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PHYSICOCHEMICAL EVALUATIONS OF THE EFFECTS OF IRRADIATION AND EVISCERATION ON THE CONSERVATION OF REFRIGERATED BLACKFIN TUNA (*Thunnus atlanticus*)

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ABSTRACT

Tuna is among the most traded fishes in Brazil, however efficiently delaying its fast deterioration is still a major practical challenge. Irradiation has been proposed as a safe and powerful alternative tool for conservation of seafood. This work investigated the effects of irradiation on the physicochemical quality of refrigerated blackfin tuna (*Thunnus atlanticus*). Analyses of pH, total volatile bases (TVB-N), ammonia and biogenic amines (histamine, cadaverine and putrescine) were performed in order to determine the degree of conservation. The samples were subjected to four different treatments aiming at evaluating the efficiency of irradiation, evisceration and both combined. The figures measured for those parameters, all of them related to the degree of conservation, were found to increase with time regardless of the treatment. In addition, data for irradiated samples remained consistently lower than for unirradiated ones, indicating a better level of preservation that led to an extended shelf life of 14 days. In contrast, excessive levels of those indicators of degradation were found in unirradiated samples after 7 to 10 days of storage. In addition, some evidence was found that evisceration slightly increased quality, consequently promoting a small extension in shelf life of unirradiated samples. Finally, it can be concluded with basis on the results of the physicochemical parameters studied that treatment of fresh refrigerated blackfin tuna by irradiation with 2.5 kGy efficiently preserved freshness and extended the shelf life of the product from 7 to 14 days.

1. INTRODUCTION

Being one of the richest sources of proteins, fish meat is a very nutritious food. However, its conservation still remains a challenge due to its fast deterioration, favored by its almost neutral pH and its high levels of water activity and proteins [1]. Tuna fish is commercially important in Brazil [2]. As the demand for seafood has been growing rapidly, so has the worldwide incidence of food-borne diseases, highlighting the need for more effective efforts to prevent them by eliminating spoilage and pathogenic bacteria, improving safety and extending shelf life. A safe and powerful alternative tool, also capable of enhancing the

beneficial effects of other food treatments is irradiation [3-6]. Described in this work are the investigations performed to determine the effects of irradiation and evisceration, either alone or combined, on the conservation of refrigerated blackfin tuna (*Thunnus atlanticus*) by determining the evolution of physicochemical parameters and thus the corresponding shelf life for each of four treatments tested.

2. EXPERIMENTS

A brief description of the experiments performed in this work is provided in this section. Twenty fresh unprocessed samples of blackfin tuna (*Thunnus atlanticus*) were purchased in Niterói, Brazil. Half of the fishes were eviscerated and washed and half were only washed. All samples were then packed in sealed plastic bags and transported in isothermal boxes filled with ice to CTEx, located in Guaratiba, Rio de Janeiro, a few hours later, where half of them were exposed to a gamma-ray dose of 2.5±0.3 kGy at a 1.4 kGy/h mean rate in a cesium-137 research irradiating facility [7]. After irradiation, all samples were immediately transported to the Department of Food Technology of the Fluminense Federal University where they remained stored for up to 14 days at 3±1^{o}C, being submitted to analyses intended to monitor their freshness by measuring pH, level of ammonia and concentrations of total volatile bases (TVB-N) and biogenic amines (histamine, cadaverine and putrescine) [8].

Measurements of TVB-N, performed in duplicate, were based on Conway Microdiffusion Method, while direct instrumental readings of pH were obtained by using the potentiometric method and ammonia levels were determined by using Nessler test. All three types of measurements were performed according to recommendations by LANARA [9]. In addition, semiquantitative analyses by thin-layer chromatography were used to measure the concentrations of biogenic amines [10] following procedures suggested by Schultz et al. [11].

3. RESULTS AND DISCUSSION

In this section, the experimental data for TVB-N and pH are presented and discussed, followed by those for ammonia and biogenic amines. Finally, shelf-life estimates based on experimental data and their maximum allowances are provided for all treatments.

3.1 Total Volatile Bases (TVB-N) and pH

The levels of TVB-N and pH have been widely used as indicators of quality and freshness of fish products [12]. The initial levels, being significantly lower than the maximum allowances enforced by Brazilian legislation [13], namely 30 mg-N/100g and 6.5, respectively indicate that all samples were fresh when the analyses began. Illustrated in Figs. 1 and 2 are the data measured for TVB-N and pH, in the same order. The spline-smoothed dashed curves, plotted through the points in order to facilitate visualization, exhibit similar increasing trends, consistently suggesting that the action of spoilage bacteria became stronger with storage time. Irradiation with 2.5 kGy reduced the levels of TVB-N and pH in the samples by 15% and 5%, respectively. In addition, following an initial latency phase of slow growth, possibly associated to a period of adaptation of surviving bacteria, the curves become steeper, indicating degradation at a faster pace, probably due to an increase in bacterial action favored by reduced competition.

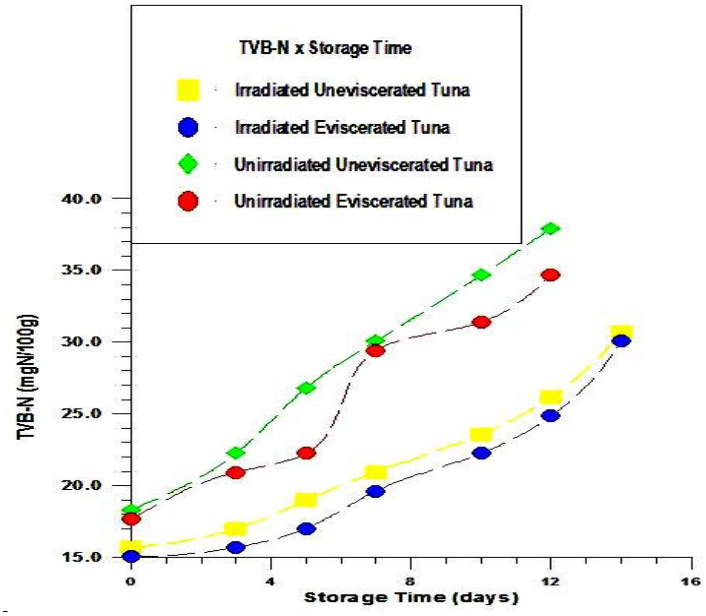

Figure 1. Levels of Total Volatile Bases (TVB-N) as function of storage time measured in refrigerated tuna fishes submitted to four different treatments: evisceration only, irradiation only, evisceration and irradiation and none.

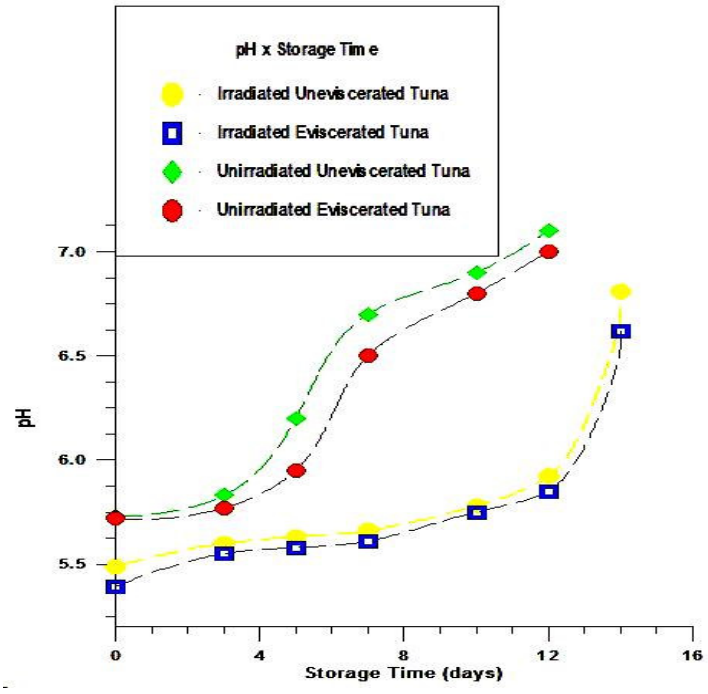

Figure 2. pH as function of storage time measured in refrigerated tuna fishes submitted to four different treatments: evisceration only, irradiation only, evisceration and irradiation and none.

The significantly lower (at 95% confidence level) values of TVB-N and pH in irradiated samples in comparison with unirradiated ones indicate an enhancement of quality by irradiation. For unirradiated samples, counts of eviscerated fishes are seen to lag behind those of uneviscerated ones, suggesting an enhanced shelf life of 2-3 days (at 90% confidence level). Therefore, the maximum allowances for both parameters were reached after 7 days of storage for unirradiated uneviscerated fishes, 8-9 days for unirradiated eviscerated samples and 14 days for irradiated samples, regardless of having been eviscerated or not.

3.2 Ammonia and Biogenic Amines (Histamine, Cadaverine and Putrescine)

Ammonia, produced by putrefaction of nitrogenous animal matter and histamine, cadaverine and putrescine, which are biogenic amines resulting from enzymatic and bacterial degradation of animal tissues [14], were not detected in the samples during the initial analyses. Detectable amounts of ammonia are not allowed in foods and a maximum allowance of 10mg/100g is required for biogenic amines [13]. The concentrations of those substances for different storage times are listed in Table 1. The level of ammonia was expressed in a three-degree scale: none, low and high; and the concentration of biogenic amines followed a four-level scale (expressed as: < 2, 2-5, 5-10 and >10 mg/100g). For each treatment tested, the storage time needed for the concentrations in the samples to reach such levels are also provided. All measured concentrations were found to increase with time, with those in irradiated samples delayed about one week in comparison with those in unirradiated ones.

Table 1. Measured concentrations of ammonia, histamine, cadaverine and putrescine of refrigerated samples of tuna fishes submitted to irradiation, evisceration or none and stored for up to 14 days

Substance	Concentration Measured (mg/100g)	Storage Time (in days) For Samples Treated with		
		None	Evisceration	Irradiation
Ammonia	Low	5	7	-
	High	7	10	14
Histamine	< 2	3	5	-
	2 – 5	-	7	10
	5 – 10	5	-	12
	> 10	7	10	14
Cadaverine	< 2	-	5	7
	2 – 5	3	7	10
	5 – 10	5	10	12
	> 10	7	12	14
Putrescine	< 2	-	-	7
	2 – 5	-	5	10
	5 – 10	5	7	12
	> 10	7	10	14

3.3 Shelf-Life Estimates

Listed in Table 2 are shelf-life estimates**,** determined as the time needed for the maximum allowances of the parameters to be reached. The analyses consistently yielded a shelf life of 14 days for the irradiated samples, regardless they had been eviscerated or not. In addition, arithmetic averages for the shelf-life estimates of unirradiated samples yielded 7±1 and 9±2 days, for uneviscerated and eviscerated tuna, respectively. Thus the corresponding shelf-life extensions promoted by evisceration and irradiation relatively to untreated samples were 2-3 and 7 days, respectively.

Table 2. Shelf lives of samples submitted to evisceration, irradiation or none estimated with basis on maximum allowances of TVB-N, pH, ammonia, histamine, cadaverine and putrescine

Treatment	Estimated Shelf Life (days)					
	TVB-N	pH	Ammonia	Histamine	Cadaverine	Putrescine
None	7	7	5	7	7	7
Evisceration only	9	8	7	10	12	10
Irradiation	14	14	14	14	14	14

4. CONCLUSIONS

The physicochemical analyses performed in this work consistently indicated that irradiation with 2.5 kGy efficiently extended the shelf life of refrigerated blackfin tuna from 7 to 14 days compared to a 2-3 day extension promoted by evisceration. In addition, when used in combination with irradiation, evisceration was not capable of producing any additional impact on the conservation of the fishes.

REFERENCES

1. O. P. Frase, S. Sumar, “Compositional Changes and Spoilage in Fish – Microbiological Induced Deterioration”, *Nutrition and Food Science*, **Vol. 1(6)**, pp. 325-329 (1998).
2. K. R. Vieira, J. E. Lins Oliveira, M. C. Barbalho, J. P. Aldatz, “Aspects of the Dynamic Population of Blackfin Tuna (*Thunnus atlanticus* – Lesson, 1831) Caught in the Northeast of Brazil”, *Collection of Scientific Papers, ICCAT*, **Vol. 58(5)**, pp. 1623-1628 (2005).
3. J. F. Diehl, “Safety of Irradiated food”, Marcel Dekker Inc., New York, USA (1990).
4. International Consultative Group on Food Irradiation (ICGFI), *Facts on Food Irradiation*, FAO/IAEA (2000).
5. N. K. Hernandes, H. C. Vital, A. U. O. Sabaa-Srur, “Irradiação de alimentos: Vantagens e Limitações”, *Bol. SBCTA*, **Vol. 37(2)**, Campinas, pp. 154-159 (2003).
6. H. C. Vital, M. Freire Jr., “Cap.11: A Irradiação de Alimentos”, *Tecnologia de Alimentos e Inovação: Tendências e Perspectivas*, Embrapa, Brasília, Brazil (2008).

7. H. C. Vital, L. F. G. Pires, R. Q. Lima, S. O. Vellozo, "Experimentos Dosimétricos no Irradiador Gama do IPE", *Anais do 5º Encontro Nacional de Aplicações Nucleares (ENAN)*, Oct. 15-20, Rio de Janeiro, Brazil (2000).
8. M. L. G. Monteiro, "Avaliação da Validade Comercial de Atuns (*Thunnus atlanticus*) Inteiros e Eviscerados Irradiados", *Monografia do Curso de Especialização Lato Sensu em Irradiação de Alimentos*, Faculdade de Veterinária da UFF, Niterói, Brazil (2009).
9. Brasil, "Métodos Analíticos Oficiais para Controle de Produtos de Origem Animal e seus Ingredientes II – Métodos Físicos e Químicos Ministério da Agricultura", Laboratório Nacional de Referência Nacional (LANARA) da Secretaria Nacional de Defesa Agropecuária, Brasília, Brazil (1981).
10. A. R. Shalaby, "Separation, Identification and Estimation of Biogenic Amines in Foods by Thin-Layer Chromatography", *Food Chemistry*, **Vol. 1(49)**, pp. 305-310 (1994).
11. D. E. Schutz, G. W. Chang, L. F. Bjeldanes, "Rapid Thin Layer Chromatographic Method for the Detection of Histamine in Fish Products", *Journal of the Association of Official Analytical Chemists*, **Vol. 59(6)**, p. 1244-1225 (1976).
12. J. J Connell, *Control of Fish Quality*. Fishing News Books, London, England (1975).
13. "Portaria nº 185 de 13 de Maio de 1997: Regulamento Técnico de Identidade e Qualidade de Peixe Fresco (Inteiro e Eviscerado)", http://extranet.agricultura.gov.br/sislegis-consulta/servlet/VisualizarAnexo?id=2157
14. A. R. Shalaby, "Significance of Biogenic Amines to Food Safety and Human Health", *Food Research International*, **Vol. 29(7)**, pp. 675-690 (1996).