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FLYING FISH (HIRUNDICHTHYS AFFINIS) BURGER: INFLUENCE OF ROSEMARY (ROSMARINUS OFFICINALIS) ON SENSORY AND PHYSICOCHEMICAL CHARACTERISTICS

PRODUTO TIPO HAMBURGUER À BASE DE PEIXE-VOADOR (HIRUNDICHTHYS AFFINIS): INFLUÊNCIA DO ALECRIM (ROSMARINUS OFFICINALIS) NAS CARACTERÍSTICAS SENSORIAIS E FÍSICO-QUÍMICAS

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RESUMO

O peixe-voador (Hirundichthys affinis) possui considerável importância socioeconômica devido ao fato de ser uma fonte alimentícia acessível para população de baixa renda. É um recurso pesqueiro explorado no mundo todo e pode ser usado como matéria prima para produzir produtos derivados de peixe devido ao seu baixo custo e alta disponibilidade na região nordeste do Brasil. O objetivo do presente estudo foi desenvolver formulações de um produto tipo hambúrguer utilizando diferentes quantidades de alecrim na sua composição e avaliar sua influência nas características físico-químicas e sensoriais do produto durante seu armazenamento sob congelamento. Para avaliar a influência do alecrim no produto foram realizadas análises de umidade, pH, acidez e análise da cor nos dias 0, 30 e 90 de armazenamento, e os atributos sensoriais foram avaliados por meio da Análise Descritiva Quantitativa. A acidez das amostras sem adição de alecrim aumentou significativamente no final do período de armazenamento. O pH aumentou das amostras com alecrim aumentou apenas nos dias 30 e 60 de armazenamento. Os valores de L* aumentaram para todas as amostras no final do período de armazenamento, porém os valores de a* foram maiores nas amostras com alecrim nos dias 0, 30 e 60. As análises sensoriais mostraram que as formulações adicionadas de alecrim obtiveram melhor manutenção das características sensoriais. O desenvolvimento de produtos à base de peixe voador associado ao uso de ingredientes naturais é uma alternativa viável para a oferta de produtos com valor agregado e uma oportunidade de renda para comunidades pesqueiras.

Palavras-chave: peixe-voador; alecrim, qualidade de alimentos.

ABSTRACT

The flying fish (Hirundichthys affinis) species has economic and social importance because it is a food for populations with low purchasing power. This is a fishery resource exploited worldwide and can be used as raw material to produce fish-based products due to its low cost and great availability in the northeastern region of Brazil. This study aimed to develop flying fish burgers formulations with different amounts of rosemary and assess its influence on the physicochemical and sensory characteristics throughout storage under freezing. To assess the influence of the rosemary during storage, moisture, pH, acidity, and color analysis were performed at 0, 30, 60 and 90 days of freezing and the sensory attributes were assessed using Quantitative Descriptive Analysis. The acidity of the sample without rosemary raised significantly at the end of the storage period. The pH raised only for the samples with rosemary at day 30 and 60. The L* values increased for all samples at the end of the storage period, however a* values where higher in samples with rosemary in days 0, 30 and 60. Sensory analysis showed that formulations with rosemary obtained better maintenance of the sensory characteristics. The development of flying fish products associated with the use of natural substances, becomes a suitable alternative to the availability of products with added value and being an income opportunity for fishing communities.

Keywords: flying fish; rosemary; global quality.

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INTRODUCTION

Flying fish (*Hirundichthys affinis*) are an exploited fishery resource worldwide. They are a source of income for coastal communities in Asian countries (Philippines, Indonesia, and India); in Caribbean countries (Barbados, Dominican Republic, Trinidad, and Tobago); in South America (Peru and Brazil); and in Africa (Benin, São Tomé, Príncipe, and Nigeria). The total production of flying fish in all countries of the world was 55,000 tons in 2015 (FOOD AND AGRICULTURE ORGANIZATION, 2016).

The production of these fish in Brazil was 54,000 tons in 2013. For this reason, Brazil ranked 8th in the world for the catch of this fish. In that year, 923 thousand tons were caught in the world (FOOD AND AGRICULTURE ORGANIZATION, 2016). This species has economic and social importance because it is a food for populations with low purchasing power, in addition, it can be used as raw material to produce fish-based products due to its low cost and great availability in the North-east region of Brazil (ARAÚJO et al., 2011).

However, the consumption of flying fish is reduced among the population caused by the physical structure of the fish that has the muscular portion very attached to its spine. With this, the development of products using this fish as raw material is fundamental to stimulate the increase of its consumption among the population (CAVALCANTE et al., 2020).

Food technologies allow the best use of the edible parts of the fish. The filleting process extracts the meat attached to the fish carcass. This technique produces mechanically separated meat (MSM) that allows the use of a raw material of high nutritional quality and reduced cost for the development of food products of greater acceptability (FUCHS et al., 2013).

Flying fish from MSM has high protein content, mild flavor and can be up to 14% of the weight of a whole fish (BLANCO et al., 2007). This meat is still little used as a raw material for fishery products that could be an income option for fishing communities around the world. With the use of the MSM technique it is possible to produce products such as fish hamburgers and other foods (GEHRING et al., 2011).

Fish capture and subsequent death initiates a series of autolytic processes with hydrolysis of proteins and fats. This process causes chemical and physical changes. Spoilage results from the activity of autolytic enzymes, rancidification of fats (especially by oxidation) and the activity of spoilage microorganisms (LIU et al., 2013; SILVA-PEREIRA et al., 2015). The preservation of fish for longer with the purpose of extending the time to market depends on the adoption of technologies that increase its shelf life (BARBOSA-PEREIRA et al., 2013; BERTOLIN et al., 2010; SPERANZA et al., 2021).

The process of lipid oxidation during processing and storage of fish products has been diminished by the food industry from the use of synthetic antioxidants. However, consumer concern about product toxicity has led to increased interest in food science in analyses on the effects of natural antioxidants on lipid oxidation (RATHOD et al., 2021; SERDAROĞLU et al., 2005).

Rosemary (Rosmarinus officinalis), often used as a condiment, is a viable option among these natural antioxidants (ROHLÍK et al., 2010; ALAVI et al., 2021). The antioxidant activity of this spice is associated with the presence of phenolic compounds, which hydrolyze free radical chain reactions by donating a hydrogen atom (LEŠNIK and BREN, 2022; BASAGA et al., 1997). Research points to the effectiveness of the antioxidant effect of rosemary in meat (GEROGANTELIS et al., 2007; ALBERGAMO et al., 2021) and fish products (GAO et al., 2014; HERNÁNDEZ et al., 2014; SEABRA et al; 2011) during the storage period.

New sustainable alternatives for maintaining the quality of food products and the use of fish that are widely available in the countries are indispensable measures for food, nutrition, and health of the populations. The investment in studies for the development of new fish food products is fundamental. Therefore, this research aimed to develop a hamburger based on MSM flying fish and evaluate the effect of rosemary on the sensory and physicochemical characteristics of the product throughout its storage period.

MATERIALS AND METHODS

Development of the hamburger

Fresh flying fish used in the elaboration of the burgers formulations was obtained recently captured from a fishing community located in the city of Caiçara do

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Norte, RN state, Brazil. It was transported in isothermal boxes with ice to the laboratory of fish technology the Agricultural School of Jundiaí/UFRN. Then it was submitted to beheading and evisceration, followed by wash in chlorinated water (10ppm). Right after, the fishes were processed, to the extraction of MSM, in a mechanical deboning machine (usitécnica – USI 100).

The MSM obtained was frozen and stored in domestic freezer (-18ºC) until burgers production. The burgers elaboration process was performed according to the good manufacturing practices (GMP) to ensure the quality of the product (BRASIL, 2002). Three formulations of flying fish burgers were produced, with different amounts of rosemary: 0% (F1), 0.5% (F2) and 1% (F3). To produce the burgers, all ingredients were previously weighted in an analytical digital balance HZT (0.1g precision). The ingredients and percentages used were adapted from the methodology proposed by Cavalcante et al. (2010). After the prepare, burger samples were stored in plastic packaging of 180 microns, they were individualized, targeted and frozen (-18ºC) in domestic freezer (table 1).

Table 1. Ingredients used in the formulations of flying fish burgers (*H. affinis*).

INGREDIENTS	FORMULATION		
	F1	F2	F3
Flying fish MSM (g)	1000	1000	1000
Corn starch (%)	10	10	10
Salt (%)	1.5	1.5	1.5
Crushed onion (%)	5	5	5
Soy oil (%)	5	5	5
Black pepper (%)	0.01	0.01	0.01
Rosemary (%)	0	0.5	1.0

F1: Burger without rosemary; F2: Burger with 0.5% of Rosemary; F3: Burger with 1% of rosemary.

Characterization of the samples

The microbiological analysis performed were positive coagulase Staphylococcus/g by the direct counting method (LANCETTE and BENNETT, 2001), coliforms count at 45ºC/g was performed by the multiple tube technique (KORNACKI and JOHNSON, 2001) and Salmonella sp. (FOOD AND DRUG ADMINISTRATION, 1992).

For the characterization of the samples, the centesimal composition and microbiological analysis were performed. The centesimal composition was performed in triplicate, with the standard sample (F1). After two days of freezing, the samples were defrosted at 5ºC, for 24 hours. Moisture, ash, and crude protein contents were determined according to Instituto Adolfo Lutz (INSTITUTO ADOLFO LUTZ, 2005), adopting 6.25 as the total nitrogen conversion factor to crude protein. Total lipids were extracted according to the Bligh and Dyer (1959). Carbohydrates were calculated by difference: [100 − (g kg−1 moisture + g kg−1 ash + g kg−1 crude protein + g kg−1 total lipids)].

Physicochemical analysis

Next day (0 time) of the elaboration of the burger's formulations, the physicochemical analysis was initiated, in triplicate. The analysis was repeated after 30, 60 and 90 days of storage under freezing (-18ºC). The physicochemical analysis realized was moisture, pH in digital pH meter, acidity index expressed in mL of NaOH 0.1 N per 100 grams of sample (INSTITUTO ADOLFO LUTZ, 2005). The colorimeter Minolta® CR10 was used for the colorimetric measure. The color was measured in triplicate and on three points of the hamburgers of each formulation. The measures of color were performed according to the CIELab system (COMMISSION INTERNATIONALE DE L'ÉCLAIRAGE, 1976), the assessments were lightness (L*), red color index (a*), yellowness index (b*) while the total difference of numerical color (ΔE) among the samples was calculated using the equation (FOOD AND DRUG ADMINISTRATION, 2016):

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$$\Delta E_{(\beta-\alpha)} = \left[\left(L_{\beta}^{*} - L_{\alpha}^{*}\right)^{2} + \left(a_{\beta}^{*} - a_{\alpha}^{*}\right)^{2} + \left(b_{\beta}^{*} - b_{\alpha}^{*}\right)^{2}\right]^{0,5} v \qquad [1]$$

Where β represents the values of the parameters of color (L*, a* and b*) measured in the 90th day and α represents the values of the same parameters measured in the day 0. A color variation (ΔE) equal to 2.3 units corresponds to a difference only perceptible to the device, however the greater variations are considered a color difference apparent to the human eye (SHARMA, 2002).

Sensory analysis

Sensory analysis was approved by the Ethic Committee of the University Hospital Onofre Lopes of the Federal University of Rio Grande do Norte [protocol n. 1.043.587; CAAE:42663315.0.0000.5292 – Aceitação e perfil sensorial de produtos à base de peixe-voador (*Hirundichthys affinis*)]. For the analysis of the sensory characteristics of the product, the Quantitative Descriptive Analysis (QDA) was used, based on the methodology described by Stone and Sidel (2004). Its application comprised steps of recruiting of the candidates, selection of the tasters, elaboration of the descriptors and analysis file, training and final selection of the team and sensory analysis of the sample. All candidates who agreed to participate in the research signed a Term of Consent which contained the objectives, the risks, benefits, and methodological procedures of the research.

There were 60 candidates recruited among students, teachers, and employees of the Department of Nutrition of the UFRN (DNUT/UFRN), and the recruiting was performed by the distribution of a questionnaire, with questions related to the availability of time to the training sessions; medical conditions which limit. The candidates who obtained less than 80% correct answers in the questions referring to the scales present in the recruitment questionnaire were excluded therefore 54 candidates were led to the selection step.

During the selection of the members of the panel, identification tests were performed regarding the basic tastes and triangular tests, according to the methodology descripted in the ISO 8586 (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2012). In recognition test of the basic tastes, the testers were familiarized with reference samples for five basic tastes (sweet, bitter, acid, umami and salted). Then they were requested to taste the samples, identify the tastes, this time with coded samples and register their judgment in a personal record. The test was carried out three times to select the candidates who could identify 80% of the basic tastes in 80% of the teste (DUTCOSKY, 2019).

The triangular tests were performed with five repetitions in alternate days with samples of fish-based products (nuggets) besides samples of commercial hamburger (chicken, meat, and fish). One triangle was presented to the candidates a time, with approximately 20g of cooked sample, duly coded with random numbers of three digits in balanced arrangements. The testers were requested to analyze and identify which one was the different sample, the candidates who could distinguish the samples in 60% were selected (FARIA and YOTSUYANAGI, 2002).

For the development of the descriptors, sensory analysis was conducted with samples of the flying fish hamburger. The 19 selected testers received samples of the three formulations of flying fish burger, and they were requested to describe the similarities and differences referring to appearance, texture, smell, and taste among the samples. The discussions were performed in 11 meetings, in which the sensory descriptors were established, and a record was created to work as a reference record for the analysis of the samples by the QDA, according to the following characteristics: external color, rancidity smell, rancidity taste and global quality (table 2). A non-structured linear scale of 10 cm was used, containing the terms that indicate the intensity of each descriptor. All the selection process and training were conducted according to the ISO 8586 (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2012).

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Table 2. Definitions and references of descriptive terms for the flying fish hamburger by the team of descriptive sensory analysis.

Descriptor	Definition	References
External color	Color of the external part of the hamburger, varying from light beige to deep brown after the frying.	Light beige: grilled fish fillet Deep brown: steak hamburger from *Sadia®*
Rancid taste	Taste of stale oil, which reminds of soap flavor.	Little: cereal bar with coconut from *Nutry®* Much: outdated Brazil nut
Rancid smell	Taste of stale oil, which reminds of soap flavor.	Little: virgin soy oil Much: outdated Brazil nut
Global Quality	Sum of the quality factors that contribute to the determination of the acceptance level of the product.	Little: low quality Much: high quality

During the training, the participants were submitted to three sensory analysis sessions in which they were requested to assess the intensity of each descriptor in the three samples of flying fish hamburger (F1, F2, F3), using the QDA record. To assess the performance of the team and validate the sensory team, a variance analysis was used, with two variation sources (samples and repetitions) to each tester. The data were tabulated with the values of the rating of each tester for each one of the three testing samples, in the three repetitions, obtaining F_{sample} and $F_{repetition}$. To the assessment of the consensus power of the team, variance analysis of two factors was used (samples and tester), the data were tabulated with the mean values of the ratings of each tester for each one of the three samples, obtained in the three repetitions. The testers who had the following presentations were selected: significant F_{sample} ($p<0.05$), non-significant $F_{repetition}$, F_{tester} and $F_{sampleXtester}$ and therefore the final panel remained with 10 testers who were selected and trained.

The final descriptive quantitative analysis occurred in the same days of the physicochemical analysis. The 10 testers selected assessed three hamburger samples (F1, F2, and F3) every 30 days during the period of 90 days of storage. The analyses were carried out in individual booths in the laboratory of food sensory analysis of the DNUT/UFRN. Each tester received the samples in disposable white plates, coded with random three-digit numbers. Along with the sample, crackers and a glass of water were given to be used be-tween the assessments. In addition, each tester received the TC, the record of definitions and references of the descriptors and the evaluation form.

Statistical Analysis

Data from the physicochemical and sensorial analysis were submitted to the variance analysis (ANOVA) and the Tukey test was carried out at 5% of significance level for comparison among the measures obtained using programs of the statistical package Action Stat®.

RESULTS

The values (% ± sd) obtained in the proximate composition of the standard flying fish hamburger sample were Moisture (76.32 ± 1.30), Ash (1.88 ± 0.01), Protein (12.88 ± 0.07), Lipid (0.99 ± 0.07), Carbohydrate (8.30), Caloric Value (Kcal/100g): 93.66.

Microbiological analysis showed satisfactory results indicated that the product developed met the microbiological standards for food in Brazil. This analysis was done only to ensure the good practices of the products that were going to be ingested by the tasters.

Moisture values of the three formulations did not change significantly ($p>0.05$) during the 90 days of storage. The formulations did not present any statistical difference in the nutritional composition during the storage period. Samples with rosemary presented an increase in the pH values during the analyzed period. The samples without rosemary had a reduction of pH on day 90 (F1). The samples F2 (0.5% of rosemary) and F3 (1% of rosemary) did not present significant difference in the acidity values during the storage period. Sample F1 (without rosemary) had a significant increase ($p<0.05$) in

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the acidity index between days 60 and 90 of the analysis (Table 3).

Table 3. Centesimal composition of the formulation of flying fish burger.

COMPOSITION	STANDARD SAMPLE
Moisture (%)	76.32 ±1.30
Ash (%)	1.88 ± 0.01
Protein (%)	12.88 ±0.07
Lipid (%)	0.99 ± 0.07
Carbohydrate (%)	8.30
Caloric Value (kcal)	93.66

** Mean and standard deviation of the analysis were carried out in triplicate.*

The values of lightness (L*) increased throughout the time for all samples at the end of the storage period (p<0,05). The L* parameters correspond to the brightness of the meat throughout the time, the readings showed a tendency to the increase of brightness in all samples. The values of yellowness index (b*) did not variate significantly throughout the time in the sample without rosemary (F1).

However, the two samples with rosemary (F2 and F3) had the values of b* increased in the day 90, an increase of the intensity of yellow color in the product is observed in the samples with rosemary. The values of a* where higher in the samples with rosemary for the analysis carried out in the days 0, 30 and 60, which ensures the increase of the red color intensity in the hamburger, directly proportional to the amount of rosemary in these days of analysis (table 4).

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Table 4. Values of moisture, pH and acidity of the formulations of flying fish hamburger during the storage under freezing.

ANALYSIS	FORMULATION		
	F1	F2	F3
Moisture			
Day 0	70.56±0.25^{aA}	71.34±0.79^{aAB}	70.80±0.69^{Aa}
Day 30	71.16±0.44^{aA}	71.33±0.12^{aAB}	71.00±0.30^{Aa}
Day 60	72.46±1.07^{aA}	72.03±0.08^{aA}	72.11±0.10^{aA}
Day 90	74.57±0.60^{aA}	70.30±0.08^{aB}	70.99±0.36^{Aa}
pH			
Day 0	6.46±0.01^{aA}	6.43±0.01^{abC}	6.41±0.02^{aC}
Day 30	6.58±0.05^{aA}	6.53±0.02^{aB}	6.53±0.02^{aA}
Day 60	6.61±0.03^{aA}	6.58±0.03^{abA}	6.54±0.01^{bA}
Day 90	6.40±0.06^{aA}	6.48±0.02^{bB}	6.47±0.01^{bB}
Acidity			
Day 0	13.77±0.60^{aB}	14.67±0.46^{aA}	13.62±0.59^{aA}
Day 30	12.74±0.83^{aB}	14.78±0.41^{bA}	15.55±0.45^{bA}
Day 60	15.55±0.44^{aA}	15.30±0.86^{bA}	15.31±0.85^{bA}
Day 90	19.30±1.94^{aA}	17.52±2.23^{aA}	15.61±1.21^{aA}

F1=without rosemary; F2=0.5% of rosemary; F3=1% of rosemary. $^{a\,b}$. Different lowercase letters in the same line demonstrate the significant variation among the three formulations by the Tukey test (p<0.05).
$^{A\,B}$. Different capital letters in the same column demonstrate the significant variation for the formulation throughout the time, by the Tukey test (p<0.05).

The average scores of the Quantitative Descriptive Analysis (QDA) obtained from the testers assessment for each characteristic are shown in Table 5. When the results of the external color are evaluated throughout the storage time, it is observed that no sample presented statistical difference throughout the storage time (p>0.05).

Regarding the rancid smell, even though statistical differences were not found throughout the storage period (p>0.05), it was observed that in the products that contained rosemary in their formulation, the values detected by the testers were lower than those of the products without rosemary. However, only at 30 days of analysis, it was possible to observe a value significantly lower (p<0.05) for the rancid smell in the formulation with addition of 1% of rosemary (F3), compared to the product without rosemary.

The rancid taste showed the same tendency to decrease as the amount of rosemary increased, however, statistical differences were not observed (p>0,05). According to the sensory board the global quality corresponds to the sum of the quality factors that contribute to determinate the product acceptance. At the end of the freezing period, the F1 and F2 formulations showed global quality significantly lower than obtained in the beginning of the analysis (p<0.05). However, in the formulation with 1% of rosemary (F3) the testers did not observe significant changes in the global quality throughout the storage (p>0.05), demonstrating that they maintained the global quality until the end of the storage

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period (table 5).

Table 5. Descriptive Quantitative Analysis of formulations of flying fish hamburger stored under freezing.

	Days of analysis			
	0	**30**	**60**	**90**
External color				
F1	3.93 ± 0.25^{bAB}	3.71 ± 0.47^{aB}	4.41 ± 0.28^{aA}	4.13 ± 0.17^{bAB}
F2	4.56 ± 0.33^{aA}	3.99 ± 0.60^{aA}	4.27± 0.48^{aA}	4.77 ± 0.28^{aA}
F3	4.23 ± 0.33^{abA}	3.77 ± 0.60^{aA}	4.56 ± 0.59^{aA}	4.54 ± 0.11^{aA}
Rancid smell				
F1	0.20 ± 0.45^{aA}	0.46 ± 0.36^{aA}	1.06 ± 0.90^{aA}	1.27 ± 1.22^{aA}
F2	0.07 ± 0.16^{aA}	0.09 ± 0.13^{abA}	0.71 ± 0.96^{aA}	0.61 ± 0.35^{aA}
F3	0.00 ± 0.00^{aA}	0.05 ± 0.07^{bA}	0.51± 0.98^{aA}	0.70 ± 0.81^{aA}
Rancid taste				
F1	0.22 ± 0.49^{aA}	0.16 ± 0.36^{aA}	1.17 ± 1.24^{aA}	1.15 ± 0.76^{aA}
F2	0.15 ± 0.34^{aA}	0.04 ± 0.09^{aA}	0.13 ± 0.29^{aA}	0.62 ± 0.55^{aA}
F3	0.07± 0.16^{aA}	0.01 ± 0.02^{aA}	0.29 ± 0.23^{aA}	0.54 ± 0.59^{aA}
Global Quantity				
F1	7.77 ± 0.19^{aA}	7.07 ± 0.09^{aB}	5.97 ± 0.33^{abC}	5.77 ± 0.22^{aC}
F2	7.59 ± 0.20^{aA}	7.48 ± 0.33^{aA}	6.48 ± 0.57^{aB}	6.02 ± 0.67^{aB}
F3	5.47 ± 0.77^{bB}	6.67 ± 0.91^{aA}	5.67 ± 0.27^{bAB}	5.62 ± 0.40^{aAB}

*Values expressed in average and Standard Deviation; F1=without rosemary; F2=0.5% of rosemary; F3=1% of rosemary. $^{a\ b}$ Different lowercase letters in the same column demonstrate the significant variation among the three formulations by the Tukey test ($p<0.05$). $^{A\ B}$. Different capital letters in the same line demonstrate the significant variation for the formulation throughout the time, by the Tukey test ($p<0.05$).

DISCUSSION

Flying fish burgers presented 1% of fat content which is considered low (BRASIL, 2000). According to the Brazilian Laws of Health, the definition of a "low-fat" product corresponds to that in which the fat content is lower than 3% in the portion (BRASIL, 1996). Therefore, flying fish hamburger can be characterized as low-fat product.

All results of the microbiological analysis are according to the resolution RDC n. 331/ 2019 of the ANVISA/MS (BRASIL, 2019), which deals with microbiological patterns for foods. Regarding the pH values, the Regulation of Industrial and Sanitary Inspection of Animal Source Food (RIISPOA) sets the values lower than -7,0 for fish consumption (BRASIL, 1984). All values were according to those recommended by the current legislation for fish. Such values vary from 6.40 to 6.61 (low suitability for the development of microorganisms), however, without significant differences among the formulations.

It is important to highlight that all values were according to the legislation, even those that increased throughout the time. The results were better than those found by Schelegueda et al. (2016), observed pH value higher than 7,15 for fish burg after the period of 15 days

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of storage under freezing. However, in other similar studies, Naveena et al. (2013) did not found effect of rosemary on breaded buffalo meat and chicken pH during storage. Herck et al. (2018) also did find an increase in pH after 30 days of storage in the raw and cooked burgers.

The increase of acidity indicates the development of hydrolytic reactions, with the production of free fatty acids, therefore, the determination of the acidity is crucial in the assessment of the deterioration status of foods that contain lipids in their composition, assessing its rancidity status (ERDMANNA et al., 2016).

Lightness (L*) values were expected, since in this condition, the formation of oxymyoglobin and desoxymyoglobin occur throughout the storage time of the product (PENNACCHIA et al., 2011).

Yellowness index (b*) values are presented differently than what is verified in literature, where there is a reduction in the parameters of b* color during the period of storage in meat products, because of the loss of color in these products (HAYES et al., 2010), pointing an effect favorable to the presence of rosemary in the hamburger samples, probably because of the reduction of the oxidation of the pigments in the hamburger.

According to the literature an increase in the parameters of red color index (a*) during the period of storage can occur because of the decrease of the oxidation of the pigments of oxymyoglobin present in the meat of the hamburger (KEENAN et al., 2015), which suggests a reduction of the oxidation of these pigments in the samples that have rosemary in their formulation.

The color variation (ΔE*ab) for each one of the formulations showed differences in terms of storage and treatment, indicating that there was difference perceptible to the human eye, because a variation higher than 2.3 is considered discernible (SHARMA, 2002). The increased values of (ΔE*ab) are originated from the increased variations of the parameter of L* color. Similar L* values are also reported in the literature by Oliveira et al. (2015), who asses the color in catfish MSM. The color variation of a certain food is caused by the presence of unstable natural pigments that participate in different reactions, therefore, the alteration of the color of a certain food indicates possible chemical and biochemical alterations that can occur during the process and storage (KEENAN et al., 2015).

Colindres and Brewer (2011) assessed the effect of natural antioxidants, such as the rosemary in the sensorial pattern of color throughout the period of six months of storage under freeze and among the results obtained, they observed that the hamburger samples with rosemary maintained their characteristics of color without sensory changes throughout the storage period.

In another recent study, 13 extracts of regular spices were compared to assess the antioxidant effect and they verified that rosemary is efficient in the inhibition of lipid peroxidation in cooked beef hamburgers (SAMPLES, 2015), which leads to the reduction in the sensory characteristics of rancidity. Similarly, other study observed the substantial suppression of the lipid oxidation in precooked pork hamburger from the use of rosemary extract during the refrigeration time during six months (JIANG et al., 2013).

FINAL CONSIDERATIONS

The development of flying fish burgers from the mechanically separated meat was shown to be a viable alternative to the offer of new fish-based products. The formulations with rosemary obtained better maintenance of the sensory characteristics during the period of storage under freezing. The addition of rosemary was also shown to be efficient for the maintenance of the acidity index in the samples of flying fish hamburger, suggesting a direct correlation with the reduction of the effects originated from the lipid oxidation.

Inclusion of fish products from fishing communities in the diet is a sustainable alternative that, in addition to being a nutritious food option, can be an income option for these communities.

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