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A comparison of γ-irradiation and microwave treatments on the lipids and microbiological pattern of beef liver

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RESUMEN

Comparación de los tratamientos por irradiación γ y microondas en los lípidos y aspectos microbiológicos del hígado de vaca.

Se estudiaron los efectos de los tratamientos por irradiación γ (0, 2.5, 5 y 10 kGy) y microondas (generados en un horno a nivel bajo y de descongelación durante 0.5, 1 y 2 min) sobre la composición química y aspectos microbiológicos de las muestras de hígado de vaca. Los análisis químicos y microbiológicos se llevaron a cabo en hígado de vaca tratado y no tratado al inicio y durante el almacenamiento en congelador a -18°C durante 3 meses. Los análisis químicos de los lípidos de hígado de vaca mostraron que los índices de acidez, peróxido y TBA se incrementaron ligeramente después de los tratamientos por irradiación y durante el almacenamiento en congelador (-18°C). Por el contrario, el índice de yodo disminuyó en el hígado de vaca tratado.

Los tratamientos de irradiación redujeron considerablemente el recuento de bacterias totales en hígado de vaca. El porcentaje de reducción de carga bacteriana por el hígado de vaca expuesto a microondas generados de un horno con un modo de descongelación de 2 min y después de 3 meses a -18°C fue del 62%. La carga bacteriana por el hígado de vaca expuesto a irradiación γ a 10 kGy después de 3 meses y -18°C disminuyó al 98%. Por lo tanto, los tratamientos de irradiación γ fueron mejores que los tratamientos por microondas para la reducción de los microorganismos asociados con el hígado de vaca. La Salmonellae no se detectó en hígado de vaca no-irradiado e irradiado a través del período de almacenamiento.

PALABRAS-CLAVE: Congelador - Hígado de vaca - Lípidos - Microondas - Microorganismos - Radiación γ.

SUMMARY

A comparison of γ-irradiation and microwave treatments on the lipids and microbiological pattern of beef liver.

The effects of γ-irradiation (0, 2.5, 5 and, 10 kGy) and microwaves (generated from an oven at low and defrost settings for 0.5, 1 and 2 min) treatments on the chemical composition and microbiological aspects of beef liver samples were studied. The chemical and microbiological analyses were performed on the non-treated and treated beef liver immediately after treatments and during frozen storage (-18°C) for 3 months. The chemical analyses of beef liver lipids showed that acid, peroxide and TBA values were slightly increased after irradiation treatments and also during frozen storage (-18°C). On the contrary, iodine value of the treated beef liver was decreased.

Irradiation treatments remarkably reduced the total bacterial counts in beef liver. The percent reduction of bacterial load for beef liver exposed to microwaves generated from an oven at defrost mode for 2 min and after 3 months at -18°C was 62%. The bacterial load for beef liver exposed to γ-irradiation at 10 kGy after 3 months at -18°C was decreased by 98%. Hence, γ-irradiation treatment was far better than microwave treatment for reduction of the associated microorganisms with beef liver. Salmonellae was not detected in non-irradiated and irradiated beef liver throughout the storage period.

KEY-WORDS: Beef liver - Frozen storage - γ-Irradiation - Lipids - Microorganisms - Microwaves.

1. INTRODUCTION

Generally, there are two common methods for food processing and preservation, i.e., microwave radiation and gamma radiation. These methods require special equipment to generate and focus this energy, as well as to prevent potentially harmful effects to humans (16). Most doses used in food γ-irradiation are between 0.1 to 3 kGy, but there are some microorganisms highly resistant to radiation. Therefore, doses above 3 kGy up to 10 kGy are needed in these cases. Also, doses up to 10 kGy were suggested for shelf life extension of some foods. It has been reported that doses up to 10 kGy had no health problems and no toxicological hazard and induced no special nutritional or microbiological problem (17). Increasing doses above 10 kGy decreased the sensory quality and induced many changes in the chemical constituents.

Microwaves have many applications in food processing. In general, the first step is conversion of microwave energy into thermal energy and the degradation of the energy into thermal vibrations of the molecules of the absorbed matter will occur (5). It is worth to mention that the chemical composition of oils, fats and food rich lipids are obviously changed upon exposure to microwaves at moderate and high oven power settings (8,9,10). Whilst, the heating at low oven power setting did not alter the chemical composition of the lipid materials.

There are some factors such as storage temperature, gaseous environment, pH, water activity, light, endogenous enzymes and the associated microorganisms which influence the shelf life and keeping quality of meat and liver (6,12). After slaughter, animal carcasses are transported without refrigeration to local retail shops where they are offered for sale over a period of 10-12 hr a day. Hence, the safety of beef liver for consumption can become questionable. It is worth mentioning that, losses up to 20 million pounds of meat due to microbial spoilage have been reported in USA and 90% of those losses would be accounted for slaughter, fabrication, and the retail area (3). As already mentioned liver progressively undergoes spoilage from the time of slaughtering, preservation and consumption even if it kept under refrigeration. Bacterial contamination has a pronounced effect on the liver quality under the aforementioned steps. Therefore, control of microbial spoilage in meat and meat products are highly desirable. Ionizing radiation has been applied on several products to improve food safety and to extend shelf life. The purpose of the present investigation was, first, to evaluate the influence of γ-irradiation and microwaves at different doses on some fat constants of the extracted lipids and on the microbial Survival of beef liver and, second, to examine the differences between the two irradiation methods on the aforementioned parameters of beef liver.

2. MATERIALS AND METHODS

2.1. Source of beef liver

Fresh beef liver samples were purchased from the central slaughter house in Cairo. Liver samples were sliced (ca. 3.0 mm thickness), separately packaged in polyethylene bags and then sealed. The treated (exposed to radiation) and untreated sliced liver were stored at -18°C in a deep freezer till analyses. The selected frozen temperature (-18°C) is the common temperature for meat and liver preservation and in line with the legalisation of Egyptian Organization for Standarization (7).

2.2. Irradiation processes

Sliced beef liver samples were placed in a presterilised polyethylene bags (15x25 cm; sterilized by γ-rays), then sealed and considered as a control. Portions of beef liver samples were exposed to γ-radiation (2.5, 5 and 10 kGy). Irradiation was conducted at the National Center for Radiation Research and Technology, Nasr City, Cairo. Using a Mega Gamma - I, Model AECL J S 6500 irradiator. The irradiation source was Cobalt 60 and the average dose rate was 2.4 kGy / hr.

Another portions of sliced beef liver were exposed to microwaves generated from an oven (Samsung MX 145) at low (30%, 110 W) and defrost (10%, 225 W) power settings for 0.5, 1 and 2 min. The microwave oven temperatures at various heating times and power settings were determined by inserting a calibrated glass thermometer into the beef liver samples immediately after removed from the microwave oven. Table I shows the internal temperatures of beef samples heated by microwaves.

Table I
Internal temperatures of beef liver samples heated by microwave oven

Power setting	Exposure time (min)		
	0.5	1	2
Low microwave, 110 W oven out put.	23.5	39.0	46.5
Defrost microwave, 225W oven out put.	66.5	78.5	82.0

* Internal temperatures for the fresh beef liver samples was 20 ± 1°C.

The non-irradiated and irradiated beef liver samples were kept at -18°C. At monthly intervals up to 3 months, triplicate samples of treated and non-treated sliced beef liver were removed from the storage and used for chemical and microbiological analyses.

2.3. Lipid extraction

The lipids were extracted from liver samples using a mixture of chloroform: methanol (2:1, v/v) (14).

2.4. Quality assurance methods

Chemical measurements of the following were determined using Standard American Oil Chemists Society Methods (1) indicated in the parentheses, acid value (Cd 3a - 63), peroxide value (Cd 8-53), iodine value (Cd 1-25) and TBA test (Cd 19-90).

2.5. Microbiological analyses

Ten grams of the non-irradiated and irradiated beef liver were placed in a blender cup containing sterile peptone water (90 ml, 0.1%) and blended for 3 min at a high speed. Consecutive serial dilutions were prepared in peptone water and used for the estimation of total plate counts (2), total coliform and fecal coliform count (13) and detection of salmonellea (18).

2.6. Statistical analysis

The influence of γ-irradiation and microwave treatments on the beef liver lipid stability tests and microbial examinations were statistically analyzed using the micro computer statistical package "Statgraphics" Statistical system (vers 2.6 serial No. 1357673 copyright USA), Statistical Graphics corporation. A two-way analysis of variance of the data was conducted to envisage the significant effects of radiation dose and storage time on the lipid stability and microbial tests parameters. All chemical and microbiological analyses were conducted in triplicate and the results are statistically evaluated.

3. RESULTS AND DISCUSSION

3.1. Effect of γ- irradiation on the lipids of beef liver

Table II shows the changes in the acid value of γ-irradiated sliced beef liver and stored at -18°C for 3 months. The acid values of the non-irradiated and γ-irradiated beef liver samples were steadily and slightly increased with time. It is worth mentioning that the acid values significantly increased after exposure to γ-radiation and also with increasing the irradiation dose. The Δ-acid values were 0.15, 0.15 and 0.15 for the γ-irradiated beef liver samples stored at -18°C for 3 months at doses of 2.5, 5 and 10 kGy, respectively. Δ-values were calculated by subtracting the acid value at zero time from the acid value after three months storage period. This means that the rate of lipid hydrolysis was the same while the content of free acids varied according to γ-irradiation dose.

The peroxide value of the non-irradiated beef liver was significantly increased with time (Table II). After treatment with γ-radiation, the peroxide value of the beef liver samples was increased and this increase was dependent upon the intensity of the irradiation. During storage, there was another gradual increase in the peroxide value of the irradiated beef liver. The Δ-peroxide value for the irradiated beef liver lipids were 0.34, 0.30 and 0.33 at doses of 2.5, 5 and 10 kGy, respectively. The Δ-values were calculated by subtracting the peroxide value at zero time from the peroxide value after 3 months storage period. This indicates that the rate of hydroperoxide formation was approximately the same, irrespective of the peroxide content of the beef liver samples at the beginning of the storage stage. It was reported that irradiation in the presence of oxygen initiated the production of free radicals and hence increase the formation of hydroperoxides (15).

Table II
Changes in the acid, peroxide, iodine and TBA values of γ-irradiated beef liver stored at -18°C over time

Treatment	Storage period (month)			
	0	1	2	3
	Acid value (mg KOH /g lipid)			
Control	2.28	2.36	2.43	2.51
2,5 kGy	2.50	2.55	2.60	2.65
5 kGy	2.80	2.85	2.90	2.95
10kGy	3.00	3.05	3.10	3.15
	Peroxide value (meq. Peroxide / kg lipids)			
Control	3.40	3.55	3.60	3.65
2.5 kGy	3.80	3.92	4.01	4.14
5 kGy	4.10	4.22	4.35	4.40
10 kGy	4.39	4.52	4.63	4.72
	Iodine value (g I_2/100 g lipids)			
Control	43.50	42.50	41.50	41.10
2.5 kGy	37.50	37.00	36.50	36.00
5kGy	34.00	33.50	33.20	32.50
10kGy	30.00	29.50	29.00	28.50
	TBA (Absorbance at 234 nm)			
Control	0.04	0.06	0.07	0.08
2.5 kGy	0.04	0.06	0.07	0.08
5k Gy	0.07	0.09	0.10	0.10
10kGy	0.09	0.10	0.11	0.12

LSD (0.05) values for acid, peroxide, iodine and TBA values were 0.03, 0.1, 2.03 and 0.01, respectively between storage periods and treatments.

Table II demonstrates the changes in the iodine value of γ-irradiated sliced beef liver and stored at -18°C for 3 months. During storage, the iodine value of the non-irradiated sliced beef liver was slightly decreased. The exposure of beef liver samples to γ-irradiation at 2.5 and 10 kGy resulted in an immediate decrease in the iodine value and slightly decreased over time compared with the iodine value of the non-irradiated beef samples. Generally speaking, the iodine value of the beef liver lipids decreased linearly with the increased irradiation dose over time. The Δ-iodine values of the γ-treated beef samples during frozen storage were -1.5, -1.5 and -1.5 for 2.5, 5 and 10 kGy, respectively. The Δ-values were calculated by subtracting the iodine value at zero time from the iodine value after 3 months storage period. These results demonstrated that the decreased in iodine values for beef liver lipids was approximately the same and the degree of

unsaturation varied according to the γ-irradiation treatments.

In this respect, the oxidation of lipids in Chinese style sausage in vacuum packaging and modified atmosphere packaging stored at 4°C and 15°C, respectively, for 5 months were investigated by Feng-Sheng *et al.* (11). They reported that the content of polyunsaturated fatty acids in sausage decreased with storage for both treatments. In addition, oxidative rancidity affects the more unsaturated fatty acids and as it progresses, polyunsaturated fatty acids polymerise or breakdown to smaller molecules with fewer double bonds. These findings lend weight to the results of this work where the iodine values of the non-and irradiated sliced beef liver samples were decreased during frozen storage.

TBA values of the non-irradiated beef liver samples were very low and gradually increased with storage (Table II). The same conclusion can be laid down for the irradiated beef liver samples. Here again, there was an increase in TBA values directly after exposure to γ-irradiation (5 and 10 kGy) and this increase was entirely dependent upon the intensity of the γ-radiation. In this respect, Caldironi and Bazan (4) found that the TBA values increased in ground raw beef stored at refrigerated temperatures indicating more oxidation.

3.2. Effect of microwaves on the lipids of beef liver

It has been reported that microwaves generated from the microwave oven at high and moderate power settings up to 6 min caused detrimental effects on various food components (8). While the exposure of foods to microwaves generated from low oven power setting possessed slight effect on the oxidation of beef liver lipids. Therefore, microwaves generated from an oven at low and defrost power settings for up to 2 min were selected to avoid the detrimental effects on beef liver components and decrease the microorganisms in a reasonable time.

Table III shows the changes in the acid values of microwaved beef liver and stored at -18°C for 3 months. The beef liver samples were exposed to microwaves generated from an oven at low and defrost power settings for 0.5, 1 and 2 min. The acid values for the non-microwaved beef liver samples demonstrated that very little changes has taken place during storage up to 3 months. The same observation can be seen with microwaved beef liver samples at different oven power settings and exposure time. However, the exposure to microwaves immediately induced significant increase in the acid value and this increase was dependent on oven power setting and exposure time. In this respect, the acid values of the microwaved beef liver at low oven power setting (110W) was slightly lower than that found at defrost oven power setting (225W). These data are in line with the recorded internal temperatures of beef liver samples heated by microwaves, i.e., the temperature generated from defrost oven setting was much higher than that produced from low oven setting (Table I).

The peroxide values for the extracted lipids from non-microwaved beef liver samples at the beginning of the experiment and after 3 months storage periods were 3.2 and 3.5 (Table III). In other words, significant increase in peroxide value occurred during storage. The exposure to microwaves at different oven power settings and exposure time also induced significant increase in the peroxide value. Here again, a significant increase in peroxide value was noticed after immediate exposure to microwaves and that was largely dependent upon the oven power setting and exposure time. The calculated Δ-peroxide values for non-microwaved at low and defrost oven settings for 0.5, 1 and 2 min after 3 months storage period were 0.3, 0.3, 0.3 and 0.3, 0.3, 03, respectively. These values indicate that the rate of hydroperoxide formation during frozen storage was approximately the same.

The changes in the iodine values of non-microwaved and microwaved beef liver samples and stored at -18°C for 3 months are shown in Table III. The data for the non-microwaved and microwaved beef liver show significant decrease in the iodine value occurred during storage at -18°C for 3 months. It is worth noting that a decrease in iodine value occurred at once after exposure to microwaves and this decrease was evidently dependent upon the oven power setting and exposure time.

The changes in TBA values of the lipids extracted from non-microwaved and microwaved beef liver samples and stored at -18°C for 3 months are shown in Table III. The TBA values of the fresh (non-microwaved) and stored beef liver for 3 months were very low (0.04 and 0.07, respectively). Also, the changes in TBA values for the microwaved beef liver samples during storage were very low. This means that there were very low amounts of hydroperoxides which decompose to give TBA secondary oxidation products. In general, the increases with both radiation dose and storage period led to an increase in TBA values.

Up to this point, one would suggest to store the beef liver at -18°C to maintain its quality without exposure to any radiation since the values of acid, peroxide and TBA (criteria of lipid stability) after 3 months of storage at -18°C are within the recommended levels for human consumption.

3.3. Effect of γ-irradiation on the microbial flora of beef liver

The total microbial count of fresh beef liver was 2.8×10^5 (Table IV). This value is generally in

Table III

Changes in the acid, peroxide, iodine and TBA values of microwaved beef liver stored at -18 °C over time

Exposure time (min)	Low microwave,110W oven out put.				Defrost microwave,225W oven out put.			
	Storage period (month)							
	0	1	2	3	0	1	2	3
	Acid value (mg KOH /g lipid)							
Control	2.25	2.30	2.35	2.40	2.25	2.30	2.35	2.40
0.5	2.40	2.45	2.50	2.50	2.40	2.50	2.60	2.70
1.0	2.60	2.60	2.65	2.65	2.50	2.60	2.72	2.80
2.0	2.65	2.70	2.72	2.74	2.87	2.88	2.90	2.90
	Peroxide value (meq. Peroxide / kg lipids)							
Control	3.20	3.30	3.40	3.50	3.20	3.30	3.40	3.50
0.5	3.30	3.40	3.50	3.60	4.30	4.45	4.55	4.60
1.0	3.40	3.50	3.60	3.70	4.60	4.80	4.85	4.90
2.0	3.50	3.60	3.70	3.80	5.00	5.10	5.15	5.20
	Iodine value (g I_2/100 g lipids)							
Control	44.00	43.00	42.00	40.50	44.00	43.00	42.00	40.50
0.5	43.00	42.00	41.50	40.00	38.00	37.00	36.00	35.00
1.0	41.00	39.50	38.50	37.00	34.00	33.00	32.00	31.00
2.0	38.00	37.00	36.50	35.50	33.00	32.00	31.50	30.50
	TBA (Absorbance at 234 nm)							
Control	0.04	0.06	0.07	0.07	0.04	0.06	0.07	0.07
0.5	0.05	0.07	0.08	0.08	0.09	0.10	0.11	0.11
1.0	0.06	0.07	0.08	0.09	0.10	0.10	0.11	0.12
2.0	0.07	0.08	0.09	0.09	0.11	0.11	0.12	0.12

LSD (0.05) values for acid, peroxide, iodine and TBA values were 0.02, 0.06, 1.83 and 0.01 between storage periods and were 0.03, 0.08, 2.42 and 0.01 between treatments.

accordance with the permissible number (10^5) for human being consumption (7). The total microbial counts at the beginning and after 3 months storage period were 2.8 x 10^5 and 2.6 x 10^5, respectively. These data demonstrate that storage at -18°C had little effect on reduction (10.7%) of total bacterial

Table IV

Effect of γ-irradiation on the microbial flora (cfu/g) of beef liver stored at - 18°C

Storage period (month)	Non-irradiated		Irradiation dose (kGy)					
			2.5		5		10	
	Total count	Total coliform	Total count	Total coliform	Total count	Total coliform	Total count	Total coliform
0	$2.8x10^5$	$4.5x10^1$	$4.2x10^4$	—	$9.0x10^3$	—	$4.9x10^3$	—
1	$2.7x10^5$	0.9x10	$2.5x10^4$	—	$4.3x10^3$	—	$2.8x10^2$	—
3	$2.6x10^5$	—	$1.5x10^4$	—	$2.0x10^3$	—	$1.6x10^2$	—
6	$2.5x10^5$	—	$8.7x10^3$	—	$9.6x10^2$	—	9.3x10	—

LSD values at 5% levels between treatments and storage periods were $1.0x10^4$

Table V
Effect of microwaves on the microbial flora (cfu/g) of beef liver stored at -18°C

Storage period (month)	Non-microwaved		Low microwave power setting						Defrost microwave power setting					
			0.5 min		1 min		2 min		0.5 min		1 min		2 min	
	Total count	Total coliform	Total count	Total coliform	Total count	Total coliform	Total count	Total coliform	Total count	Total coliform	Total count	Total coliform	Total count	Total coliform
0	$3.7x10^5$	9.3x10	$2.4x10^5$	—	$2.0x10^5$	—	$1.7x10^5$	—	$1.9x10^5$	—	$1.8x10^5$	—	$1.4x10^5$	—
1	$3.6x10^5$	3.3x10	$2.2x10^5$	—	$1.8x10^5$	—	$1.5x10^5$	—	$1.8x10^5$	—	$1.7x10^5$	—	$1.3x10^5$	—
2	$3.5x10^5$	—	$2.0x10^5$	—	$1.5x10^5$	—	$1.3x10^5$	—	$1.7x10^5$	—	$1.6x10^5$	—	$1.2x10^5$	—
3	$3.4x10^5$	—	$1.8x10^5$	—	$1.4x10^5$	—	$1.2x10^5$	—	$1.6x10^5$	—	$1.5x10^5$	—	$1.1x10^5$	—

LSD values at 5% levels between treatments and storage periods were $3.4x10^4$ and $4.0x10^4$, respectively.

counts. After exposing the beef liver to 2.5, 5 and 10 kGy immediately caused a reduction in the total microbial counts reached 85%, 96% and 98%, respectively compared with control. After 3 months storage period, the percent reductions were 94%, 99% and 99% for the irradiated beef liver at 2.5, 5 and 10 kGy, respectively.

These values show that the microbial counts for the fresh beef liver (non-irradiated) were higher than that of irradiated beef liver. As a general trend, the total bacterial counts decreased with the increase of the γ-irradiation dose (Table IV). The irradiation dose of 10 kGy (the recommended application dose) reduced the microbial counts immediately after exposure to about 98%. At the same dose (10 kGy) after 3-month storage at -18°C possessed a reduction of 99%. These results clearly demonstrate that γ-irradiation was the main factor for killing the microbes whilst frozen storage (-18°C) had a minor effect on reduction of total bacterial counts. At irradiation dose of 5 kGy, the reduction percentage of total bacterial counts reached 99% after 3-month storage period. Hence, from the safety point of view one would suggest to apply 5 kGy for preservation of beef liver.

The counts of coliform bacteria of the un-irradiated beef liver were 450 and became 90 after one month storage at -18°C (table IV). After 3 months of frozen storage the coliform bacteria associated with beef liver was not detected. These results indicate that coliform bacteria are susceptible to frozen storage. The exposure to γ-irradiation at varios doses immediately killed the coliform. Here again, the γ-irradiation treatment was superior to that of frozen storage for reduction of the associated microorganisms with beef liver.

3.4. Effect of microwave treatment on the bacterial flora of beef liver

Table V shows the total bacterial load of untreated and microwaved beef liver at -18°C for 1, 2 and 3 months. The total bacterial counts at the beginning and at the end of the experiments for the non-microwaved beef liver were 3.7 x 10^5 and 3.4 x 10^5, respectively. Hence, the percent reduction of total bacterial count of beef liver was 8% during this period. This means that frozen storage (-18°C) had very little influence on reduction of bacterial load. In this respect, statistical analysis of the total bacterial count for non-treated beef liver samples demonstrated that there was no significant difference during frozen storage period.

The exposure of beef liver samples to low microwave power setting for 0.5, 1 and 2 min at the beginning of the experiment induced a reduction in the total bacterial counts amounted to 35 %, 45 % and 54 %, respectively. This means that microwave treatment immediately after exposure to microwaves at low power setting had an obvious effect towards the reduction of bacterial count.It is of interest to note that the bacterial load after exposure to microwaves at low power setting decreased with increase of exposure time. During frozen storage (-18°C) the reduction percentages of total bacterial counts for 1, 2 and 3 months were 8%, 16% and 25%, respectively. Similar figures were obtained for beef liver samples exposed to low microwave setting for 1 and 2 min and stored for 1, 2 and 3 months. These results demonstrate that microwave treatment was more effective in lowering the bacterial load than frozen storage taking into account the value of the control experiment. In addition, statistical analysis of the total bacterial counts showed significant decrease due to the exposure to microwaves for various periods generated from low oven power setting.

The exposure of fresh beef liver to microwaves generated from defrost power mode for 0.5, 1 and 2 min resulted in lowering the bacterial load by 48%, 51% and 62% compared with the non-irradiated sample. These values elucidate that the total bacterial count decreased with the increase of exposure time. Also, the percent reduction of

bacterial load using the oven at defrost setting mode was higher than that achieved from oven of low setting mode. This is due to the microwave oven output of the defrost setting (225W) was higher than that at low microwave output setting (110W). Dealing with the influence of frozen storage (-18°C) on the total bacterial count, as a general trend further reduction in the bacterial load was noticed irrespective of exposure time. However, this reduction in bacterial load was much lower than that resulted from exposure to microwaves. One would consider that frozen storage played a minor role whilst microwaves had the major effect on lowering the bacteria associated with beef liver.

The total coliform bacteria accompanied by fresh beef liver was 9.3x10. After one month storage at -18°C the total coliform bacteria was reduced by 64.5%. In addition, the coliform bacteria did not present after 2 and 3 months of frozen storage in the beef liver. This means that coliform bacteria is very sensitive to cooling (-18°C) and lose viability. It is worth mentioning that microwaves generated from an oven at both low and defrost modes completely prevented the survival of coliform.

It is of interest to note that the bacterial load reduction for beef liver exposed to microwaves generated from an oven at defrost mode for 2 min and after 3 months frozen storage was 62%. The percent reduction of bacterial load for beef liver exposed to γ-irradiation at the recommended dose (10 kGy) after 3 months storage was 98%. Looking at these figures, one can deduce that γ-irradiation treatment was more efficient than microwave treatment in eliminate Bacteria with beef liver.

Salmonellae culture did not produce an alkaline slants with acid butts with or without production of H_2S gas. Hence, Salmonellae was not detected in irradiated (γ-and microwave irradiation) or non-irradiated beef liver samples throughout the storage period. The microbiological examination data, of the present work, were in accordance with the microbiological safety data of shrimp and pork chops treated microwaves (19,20).

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