Avanços Científicos e Tecnológicos nas Ciências Agrárias

Raissa Rachel Salustriano da Silva-Matos
José Eudes de Morais Oliveira
Samuel Ferreira Pontes
(Organizadores)

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APRESENTAÇÃO

A área de Ciências Agrárias é ampla, englobando os diversos aspectos do uso da terra para o cultivo de vegetais e criação de animais, atualmente um dos grandes desafios do setor é aumentar a produção utilizando os recursos naturais disponíveis para garantir a produtividade necessária para atender a demanda populacional crescente, garantindo a preservação de recursos para futuras gerações.

Nesse sentindo, aprimorar as tecnologias existentes e incentivar o desenvolvimento de inovações para setor pode proporcionar o aumento da produtividade, bem como otimizar os processos e utilização dos insumos, melhorar a qualidade e facilitar a rastreabilidades dos produtos. Assim as Ciências Agrárias possuem alguns dos campos mais promissores em termos de avanços científicos e tecnológicos, com o uso dos Veículos Aéreos Não Tripulados (VANTs) conhecidos como drones, utilização de softwares, controle biológicos mais efetivos e entre outras tecnologias.

Diante desta necessidade e com o avanço de pesquisas e tecnologias é com grande satisfação que apresentamos a obra “Avanços Científicos e Tecnológicos nas Ciências Agrárias”, que foi idealizada com o propósito de divulgar os resultados e avanços relacionados às diferentes vertentes das Ciências Agrárias. Esta iniciativa está estruturada em dois volumes, 1 e 2. Desejamos uma boa leitura!

Raissa Rachel Salustriano da Silva-Matos
José Eudes de Morais Oliveira
Samuel Ferreira Pontes

SUMÁRIO

CAPÍTULO 15

EFFECTS OF THE UTILIZATION OF OZONISED WATER IN THE PROCESSING OF JAMAICA WEAKFISH (*Cynoscion jamaicensis*)

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Érika Fabiane Furlan
Unidade Laboratorial de Referência em Tecnologia do Pescado - Instituto de Pesca/APTA/ Secretaria de Agricultura e Abastecimento do Estado de São Paulo
http://lattes.cnpq.br/1821513214759586
effurlan@pesca.sp.gov.br

Cristiane Rodrigues Pinheiro Neiva
Unidade Laboratorial de Referência em Tecnologia do Pescado - Instituto de Pesca/APTA/ Secretaria de Agricultura e Abastecimento do Estado de São Paulo
http://lattes.cnpq.br/6428511290689751

Thais Moron Machado
Unidade Laboratorial de Referência em Tecnologia do Pescado - Instituto de Pesca/APTA/ Secretaria de Agricultura e Abastecimento do Estado de São Paulo
http://lattes.cnpq.br/0545120874674362

Rúbia Yuri Tomita
Unidade Laboratorial de Referência em Tecnologia do Pescado - Instituto de Pesca/APTA/ Secretaria de Agricultura e Abastecimento do Estado de São Paulo
http://lattes.cnpq.br/2976050072939164

RESUMO: A presente pesquisa reproduziu a realidade industrial de processamento de filés e estudou os efeitos da utilização da água ozonizada no processamento da pescada-goete sobre os parâmetros físico-químicos, microbiológicos e sensoriais do peixe inteiro e dos filés mantidos sob refrigeração, em um estudo de vida útil. Foram investigados o pH, nitrogênio básico volátil, a rancidez oxidativa, *Salmonella* spp, coliformes totais, *Staphylococcus aureus*, microrganismos mesófilos e psicrotróficos, fungos e leveduras. Os resultados não demonstraram diferença estatisticamente significativa entre as amostras sanitizadas com água ozonizada quando comparadas àquelas tratadas com água clorada (5ppm), conforme preconizado pela legislação brasileira. A água ozonizada pode ser alternativa efetiva à água clorada no processamento de peixes inteiros e filés de pescada, minimizando os resíduos de cloro no produto, ou seja, a formação de organoclorados em desdobramento nas lipoproteínas de origem animal e nos descartes resultantes do processamento.

PALAVRAS-CHAVE: Qualidade do pescado, Tecnologia do pescado, Pescado, Segurança alimentar, Ozônio, Indústria pesqueira.

EFEITOS DA UTILIZAÇÃO DA ÁGUA OZONIZADA NA LINHA DE

ABSTRACT: The present research reproduced the industrial fillet processing reality and studied the effects of the utilization of ozonised water in the processing of Jamaica Weakfish on physicochemical, microbiological and sensorial parameters in the whole fish and in the fillets kept under refrigeration in a study of shelf life. pH, basic volatile nitrogen, rancidity, Salmonella spp, total coliforms, Staphylococcus aureus, mesophilic and psychotropic microorganisms, fungus and yeasts were investigated. Results did not show difference statistically significant between samples treated with ozone when compared to those treated with chlorinated water (5ppm), as recommended by Brazilian legislation. Ozonised water can be an effective alternative to chlorinated water in fish processing, minimizing the formation of chlorine residues in the product, in other words, organochlorines in unfolding in animal lipo-proteins and in the processing disposal.
KEYWORDS: Seafood quality, Seafood technology, Fish, Food safety, Ozone, Seafood industry.

1 I INTRODUCTION

The quality of fish products is a worldwide requirement, not only for the benefits associated with its consumption, but also by the growing demand from consumers and health authorities about the quality of products offered.

Despite the evolution in the seafood production systems, recent studies have indicated deficiencies in the hygienic-sanitary practices of its handling, including on board of fishing vessels (Pastoriza, 2008a; Machado et al., 2010), as well as food safety problems related to the use of sanitizing substances and food additives (Chiattone *et al*., 2008; Furlan & Torres, 2010). Additionally, for attainment of a seafood product of quality, the adequate use of cold, among other technologies for preservation of seafood, is indispensable (Soares, 2007).

In this context, the use of ozone is positioned as a promising technology (Manousaridis *et al*., 2005), because, in addition to the sanitizing function, it can improve the sensorial quality of the seafood (Campos *et al*., 2006) and even increase its shelf life (Campos *et al*., 2004; Campos *et al*., 2006; Manousaridis *et al*., 2005; Nerantzaki *et al*., 2005; Pastoriza *et al*., 2008[a]; Pastoriza *et al*., 2008[b]; Silva & Gonçalvez, 2014). The use of ozone by the world food industry, in the handling and processing of innumerable foods has been reported for its capacity to guarantee hygiene and quality (Manousaridis *et al*., 2005; Nerantzaki, 2005; Silva & Gonçalves, 2014), in addition to having the advantage of not favouring the formation of toxic residues (Chiattone *et al*., 2008), making possible its application in many foods as a safe and efficient bactericidal agent (Guzel-Seydim *et al*., 2004; Pastoriza *et al*., 2008[a]).

Ozone is a substance with elevated bactericidal and fungicidal action, acting also against protozoa, virus and fungus, and bacteria spores (Kim *et al*., 1999; Khadre *et al*., 2001; Chiattone, 2008). It has already been highlighted that the microbial inactivation by ozone varies in accord with the generation system, concentration, contact time (Pastoriza *et al*., 2008[a]), temperature (Kim *et al*., 1999; Pastoriza *et al*., 2008[a]), quantity of organic matter, pH, and presence of chemical additives (Kim *et al*., 1999). Its germicidal action is due to its high oxidising potential (Khadre *et al*., 2001; Kim *et al*., 1999; Manousaridis *et al*., 2005), with effects documented in a large variety of microorganisms (Kim *et al*., 1999; Guzel-Seydim *et al*., 2004; Campos *et al*., 2004; Manousaridis *et al*., 2005; Nerantzaki *et al*., 2005; Campos *et al*., 2006; Cantalejo, 2007; Pastoriza *et al*., 2008[a]; Pastoriza *et al*., 2008[b]; Chiattone, 2008; Crapo *et al*., 2010), including positive and negative Gram bacteria, spores and vegetative cells (Kim *et al*., 1999; Guzel-Seydim *et al*., 2004; Chiattone, 2008). Some authors observed that negative Gram bacteria are more sensitive to the application of ozone than the positive (Khadre *et al*., 2001; Chiattone, 2008).

However, as it has already been emphasized by other authors, researches are necessary for better understanding and utilization of its characteristics, as well as for exploring new applications, more adequate concentrations, and the best methods of application of ozone in divers species of seafood (Nerantzaki, 2005; Gonçalves, 2009).

In Europe and the United States, ozone has been employed in the food and drink industry, suggesting its technical and economic feasibility (Khadre *et al*., 2001). According to Kim *et al*. (1999), this bactericide can be used in the removal of odours of deposits of some cheeses without affecting its physicochemical and sensorial properties and also increasing the time of shelf life. It can be utilized in the treatment of eggs, poultry, vegetables, cereals, grains, milk, fruit, as well as in the treatment of water, making it sterile for application in the food industry. The beverage industry in the United States utilizes ozone to clean and disinfect equipment, utensils and the processing plant as a whole, without producing residues that are toxic to the environment, which is an important advantage for the food industry (Kim et al., 1999; Sopher *et al*, 2007; Pastoriza *et al*., 2008[b]).

Considering the lack of research related to the sanitizing efficiency of ozone with Brazilian seafood commercial species, and the necessity of data to subsidise the evaluation of its specific application in this productive chain, the present study investigated the efficiency of ozone in the processing water of the Jamaica Weakfish (*C. jamaicensis*) to verify its effect on its quality and stability in the presentations: whole fish and fillet, and the latter has been maintained under controlled refrigeration conditions in a shelf life study.

2 I MATERIALS AND METHODS

2.1 Processing of seafood

Samples of Jamaica Weakfish (*Cynoscion jamaicensis*) were acquired directly from the fishery industry located in the Guarujá–SP, Brazil, and the processing was performed in a laboratorial unit appropriately equipped with a pilot seafood processing unit, in an acclimated environment (15^{O}C ± 1^{O}C) associated with Good Manufacturing Practices - GMP.

Three distinct lots of whole fish were processed, reproducing the reality of industrial processing, fulfilling the stages of cleaning of the whole fish, evisceration, washing, filleting, washing, draining, weighing, packaging and refrigeration.

The study evaluated 3 distinct treatments of washing of the whole fish: A) ozonised water in a concentration of 2 ppm, for 5 min.; B) ozonised water in a concentration above to 2 ppm, for 5 min.; and C) chlorinated water in the concentration of 5 ppm for 1 min. This last treatment, with chlorine, reproduces of practices in the Brazilian industries (Brazil, 2017). The temperature of the washing water was monitored and oscillated from 0 to 1^{O}C.

The filleting process was performed under ozonised or chlorinated water, in the same concentrations of the treatments described above, and the average temperature of fish was from 3^{O}C to 3.5^{O}C. After draining the water, the fillets were weighed, packaged in Styrofoam trays, and then wrapped in plastic film, sealed, identified and stored under refrigeration (4^{O}C ± 1^{O}C) until analysis.

After the diverse treatments of washing, the samples of whole fish were submitted to physicochemical, microbiological and sensorial analyses. The fillet samples were submitted to the same analyses after 1, 3, and 6 days of storage under the controlled conditions. Each lot of seafood was submitted to the processing and to the treatments described, Three campaigns of processing were performed to minimize the effect of the differences that are intrinsic to the lots from distinct fisheries.

2.2 Generation of Ozone

An ozone generating system was utilized (BRO-3 - Brasil Ozônio Ind. e Com. de Equipamentos e Sistemas Ltda.) which, by the corona effect, produces ozone (O_3) from atmospheric air. In the system utilized, the ozone produced was inserted into the water by way of a Venturi type injector, which functions by means of a difference of pressure. To confirm the initial concentration of ozone in the washing water, according to the treatments described, an aliquot of 25mL of the water of the washing tank was tested with a colorimetric analysis kit (CHEMetrics® – www.

chemetrics.com).

2.3 Physicochemical analyses

All of the physicochemical analyses were performed in triplicate and included the determination of pH and quantification of the Nitrogen of the Total Volatile Bases (N-TVB), according to the official methods (Brazil, 1999, and Brazil, 1981, respectively), as well as, the quantification of reactive substances of the Thiobarbituric Acid (TBArs), where the malonic aldehyde (MA) was quantified by the colorimetric method proposed by Vyncke (1970).

2.4 Microbiological Analyses

The analysis of *Salmonella sp,* positive coagulase *Staphylococcus*, total and thermo-tolerant coliforms were investigated, as well as total mesophyll and psychrotrophic micro-organisms, fungi and yeast (Brasil, 2003), and *Pseudomonas aeruginosa* (APHA, AWWA & WEF, 2005). All determinations were performed in triplicate.

2.5 Sensorial Analysis

The analyses were performed by trained judges who were familiarized with the terms and tables of specific attributes of the studied specie, which were elaborated based on the Regulation of the European Union (Regulation EC, 1996). The team was comprised of 38 judges, being 17 men and 21 women with ages varying from 21 to 65 years. The descriptive test were always performed with a minimum of 21 judges who evaluated parameters related to odour, general appearance and texture of the samples of for whole fish or for fillets, using the different tables elaborated for each type of presentation. A numeric system of evaluation was utilized, which, by means of a table of scores, described and evaluated the intensity of the sensorial attributes, in a demerit scale of 1 to 4. The resulting scores of the analyses were subdivided in grades or indicative zones of the degree of freshness of the two presentations, according to Table 1.

	Score	
Degree of Freshness	**Whole fish**	**Fillet**
Excellent	20 to 18	12 to 10
Good	17.99 to 14	9.99 to 7
Regular	13.99 to 11	6.99 to 5
Rejected	≥ to 10.99	≥ to 4.99

Table 1. Scores used for the qualification of whole and fillet fish

* Adapted from Shewan, (1953)

2.6 Statistical Analysis

The relations between the different treatments and parameters analysed, were verified using SYSTAT program ($p<0.05$).

3 I RESULTS AND DISCUSSION

The Jamaica Weakfish (*C. jamaicensis*) is one of the main species in volume of disembarkation in the Southeast of Brazil (Ávila-da-Silva *et al.*, 2019). The industrial production volume in the State of São Paulo evolved 1,12 t of Jamaica Weakfish in 2009 (Neiva *et al*, 2010) to 1,94t in the same state, from April to June of 2019 (Ávila-da-Silva et al., 2019).

The present study generated original data with a relevant commercial species *C. jamaicensis*, commonly found on the Brazilian coast and consumed by the population, in addition to aiding in the discussion about the use of ozone in the productive chain of seafood, in order to supply important information for this proposal in the country, since its use in food is not regulated.

In view of the complexity of the process of seafood decomposition, the use and combination of different parameters, such as physicochemical, microbiological and sensorial, among others, is the most indicated to evaluate its quality (Hernández *et al*, 2009). This approach was also important to verify the utilization of ozone in the processing water of Jamaica Weakfish, aiming to promote the production of minimally processed product without alterations in its quality (Patil *et al.*, 2010). In addition to this, as highlighted by Liu Qi *et al.* (2010), this study is relevant because the antimicrobial efficiency of the sanitizing agent varies in accordance with the specie of the microorganism, as well as the composition of the microbial biota is distinct according to the type and the species of seafood, origin and practices of production and handling.

3.1 Physicochemical Analyses

The values of pH observed on “day 0”, that is on the day of the processing, in three campaigns referring to the samples of raw material (whole fish), were in accord with the established by the RIISPOA (Brazil, 2017), indicating its appropriateness for consumption. The results did not present any significant difference ($p<0.05$) among the distinct treatments, and neither when compared to the control sample (fish not submitted to washing). Cantalejo (2007) also did not observe significant alterations in the pH, as well as in the brightness of fillets of tuna after treatment with ozone.

In the shelf life study, the results of pH of the fillets submitted to the different treatments varied from 6.8 on day 1 to 7.8 at the end of 6 days, but after the 3rd day of storage, the values observed, independently of the treatment, exceeded the limit established by the RIISPOA, which can vary to 7.0 (Brazil, 2017) . The statistical analysis demonstrated that the variation of pH in the fillets was highly related to the variable time ($p<0.05$), although it is not possible to distinguish if the alterations caused by the degradation of the meat are due to the microbial activity or if result from action of enzymes present in the muscle tissue (Campos *et al*., 2004).

As highlighted by Pastoriza *et al*. (2008[b]) soon after the capture, in the majority of the fish species, the pH is less than 7 due to the presence of lactic acid originated from the hydrolysis of the glycogen produced after the slaughter. However, undesirable alkaline products such as ammonia and trimethylamine are formed by bacterial action, raising the pH to above 7. In addition, to being parameter of quality, the pH of the matrix can also interfere in the efficiency and in the general conditions of the treatment with ozone, as observed by Patil *et al*. (2010), when the kinetics of inactivation of *E. coli* in apple juice was faster in more acid pH.

According to Ogawa *et al*. (1999), for fish with excellent freshness the content of N-TVB reaches 5 to 10 mg N.100 g^{-1}; fish with reasonable freshness can reach up to 15 to 25mg N.100g^{-1}. In the beginning of putrefaction, this content can go up to 30 to 40 mg N.100 g^{-1} and, when it is much deteriorated, such content should be found above 50 mg N.100 g^{-1}. In the present study it can be observed, on "day 0" in the samples of whole fish the contents of N-TVB were below 30mg N.100g^{-1}, in accordance to what is established by the national legislation (Brazil, 2017). The statistical analysis demonstrated that there was no influence of any treatment on the content of N-TVB, as well as when compared to the control sample, at the level of 95% of significance.

In the study of shelf life, all of the fillet samples demonstrated contents of N-TVB below the limit recommended by legislation (Brazil, 2017), for up to 3 days of storage under refrigeration, independently of the treatment to which they were submitted, whose values were 24.3; 27.11, and 25.16 mg N.100g^{-1}, for the treatments A, B and C, respectively. After 6 days of storage, this limit of 30 mg N.100g^{-1} was exceeded. The statistical analysis demonstrated a relation between the formation of volatile compounds and the alterations of pH ($p<0.05$), as well as between the time of storage and the variation of N-TVB ($p<0.05$). The statistical analysis also evidenced that mesophyll and psychrotrophic bacterias had a highly significant relation with the variation of N-TVB ($p<0.05$).

Crapo *et al*. (2004) verified that the ozone was as efficient as the chlorine in the reduction of the levels of *Listeria innocua* on contact surfaces, however, the application of ozonised water in fillets and fish eggs was not as effective for the bacterial control, principally regarding the fillets, due to the reduction of its efficiency in presence of organic matter.

Other studies, that used combined washing treatments with ozonised water in processing and storage in ozonised ice (Pastoriza *et al*., 2008[a] and Pastoriza *et al*., 2008[b]), the content of N-TVB in a variety seafood was below the recommended limits for 12 days. On the other side, Campos *et al*. (2006) and Álvarez *et al*. (2009) also used ozonised ice and water, and did not obtain significant differences in the results for *Psetta maxima* and *Pagellus bogaraveo*, respectively, treated with or without ozone. A similar treatment, by Aubourg *et al*. (2009) for *Oncorhynchus mykiss*, surpassed 16 days without exceeding the limits of N-TVB. Yet, Nerantzaki *et al*. (2005) utilized this same species and verified the efficiency of the immersion in ozonised water, notwithstanding, the time of 90 minutes necessary for the treatment makes impracticable its application in the industrial routine.

Manousaridis *et al*. (2005) attained 14 and 12 days of acceptability for *Mytilus galloprovinciali*, respectively, for the treatments with and without ozone. When *Crassostrea gigas* was immersed in ozonised water, Liu Qi *et al* (2010) verified that the results of N-TVB were low for 22 days due to the chemical composition of the meat of oysters.

In this research, the reduced shelf life observed may have been influenced by the fragility of the musculature of the studied species, as well as by the low quality of disembarked seafood, a fact indicated by Machado *et al*. (2010) due to poor handling practices and/or inadequate conditions of storage onboard. These factors accelerate the process of deterioration and are commonly observed in the State.

The lipidic oxidation is one of the principal causes of the loss of quality in meat products, which means great economic losses for the industry. Even in products warehoused under freezing, the lipidic oxidation continues to occur, altering its quality and compromising its acceptability by the consumers (Oliveira *et al*., 2008; Özen *et al*, 2011; Ozogul *et al*, 2011).

As there is no regulation, the present study considered 1mg $MA.kg^{-1}$ as the limit for TBArs, because above it, already occurs a sensorial association to the odour of rancidity, that means, lipidic oxidation in an advanced stage (Kim *et al*., 2000) and sensorial rejection. All samples of whole fish submitted to the different treatments were below this limit. They varied from 0.71mg $MA.kg^{-1}$ in the sample submitted to ozone treatment (2ppm), up to 1.00mg $MA.kg^{-1}$ in the control sample.

In the shelf life study, independent of the treatment to which fillets were submitted, 3 days after treatments the limit had been exceeded. At the end of 6 days of storage occurred an increase in the concentration of TBArs reaching the value of 1.99 mg $MA.kg^{-1}$ in the fillet sample submitted to treatment with ozone (2 ppm). No significant statistical relation of the different treatments with ozone and the lipidic oxidation of the fillets ($p<0.05$) was observed. Campos *et al*. (2006) utilized crushed ozonised ice (0.2mg.L^{-1}) and warehousing at 2°C to extend the shelf life of cultivated *Psetta máxima*, reaching 0.2mg MA.kg^{-1} after 35 days of storage. Crapo *et al*. (2010) reported acceleration of the process of rancidness in fish fillets frozen and sanitized with ozonised water (0.6 to 1.5 ppm).

Significant statistical relation between the variation of TBArs and sensorial analysis ($p<0.05$) was reported, and it confirmed that advanced lipid oxidation can be sensorially observed and this analysis can be an important instrument to evaluate this parameter. In addition, statistical analysis also demonstrated relation between the variation of TBArs and presence of psychrotrophic bacteria ($p<0.05$).

3.2 Microbiological Analyses

Salmonella sp is an important analytical parameter, considering the risk that it represents when present in food and due to the innumerable cases already reported of gastroenteritis from the consumption of seafood (Hadjichristodoulou *et al*., 1999; Soto *et al*., 2001). The Brazilian legislation recommends an absence of *Salmonella sp* in 25g (Brazil, 2001).

The present study, it was determined its presence in a sample of whole fish submitted to the treatment with ozone in the concentration above 2ppm (Table 2), and in a sample of fillet, one day after the treatment with chlorine in one of campaigns, being important to emphasize that this risk can be minimized by efficient thermal treatment and since no post-processing contamination occurs.

The results obtained for the positive coagulase *Staphylococcus aureus* analyses demonstrated that as much as in the whole fish as in the fillets, the population results were always below 10, independently of the treatment.

Pseudomonas aeruginosa is a ubiquitous bacterium and presents tolerance to a large variety of physical conditions as temperature, and chemical substances, as for example, disinfectants (Lincopan & Trabulsi, 2008). In this study, this bacterium was present in the whole fish (Table 2) and in the fillets submitted to the distinct treatments and stored under refrigeration, a fact that can explain the reduced shelf life of the fillets studied, because *P. aeruginosa* is a deteriorative bacterium of elevated metabolic activity.

Microorganism	Treatment			
	Ozone at 2 ppm	Ozone > 2 ppm	Chlorine 5 ppm	Control
Faecal Coliforms (UFC/g)	$2.5x10^3$	< 10	$2.6x10^2$	< 10
Total Coliforms (UFC/g)	$9.9x10^3$	$1.3x10^3$	$2.1x10^3$	$7.6x10^2$
Mesophyll (UFC/g)	$9.2x10^4$	$1.4x10^5$	$2.4x10^5$	$2.7x10^5$
Fungus and Yeasts (UFC/g)	< 10	$1.2x10^2$	5.2x10	2.3x10
Salmonella spp (in 25g)	Absent	Present	Absent	Absent
Staphylococcus aureus	< 10	< 10	< 10	< 10
Pseudomonas aeruginosa (in 25g)	$1.3x10^4$	$8.3x10^3$	$1.2x10^3$	$1.6x10^3$
Psychrotrophic (UFC/g)	$1.3x10^6$	$1.8x10^2$	$7.2x10^6$	$3.6x10^6$

Table 2 . Result of microorganism research in whole fish.

Total coliform is an indicator of the conditions of hygiene in the manufacturing processes, because sanitizers easily inactive them (Silva *et al*, 2007). The results obtained in the analyses of faecal and total coliforms indicate that it was not observed any difference related to the treatments to which the whole fish and fillets were submitted ($p<0.05$), even though it has already been indicated that Gram negative bacteria is more sensitive to the application of ozone (Khadre *et al*., 2001; Chiattone, 2008).

It was verified the existence of a significant relation between the variation of mesophyll and psychrotrophic bacteria related to the time of storage of the fillets ($p<0.05$). These results can be explained by the fact that, in general the psychrotrophic bacteria along with the mesophyll characterize the total deteriorating microbial load of the seafood. However, the statistical analysis of this data made evident that there was no significant difference between the values obtained for mesophyll and psychrotrophic bacteria and the distinct treatments, as much for the whole fish as for the fillets in the study of shelf life.

Nerantzaki *et al*. (2005) observed lower values of mesophyll bacteria, *Pseudomonas spp* and the H_2S producers in rainbow trout samples (*Oncorhynchus mykiss*) cultivated, and that were submerged in an ozonised solution ($1.0mg.L^{-1}$) for 60 and 90 minutes, and then packaged. These autors highlighted the necessity of optimizing the conditions of treatment with ozone to reach the maximum extension of shelf life, because this is a promising technology in the field of food technology and preservation.

Therefore, as it has already been made evident by Chiattone *et al*. (2008), it is important to emphasize that the efficiency of the ozone demonstrated here is compatible to the use of chlorinated water, with the advantage that the ozone, according to the scientific literature, does not generate residues in the seafood, nor in the water generated in the processing.

3.3 Sensorial Analysis

In the study of shelf life, a loss of sensorial quality was perceived in all fillet samples over time, varying from “good” quality in the beginning of the study, and finalizing with “regular” quality. However, the statistical analysis revealed that there was no significant difference ($p<0.05$) between the grades of quality obtained in the sensorial analysis of the fillet samples and the different treatments to which they were submitted.

Others shelf life studies obtained very different results, Campos *et al*. (2005) observed good quality up to 8 days after the beginning of the analysis, and acceptability of the ozonised samples up to 19 days. Pastoriza *et al*. (2008[b]) obtained 7 days of acceptability after treatment with ozone, and 12 days only under refrigeration in the boat. Manousaridis *et al*. (2005) reached 12 days of acceptability in their study with the mussels *Mytilus galloprovinciali* ozonised ($1.0mg.L^{-1}$, for 90 minutes). However, it should be emphasized that the species utilized are diverse and the time employed in treatments is extremely long, once more demonstrating the necessity of studies with the varied species and types of presentation to make possible its application in the industrial routine.

The analysis of the results also demonstrated that the sensorial evaluation and the variation of TBArs, as well as the sensorial evaluation and the psychrotrophic bacteria counts have a significant relation ($p<0.05$), as much in the whole fish as in the fillets, although in neither of the cases has there been observed a relation with the different treatments.

Considering the data obtained in the three processing campaigns, the statistical analysis demonstrated no significant significant difference ($p<0.05$) between the treatments utilized for all of the variables studied, as much in the whole fish as in the study of shelf life performed with the fillet of Jamaica Weakfish maintained under refrigeration for 6 days.

4 I CONCLUSIONS

Results indicated that the utilization of ozonised water in the processing of Jamaica Weakfish can be an important alternative to the chlorinated water, commonly utilized in the Brazilian industrial routine, also for its advantage of not generating residues in the musculature of the seafood, nor in the residual water originating from the processing. It is fundamental the performance of more studies to test and develop ideal conditions of ozonisation for seafood products, as well as to aid its evaluation, seeking the regulation of use in the productive chain of seafood.

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