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Evaluation of technology and sensory quality of cream cracker enriched with minced cobia *(Rachycentron canadum)*

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Abstract

Considering the intense demand of the food industry for new products, especially in the cookie market, the enrichment of crackers with fish proteins is suggested as a good alternative for the use of cobia *(Rachycentron canadum)*, which could be used to produce a popular food of high nutritional value for practical consumption. The objective of this study was to obtain minced cobia and characterize its nutritional value when used to enhance crackers. The minced cobia was added to the crackers at 3, 7 and 10% and the products were evaluated for the physicochemical, sensory and technological properties. With the addition of minced cobia to the formulations, the nutritional enrichment of the crackers was possible as proven by the increase in protein content, by the amino acid profile and by the high digestibility of the added fish protein. The enriched crackers were well accepted by the judges and presented good technological quality.

Introduction

In Latin American countries, the interest in producing foods that are sources of good quality protein is increasing because such foods are seen as a possible solution to the problems of malnutrition (Oliveira *et al*., 1997). The proteins from animal sources such as fish are considered nutritionally superior to those of plant origin because they contain a better balance of essential amino acids (Kristinsson and Rasco, 2000).

With respect to the quantity of fish proteins, and despite the variation among fish species, the protein content is always high, in the range of 15-25%. In terms of fish protein quality, all essential amino acids are present, with high lysine content. The digestibility is high, above 95%, depending on the species (Oetterer, 2002). Among the native species of the Brazilian coast, cobia *(Rachycentron canadum)* has been highlighted in recent years as an alternative species for worldwide aquaculture (Figueiredo and Menezes, 2000).

A cookie is defined as the product obtained by mixing flour(s) and/or starch (es) with other ingredients, submitting the mixture to the process of kneading and cooking, with or without fermentation. It may exhibit frosting, stuffing, and various formats and textures (ANVISA, 2005). The cracker, type of cookie, is classified as fermented and has a high protein content (approximately 11%) (Maciel *et al*., 2008). According to ANIB - National Association of Cookie Manufacturers, Brazil ranks as the 2nd largest producer of cookies, with a record of 1,250 million tons produced in 2012, representing 2.5% of growth since 2011 when 1,220 million tons were produced.

This production potential, together with the wide acceptance of these products by people of all ages, drives the study of the cracker as a vehicle for protein and other nutrients derived from fish. No studies were found on the enrichment of crackers or other baked products specifically using minced cobia. The objective of this work was to obtain the minced cobia and characterize its nutritional value for use in the enrichment of cracker, followed by an evaluation of the effect of the addition of minced cobia on the technological and sensory characteristics of the crackers.

Materials and Methods

Raw material

The cobia *(Rachycentron canadum)* was cultured by the Marine Aquaculture Station (EMA/FURG) and the strong wheat flour (9.4% moisture, 9.8% protein, 1.4% lipids, 0.14% ash and 79.26% carbohydrates) was obtained from Moinho do Sul, Rio Grande, RS, Brazil. The ingredients such as salt, compressed yeast, soybean oil, baking soda and soy lecithin were

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purchased from local stores. The non-diastatic malt was supplied by the Liotécnica Company, SP, Brazil. All chemical reagents used in this study were of analytical grade.

Minced cobia preparation

The cobia species were cleaned, gutted, filleted and pulped in a depulper (High Tech HT/2500, Brazil) with the resultant minced meat being washed 3 times for 5 min each, using distilled water as the solvent, in a 1:1.5 ratio (w/v meat/water). The minced cobia was then manually compressed on cotton cloths to remove the excess water and lyophilised (Liotop L108, Brazil) for 48 h. The lyophilised minced cobia was ground in a knife mill (Tecnal TE - 633, Brazil) and sieved through a 42-mesh sieve.

Characterization of the lyophilised minced cobia

The lyophilised minced cobia was characterized according to the analyses of proximate composition, following the official method of the AOAC (2000). The analyses were moisture content (gravimetry), proteins (micro-Kjeldahl, Nx 6.25), lipids (Soxhlet) and ash content (gravimetry). Analysis of the amino acid profile was done by HPLC according to the method of Risso and Amaya-Farfan (2013). The protein digestibility analysis was performed according to the method described by Akeson and Stahmann (1964). The functionality properties were determined as follows: solubility and water-holding capacity (WHC) according to Morr *et al.* (1985) and Regenstein *et al.* (1979); oil-retention capacity (ORC) according to Fonkwe and Singh (1996); emulsifying capacity according to Okezie and Bello (1988) and foaming capacity (FC) according to Glória and Reginato d' Arce (2000).

Crackers production

The 'sponge and dough' method described by the work of Lima (1998) was used for the production of the crackers. The standard formulations in the sponge step was formulated with 65% of wheat flour, 0.5% of biological yeast (Saccharomyces cerevisiae), 25% of water and 6.5% of soy oil (all values based in total quantity of wheat flour) and the dough step was completed with 35% of wheat flour, 2% of non-diastatic malt, 1.7% of sodium chloride, 0.45% of baking soda and 0.1% of soy lecithin. For the preparation of the enriched crackers, the standard formulation was used with lyophilised minced cobia replacing the flour at concentrations of 3, 7 and 10% (basis wheat flour). The minced cobia was added in the dough-mixing step.

The sponge was prepared by mixing wheat flour, water, yeast and soy oil in the proportions established previously. Then, the sponge was transferred to a covered plastic container and placed in a fermentation oven, where it remained at 30°C for 18 h. In the dough-mixing stage, the soybean oil, wheat flour, malt, baking soda, salt and lecithin were added to the fermented sponge; the minced cobia was also added in the enriched formulations. The ingredients were first homogenized in a planetary mixer (KitchenAid, Brazil), ending with manual mixing at room temperature. The dough was placed in a covered plastic container and transferred to the fermentation oven where it remained at 30°C for 6 h.

Cracker dough obtained was laminated by several manual passages by a domestic cylinder roller until the dough reached a sheet of 2.0 mm in thickness. At the final step, the laminated dough was cut and stamped by hand. The crackers were placed in a metal pan and baked at a temperature of 250°C for 6 min in an electric oven. After this, the crackers were cooled to room temperature for 30 min and packed in plastic bags.

Quality evaluation of the crackers

Crackers quality was evaluated through the determination of the proximate composition according to the official method of the AOAC (2000), and physical measurement. Chemical determinations were: moisture content (gravimetry), proteins (micro-Kjeldahl, Nx6.25), lipids (Soxhlet) and ash content (gravimetry). The physical measurements included crackers specific volume (ml/g) by the method of displacement of millet seeds (Pizzinato *et al.*, 1993). Colour was measured by a Minolta® Colorimeter CR400 following the colour system in space $L^*a^*b^*$ or CIE$L^*a^*b^*$. Under this system, the L^* (brightness) values and the a^* and b^* (chromaticity coordinates) values were analysed. In addition, texture was analysed with a texturometer for firmness and brittleness following the methodology described in the equipment manual (Stable Micro Systems Texture Analyser TA-XT2). Most determinations were made in triplicate, with the exception of the physical and instrumental measurements, which were carried out on 10 crackers from each treatment.

Sensory analysis of the crackers

Sensory analysis (Dutcosky, 1996) was performed with 50 untrained judges, 72% female and 28% male, ranging from 18 to 35 years. The judges ordering samples of crackers with minced cobia by preference, using the random code of 3 digits used to identify the samples. The hedonic scale of 7-points (7- "like very much", 1- "dislike very much") was used to assessed the attributes appearance, colour, aroma, texture, flavor and overall quality. The purchase intention was assessed by a 5-point scale (5- “definitely buy”, 1- “certainly would not buy”) for the cracker samples formulated with the minced cobia. The procedures adopted in this study met the criteria of the Ethics in Human Research according to Resolution nº. 466/12 of the National Health Council.

Statistical analysis

The results of the physicochemical, technological and sensory analysis determinations were treated by analysis of variance (ANOVA), and the means of the data were compared using the Tukey test at a 5% level of significance. The results of the ranking test in the sensory evaluation were statistically confirmed using the table of Newell and MacFarlane, which establishes the value of the critical differences between total ordering to a 5% level (Dutcosky, 1996).

Results and Discussion

Characterizing the minced cobia

A washed, white, minced product with a light fish odour compared with the unwashed pulp was obtained. The yield of the washed, wet minced cobia obtained in the process was 30%, based on the weight of the whole fish. Centenaro *et al*. (2007) obtained a yield of 31.6% wet pulp from the bluewingsearobin *(Prionotus punctatus),* and Pereira *et al*. (2003) obtained a pulp yield of 31.06% from silver carp *(Hypophthalmichthys molitrix)* through mechanical deboning.

Proximate composition

The lyophilised minced cobia showed, on average, 1.27% ash and 7.70% lipids. The composition was notable mainly for its protein content, which was approximately 84%. Other authors obtained similar protein values for fish in general, indicating that fish is a good source of protein for incorporation into all kinds of foods, from products such as burgers, nuggets and other breaded products, (Centenaro *et al*., 2007; Bonacina and Queiroz, 2007) baked products such as cakes and cookies (Veit *et al*., 2012; Rebouças *et al.,* 2012) and thus can be used to enhance their desirability.

Rebouças *et al.* (2012) obtained a fish protein concentrate with 85% protein and 8% lipid. Centenaro *et al.* (2007) obtained a dry pulp of the bluewingsearobin *(Prionotus punctatus)* with a value approaching 82% of protein. Garcia and Sobral (2005) found protein equal to 80% in the lyophilised myofibrillar protein of Nile tilapia *(Oreochromis niloticus),* and Piotrowicz (2012) obtained a protein content of 83.9% in the mechanically separated meat (MSM) of anchovy *(Engraulis anchovy).*

Table 1. Amino acids profile (mg/g) of minced cobia.

Amino Acid	Minced cobia (mg/g)	FAO/WHO Children (10-12 years of age)	FAO/WHO Adults
Alanine	55.1		
Arginine	61.0		
Aspartic Acid	103.0		
Glutamic Acid	143.3		
Glycine	52.8		
Isoleucine	38.5	28.0	13.0
Leucine	64.6	44.0	19.0
Lysine	76.5	44.0	16.0
Cystine	19.6	22.0	17.0
Methionine	27.2	22.0	17.0
Phenylalanine	27.7	22.0	19.0
Tyrosine	30.0	22.0	19.0
Threonine	33.8	28.0	9.0
Valine	37.4	25.0	13.0
Histidine	15.9	19.0	16.0
Proline	38.7		
Serine	34.9		

FAO/WHO (1991) - standard amino acids requirements for children (10-12 years of age) and adults.

Amino acid profile

According to Table 1, aspartic acid, glutamic acid, leucine and lysine amino acids were found at a higher concentration in the minced cobia in this study. However, in general, all amino acids present in the minced exceeded the FAO/WHO (1991) requirements established for children between 10 to 12 years of age and for adults. Qualitatively, fish meat presents all essential amino acids, with high lysine level (Oetterer, 2002); this was confirmed in this study on minced cobia, which showed 76.5 mg of lysine/g sample.

Digestibility

The minced cobia showed an average digestibility of approximately 97%. The digestibility of fish meat is typically high, more than 95%, depending on the species, and higher than the digestibility of meat and milk in general (Oetterer, 2002). Abdul-Hamid *et al*. (2002) analysed the nutritional quality of protein hydrolysate in powder form from tilapia *(Oreochromis mossambicus)* using two different drying temperatures: 150°C and 180°C. The quality of the two protein hydrolysates was high, with *in vitro* digestibility values of 88.4 and 92%, respectively.

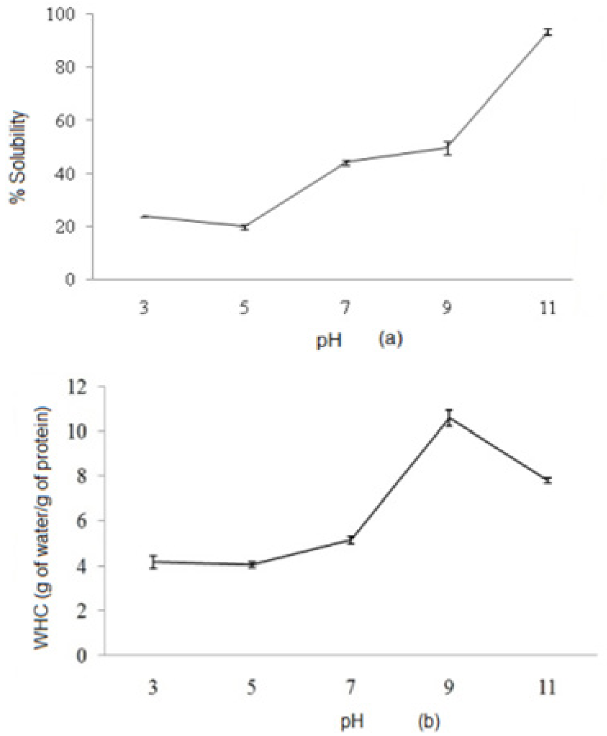

Figure 1. Solubility curve of minced cobia (a); Curve of the water-holding capacity (WHC) of the minced cobia (b) at different pH values.

Functionality properties of minced cobia

A solubility rate of 24% was observed beginning at pH 3 and declined to 20% at pH 5, where it showed the lowest value in the tested pH range. From this, the solubility of minced cobia kept increasing, with the highest value being observed at pH 11, with 93% solubility (Figure 1). These results agree with Sathivel *et al*. (2003), who studied the effect of pH on the solubility of protein isolates of different species of fish and found lower solubility near a pH of 4.0. Similar results were reported for other species of fish, such as sardines (Batista *et al*., 2007) and croaker (Fontana *et al.*, 2009). The lowest values for the WHC were observed at pH 3 and pH 5, which were 4.15 and 4.03 g of water/g of protein, respectively. The WHC was greater in the alkaline pH range than in the acidic pH range, with the maximum WHC of 10.58 g of water/g of protein being observed at pH 9 (Figure 1).

The minced cobia showed an ORC of 2.5 ml oil/g of protein and an emulsifying capacity of 23.40 ml emulsified oil/g protein. Fontana *et al.* (2009) obtained an average ORC of 3.1 ml oil/g protein for wet minced croaker. The oil retention capacity is one of the most important functionality properties in the development of products and may influence the order of the addition of the dry ingredients into the mix, contributing to a uniform distribution. According to Kinsella (1976), high values of ORC are desirable in products such as meat extenders to improve its feel to the mouth, as well as in viscous products such as soups, processed cheese and pasta. The lyophilised minced cobia did not present foam capacity. This result could be due to the amount of lipids that can reduce the foam formation and stability due to the alteration of the protein expansion at the interface, and the weakening or breakage of the cohesive forces needed between the protein layers around the air cells could result in the collapse of the foam.

Table 2. Proximate composition (dry basis) of standard crackers (S) and enriched with 3% (MC3), 7% (MC7) and 10% (MC10) of minced cobia.

Components	S	MC3	MC7	MC10
Moisture	5.28±0.10[a]	4.60±0.09[b]	3.46±0.09[c]	3.53±0.02[c]
Ash	2.61±0.04[b]	2.82±0.01[a]	2.74±0.02[a]	2.55±0.07[b]
Lipids	8.41±2.23[b]	9.37±1.45[b]	9.42±0.12[b]	17.56±1.13[a]
Proteins	10.66±0.41[d]	14.01±0.26[c]	17.04±0.09[b]	18.75±0.11[a]
Carbohydrates*	78.32	73.80	70.80	61.14

*Obtained by difference. Mean followed by same letters in the same lines did not differ statistically ($p \leq 0.05$).

Proximate composition

As the amount of the minced cobia addition increased, a decrease in moisture values occurred (Table 2). This is mainly because the formulations in which the dough was added with the protein from the minced cobia needed more water than the standard formulation. However, crackers lost water during baking. In this case, the dryness may be related to the water-holding capacity (WHC) of the minced cobia. The moisture content of all the crackers was between 3.5 and 5.3%. According to Vitti et al. (1988), crackers produced in the laboratory have moisture content close to the range found industrially (up to 6%). In addition, the moisture content has an important effect on the shelf-life of the cracker, and the type of cookie may influence the occurrence of spontaneous breaking or cracking (Wade, 1988).

Regarding the ash content, the Brazilian legislation (ANVISA, 1978) states that cookies should have at most 3% (w/w). The values of ash content found for the cracker formulations remained below the maximum limit. An increase in the lipid content of the formulations by the addition of the minced cobia was also noted. However, this content was only significantly higher in the formulation with the 10% minced cobia. Despite being high, the lipid content present in these cracker formulations should be attributable to the polyunsaturated fatty acids present in the fish, which are beneficial to health and

Table 3. Texture parameters of standard crackers (S) and enriched with 3% (MC3), 7% (MC7) and 10% (MC10) of minced cobia.

Formulations	Texture analysis	
	Hardness (N)	Brittleness (mm)
S	17.44 ± 6.56^a	2.55 ± 0.76^a
MC3	15.14 ± 5.51^a	0.91 ± 0.53^b
MC7	14.34 ± 1.86^a	0.31 ± 0.22^c
MC10	7.73 ± 0.92^b	0.77 ± 0.54^{bc}

Mean followed by same letters in the same column did not differ statistically ($p \leq 0.05$).

vital in the prevention of some diseases.

The addition of the minced cobia increased the protein content of the crackers gradually, with significant differences being in the protein content of the products. The formulation with the highest protein content achieved in this study was the cracker with 10% added minced cobia, which represented approximately 18.7% protein and resulted in an increase of 76% over the control cracker. Haj-Isa and Carvalho (2011) developed two formulations of cookies enriched by the addition of 27.0 and 22.5% wet meat from the Argentine hake (Merluccius hubbsi) and obtained cookies with 7.1 and 6.0% protein. Veit *et al.* (2012) developed chocolate and carrot cakes from fillets of tilapia *(Oreochromis niloticus)* in concentrations of 20 and 12% of cooked and mashed fillets, respectively, and found a protein content of 10.9% for the chocolate cake and 7.9% for the carrot cake.

Specific volume

The specific volume is important in the determination of quality because it is often influenced by the quality of the ingredients used in the formulation. The formulations prepared in this study showed significant differences among the groups ($p \leq 0.05$) with respect to specific volume, which showed values between 2.10 and 2.38 ml/g, and the cracker enriched with 7% minced cobia presented similar values to the standard cracker, which indicated that the fish protein had no influence on this technological characteristic.

Colour

The cracker with 3% minced showed higher brightness L^* (70.71±1.15), resulting in a lighter product with a lower chromaticity value of the coordinate a^* (4.98±1.30), which was less prone to a reddish tone, whereas the cracker with 10% minced showed a lower brightness value L^*(62.28±2.90), resulting in a darker cracker than the others. Perez and Germani (2007) prepared a cracker using eggplant flour and observed that with the increasing addition of flour, the cracker had a darker colour. Thus, the colour of the cookies is directly related to the ingredients contained in the formulation. The minced cobia used in this study had a slightly yellowish colour compared to wheat flour, and this influenced the colours of the formulations, leading to browning of the crackers.

Texture

The instrumental measure of hardness is represented by the maximum force drawn on the graph generated during analysis (the largest positive peak). This parameter is directly related to the hardness when biting the cookies. The instrumental measurement that determines the distance covered until the first break is the brittleness of the product. This parameter is directly related to the crispness of the cookies (Ruffi, 2011). With respect to the hardness, the crackers were not significantly different among the formulations, except for the formulation with 10% minced cobia (Table 3). The addition of this high quantity of minced decreased the hardness of the crackers. The reduction in hardness can be attributed to the higher content of lipids present in the minced cobia, which has a lubricating effect on the crackers (Moraes *et al.*, 2010).

In the minced-added formulations, brittleness values ranged from 0.31 to 0.91 mm. In the instrumental analysis, the supplemented crackers had greater ease of breakage or greater crispness than the standard-formulation crackers. Hardness is one of the factors that determine the acceptability of foods by the consumer. Moreover, low brittleness values are more desirable (Assis *et al.*, 2009). Ruffi (2011) found hardness values between 7.55 and 12.39 N and brittleness between 1.45 and 1.89 mm for crackers with added soy derivatives.

Sensory analysis

Crackers enriched with 7 and 10% minced cobia had the lowest scores, 93 and 84 respectively; that is, they were less preferred by the judges compared to the cracker enriched with 3% minced cobia (score 123), which differed significantly ($p \leq 0.05$) from the more enriched crackers.

According to the Newell MacFarlane table (number of samples = 3 and number of judges = 50), the critical value of the difference between the samples is 24 (Dutcosky, 1996). Thus, values that differ between the samples by more than 24 indicate a significant difference at the level of 5% significance. This was observed between cracker samples enriched

Table 4. Hedonic scale (7-points) of cracker samples enriched with 3% (MC3), 7% (MC7) and 10% (MC10) of minced cobia relative to the evaluated sensory attributes.

Formulations	Appearance	Colour	Odour
MC3	6.13±0.72[a]	6.23±0.72[a]	6.13±0.88[a]
MC7	6.00±0.71[a]	6.22±0.44[a]	5.22±1.30[a]
MC10	6.10±0.99[a]	5.90±1.37[a]	5.60±1.26[a]
Formulations	**Texture**	**Flavour**	**Overall quality**
MC3	5.35±1.52[a]	5.97±1.14[a]	5.90±0.87[a]
MC7	5.67±0.71[a]	6.33±0.71[a]	6.10±0.60[a]
MC10	5.80±1.55[a]	5.50±1.51[a]	6.20±0.92[a]

Mean followed by same letters in the same column did not differ statistically ($p \leq 0.05$).

with 3 and 7% minced cobia and between the crackers enriched with 3 and 10% minced cobia; that is, the sample with 3% minced cobia differs from the others. Values with a difference of less than 24 indicate a lack of significant difference at a significance level of 5%, between the crackers, as observed between the samples with 5 and 10% minced cobia; thus, no preference was observed between these two samples.

No significant difference ($p \leq 0.05$) was observed among the samples with minced cobia for all the sensory attributes analysed, indicating an equivalent acceptance for these characteristics (Table 4). The scores for the sensory attributes were values somewhat greater than 5.0 and 6.0, with the hedonic terms including 'liked moderately' and 'liked', which demonstrate the wide acceptance of the crackers relative to these characteristics.

Purchase intention showed no significant difference ($p \leq 0.05$) between the values reached by the crackers enriched with minced cobia. The crackers obtained an average value between 3.0 and 4.0, corresponding to the terms 'maybe I would buy/ maybe I would not buy' and 'I would probably buy', with an intention attitude approaching the latter one.

Conclusion

Minced cobia exhibited a composition of 84% protein, 97% digestibility and an amino acid profile of optimal nutritional quality, showing that the fish is a good source of protein for incorporation into baked products. Functionality properties of solubility, water and oil-retention capacity and emulsifying capacity showed that minced cobia could provide good characteristics to crackers. Products with the addition of 10% minced cobia showed the greatest increase in protein content, which was 76% compared to the standard cracker. The addition of minced cobia produced a decrease in the hardness and brittleness of the crackers and a slight dark colour. Sensory analysis showed good acceptability of the enriched crackers, receiving hedonic terms from 'liked moderately' to 'liked very much' and indications of probable intention to purchase.

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