



# Smoked-breaded restructured products from minced *Cayman yacare* meat, Brazilian Pantanal

Produtos reestruturados, empanados e defumados a partir de carne picada de *Cayman yacare*, Pantanal brasileiro

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Residues from Cayman farming processing are usually designated to animal feed. Due to its high nutritional value, the use of those residues as restructured products in human alimentation can be beneficial as another source of revenue to alligator farmers. In this study was evaluated composition and acceptance of a smoked-breaded restructured product (nuggets) elaborated with minced *Cayman yacare* meat. The product was submitted to two smoking processes to further enhance palatability (liquid and powder smoke). The products are composed in 61.30% moisture, 18.27% crude protein, 10.32% total lipids, 2.54% mineral matter and 7.85% carbohydrates, with no difference between the treatments. Colorimetry showed an average red intensity ( $a^*$ ) 17.85, and a yellow intensity ( $b^*$ ) 23.75, with an average luminosity ( $L^*$ ) 51.94 between the two smoking methods. Score for sensory parameters were all above 7 on a hedonic scale 1 to 9, and for purchase intent, the score was 4, whose scale used was 5 points. With these results, the analysed product is considered to have high market potential. In conclusion, the product developed was well accepted and with high nutritional value that can be used as an alternative to meat generated in *Cayman yacare* deboning process.

Keywords: chemical composition, alligator farming, nuggets.

Os resíduos do processamento de Cayman são geralmente destinados à alimentação animal. Devido ao seu alto valor nutricional, a utilização desses resíduos como produtos reestruturados na alimentação humana pode ser benéfica, como mais uma fonte de renda para os jacaricultores. Nesse estudo avaliou-se a composição e aceitação de um produto reestruturado empanado e defumado (nuggets) elaborado com carne picada de *Cayman yacare*. O produto foi submetido a dois processos de defumação para aumentar ainda mais a palatabilidade (fumaça líquida e em pó). Os produtos são compostos em 61,30% de umidade, 18,27% de proteína bruta, 10,32% de lipídios totais, 2,54% de matéria mineral e 7,85% de carboidratos, não havendo diferença entre os tratamentos. A colorimetria apresentou intensidade média de vermelho ( $a^*$ ) de 17,85 e de amarelo ( $b^*$ ) de 23,75, com luminosidade média ( $L^*$ ) de 51,94 entre os dois métodos de defumação. A pontuação para os parâmetros sensoriais foram todos acima de 7 em uma escala hedônica de 1 a 9, e para a intenção de compra, a pontuação foi 4, cuja escala utilizada foi de 5 pontos. Com esses resultados, o produto analisado é considerado de alto potencial de mercado. Conclui-se que o produto desenvolvido foi bem aceito e com alto valor nutricional, podendo ser utilizado como alimento alternativo gerado no processo de desossa do *Cayman yacare*.

Palavras-chave: composição química, jacaricultura, nuggets.

## 1. INTRODUCTION

Decades ago, alligator farming was considered an activity primarily focused on harvesting skins and leather tanning for bags, belts, and shoes [1]. Due to being strictly carnivorous, feed for the animals had a high cost, turning the production into a low-profit business and, forcing farmers to search for alternative ways to increase their revenue, such as meat commercialization [2, 3]. Alligator meat is a rich

source of animal protein with low amounts of intermuscular and intramuscular fat with higher proportions of polyunsaturated fatty acids [4] as well as a high acceptance rate due to its attractive appearance and flavor [5]. However, the meat used for human consumption is generally the tender tail, which represents only 33% of the carcass weight [6].

Due to its quality and nutritional appeal, the use of other commercial cuts in human food is being studied [5] and, as in other animal productions, the processing of meat generates several residues, which many of them, are generally used as ingredients in animal feed [7]. However, among the residues are the trimmings and scraps generated from deboning of the Cayman processing. These aren't economically attractive, as they are small pieces, except for their nutritional value, which is similar to other commercial cuts of this species in question. However, these generated residues have characteristics suitable for processing various types of food products, such as hamburgers, sausages, nuggets, bologna, among others, with excellent sensory acceptability [8-11].

Despite all the benefits and food alternatives showed above, there are few studies related to the use of residues and value-added products from the processing of alligator meat in the Brazilian Pantanal.

In this study, the chemical composition and sensory profile of restructured breaded products (nuggets) were analyzed, made from ground residual meat from minced *Cayman yacare* submitted to two different smoking processes (liquid smoke and powdered smoke).

## 2. MATERIAL AND METHODS

The study received approval from Instituto Chico Mendes de Conservação da Biodiversidade (SisBIO), with protocol No. 78692-1/2021, as well as approval by the Ethics Committee for Animal Use, Universidade Federal de Rondônia (CEUA/UNIR), with protocol No. 0012/2021/2\_UNIR. In addition, the study was submitted with approval to the Research Ethics Committee at the Universidade Estadual de Maringá (UEM), and received protocol number CAAE No. 66216122.4.0000.5300. It is important to highlight that an external sensory examining board was invited.

Residual meat from *Cayman* carcasses from Brazilian Pantanal was used from the company Caimasul regulated with registration No. 5849143 at the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), located in Corumbá city, Mato Grosso do Sul state, Brazil.

The obtained meat was minced and seasoned for the structuration of nuggets-like products stuffed with provolone cheese. The obtained mass was divided into two portions for the elaboration of the treatments. The same ingredients were used in both formulations, except for inclusion of the type of smoking product, one being the liquid (Treat 1) and the other the smoking condiment (Treat 2) (Table 1).

Table 1: Formulation of smoked-breaded restructured products from minced *Cayman yacare* meat.

Ingredients	Smoked-breaded restructured	
	Liquid smoke (g)	Powder smoke (g)
Minced meat	1000.0	1000.0
Water	100.0	100.0
Salt (NaCl)	50.0	50.0
White pepper	2.0	2.0
Garlic powder	8.0	8.0
Wheat flour	50.0	50.0
Corn flour	250.0	250.0
Egg	150.0	150.0
Breadcrumbs	250.0	250.0
Smoked	10.0	10.0

The ingredients were placed in a container with their respective smoking products (Treat 1 = liquid and Treat 2 = powder) and homogenized. Then the smoked-breaded restructured ones were elaborated with the filling and subjected to processing. This processing operation involved three fundamental steps,

being predest (pre-flouring), batter (suspension of solid in liquid) and elaborate (final coating) [12]. Wheat flour was used for the predest, for the batter, the egg and for the elaborate, the panko flour.

Breaded products were fried in soybean oil at 240° C at 10 seconds. After cooling, the samples were separated for microbiological analysis and kept in a refrigerator (5 to 7° C) and the other samples of the smoked breaded restructured were packaged and kept in a freezer at -18° C until the analyses was performed.

Moisture and mineral matter analysis were performed by the Association of Official Analytical Chemistry (AOAC, 2010) [13]; crude protein contents were determined by the semi-micro Kjeldahl method while the Bligh & Dyer (1959) [14] method was used to extract total lipids. Carbohydrates were calculated by difference of the other components and caloric value was obtained by total sum of the multiplication of crude protein, total lipids, and carbohydrates multiplied by the factors 4, 9, and 4. In order to obtain the pH of the samples, they were homogenized with distilled water and subjected to reading on the pH meter (DM 22, Digimed). The determination of water activity was performed using the Labswift-Novasina device.

Colorimetry was evaluated in a colorimeter portable CR-400 Minolta Chromameter (Minolta Cia Ltda.), calibrated with white standard. Three readings were performed on each sample, using a methodology described by Cavenaghi et al. (2021) [15], where L\* defines the luminosity (black-white), a\* the red-green spectrum, and b\* the yellow-blue spectrum.

The microbiology of smoked-breaded restructured products from Brazilian Pantanal Cayman meat was carried out at the Laboratório de Microbiologia e Microscopia de Alimentos, at Departamento de Análises Clínicas, belonging to the Universidade Estadual de Maringá (UEM), Maringá city, Paraná state, Brazil.

Thus, 100g samples of each treatment and of the flour were kept in a refrigerator to carry out the determination analysis for the most probable number (MPN) of coliforms at 35 and 40 °C, *Staphylococcus coagulase* positive count in a forming unit colony (CFU) per gram and *Salmonella* spp. in 25g of sample, according to APHA (1988) [16]. The microbiological protocol followed the standards recommended by IN No. 60 ANVISA and Resolution RDC No. 331, of September 22, 2020, of the National Health Regulatory Agency (Brasil, 2013) [17].

For the sensory analysis, eighty participants received both products along with a glass of water and a form to evaluate the six sensorial attributes (color, texture, aroma, flavor and global impression), using the 9-point hedonic scale, from 'I dislike it very much' (=1) to 'I like it very much' (=9), according to methodology of Fernandes et al. (2015) [9]. In this same form, the purchase intention of these elaborated products was also evaluated. Therefore, this analysis was performed using a 5-point hedonic scale, ranging from a score of 1= 'I would definitely not buy it' to a score of 5= 'I will definitely buy it' [6].

The experimental design was completely randomized, with two treatments, being restructured breaded with the application of liquid smoke (Treat 1) and powdered smoke (Treat 2). The results of the variables analyzed in chemical composition, colorimetry (n=5) and sensorial analysis (n=80) were submitted to analysis of variance, and the averages were compared by the F test at the 5% probability level (Statistical Analysis System - SAS, SAS Inst. Inc. Cary, NC, USA). The microbiological analyzes were carried out only to characterize the smoked restructured elaborate, thus performing a descriptive analysis.

### 3. RESULTS AND DISCUSSION

The meat of the trimmings shown 74.31% moisture, 23.46% crude protein, 0.37% lipids, 0.79% ash and 1.07% carbohydrates. However, with the processing of elaboration of the product and frying it, there was a change in the levels of these nutrients. There was a reduction in moisture content around 17.54%, in crude protein around 22.34%, however, there was an increase in lipid 19,0% and ash 182.27% contents. The reduction in moisture was due to inclusion of dry ingredients (wheat, corn and bread bran flour) which reduced the water content.

In crude protein content there was a reduction due to addition of these same ingredients, despite containing protein, the content is low, with their inclusions in the formulation reduced the protein content in the product. As for the lipid content, as they were fried in oil, there was absorption in the product, consequently increasing this percentage. As there was addition of sodium chloride in the products, smoke

compounds regardless of being in liquid or powder form, are shown increasing in mineral matter of the elaborated product. As for carbohydrates, it is known that meat, regardless of animal species, has a low content, although with the elaboration of the product, flours were added that greatly increased the carbohydrate content 626.16% of the product. With this increase in the levels of carbohydrates and lipids, there was an increase in caloric value of the product. The meat of trimmings shown 97.17 kcal 100g<sup>-1</sup>, while the restructured breaded 213,12 Kcal 100g<sup>-1</sup>, with an increase of 119.60%.

No statistical difference was reported in the chemical analysis between two products made with different smokes (liquid and powder). The average chemical composition of the product was 61.30% moisture, 18.27% crude protein, 10.32% total lipids, 2.54% mineral matter and 7.85% total carbohydrates (Table 2).

The smoked Cayman had higher moisture contents 61.30% than similar products of rainbow trout 53.63% and chicken 44.15%, with lower crude protein contents 18.27%, against 26.45% trout and 30.28% for chicken and total lipids 10.32%, against 17.56% trout and 14.95% chicken [18]. This difference can be explained by cooking method, where the restructured was fried with different types of smoke, unlike other authors, who smoke the meat before preparing the product and frying, resulting in less moisture due to dehydration process that occurs. in the smoking process, consequently concentrating the other nutrients of this product, such as proteins and lipids. However, this product made with the different smokes complied with all the minimum requirements set out in Brazilian legislation [17].

Canto et al. (2015) [6] analyzed Pantanal Cayman trimmings burgers subjected to different smoking techniques, being a liquid, which is equivalent to one of the methodologies used in current study; these authors obtained lower moisture content 60.86% and lipids 6.7% for the hamburger, although higher levels of crude protein 27.08% and ash 4.17%. This difference is due to ingredients and methodology applied. Textured soy protein was used in the hamburger, which provided an increase in the protein content, as well as the dehydration process, concentrating the protein levels. Although despite using bacon, the lipid content was lower, due to product being subjected to dehydration for 60 min at 60 °C, promoting the loss of lipids, while in current study, the restructured ones were fried in oil, absorbing more of the frying oil.

Table 2: Chemical composition in smoked-breaded restructured products from minced Cayman yacare meat.

Parameters	Smoked-breaded restructured products		p value
	Liquid smoke	Powder smoke	
<b>Chemical composition (%)</b>			
<b>Moisture</b>	61.28 ± 0.02	61.32 ± 0.02	0.9709
<b>Crude Protein</b>	18.22 ± 0.05	18.32 ± 0.05	0.6610
<b>Total Lipids</b>	10.32 ± 0.01	10.33 ± 0.01	0.9489
<b>Mineral Matter</b>	2.23 ± 0.29	2.27 ± 0.25	0.7068
<b>Carbohydrates</b>	7.77 ± 0.08	7.93 ± 0.08	0.8716
<b>Caloric value (kcal per 100g)</b>	213.39 ± 0.28	212.84 ± 0.27	0.9266
<b>pH</b>	6.89 ± 0.01	6.88 ± 0.01	0.8773
<b>Aw<sup>1</sup></b>	0.88 ± 0.01	0.88 ± 0.01	0.9976

Values are represented as mean ± standard deviation; <sup>1</sup>Means ± standard deviation were compared by the F test at the 5% probability level. <sup>1</sup>Aw = water activity.

The smoked-breaded restructures did not show a significant difference for Aw 0.88 and pH 6.88 Table 2, shown that the use of liquid or powdered smoke did not influence the final product. Souza et al. (2022) [19] states that these foods can be classified as foods with high water activity, as this class contains more than 20% moisture and Aw above 0.60. Meat products, due to the high protein content in their composition, tended to have a higher pH.

Colorimetry analysis showed no difference between the two smoking methods, with both of them shown average luminosity (L\*) 51.94, a red intensity (a\*) 17.85, and a yellow intensity (b\*) 23.75 (Table 3). Although there is no literature regarding the colorimetry of smoked-breaded products, when

compared with traditional chicken nuggets, this product shows a higher intensity of red (17.85 against 2.08) and yellow (23.75 against 12.42), with a lower luminosity (51.94 against 60.99), making it slightly darker and with attractive color [20, 21].

Table 3: Colorimetry analysis of smoked-breaded restructured products from minced Cayman yacare meat.

Parameters	Smoked-breaded restructured products		p value
	Liquid smoke	Powder smoke	
<b>L*</b>	52.40 ± 0.46	51.48 ± 0.46	0.1466
<b>a*</b>	18.01 ± 0.16	17.69 ± 0.16	0.5569
<b>b*</b>	23.97 ± 0.22	23.53 ± 0.22	0.0928

Values are represented as mean ± standard deviation; Means ± standard deviation were compared by the F test at the 5% probability level; L\* - luminosity (black-white); a\* - red-green spectrum; b\* - yellow-blue spectrum.

Microbiological analysis of the smoked-breaded restructured (Table 4) followed the standards established by the National Health Regulatory Agency (ANVISA), which requires MPN g<sup>-1</sup> <3 for coliforms at 35° and 45° C, absence of *Salmonella* ssp. and counts inferior than 1x10<sup>2</sup> for *Staphylococcus coagulase positive* [17].

The results obtained in the microbiological analyses are in accordance with RDC No. 331 [17], with the absence or low index of investigated microorganisms, indicating good quality of the elaborated raw material and adequate (manufacturing) handling process during the preparation of the smoked-breaded restructured, which was appropriate (manufacturing) (Table 3).

Table 4: Microbiological analysis of smoked-breaded restructured products from minced Cayman yacare meat.

Parameters	Smoked-breaded restructured	
	Liquid smoke	Powder smoke
<b>Coliforms at 35° C (MPN g<sup>-1</sup>)</b>	<3	<3
<b>Coliforms at 45° C (MPN g<sup>-1</sup>)</b>	<3	<3
<b>Coagulase-positive <i>Staphylococcus</i> (CFU g<sup>-1</sup>)</b>	<1x10 <sup>2</sup>	<1x10 <sup>2</sup>
<b><i>Salmonella</i> ssp. (25g)</b>	ABSENT	ABSENT

MPN= Most probable number. CFU = Colony forming unit.

Through the sensorial analysis, it can be observe that the untrained tasters showed very good scores in the evaluations of the attributes referring to restructured ones made with liquid smoke and breaded powder, whose average scores ranging from 7 to 7.9, corresponding to a 'I liked it regularly and a lot' on the nine-point hedonic scale (Table 5). No statistical difference was observed between the two treatments with the use of smoking smoke of different characteristics (liquid and powder).

The average purchase intent score was 4 on a 5-point hedonic scale, meaning that they would likely buy the product if it were available on the market. Thus, shown that what the product has market potential. In addition, no statistical difference was detected between two methods that the restructured ones were elaborated with the use of smokes.

Table 5: Sensorial analysis of smoked-breaded restructured products from minced *Cayman yacare* residual meat.

Parameters	Smoked-breaded restructured products		p value
	Liquid smoke	Powder smoke	
<b>Atributtes*</b>			
<b>Color**</b>	7.00 ± 0.10	7.20 ± 0.10	0.5873
<b>Texture</b>	7.93 ± 0.13	7.67 ± 0.13	0.2635
<b>Aroma</b>	7.36 ± 0.07	7.50 ± 0.07	0.5743
<b>Flavor</b>	7.20 ± 0.07	7.33 ± 0.07	0.7505
<b>Global</b>	7.70 ± 0.10	7.90 ± 0.10	0.1579
<b>Impression</b>			
<b>Purchase</b>	4.07±0.05	4.00±0.03	0.8003
<b>Intention</b>			

Means ± standard deviation by F test (P<0,05). \*9 point hedonic scale; \*\*5 point hedonic scale.

The scores given by the tasters in the sensory analysis were higher when compared to scores reported by Fernandes et al. (2017) [8], Fernandes et al. (2015) [9] and Simoncini et al. (2017) [22] for smoked Cayman meat burgers, especially with regard to flavor 6,86 and texture 6,28, meaning that the restructured smoked-flavored breaded burger can a good option for the consumer market, perhaps even better than the hamburger that is a most common on supermarket shelves.

#### 4. CONCLUSION

Smoked-breaded restructured products from minced *Cayman yacare* meat showed good acceptability in the sensorial analysis, as well as composition inside the delimited by legislation, with a lower amount of total lipids than similar products. No difference was detected between two smoking methods, shown flexible technical feasibility in the preparation process, resulting in an excellent product made from Cayman boning trimmings and trimmings. It is suggested that this study be continued, by determining the profile of fatty acids and omegas found in this product (nuggets). Then, correlate nutrients with market prices, this will allow observing the price change for nutritional quality.

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