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Enhancing Basa Fish (*Pangasius Bocourti*) Fillets Shelf Stability and Hygienic Quality Using Gamma Irradiation with Lemon Grass at Different Concentrations

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Abstract: The mild flavor, high protein content, and low cost of Basa fish *(Pangasius bocourti)* make it a popular food. However, Basa fillets are extremely perishable, which makes transportation and storage difficult, much like many other fish products. Lipid oxidation and microbial contamination are two major causes of fish fillet degeneration, which can result in serious financial losses as well as possible health hazards. Many preservation methods, such as cold storage, chemical preservatives, and irradiation, have been used for enhancing the shelf stability and hygienic quality of seafood. A common method for food preservation that effectively decreases the microbial load and increases shelf life is gamma irradiation., when combined with natural antimicrobial and antioxidant agents, like plant extracts, irradiation could further enhance preservation efficiency. Because lemongrass (*Cymbopogon citratus*) contains a lot of bioactive substances including flavonoids and citral, it is well-known for its antibacterial, antioxidant, and flavor-enhancing qualities. A potential method for enhancing the safety and quality of Basa fish fillets is to combine gamma irradiation with varying concentrations of lemongrass extracts. This study is to assess the efficiency of 4.5 kGy of gamma irradiation in conjunction with varying concentrations of lemon grass (2%, 4%, and 6%) for improving the hygienic quality and shelf stability of Basa fish (*Pangasius bocourti*) fillets during cold storage. The findings demonstrate that by suppressing bacterial development and preserving sensory qualities, the combination of 4.5 kGy gamma irradiation and lemongrass extract significantly increased preservation efficiency, especially at a 6% concentration. This study concludes that the combination of gamma irradiation by dose 4.5 kGy and lemongrass extract by 6% concentration is an effective preservation method for extending the safety and quality of Basa fish fillets during cold storage.

Key words: *Pangasius bocourti*, Lemongrass, Gamma Irradiation, Cold Storage.

1. Introduction

Fish is a rich resource of protein, omega-3 fatty acids, vitamins, and minerals and plays a significant role in human nutrition. Supplementation of fish, a minimum of two times a week in the human diet, is recommended and considered to be healthy **Sarvenaz and Sabine (2018).**

(Pangasius bocourti) is a major protein source, particularly for low-income people. Due to a lack of knowledge about processing and preservation methods, this large production of this fish is generally sold as wet fish at a lower price, (**Danuwat, *et al.,* 2016.).** In Egypt, Basa fish has gained popularity, primarily through imports, due to its favorable characteristics such as rapid growth, high yield, absence of intramuscular bones, white flesh, and pleasant taste, the fish is a new economic fish that was promoted to be cultured, **Pornpisanu *et al*., (2010) and Abu Ahmed *et.al*, (2023).**

Nevertheless, because of enzymatic activity, lipid oxidation, and microbial attack, these fishes are extremely perishable and their quality deteriorates over time **(Nielsen and Jessen, 2007).** In Egypt, a number of research investigated the using imported Basa fish in different cuisine items. In order to improve the nutritional value and sensory qualities of fish burgers and kofta made from Basa fillets **Abu Ahmed *et.al*, (2023).).** Furthermore, studies have been done to enhance the marinated Basa fillets' fatty acid profiles, physicochemical characteristics, and microbiological quality when they are kept refrigerated. This study assessed how several treatments, such as the application of pepsin enzyme, citric acid, and essential oils of rosemary, affected the fillets' quality and shelf life **(Raghda - Abd El-Fatah, *et al*, 2023).**

Gamma irradiation is a widely accepted food preservation technique that effectively reduces microbial load and extends shelf life without compromising the sensory and nutritional qualities of food, when combined with natural antimicrobial agents, such as plant extracts, irradiation may further enhance preservation efficiency **(Nor Mahrour *et al.,* 2003).** Lemongrass (Cymbopogon citratus) is known for its antimicrobial, antioxidant, and flavor-enhancing properties due to its high content of bioactive compounds like citral and flavonoids **(Olorunnisola *et al*., 2014).**

The intention of this study is to assess the efficiency of 4.5 kGy of gamma irradiation in conjunction with varying concentrations of lemon grass (2%, 4%, and 6%) for improving the hygienic quality and shelf stability of Basa fish (*Pangasius bocourti*) fillets during cold storage.

2. Materials and Methods

2.1. Preparation of Lemongrass Extract

Fresh, fully grown lemongrass (*Cymbopogon citratus*) leaves were gathered from the Nuclear Research Center's medical and fragrance farm in Anshas. After being cleaned with fresh water, the leaves were cut into uniformly sized pieces using clean stainless-steel scissors, ranging in length from 2 to 3 cm. They were then allowed to air dry before being oven-dried for three to five hours at 45°C. Following drying, a milling machine was used to grind the plant components into a powder.

The lemon grass aquas extract was made in three (3) distinct stainless bowls for the three (3) distinct treatments. 20g of powdered lemon grass was mixed with 1000 ml of water to create a 2% lemon grass extract for the initial treatment. 40g of powdered lemon grass was added to 1000 milliliters of water for the second treatment, creating 4% lemon grass extract. Using a 6% lemon grass extract method, the final concentration was created by mixing 60 g of powdered lemon grass with 1000 ml of water, (**Omoruyi *et al.,* 2019).**

2.2. Sample Preparation

Fresh Basa fish *(Pangasius bocourti)* were brought to the lab in a refrigerated condition (4°C) after being purchased from a nearby El-Obour market. After immediately washing the entire Basa fish with tap water to get rid of any filth or slime on the surface, the fish were filleted (the skin was taken off of the fillet) and given another wash with tap water to get rid of any remaining blood.

After being trimmed and cleaned with distilled water, the fillets were split up into four experimental groups: three experimental groups that received 4.5 kGy gamma irradiation along with varying concentrations of lemongrass extract (2%, 4%, and 6%), and a control group of Basa fillets that did not receive any treatment. After the fish samples were put in their appropriate treatments and left in the mixture for 20 minutes, they were drained, according to (**Omoruyi *et al.*, 2019).**

2.3. Irradiation process

The prepared Basa fillets were placed in sterile polyethylene bags either treated with lemon grass or not treated (control), samples treated with different concentration of lemon grass (2;4 and 6%) were subjected to gamma irradiation at a dose of 4.5 kGy, by CO60 Russian Gamma chamber (providing a dose ratio of 665.6 Gy/h), the Cyclotron project, Nuclear Research Center, Egyptian Atomic Energy Authority., Cairo, Egypt.

2.4. Cold storage at 4ºC

All fish fillet samples were kept in a refrigerator at 4^{o}C ±1, until they were taken out every three days for chemical, microbiological, and sensory analysis.

2.5. Physiochemical quality attributes

The total volatile basis nitrogen and trimethyleamine were determined according to the method of **AMC (1979)** technique. The oxidative stability of the minced fish was monitored using Thiobarbituric Acid Reactive Substances (TBARS), a lipid oxidation indicator **(Zhang and Xie, 2015).** A chloroform-methanol solution was used to extract the lipids from the minced fish before the TBA reagent was added in order to conduct the TBARS assay. The absorbance of the finished solution was measured at 532 nm using a spectrophotometer. Peroxide value of the lipid was analyzed according to the method described by **Takagi *et al.* (1978).** The pH value was measured using a digital pH meter according to the method described by **Abdel-Naeem *et al.* (2021)**

2.6. Microbial examination

As advised by the **APHA (1992),** total bacterial count (TBC) and psychrophilic bacteria were determined by plating on plate count agar medium, and total mold and yeast were counted on Oxytetracycline glucose yeast extracts agar (Oxoid CM 545), **Oxoid manual (2006).** *Stahylococcus aureus* was counted on Baird parker agar media according to **Oxoid manual (2006).** Coliforms group and *E. coli* were enumerated using violet red bile agar medium method recommended by the FDA **(Feng, *et al*., 2002)**. The results were calculated as log $_{10}$ fu/g.

All the biosafety instructions / precautions were implemented and strictly followed all over the experimental work procedures. At the end of the experiment all bacterial cultures, isolate and remains of potential biological hazards were safely disposed via autoclaving.

2.7. Sensory Evaluation

Using a 9-point hedonic scale (1 being severely disliked and 9 being extremely liked), a panel of expert judges assessed sensory qualities such as appearance, odor, and texture. The samples were assessed during the cold storage period at 4±1°C as well as at the beginning time (zero time). Samples were rejected if there were unacceptably noticeable changes in appearance of mold spots on its surface or odor, or if the overall bacterial count was greater than 1×10^{6} according to **NFSA (2021)** and **yerlikaya *et al*. (2005)**

2.8. Statistical analysis

The results were statistically analyzed and recorded as mean ± standard error using **SPSS (2009)**.

3. Results and discussions

Table (1). Proximate chemical composition of fresh Basa fish fillets

Chemical composition	%
Moisture	75.94 ± 0.055
Protein	14.02 ± 0.076*
Lipid	7.65 ± 0.050*
Ash	1.48 ± 0.015*
Carbohydrates	0.87 ± 0.050[1]

* on dry weight basis
[1] calculate by difference

Recent years have seen a rise in the acceptance and popularity of the Basa because of its low price and outstanding sensory qualities, especially its firm texture after cooking, white meat, pleasant taste, delicate flavor, and absence of fishy odor and spines. Its high protein level, abundance of essential amino acids, and low-fat content further contribute to its good nutritional quality, offering its fillet a desirable option for seafood industry. In this study, Fresh Basa fish fillets had proximate chemical compositions of 75.94, 14.02, 7.65, and 1.48 for moisture, protein, lipid, and ash, respectively, as shown in Table 1. These outcomes are corresponding to those obtained by **Raghda - Abd El-Fatah *et al.* (2023).**

Table (2). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on the TVBN mg/100g of Basa fish during cold storage at 4 ±1°C

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	5.68±.012a	5.69±.017a	5.69±.018a	5.69±.020a
3	21.40±.045b	10.16±.023b	8.08±.023b	6.93±.006b
6	30.16±.029c	16.01±.049c	11.71±.020c	9.25±.029c
9	38.74±.023d ®	20.13±.035d	15.00±.056d	11.91±.015d
12		30.02±.039e	20.06±.032e	15.41±.015e
15		35.75±.015f ®	26.90±.071f	20.07±.009f
18			31.55±.038g	26.76±.023g
21			35.04±.026h ®	30.88±.012h
24				35.24±.019i ®

Means followed by the same letter are not significantly different at $P < 0.05$ by Duncan's multiple range test a, b, c,. for columns.
®: rejected

Table (2) illustrates the effects of 4.5 kGy of gamma irradiation and varying concentrations of lemon grass (2,4, and 6%) on TVBN during cold storage. While there were no differences between any of the treatments at zero time, all treatments showed a considerable increase in TVBN over the cold storage period. This increase in TVBN contents may have resulted from microbial and enzymatic activity breaking down nitrogenous compounds. **(Özogu *et al*, 2006).** Wherever there was a high rate of increase in control samples while irradiation with 2; 4 and 6% Lemon grass extract reduce the rate of TVBN increases, which the samples were rejected at 9, 15; 21 and 14 days of cold storage for control and irradiated samples treated with (2;4 and 6%), respectively.

According to Egyptian regulations, the rejection occurred when the TVBN level reached the maximum limit of 35 mg/100g **(EOS, 2005).** In this work, samples treated with varying concentrations of lemon grass and exposed to 4.5 kGy of gamma irradiation were successful in reducing the rate of TVBN increment during cold storage at 4 º C ± 1. This was notably applicable at 6% lemon grass. The results were in close agreement with those obtained by **Sarnes *et al.* (2020)** who suggested adding 0.2% lemongrass essential oil to the Pangasius to increase the shelf life of Pangasius fillet and improve its quality,

Table (3). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on the TMAN mg/100g of Basa fish during cold storage at 4 ±1ºC

days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	1.37±.021a	1.42±.015a	1.43±.015a	1.36±.035a
3	4.45±.009b	2.62±.021b	2.18±.015b	2.05±.062b
6	7.72±.034c	3.89±.012c	2.92±.030c	2.77±.017c
9	12.90±.020d ®	6.69±.012d	3.77±.020d	3.16±.023d
12		8.09±.018e	5.24±.020e	4.41±.009e
15		11.03±.029f ®	6.97±.015f	5.91±.035f
18			9.04±.031g	7.83±.012g
21			10.45±.015h®	8.82±.012h
24				10.04±.030i ®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, …. for columns.
®: rejected

Table (3) shows that TVBN at the initial for control and irradiated with different concentration of lemon grass (2;4 and 6%) were 1.37±.021;1.42±.015; 1.43±.015 and 1.36±.035, respectively. Whereas, during cold storage, there were notable, steady increases in TMA concentrations in all samples. However, those treated with 4.5 kGy displayed a slower rate of increase, particularly when the percentage of added grass lemon extract increased. On days 9, 15, 18, 21, and 24 for the control and irradiated samples with different levels of lemon grass extract, the TMA content levels were exceeding the maximum allowable amount of 10 mg/100g, as per Egyptian guidelines **(EOS, 2005),** at 2; 4 and 6%, respectively (the time of sample rejection).

The TBA test is a widely used diagnostic to assess the degree of lipid oxidation. The level of lipid oxidation in Basa fish fillets during cold storage is listed in Table (4), **Siriporn *et al.* (2007)** found that Irradiated samples had higher TBA values than had the control ($p < 0.05$). Similarly, was noticed in this study there were slightly increased in TBA of irradiated samples treated with 2; and 4 lemon grass extract at zero time wherever irradiated samples with 6% Lemon grass was slightly lower among treatments, this result may be due to the adding lemon grass at 6% to irradiated samples, these results agree with those obtained by **Alzobaay, *et. al*,(2021) and Sarnes, *et al.* (2020).** Cold storage significantly increased the contents of TBA in all samples but at lower rate of increase with irradiated samples treated with Lemon grass extract. The levels of TBA exceeded the maximum acceptable level reported by the Egyptian standards **(EOS, 2005)** (4.5 mg malonaldehyde/ Kg) on days 9, 15, 18, 21 and 24 of cold storage for samples control and irradiated samples with (2;4 and 6%), respectively.

Table (4). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2; 4 and 6 %) on the TBA mg malonaldehyde/kg of Basa fish during cold storage at 4 ±1ºC

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	.24±.002a	.24±.004a	.24±.002a	.24±.002a
3	1.49±.002b	.89±.005b	.75±.002b	.65±.001b
6	3.61±.001c	1.41±.001c	1.13±.002c	.96±.003c
9	5.12±.006d ®	2.79±.002d	2.03±.003d	1.53±.034d
12		4.04±.002e	2.81±.001e	2.03±.027e
15		6.43±.003f ®	3.07±.004f	3.07±.003f
18			4.12±.006g	3.98±.004g
21			6.53±.012h ®	4.36±.031h
24				6.68±.006i ®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, …. for columns.
®: rejected

Table (5) displayed the peroxide values of the treated fillets and the control. The peroxide values of the samples did not differ significantly (p>0.05). One indicator of oxidative rancidity is the production of peroxide. All of the fillets stay below 10 m Eq/kg throughout storage, indicating that they did not surpass the threshold for human consumption. A low peroxide value may indicate early oxidation or the late stage of badly oxidized fillets, where the lipid composition of Pangasius itself has caused more H_2O_2 to be oxidized, **(Waindu and Jamala, 2013; Rathod *et al.,* 2018 Alzobaay, *et. al*, ,2021).**

Table (5). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2; 4 and 6 %) on the peroxide value (m Eq/kg) of Basa fish during cold storage at 4 ±1ºC

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	1.16±.038a	1.30±.032a	1.41±.017a	1.53±.026a
3	1.64±.032b	1.54±.021b	1.76±.018b	1.67±.023b
6	2.45±.012c	2.43±.018c	2.22±.022c	2.26±.023c
9	5.09±.012 d ®	2.86±.024d	2.97±.015d	3.01±.009d
12		3.61±.024e	3.22±.027e	3.40±.020e
15		6.05±.032 f ®	4.18±.362f	3.86±.012f
18			4.76±.026g	4.50±.009g
21			5.90±.023h®	5.75±.012h
24				6.04±.015 I®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, ….for columns .
®: rejected

Table (6). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2; 4 and 6 %) on the pH value of Basa fish during cold storage at 4 ±1ºC

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	6.37±.012a	6.30±.009	6.23±.006	6.18±.009
3	6.42±.015b	6.35±.015	6.30±.012	6.20±.009
6	6.63±.026c	6.41±.012	6.37±.009	6.28±.012
9	6.79±.006d ®	6.48±.012	6.42±.012	6.35±.009
12		6.52±.009	6.52±.012	6.47±.010
15		6.70±.015 ®	6.63±.012	6.62±.009
18			6.71±.015	6.72±.042
21			6.76±.019®	6.71±.006
24				6.77±.009®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, ….for columns .
®: rejected

There was no significant difference in pH value (p>0.05) between the control sample and the samples treated (gamma irradiation with 4.5 kGy with 2;4 and 6% lemon grass extract) Basa fillets at zero time of cold storage. Variations in pH values during cold storage at 4 ±1ºC are shown in Table (6), nevertheless, as indicated in Table 6, the pH value for all treatments increased noticeably during cold storage, while the rate of increase decreased when more lemon grass extract was applied, this increase could be the result of microbial burdens influencing the fillets' pH value. **Ahmad *et al.*, (2012)** stated that Alkaline chemicals (such as ammonia and TMA) are produced by microbial and enzymatic processes and accumulate, raising pH value.

Table (7). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on the TBC log cfu/g of Basa fish during cold storage at 4 ±1ºC

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	4.55±.022a	2.24±.018a	2.04±.018a	1.99±.036a
3	4.76±.021b	2.65±.023b	2.54±.018b	2.42±.018b
6	5.10±.020c	4.72±.009c	3.17±.015c	3.14±.014c
9	6.68±.012d ®	4.10±.009d	3.76±.021d	3.32±.026d
12		5.80±.019e	4.04±.021e	3.92±.020e
15		6.57±.012f®	4.71±.021f	4.24±.020f
18			5.14±.012g	4.82±.029g
21			6.41±.020h ®	5.74±.006h
24				6.26±.022i ®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, ….for columns .
®: rejected

Following a 24-day period of cold storage at 4 C in Table (7) which displays the total bacterial counts (TBC) of the Basa fillets. The initial total bacterial count of control Basa fillets in this study was 4.55±.022 log CFU/g. In contrast, samples treated with 4.5 kGy gamma irradiation in combination with 2; 4% and 6% lemon grass extract had lower TBC, particularly when the concentration of lemon grass extract was increased. For irradiated samples combined with 2; 4 and 6% lemon grass extract, the TBC was 2.24±.018; 2.04±.018; and 1.99±.036 log CFU/g, respectively. These findings are consistent with **Siriporn *et al.* (2007)** and could be a consequence of the combined effects of irradiation and lemon grass extract.

Regarding, cold storage period there was a significant increment during cold storage period reaching to 6.68±.012; 6.57±.012; 6.41±.020h and 6.26±.022 log10 $\log^{10}$ cfu/g at 9;15; 21 and and 24 th day, respectively. these results agree with those obtained by **NFSA (2021).** These findings demonstrate the potent antibacterial properties of 4.5 kGy irradiation in conjunction with lemon grass in extending shelf life and ensuring safety regulations. This could be because of the antibacterial properties of lemon grass extract shown in earlier research, as well as the fact that gamma irradiation efficiently lowers the initial bacterial load and slows microbial growth during storage.

The psychrophilic bacterial count changes of fresh Basa fillets treated with gamma irradiation by dose 4.5 kGy combined with 2; 4 and 6% Lemon grass extract and control (no treatment) were tabulated in Table (8). it could be noticed that, the psychrophilic bacterial count in the control sample was recorded as 2.13± .082 log10 cfu/g, whereas all irradiated samples with Lemon grass extract showed no detectable bacterial counts (0.00 ± 0.000 log10 cfu/g). This significant reduction suggests that gamma irradiation with Lemon grass extract effectively eliminated psychrophilic bacteria immediately after treatment, Total $\log^{10}$ psychrophilic counts for all treatments of Basa fish fillets either control or irradiated samples with 2; 4; and 6 % Lemon grass extract, respectively, were significantly increased during the cold storage period reached to 5.29±.012; 3.06±.025; 5.02±.019 and 5.02±.003 log10 cfu/g at 9; 15; 21 and 24th day of storage period, respectively. This highlights the strong antibacterial effect of gamma irradiation combined with Lemon grass extract especially with the level of 6% in prolonging shelf life and maintaining safety standards **Sweetie *et al*. (2015), Shawki *et.al*,(2012) and; Özden and Erkan (2010).**

Table (8). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on the Psychrophilic bacteria log CFU/g of Basa fish during cold storage at 4 ±1ºC

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	2.13±.082	.00±.000	.00±.000	.00±.000
3	3.15±.029	.00±.000	.00±.000	.00±.000
6	4.30±.020	1.14±.020	.00±.000	.00±.000
9	5.29±.012®	1.64±.018	1.15±.018	.00±.000
12		2.10±.015	2.18±.015	1.11±.015
15		3.06±.025 ®	3.46±.015	2.34±.035
18			4.55±.030	3.72±.017
21			5.02±.019®	4.64±.022
24				5.02±.003 ®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, ….for columns .
®: rejected

The results in (Table 9) showed that Total mold and yeast log^{10} cfu/g of Basa fish fillets treated with 4.5 kGy combined with different concentrations of Lemon grass extract (2; 4 and 6%) at zero time were not detected. Regarding cold storage, there was a gradual significant increase in total mold and yeast counts reaching 4.47±.021 (log^{10} cfu/g) at the 9th day of storage for the control sample whereas the panelists completely rejected this sample because of the visual appearance of mold spots on its surface. It is obvious that total mold and yeast counts of samples treated with gamma irradiation with different concentrations of Lemon grass (2; 4 and 6 % respectively) during the storage period were gradually increased which is completely rejected by the panelists because of the visual appearance of mold spots on its surface at days 15; 21 and 24th respectively. These results are in agreement with **Shawki *et al*, (2012)**

Table (9). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2; 4 and 6 %) on the total mold &yeast count CFU/g of Basa fish during cold storage at 4 ±1ºC

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	2.40±.012a	NDa	ND	NDa
3	2.75±.018b	NDa	ND	NDa
6	3.56±.020c	1.17±.017b	ND	ND
9	4.47±.021d®	1.39±.018c	1.07±.015b	ND
12		2.48±.032d	1.16±.020c	1.08±.015b
15		3.34±.029e ®	1.55±.026d	1.16±.023c
18			2.34±.018e	1.49±.035d
21			2.87±.023f ®	1.860±.026e
24				2.57±.041f ®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, ….for columns .
®: rejected

Table (10). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on *staphylococcus aureus* count CFU/g of Basa fish during cold storage at 4 ±1ºC

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	1.75±.018a	ND	ND	ND
3	1.78±.029a	ND	ND	ND
6	2.14±.006b	ND	ND	ND
9	2.54±.024c ®	ND	ND	ND
12		ND	ND	ND
15		ND	ND	ND
18			ND	ND
21			ND	ND
24				ND

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, ….for columns .
®: rejected

The effects of 4.5 kGy gamma irradiation in combination with different levels of lemon grass extract (2%; 4%, and 6%) on *Staphylococcus aureus* in Basa fish kept at 4 ±1ºC are shown in Table (10) data. The results reveal that all treated samples had no detectable bacterial counts (ND), but the control group's S. aureus count increased gradually over time, this implies that S. aureus was successfully eradicated from the onset of the cold storage period by gamma irradiation and lemon grass. All treated samples showed no signs of S. aureus contamination over the 24-day cold storage period. This result is in line with research showing that by destroying microbial DNA and stopping replication, gamma irradiation successfully lowers bacterial contamination in seafood **(Farkas, 2016).** Furthermore, because lemon grass contains a lot of citral and other bioactive chemicals, it has been shown to have antibacterial qualities **Hoque *et al*., (2008) and Gonçalves *et al*., (2018).** The treated samples retained their microbiological safety for more than 24 days, but the control sample was judged unfit for ingestion by day 9. This demonstrates that gamma irradiation and natural plant extracts, such as lemon grass, can be used to prolong the shelf life of seafood, guaranteeing food safety and lowering the need for artificial preservatives.

Table (11). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on *Coliform group* CFU/g of Basa fish during cold storage at 4 ±1ºC

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	1.61±.045b	ND	ND	ND
3	1.74±.086b	ND	ND	ND
6	2.08±.139c	ND	ND	ND
9	2.41±.067d®	ND	ND	ND
12		ND	ND	ND
15		ND	ND	ND
18			ND	ND
21			ND	ND
24				ND

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, ….for columns .
®: rejected

The coliform group count of the control sample increased over time, starting from 1.61±0.045 CFU/g at day 0 and reaching 2.41±0.067 CFU/g by day 9, at which point the fish was rejected due to microbial spoilage **(EOS, 2005)**. The continued microbial growth in the control group suggests that natural spoilage progresses over time in untreated fish. It is evident that at zero time and during the whole cold storage period, the coliform group counts of the irradiation samples containing lemon grass extract were undetectable, Coliforms were not detected during the 24-day storage period, demonstrating that gamma irradiation and lemongrass extract successfully eradicated coliforms and prevented their regeneration. This implies that gamma irradiation and lemongrass work in concert. perhaps as a result of the sterilizing effects of radiation and the antibacterial qualities of lemongrass essential oils, which are high in citral and limonene. Seafood can be effectively microbially decontaminated by gamma irradiation (4.5 kGy), which prolongs its shelf life by lowering pathogens and rotting germs. (**Shawki, *et al.* (2012); Sheng and Wang (2021)** Bioactive substances like citral and myrcene, which break down bacterial membranes, are responsible for the well-established antibacterial and antioxidant qualities of lemongrass (Cymbopogon citratus) extract. Gamma irradiation (4.5 kGy) combined with lemongrass extract (2; 4 and 6%) significantly inhibits coliform growth in Basa fish, extending its microbial shelf life well beyond that

Table (12). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on *E coli* CFU/g of Basa fish during cold storage at 4 ±1°C

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	2.18±.012a	ND	ND	ND
3	2.25±.006b	ND	ND	ND
6	2.32±.018c	ND	ND	ND
9	2.53±.009d ®	ND	ND	ND
12		ND	ND	ND
15		ND	ND	ND
18			ND	ND
21			ND	ND
24				ND

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, …. for columns.
®: rejected

Similarly, it is evident that the *E. coli* counts of irradiated samples containing lemon grass extract were undetectable at zero time and during the entire duration of cold storage for the synergistic impact gamma irradiation with varying quantities of lemon grass shown in Table (12). It was 2.18±.012 log 10 cfu/g for the control sample, but during cold storage, there was a noticeable rise, reaching 2.53±.009 log 10 cfu/g on the ninth day of storage. These results are in agreement with **sheng and Wang (2021) and yusufu *et, al*.(2021)**

Table (13). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on the sensory characteristics (Appearance) of Basa fish fillets during cold storage at 4 ±1°C

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	8.90±0.05a	8.90±.058a	8.90±.058a	8.80±.058a
3	8.67±.067b	8.60±.058b	8.50±.058b	8.53±.033b
6	6.15±.029c	7.96±.038c	8.20±.058c	8.06±.076c
9	3.16±.019d ®	7.56±.019d	7.60±.058d	7.60±.058d
12		6.30±.015e	6.45±.029e	7.50±.058d
15		3.71±.015f®	6.40±.015e	7.10±.009e
18			5.30±.017f	6.30±.017f
21			3.31±.029g ®	5.01±.023g
24				3.10±.026h ®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, ….for columns.
®: rejected

Table (14). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on the sensory characteristics (odor) of Basa fish fillets during cold storage at 4 ±1ºC

Days	Control	Doses 4.5 kGy + Lemon grass %		
		2	4	6
0	8.93±.067a	8.85±.029a	8.78±.044a	8.92±.044a
3	8.77±.033b	8.60±.029b	8.58±.044b	8.52±.044b
6	6.63±.120c	8.16±.123c	8.22±.044c	8.04±.038c
9	2.93±.088d ®	7.69±.054d	7.31±.052d	7.18±.076d
12		6.51±.019e ®	7.23±.044d	7.15±.029d
15			7.10±.009e	7.07±.035d
18			5.21±.012f	6.00±.009e
21			3.39±.018g ®	5.21±.018f
24				2.99±.018g ®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, ….for columns.
®: rejected

Table (15). Effect of gamma irradiation at dose 4.5 kGy and Lemon grass with different concentration (2,4 and 6 %) on the sensory characteristics (texture) of Basa fish during cold storage at 4 ±1ºC

Days	Control	Doses / kGy		
		1	2	3
0	8.93±.033a	8.87±.033a	8.80±.058a	8.93±.067a
3	8.53±.067b	8.78±.044b	8.48±.044b	8.52±.044b
6	6.50±.058c	8.17±.035c	8.16±.021c	8.03±.034c
9	2.99±.015d®	7.61±.021d	7.65±.076d	7.22±.044d
12		6.68±.020e	7.22±.060e	7.01±.058e
15		3.59±.019f ®	7.05±.037f	6.90±.000e
18			5.40±.012g	6.11±.007f
21			3.29±.012h ®	5.29±.021g
24				3.07±.044h ®

Means followed by the same letter are not significantly different at P < 0.05 by Duncan's multiple range test a, b, c, …. for columns.
®: rejected

The mean sensory ratings for appearance, texture, and odor of Basa fish fillets, either as control (no treatment) or as samples treated with 4.5 kGy gamma irradiation in combination with varying levels of lemon grass extract (2; 4, and 6%), are displayed in Tables (13, 14, and 15). It is clear that the panelists rejected the control samples outright on the ninth day of cold storage because of their flabby texture and putrefaction odor. Although the shelf life of Basa fish fillets was extended by applying gamma irradiation with lemon grass extract to days 15, 21, and 24 of cold storage, the panelists rejected these samples because of the presence of mold. These findings are consistent with those reported by **Shawki *et al.* (2012)**

4. Conclusion

This study shows that gamma irradiation combined with lemongrass extract can effectively increase the shelf stability and hygienic quality of Basa fish fillets during cold storage. The antibacterial and antioxidant properties of lemongrass extract further improved preservation, moreover the 4.5 kGy irradiation dose significantly reduced spoiling, lipid oxidation, and microbiological contamination. The best results were obtained with 6% lemongrass extract, which extended the fillets' sensory acceptability and microbiological safety for up to 24 days. These findings suggest that a combination of 4.5 kGy gamma irradiation and 6% lemon grass extract can safely and effectively extend the shelf life of seafood products.

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تعزيز الثبات التخزيني والجودة الصحيه لشرائح اسماك الباسا باشعة جاما مع تركيزات مختلفه من مستخلص حشيشة الليمون

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الملخص العربى

يُعدّ سمك الباسا (*Pangasius bocourti*) من المأكولات البحرية الشائعة بسبب تكلفته المنخفضة وقيمته الغذائية العالية، لكنه سريع التلف نتيجة التلوث الميكروبي وأكسدة الدهون. يهدف هذا البحث إلى دراسة تأثير تشعيع بأشعة جاما بجرعة (4.5 كيلوجراي) مع مستخلص عشبة الليمون بتراكيز مختلفة (2%، 4%، 6%) في تحسين ثبات الجودة الكيمائية والحسية والأمان والجودة الصحية لشرائح سمك الباسا أثناء التخزين البارد عند 4°م. أظهرت النتائج أن استخدام أشعة جاما مع التركيزات المختلفة لمستخلص عشبة الليمون قللت بشكل كبير من الحمل الميكروبي، وأكسدة الدهون، والتلف الإنزيمي، مما أدى إلى إطالة الثبات التخزينى للشرائح خاصة عند تركيز 6%، حيث ساهمت في تثبيط نمو البكتيريا والحفاظ على الصفات الحسية. توضح هذه الدراسة التأثير التعاونى بين اشعة جاما بجرعة 4.5 كيلو جراى ومستخلص عشبة الليمون كطريقة فعالة لحفظ وتحسين جودة وسلامة شرائح سمك الباسا. و قد أظهرت نتائج هذه الدراسة أن التأثير التعاونى بين اشعة جاما ومستخلص عشبة الليمون يحسن بشكل فعال من استقرار وجودة شرائح سمك الباسا أثناء التخزين بالتبريد. حيث أدى استخدام جرعة 4.5 كيلوغراي من اشعة جاما مع تركيزات مختلفه من مستخلص عشبة الليمون (2، 4 ، 6 %) في تقليل التلوث الميكروبي وأكسدة الدهون والفساد لشرائح سمكة الباسا اثناء التخزين بالتبريد وقد كان تركيز 6% هو الأكثر فاعلية، حيث ساعد في زيادة القبول الحسي و الثبات التخزينى و الجودة الصحيه للشرائح حتى 24 يومًا. تشير هذه النتائج إلى أن استخدام التأثير التعاونى لأشعة جاما مع المستخلصات النباتية الطبيعية وخصوصا حشيشه الليمون يقدم طريقة واعدة وآمنة لإطالة العمر الافتراضي لمنتجات المأكولات البحرية.