8.210^6	$8.9x10^2$	ND
13		$2.1x10^7$®	$5x10^3$	$4.2x10^1$
14			$9.7x10^4$	$6.3x10^1$
15			$2x10^5$	$7.7x10^1$
16			$4x10^6$	$2.4x10^2$
17			$7.1x10^6$®	$7x10^2$
18				$9x10^2$
19				$3 x10^3$
20				$6 x10^3$
21				$8.8 x10^3$
22				$5 x10^4$
23				$6 x10^4$
24				$7 x10^5$
25				$8 x10^6$®

® Rejected
ND= Not Detected



Fig(8): Effect of gamma irradiation on total bacterial count of imitated shrimp during cold storage

Total psychrophilic bacteria:

The enumeration of psychrophilic microorganisms 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. Raw foods held under refrigeration prior to processing, as well as non sterile heat processed food that really on refrigeration for shelf-life, are subjected to quality loss and possible spoilage by psychrophilic bacteria (**Gilliand, *et al.*, 1984**).

Table (15) and Fig (9) shows the effects of gamma irradiation on the total psychrophilic bacteria in imitated shrimp samples under investigation during cold storage (4 ±1 °C). These data reveal that the initial count of total psychrophilic bacteria was $1x10^2$ cfu / g for control samples of imitated shrimp before storage.

It is evident from the obtained results that gamma irradiation greatly reduced the total psychrophilic bacterial count presented in all imitated shrimp samples under investigation, the counts reduced to 1x10 cfu / g for samples received 1 kGy gamma irradiation dose. Meanwhile, the counts of psychrophilic bacteria were not detected in irradiated samples at doses of 3 and 5 kGy. This reduction in the counts of psychrophilic bacteria is mainly due to the destructive effect of gamma irradiation on microorganisms, which are major factors in imitated shrimp spoilage even under cold storage conditions.

During cold storage (4 ±1 °C) of imitated shrimp, the counts of total psychrophilic bacteria increased for control samples where, the psychrophilic count reached 2×10^4 cfu / g for control sample after 8 weeks while irradiated sample at dose 1 kGy reached 9 x 10^4 cfu / g after 13 weeks. On the other hand, the counts of total psychrophilic bacteria not detected during cold storage for irradiated samples at doses 3 and 5 kGy after 17 and 25 weeks.

Generally, it could be concluded that the applied doses of gamma irradiation were effective for improving the keeping quality of irradiated imitated shrimp samples and extended their shelf life to 13, 17 and 25 weeks.

Table (15): Effect of gamma irradiation on Psychrophilic bacteria counts (cfu / g) of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	$1.0x10^2$	$2.0x10^1$	ND	ND
1	$4.0x10^2$	$7.0x10^1$	ND	ND
2	$7.0x10^2$	$2.3x10^2$	ND	ND
3	$8.8x10^2$	$4.7x10^2$	ND	ND
4	$3.0x10^3$	$7.0x10^2$	ND	ND
5	$5.0x10^3$	$2.8x10^3$	ND	ND
6	$9.0x10^3$	$4.1x10^3$	ND	ND
7	$9.8x10^3$	$6.6x10^3$	ND	ND
8	$2.0x10^4$®	$8.9x10^3$	ND	ND
9		$1.0x10^4$	ND	ND
10		$2.7x10^4$	ND	ND
11		$4.3x10^4$	ND	ND
12		$8.0x10^4$	ND	ND
13		$9.0x10^4$®	ND	ND
14			ND	ND
15			ND	ND
16			ND	ND
17			ND®	ND
18				ND
19				ND
20				ND
21				ND
22				ND
23				ND
24				ND
25				ND®

® Rejected
ND= Not Detected

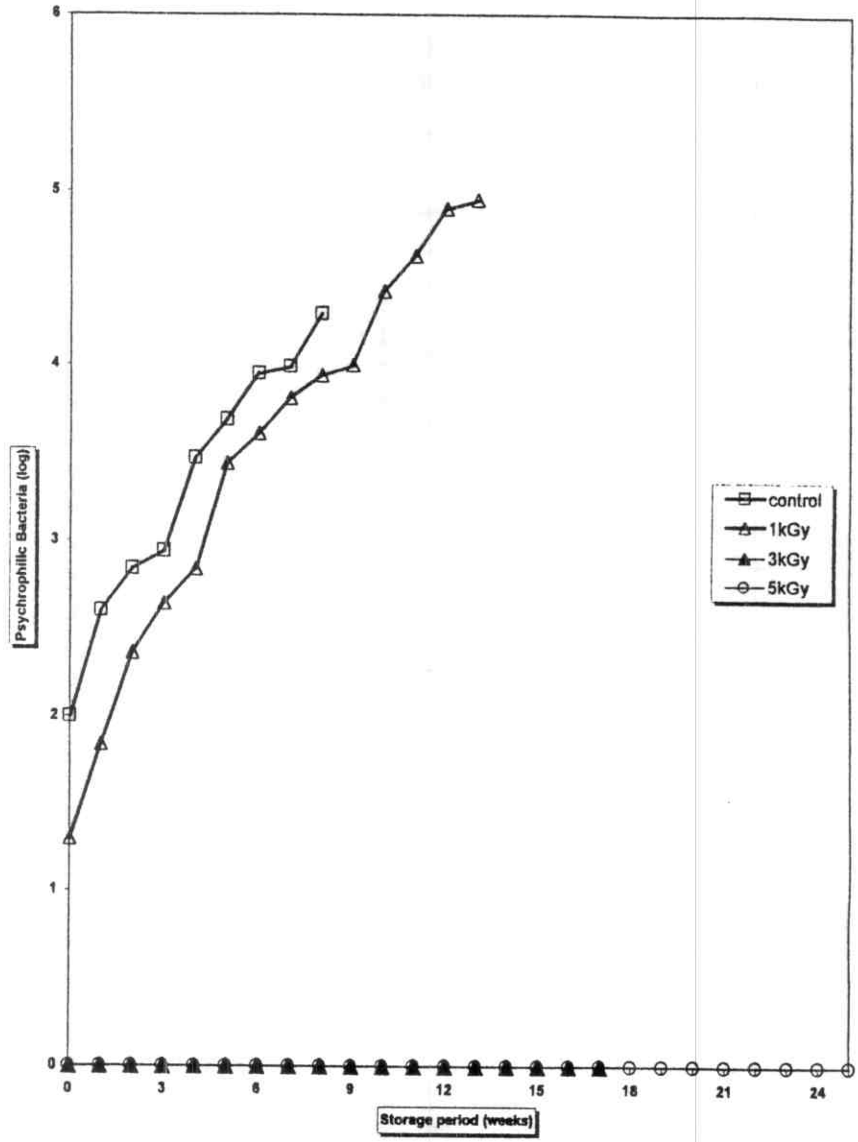


fig.(9): Effect of gamma irradiation on psycrophilic bacteria of imitated shirmp during cold storage

Total yeast :-

Data tabulated in Table (16) and Fig (10) represents the effect of gamma irradiation and cold storage at (4 ±1 °C) on the total yeast of imitated shrimp. From these data, it could be noticed that the total count yeast were <10 cfu / g for control samples of imitated shrimp. This low level of total count yeast for control samples of imitated shrimp due to probably the results of heat processing, which, effectively eliminate the yeast **(Holling Worth, *et al.*, 1991).**

It is clear that the total count yeast was not detected in irradiated samples at 1, 3 and 5 kGy gamma irradiation doses. These results are in agreement with those obtained by **Choudhury, *et al.*, (1998) and Shawki, (1998).**

The same results further show that the counts of total yeast increased during cold storage (4 ±1 °C) in all samples under investigation, but the rate of increase in control sample was higher than irradiated samples. Where, the total yeast reached 3.3 x 10^2 for control samples after 8 weeks of cold storage, while it was < 10 cfu / g for all irradiated samples.

Regarding irradiated samples, although gamma irradiation could greatly reduced the yeast counts or retarded its increase but an increase in the yeast counts could observe during cold storage. The counts of total yeast reached 2.4 x 10^2; 2 x 10^2 and 1.1 x 10^2 cfu / g after 13; 17 and 25 weeks of cold storage for irradiated samples at doses of 1, 3 and 5 kGy, respectively. Hence, the samples were sensory rejected open formation slime and visible growth mold . These results are in agreement with those obtained by **Bassiouny, *et al.*, (2002).**

Table (16): Effect of gamma irradiation on Yeast (cfu /g) of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	< 10	ND	ND	ND
1	< 10	ND	ND	ND
2	< 10	ND	ND	ND
3	$3.1x10^1$	ND	ND	ND
4	$3.2x10^1$	ND	ND	ND
5	$4.6x10^1$	<10	ND	ND
6	$5.1x10^1$	<10	ND	ND
7	$3.0x10^2$	<100	ND	ND
8	$3.3x10^2$®	<100	ND	ND
9		<100	ND	ND
10		<100	ND	ND
11		$1.0x10^2$	ND	ND
12		$1.9x10^2$	<10	ND
13		$2.4x10^2$®	<10	<10
14			<100	<10
15			<100	<10
16			$1.4x10^2$	<10
17			$2x10^2$®	<10
18				<10
19				<100
20				<100
21				<100
22				<100
23				<100
24				$1x10^2$
25				$1.1x10^2$

® Rejected
ND (not detected)

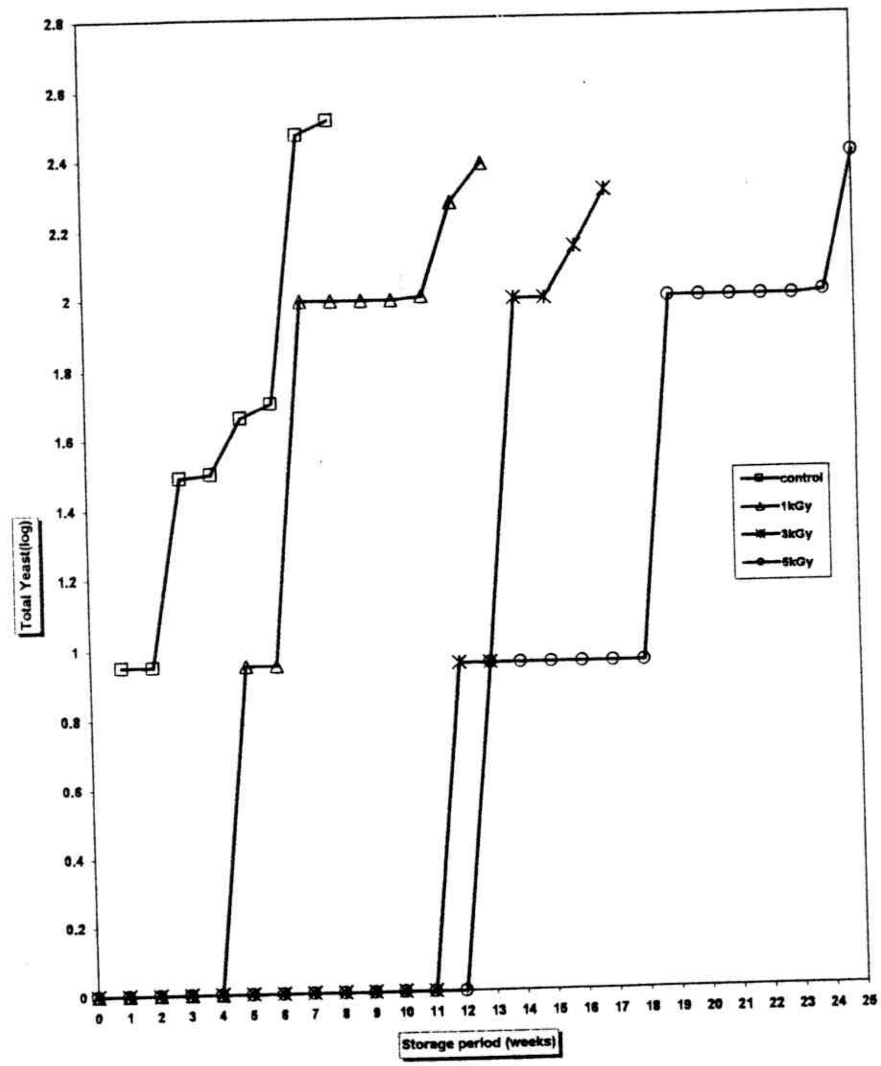


Fig.(10): Effect of gamma irradiation on the total yeast of imitated shrimp during cold storage

Total mold:-

Table (17) and Fig (11) indicates the effect of gamma irradiation and cold storage at 4 ±1 °C on the total mold of imitated shrimp.

From these data, it could be observed that the counts of total mold was <10 cfu / g for control samples of imitated shrimp. This reduce of total count mold for control sample due to heat processing, while, the total mold count was not detected in irradiated imitate shrimp samples at 1, 3 and 5 kGy gamma irradiation doses. These results are in agreement with those obtained by **Ibrahim, (1980); Choudhury, *et al.*, (1998) and Shawki, (1998).**

Regarding, irradiated samples, the count of total mold observed during cold storage. The count of total mold reached 4.1 x 10^3 cfu / g for control sample after 8 weeks of cold storage, while total mold was not also detected in irradiated samples of imitated shrimp at doses 1, 3 and 5 kGy until 10, 15 and 23 weeks of cold storage, respectively, then the counts of total mold mould started to increase and reached 3.2 x 10^3; 3 x 10^3 and 1 x 10^3 cfu / g for irradiated samples at doses 1, 3 and kGy after 13, 17 and 25 weeks of cold storage, respectively.

These results are in agreement with those mentioned by **Ibrahim, (1980); Shawki, (1998) and Bassiouny, *et al.*, (2002).**

Table (17): Effect of gamma irradiation on mould (cfu /g) of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	< 10	ND	ND	ND
1	< 10	ND	ND	ND
2	< 10	ND	ND	ND
3	< 10	ND	ND	ND
4	< 100	<10	ND	ND
5	$1.1x10^2$	<10	ND	ND
6	$1.8x10^2$	<10	ND	ND
7	$2.1x10^3$	<100	<10	ND
8	$4.1x10^3$ ®	<100	<10	ND
9		<100	<10	ND
10		<100	<10	ND
11		$1.2x10^2$	<100	ND
12		$2.1x10^2$	<100	ND
13		$3.2x10^3$ ®	<100	<10
14			<100	<10
15			<100	<10
16			$1.8x10^2$	<10
17			$3x10^3$ ®	<10
18				<100
19				<100
20				<100
21				<100
22				<100
23				<100
24				$2x10^2$
25				$1x10^3$ ®

® Rejected
ND (not detected)

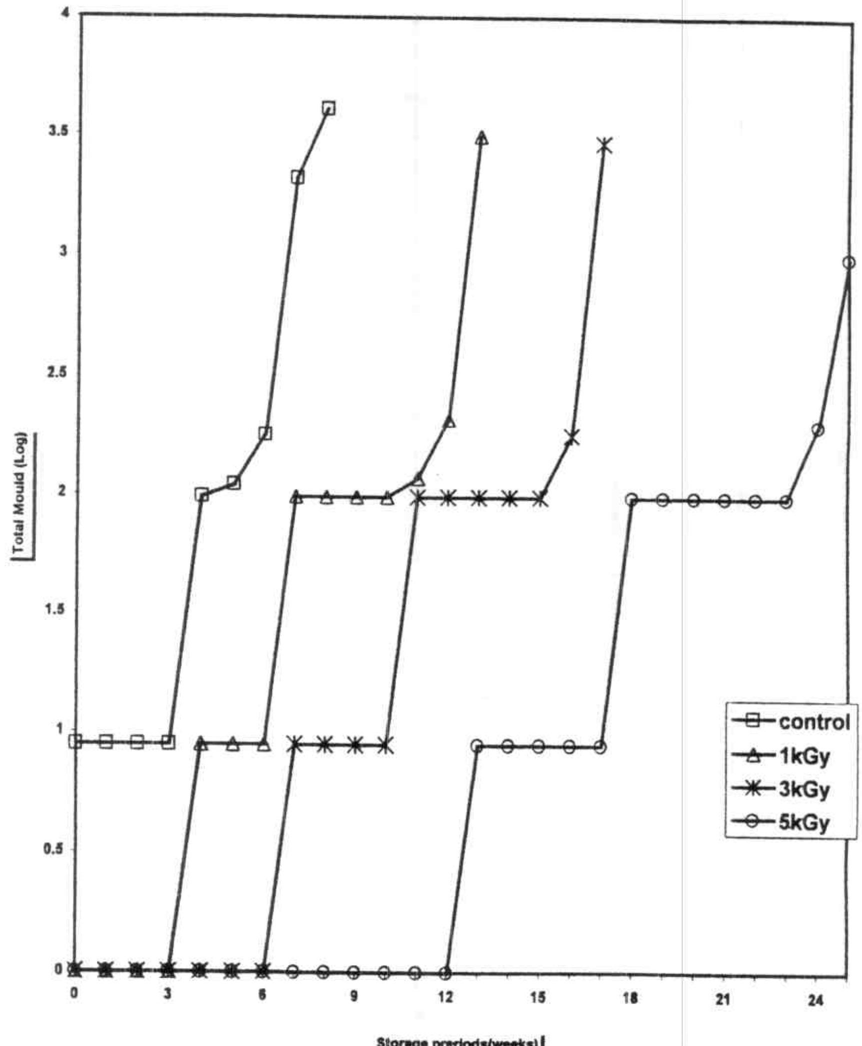


Fig.(11): Effect of gamma irradiation on total mould of imitated shirmp during cold storage

Effect of gamma irradiation on the total volatile basic nitrogen contents of imitated shrimp during cold storage:

The effect of gamma irradiation on the total volatile basic nitrogen (TVN) of imitated shrimp during cold storage is shown in Table (18) and Fig (12).

The changes in the TVBN contents are considered a chemical quality index of imitated shrimp during cold storage (4 ± 1 °C) as affected by gamma irradiation.

From the obtained results it could be observed that the content of TVN in the control sample was 1.69 mg/ 100g (on wet weight basis). These results, almost agreed with the findings obtained by **Yoon, *et al.*, (1988)**, who indicated that TVN content of imitated crab was 4.5 mg/100g.

It is obvious from the same table that gamma irradiation at different applied doses had no real changes in the TVN values of imitated shrimp samples as compared to control one. These results are in agreement with those obtained by **Ibrahim, (1980) and Shawki, (1998)** as they mentioned that gamma irradiation had no real effect on the TVN content of bolti fish and fish products.

During cold storage (4 ± 1 ° C), the TVN content increased to 19.61 mg N /100g after 8 weeks of storage for control sample of imitated shrimp.

Regarding, irradiated samples, the TVN content reached 10.91, 12.9 and 13.97 mg/100g after 13, 17 and 25 weeks of cold storage for irradiated samples at doses of 1, 3 and 5 kGy, respectively. The rate of increase in TVN content of irradiated samples at high dose levels (3 and 5 kGy) was lower than those irradiated samples at 1 kGy dose during cold storage. The increase in TVN is mainly due to the formation of basic nitrogen compounds by proteolytic bacteria. **(Yoon, *et al.*, 1988; Shawki, 1998 and El-Hanafy, 2001).**

Generally, it is clear that TVN showed a pronounced gradual increase for both non-irradiated and irradiated imitated shrimp samples with increase cold storage period, where, the rate of increase in non irradiated imitated samples was higher than in irradiated ones when they compared for the storage period.

Table (18): Effect of gamma irradiation on Total volatile Nitrogen (mg nitrogen / 100g)of imitated shrimp during cold storage.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	1.69	1.76	1.93	2.60
1	1.89	2.31	2.23	2.64
2	1.98	2.95	2.72	2.72
3	2.26	3.45	2.99	2.84
4	2.57	3.85	3.21	2.92
5	4.93	4.27	3.38	3.11
6	8.21	5.01	3.98	3.46
7	13.81	6.71	4.34	3.82
8	19.61®	7.89	5.91	4.21
9		8.31	6.32	4.87
10		8.93	6.77	5.16
11		9.35	7.12	5.88
12		9.98®	7.66	5.91
13			8.24	6.28
14			8.89	6.76
15			9.91	7.00
16			11.71	7.48
17			12.90®	8.09
18				8.58
19				9.12
20				9.71
21				10.11
22				10.81
23				11.60
24				11.90
25				13.97®

® Rejected

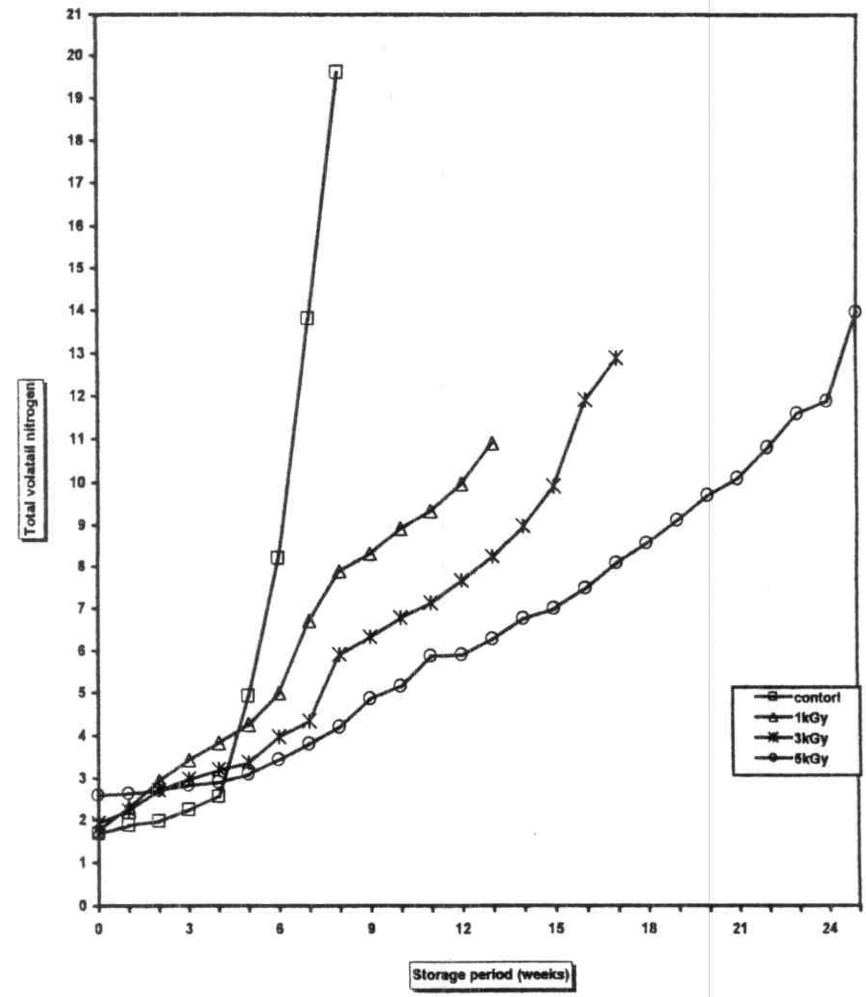


Fig.(12): effect of gamma irradiation on total volatail nitrogen of imitated shrimp during cold storage

Effect of gamma irradiation on the thiobarbituric acid (TBA) of imitated shrimp during cold storage:

TBA determines the concentration of some oxidation products, such as malonaldehyde, which are always found in fats exposed to oxidative deterioration.

Table (19) and fig (13) illustrates the thiobarbituric acid (TBA) value of imitated shrimp underinvistigation as affected by gamma irradiation and cold storage ($4 \pm 1\ ^{\circ}C$) as a parameter for the autoxidation of fish lipid. It could be noticed that, the TBA value of extracted lipid from control imitated shrimp sample was 0.58 mg malonaldehyde/kg sample. The application of gamma irradiation led to a slight gradual increase in TBA value of imitated shrimp lipids with increasing gamma irradiation dose. The TBA increased to 0.61, 0.66 and 0.70 mg/kg after subjected imitated samples to gamma ray at doses of 1, 3 and 5 kGy, respectively.

These results agreed with those obtained by **Al-Kahtani, (1996), Shawki, (1998)** who found that TBA values of fish and fish products were increased by increasing gamma irradiation doses.

This increase of TBA value as a results of these treatments might be due to the increase of aldehydes formed from the decomposition of lipid peroxides during treatments.

Moreover, TBA of all samples under investigation also, showed a gradual increase during cold storage and reached to 0.81; 0.91; 1.15 and 1.60 mg malonaldehyde/kg sample at the end of storage period for control and irradiated samples at doses of 1, 3 and 5 kGy, respectively.

The observed increase in TBA value during cold storage may be due to the decomposition of hydroperoxides (the primary initial products of lipid oxidation) to its secondary products aldehydes and ketones as mentioned by **Gray, *et al.*, (1996).**

Table (19): Effect of gamma irradiation on Thiobarbituric acid value (mg /kg) of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	0.58	0.61	0.66	0.70
1	0.58	0.64	0.69	0.73
2	0.59	0.67	0.72	0.77
3	0.60	0.70	0.76	0.79
4	0.71	0.72	0.78	0.82
5	0.74	0.74	0.80	0.84
6	0.76	0.76	0.83	0.87
7	0.78	0.78	0.85	0.89
8	0.81®	0.82	0.87	0.90
9		0.84	0.89	0.91
10		0.86	0.90	0.93
11		0.87	0.91	0.95
12		0.88	0.94	0.98
13		0.91®	0.97	1.02
14			0.98	1.09
15			1.00	1.14
16			1.02	1.19
17			1.15®	1.24
18				`1.26
19				1.29
20				1.31
21				1.38
22				1.42
23				1.49
24				1.55
25				1.60®

® Rejected

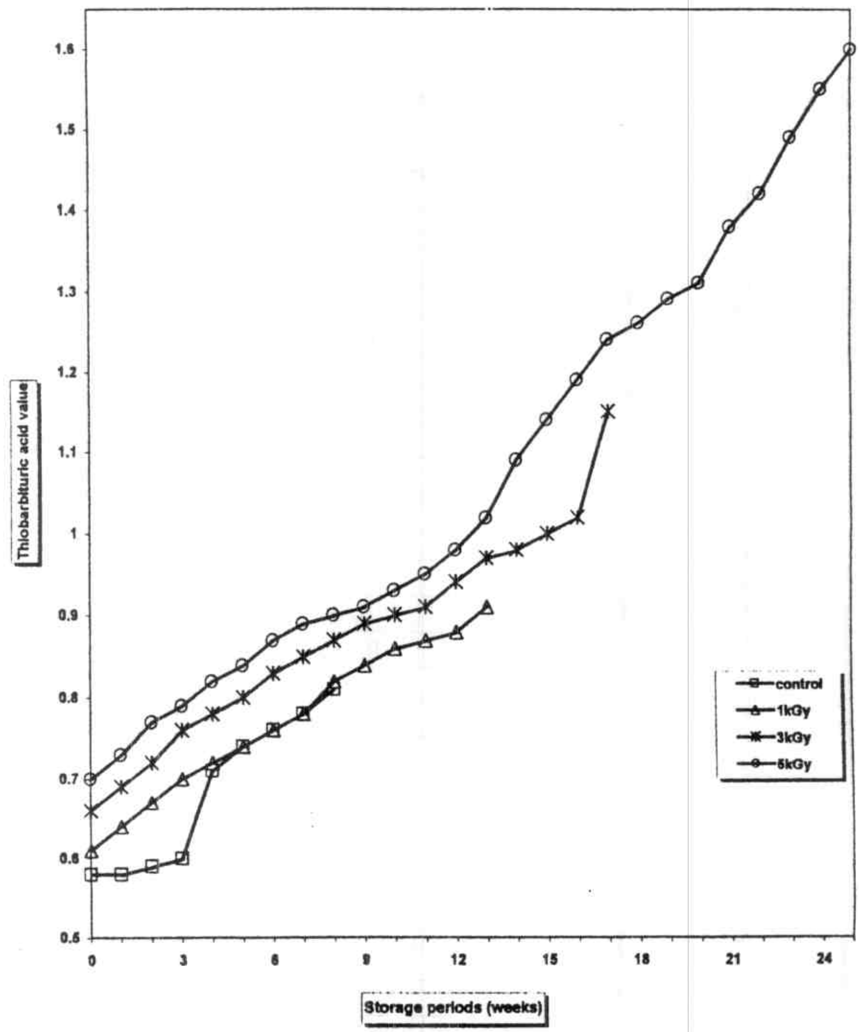


Fig (13):Effect of gamma irradiation on Thiobarbituric acid value of imitiated shrimp during cold storage

Effect of gamma irradiation and cold storage on the water holding capacity % of imitated shrimp:

Most important functional properties proteins are related to their interaction with water. Consequently, protein – water interactions determine functional properties of proteins in foods such as: water binding, water retention, swelling, solubility, emulsifying properties, viscosity, gelation and syneresis. Water binding capacity is a limiting factor in protein food applications.

Water holding capacity (WHC) plays a major role in the formation of food texture, especially in comminuted meat products and baked dough, **Zayas, (1997).**

Table (20) and Fig. (14) represent the WHC % assessed for irradiated and non-irradiated imitated shrimp post treatment and during cold storage (4 ± 1 ° C). The initial WHC % for control samples of imitated shrimp was 86.3 % and it increased after exposing by applied doses (1, 3 and 5 kGy) gamma irradiation reached to 86.80, 88.58 and 89.9 %, respectively. These results are in agreement with those obtained by **Khallaf, (1982).**

It is obvious that the irradiation process caused an increase in WHC % of imitated shrimp.

This increase in WHC % may be due to the effect of irradiation on meat protein is caused by radiolytic changes in the protein (**Zayas, 1997**).

During cold storage (4 ± 1 ° C), the WHC % decreased and reached to 76.71 % after 8 weeks of storage for control sample of imitated shrimp.

Regarding, irradiated samples the WHC % reached 77.86, 75.10 and 74.70 % after 13, 17 and 25 weeks of cold storage for irradiated samples at doses 1, 3 and 5 kGy, respectively.

These results are in agreement with those obtained by **El-Hanafy, (2001).**

This decrease in WHC % during cold storage may be due to the change in pH as a result of fast microbial growth of lactobacilli and micrococci that are predominant in imitated shrimp, water-binding capacity could decrease markedly. Accumulation of acids especially, sugar was added **(Zayas, 1997)**.

Table (20): Effect of gamma irradiation on the WHC percentage of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	86.30	86.80	88.58	89.90
1	85.00	86.13	88.00	87.99
2	84.76	85.86	87.27	87.36
3	83.42	85.00	86.42	87.15
4	81.11	84.47	85.56	86.66
5	79.93	83.10	84.67	86.18
6	78.40	82.92	83.78	85.64
7	77.13	82.30	83.20	85.00
8	76.71®	81.65	82.57	84.35
9		80.04	81.89	83.79
10		79.22	81.00	83.68
11		78.68	80.23	83.49
12		77.86	79.17	82.25
13		76.5®	78.28	81.56
14			77.47	80.78
15			76.69	79.90
16			75.95	78.86
17			75.10®	78.10
18				77.64
19				77.09
20				76.37
21				75.83
22				75.17
23				75.00
24				74.86
25				74.70®

® Rejected.

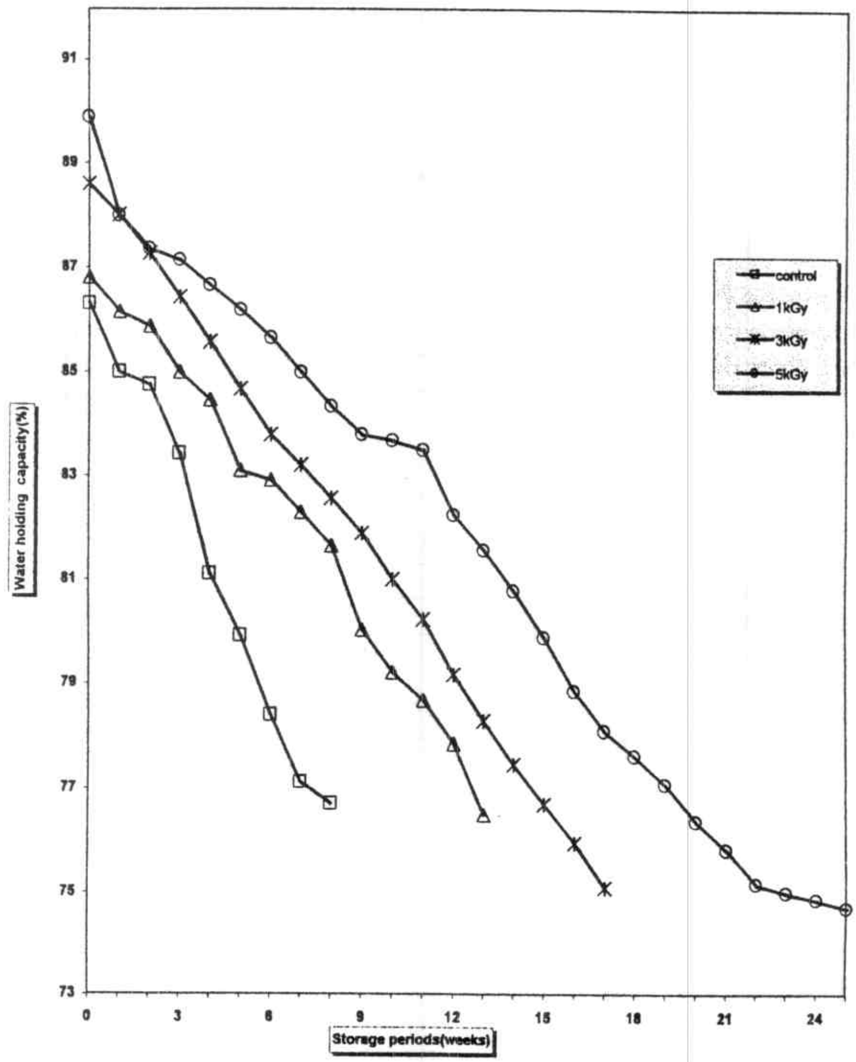


Fig (14): Effect of gamma irradiation on the water holding capacity of imitiated shrimp during cold storage

Effect of gamma irradiation and cold storage on the salt extractable protein percentage of imitated shrimp during cold storage:-

The effect of gamma irradiation on the salt extractable protein (SEP) % of imitated shrimp during cold storage is shown in Table (21) and Fig (15).

From the obtained results it, could be observed that the SEP % in the control sample was 47.40%.

It is obvious from the same table and fig that gamma irradiation at different applied doses had no effect in the SEP % of imitated shrimp samples compared to control one.

During cold storage (4 ± 1 ° C), the SEP % was slightly decreased reached to 47.1 % after 8 weeks of cold storage for control sample of imitated shrimp.

Regarding irradiated samples the SEP % reached 47.16, 47.13 and 47.03 % after 13, 17 and 25 weeks of cold storage for irradiated samples at doses of 1, 3 and 5 kGy, respectively.

These results are in agreement with those obtained by **El-Hanafy, (2001).**

Table (21): Effect of gamma irradiation on salt extractable protein percentage of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	47.40	47.40	47.38	47.36
1	47.39	47.37	47.38	47.36
2	47.35	47.36	47.37	47.35
3	47.30	47.34	47.36	47.35
4	47.26	47.33	47.35	47.34
5	47.20	47.32	47.34	47.33
6	47.15	47.30	47.32	47.31
7	47.12	47.28	47.30	47.30
8	47.10®	47.26	47.28	47.29
9		47.24	47.25	47.28
10		47.22	47.23	47.27
11		47.20	47.22	47.25
12		47.18	47.20	47.23
13		47.16®	47.19	47.21
14			47.18	47.20
15			47.16	47.18
16			47.14	47.17
17			47.13®	47.15
18				47.13
19				47.12
20				47.11
21				47.10
22				47.09
23				47.07
24				47.05
25				47.03®

® Rejected.

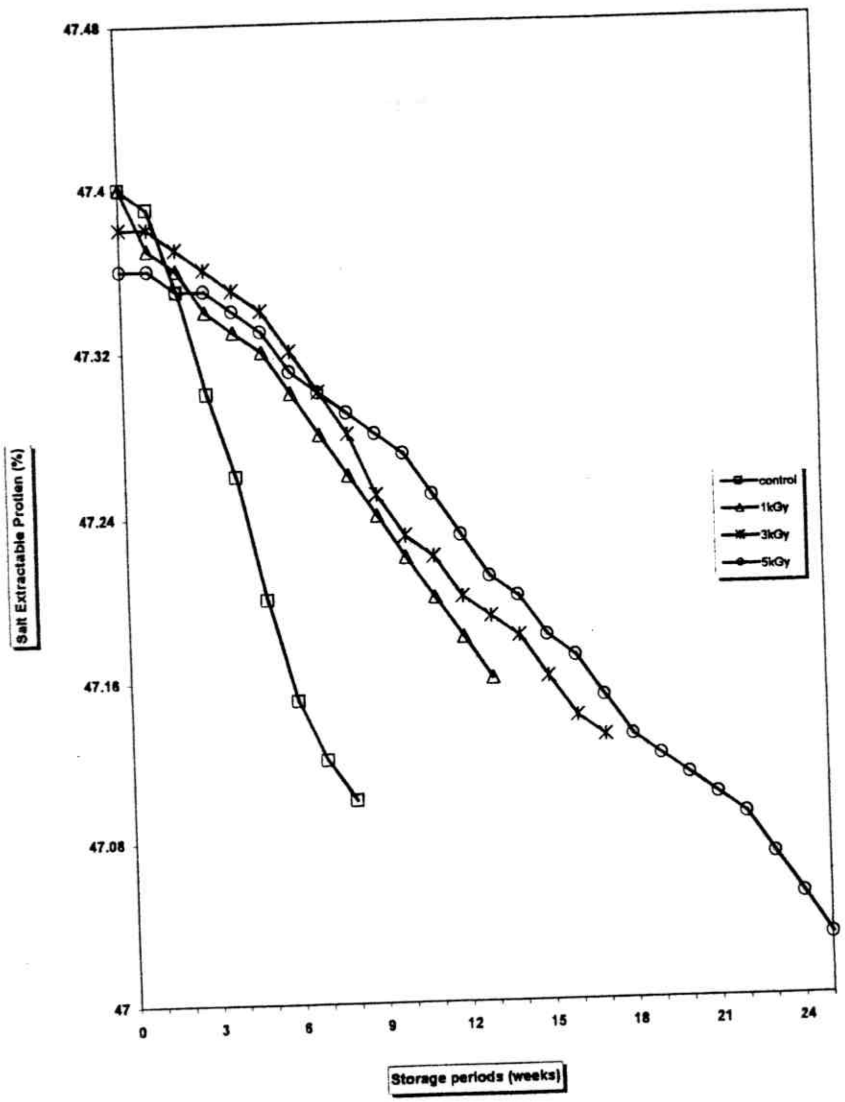


Fig (15) :Effect of gamma irradiation on the SEP of imitiated shrimp during cold storage

Effect of gamma irradiation on pH value of imitated shrimp shrimp during cold storage:

Data concerning the pH value of both control and irradiated imitated shrimp during cold storage are shown in Table (22) and Fig (16). It is obvious from these results that irradiation treatments had no real changes on the pH value of imitated shrimp samples. Where, the pH value of control sample was 6.83 while, it was 6.87, 6.89 and 6.91 for the irradiated imitated shrimp at 1, 3 and 5 kGy doses of gamma irradiation, respectively.

During cold storage, the same table indicate also, that the pH value of both irradiated and non irradiated imitated shrimp samples under investigation were clearly decreased during cold storage, but the rate of decrease in pH value of irradiated sample was lower than control due the destructive effect of gamma irradiation on the initial microbiological counts of imitated samples. The pH value of control sample reached to 5.30 after 8 weeks of cold storage. While, the pH values of the irradiated sample at doses 1, 3 and 5 kGy were 5.85, 6.10 and 6.14 after 13, 17 and 25 weeks of cold storage at ($4 \pm 1\,^{\circ}C$), respectively.

This decrement in the pH value can be attributed to the growth of microorganisms, which produced acids especially lactic acid during cold storage **(Lyver and Smith, 1998).**

These results are in agreement with those reported by **Yoon, *et al.*, (1988); Chen, *et al.*, (1996) and Lyver and Smith (1998)** who reported that the pH value of imitated crab were decreased by cold storage.

Table (22): Effect of gamma irradiation on pH value of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	6.83	6.87	6.89	6.91
1	6.61	6.86	6.88	6.90
2	6.34	6.84	6.89	6.89
3	6.21	6.80	6.87	6.88
4	6.00	6.71	6.83	6.87
5	5.91	6.65	6.80	6.88
6	5.67	6.60	6.76	6.86
7	5.40	6.54	6.73	6.85
8	5.30®	6.43	6.70	6.84
9		6.35	6.61	6.84
10		6.20	6.52	6.82
11		6.11	6.48	6.80
12		6.00	6.42	6.80
13		5.85®	6.38	6.78
14			6.34	6.71
15			6.30	6.70
16			6.23	6.66
17			6.10®	6.61
18				6.53
19				6.49
20				6.44
21				6.38
22				6.30
23				6.25
24				6.18
25				6.14®

® Rejected.

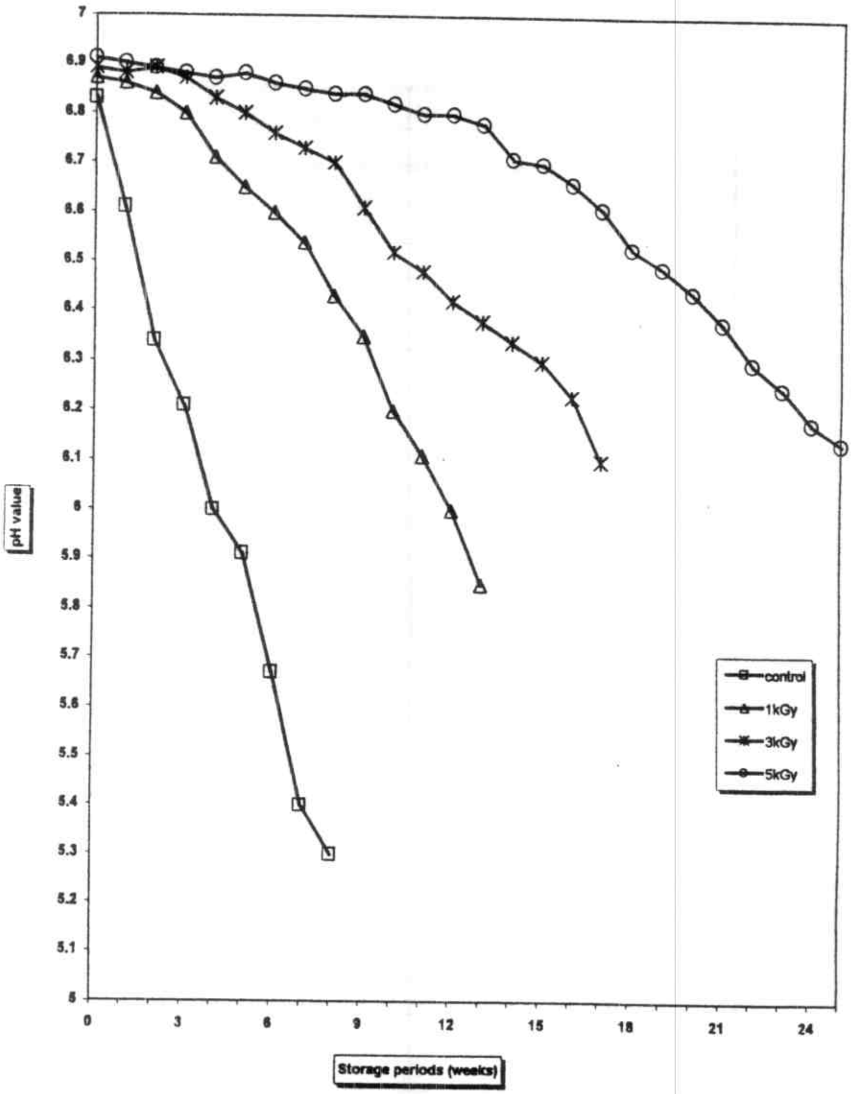


Fig (16): Effect of gamma irradiation on the pH value of imitiated shrimp during cold storage

Effect of gamma irradiation and cold storage on the chemical constituents of imitated shrimp:

Moisture content:

Data in Table (23) and Fig (17) represents the percentage of moisture content on imitated shrimp as affected by gamma irradiation and cold storage (4 ± 1 °C). The results indicate that gamma irradiation at the different applied doses (1, 3 and 5 kGy) had no real changes in the moisture content of imitated shrimp samples undertaken.

These results are in agreement with those obtained by **Ibrahim, (1980); Hammad, (1985); Shawki, (1998)** who reported that there was no detectable changes in the moisture content of fish and fish products exposed irradiation process.

Regarding to the cold storage of imitated shrimp samples, the moisture content of unirradiated and irradiated samples were slightly decreased as storage time increased. The percentage loss in moisture content of the control samples was 0.79 after 8 weeks, of storage at (4 ± 1 °C). While, these losses reached 1.81; 2.28 and 3.28 for samples received 1, 3 and 5 kGy after 13, 17 and 25 weeks during cold storage, respectively.

These results are in agreement with those obtained by **Hammad, and Bassiouny, et al., (2002)** as they found that the moisture content was decrease during cold storage of fish and fish products. This decrease in moisture content during cold storage may be due to the decrease in water holding capacity and loss of drip. **(Hammad, 1985).**

Table (23): Effect of gamma irradiation on the moisture content of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	74.69	74.60	74.33	74.28
1	74.64	74.57	74.24	74.11
2	74.56	74.52	74.12	74.00
3	74.52	74.41	74.06	73.86
4	74.49	74.28	73.86	73.77
5	74.41	74.10	73.79	73.63
6	74.30	73.97	73.51	73.55
7	74.11	73.90	73.42	73.47
8	73.90®	73.81	73.20	73.37
9		73.66	73.15	73.20
10		73.49	73.08	73.05
11		73.30	72.94	72.96
12		73.09	72.81	72.84
13		72.79®	72.60	72.72
14			72.43	72.68
15			72.31	72.59
16			72.20	72.42
17			72.05®	72.38
18				72.29
19				72.20
20				72.09
21				72.00
22				71.89
23				71.61
24				71.39
25				71.04®

®: Rejected

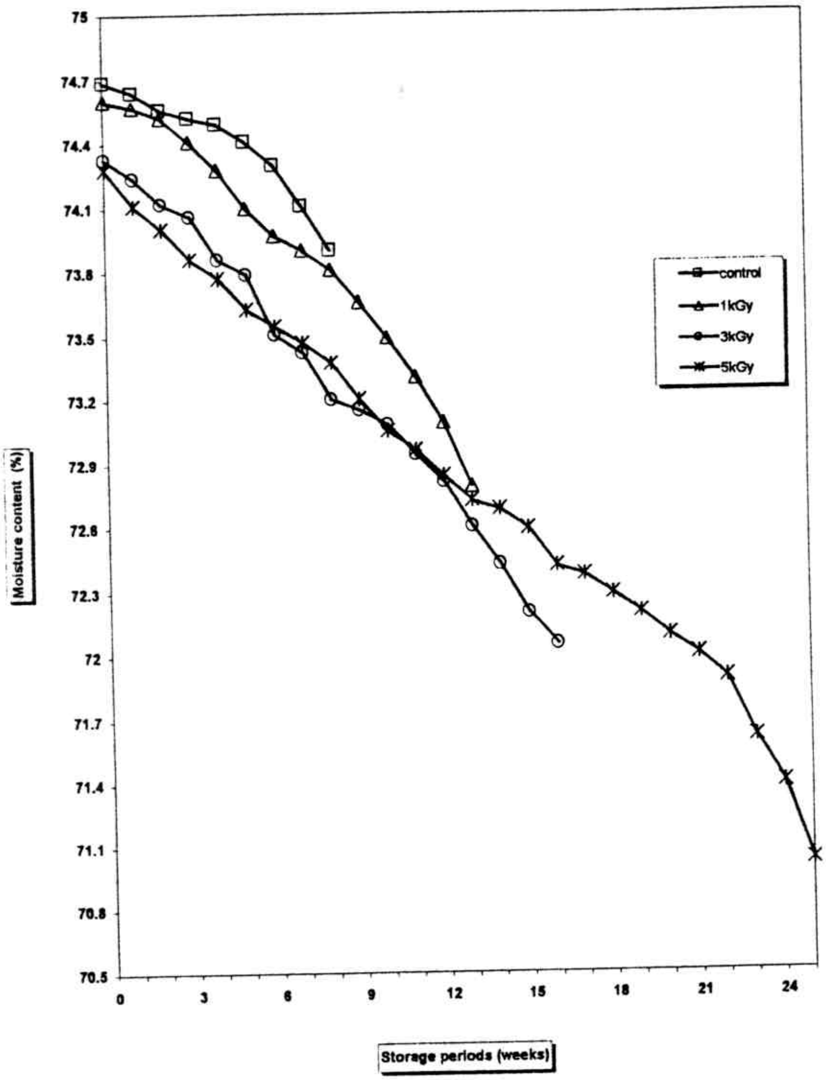


Fig (17): Effect of gamma irradiation on the moisture content of imitiated shrimp during cold storage

Crude protein:

The quality of seafood protein is high, comparable with meat and poultry. Protein from seafood is easily digested, with most species showing a protein digestibility greater than 90% **(Pigott and Tucker, 1990).**

Data tabulated in Table (24) and Fig (18) show the protein content of imitated shrimp and the influence of irradiation on it during cold storage. It is obvious from these results that the application of gamma irradiation doses (1, 3 and 5 kGy) had no remarkable effects on the protein content of imitated shrimp samples.

Science, the protein content was 47.09% for the control sample while, it was 47.08, 47,07 and 47.07% for the samples exposed to 1, 3 and 5 kGy gamma irradiation, respectively **Ibrahim, (1980) and Shawki, (1998).**

Moreover, the same table indicates also, that the protein content of all samples undertaken showed a slight decrease during cold storage and reached to 46.91, 46.71, 46.66 and 46.40 % after 8, 13, 17 and 25 weeks for control and the samples exposed to 1, 3 and 5 kGy, respectively.

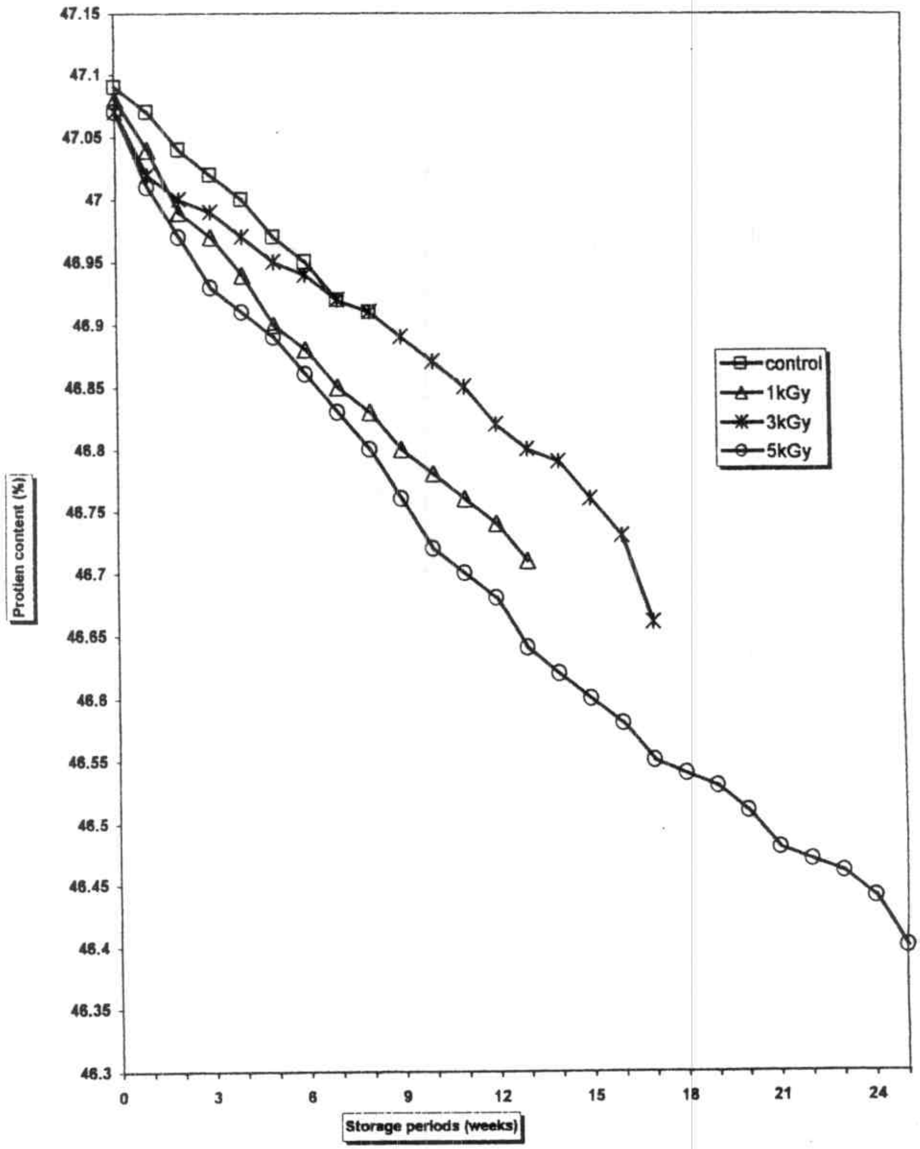
These results agreed with those found by **Ibrahim, (1980); Shawki, (1998)** who reported that the protein content was slightly decreased during cold storage for fish and fish products.

These changes might be due to the bacterial decomposition and escape of some soluble nitrogen within the separated fluid.

Table (24): Protein* content of imitated shrimp fish as affected by gamma irradiation during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (k G y)		
		1	3	5
0	47.09	47.08	47.07	47.07
1	47.07	47.04	47.02	47.01
2	47.04	46.99	47.00	46.97
3	47.02	46.97	46.99	46.93
4	47.00	46.94	46.97	46.91
5	46.97	46.90	46.95	46.89
6	46.95	46.88	46.94	46.86
7	46.92	46.85	46.92	46.83
8	46.91®	46.83	46.91	46.80
9		46.80	46.89	46.76
10		46.78	46.87	46.72
11		46.76	46.85	46.70
12		46.74	46.82	46.68
13		46.71®	46.80	46.64
14			46.79	46.62
15			46.76	46.60
16			46.73	46.58
17			46.66®	46.55
18				46.54
19				46.53
20				46.51
21				46.48
22				46.47
23				46.46
24				46.44
25				46.40®

®: Rejected
* On dry weight basis



Fig(18):Effect of gamma irradiation on the protien content of imitiated shrimp during cold storage

Crude fat:

Data in Table (25) and Fig (19) show the effect of gamma irradiation on the fat content of imitated shrimp during cold storage. It is clear that the gamma irradiation of imitated shrimp at different doses slightly decreased the fat content, as it decreased from 7.74 % for the control samples to 7.73, 7.71 and 7.68 % for the imitated shrimp exposed to 1, 3 and 5 kGy, respectively.

It could be noticed also that, the fat content of control and irradiated imitated shrimp showed a minor changes during cold storage at (4 ± 1 °C).

The fat content of control sample was decreased from 7.74% at the initial time of cold storage to 7.58 % after 8 weeks of cold storage. While, the fat content of irradiated imitated shrimp exposed to doses of 1, 3 and 5 kGy were 7.73, 7.71 and 7.68 % at zero time and reached to 7.47, 7.34 and 7.15 % after 13, 17 and 25 weeks of end cold storage, respectively. These results are in agreement with those mentioned by **Botta and Show, (1976); Hammad, (1985); Shawki, (1998) and Bassiouny, *et al.*, (2002).** They reported that the fat content of fish, fish products and surimi slightly decreased during cold storage.

Table (25): Effect of gamma irradiation on the crude fat* content of imitated shrimp during cold storage at 4± c°.

Storage period (weeks)	Control	Radiation Dose (kGy)		
		1	3	5
0	7.74	7.73	7.71	7.68
1	7.72	7.72	7.68	7.65
2	7.69	7.70	7.66	7.64
3	7.67	7.68	7.64	7.62
4	7.66	7.67	7.61	7.60
5	7.63	7.65	7.60	7.58
6	7.61	7.62	7.57	7.56
7	7.60	7.60	7.55	7.54
8	7.58®	7.57	7.53	7.52
9		7.55	7.51	7.50
10		7.53	7.50	7.49
11		7.51	7.48	7.47
12		7.50	7.46	7.46
13		7.47®	7.44	7.44
14			7.41	7.42
15			7.38	7.40
16			7.35	7.38
17			7.34®	7.36
18				7.35
19				7.33
20				7.31
21				7.29
22				7.26
23				7.24
24				7.19
25				7.15®

® Rejected.

* On dry weight basis.

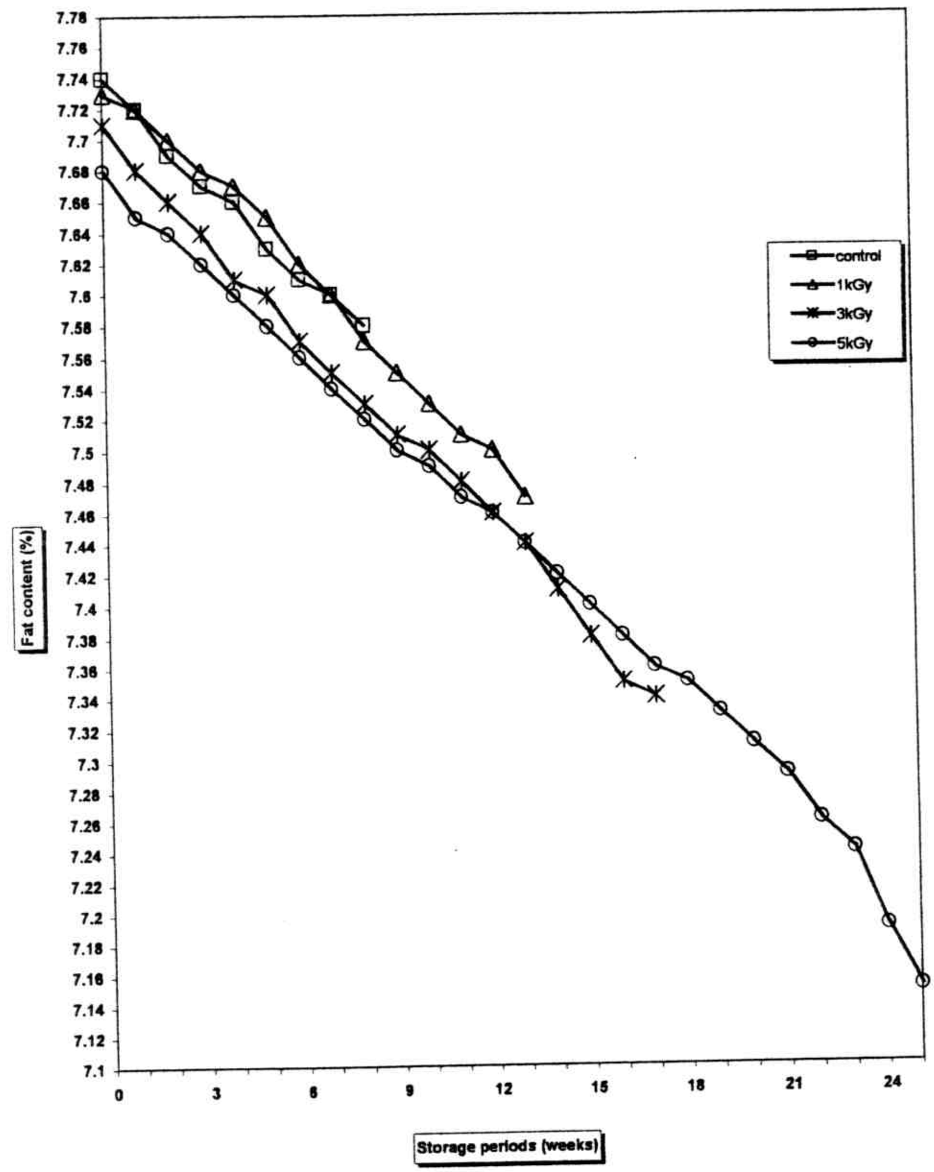


Fig (19): Effect of gamma irradiation on the fat content of imitiated shrimp during cold storage