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Carcass yield and proximate composition of black caiman (*Melanosuchus niger*) meat

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The Amazon region is recognized as source of fish for the food industry. The interest in new products made from exotic animal meat has increased. The present study was carried out to evaluate carcass and meat characteristics of Amazon caiman. Samples (*n*=184) of *Melanosuchus niger* were collected from a protected area in the Amazonas State (Brazil). The meat was analyzed for proximate composition: Moisture content 78.17%, protein 19.23%, lipids 1.09%, and ash 0.73%. The yield of the carcasses and cuts were evaluated, and the average yield of carcass was 57.02%. The tail cuts had the highest yield. The results obtained can be useful for new Amazon basin products as well as for product labeling.

Key words: Amazon, açu, crocodilian, protein, harvesting.

INTRODUCTION

In addition to environmental protection concerns, the trends in the current commercial market are towards creating supply chains that are socially responsible and economically viable. Accordingly, sustainable products have gained notoriety. Adding value through the characterization, qualification, and classification of crocodilian products is essential for fair trade in order to prevent *ribeirinhos,* local population who live on caiman hunting, from suffering loss of profit and to ensure that the product pricing is affordable and that the products are safe. In the Brazilian Amazon, two species of crocodilians have potential commercial applications due to their larger size, abundance, and natural history, spectacled caiman (*Caiman crocodilus*) and black caiman (*Melanosuchus niger*) (Da Silveira, 2000). The management systems in the alligator harvest units in the State of Amazonas follow the harvest and source-sink models. These models are based on the removal of individuals from a natural

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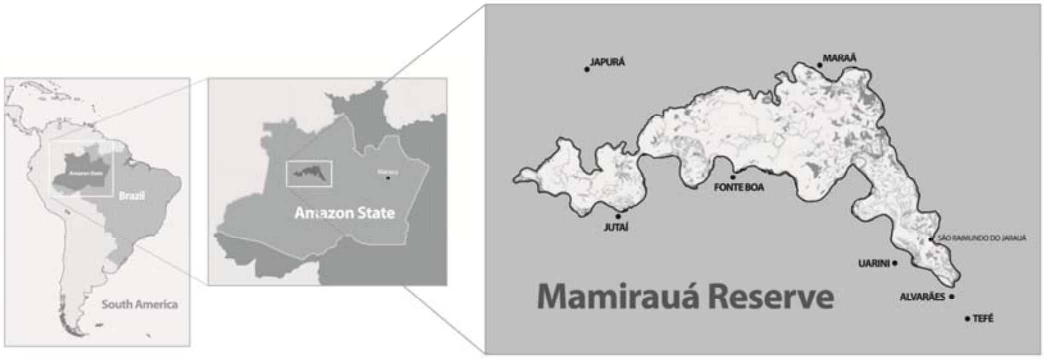

Figure 1. Mamirauá map showing the collection site and the surrounding municipalities.

population without reducing the population size (Chabreck et al., 1997). Despite the possibility of having an appropriate management of species, caimans are still subject to illegal hunting for meat (Da Silveira et al., 1998; Da Silveira and Thorbjarnarson, 1999) and be used as bait to capture other species such as piracatinga (*Calophysus macropterus*) in the Solimões, Purus, and Amazonas river basins. Da Silveira and Thorbjarnarson (1999) observed the recovery of *M. niger* population after extensive skin operating in the 1960 decade has taken place despite widespread commercial meat hunting. Somewhat paradoxically, while skin hunting significantly reduced caiman populations, meat hunting has not. Their study in the Mamirauá Sustainable Development Reserve shows how it differs from the previous system of skin hunting. This difference includes a complex interaction of factors: the legality of the hunt, differences in economic incentives of skin and meat hunting and the sizes of animals hunted, the ease of transport of the products (skins vs meat), caiman sexual size dimorphism, and patterns of sex-specific habitat selection by the two species of caiman. In general, the strategy of slow the rate of destruction of natural environments and the consequent extinction of wild species, could be a reasonable way to enhance the environment through the sustainable use of its natural flora and fauna (Hilborn et al., 1995). There has been growing international interest in exotic meats, and South American producers have seen this market as a new commercial possibility (Uhart and Milano, 2002). Therefore, scientific information on the standardization of commercial cuts, yield, meat quality, and nutritional values are necessary for the producers who are interested in offer these wild products for sale. The proximate composition data have been reported for other species, however, there are no data available for *M. niger*. In addition, its use could generate new jobs and increase the income of Amazon riverside populations involved in animal fishing and hunting, as well as increase the availability of new Amazon products. The acknowledgement about the meat quality and carcass yield is important for the evaluation of commercial viability focusing on the economic exploitation of species, in addition to providing subsidies for their technological use. According to the assumptions of conservation and sustainable use, and the findings of Da Silveira and Thorbjarnarson (1999), one of the important factors for conservation is the difficult to work with the meat than with skin. It is of great importance to know if the animal the size influences the yield of the carcass and its commercial cuts, to draw the minimum number of animals with the best possible performance. In this context, the objective of this study was to determine whether there is correlation between the size of the live animal and carcass yield or cuts yield.

MATERIALS AND METHODS

The samples were collected after the commercial slaughter of 184 *M. niger*, authorized by the Brazilian Environmental authorities and conducted by the São Raimundo Jarauá Community Fishing Association, Mamirauá Institute for Sustainable Development, Amazon Forests Agency, and Pescador Fish Industry. The animals were captured in their natural environment in the surrounding areas of São Raimundo do Jarauá, in the municipality of Maraã - AM - Brazil, a community within the focal area of Mamirauá Sustainable Development Reserve, which includes the caiman management in its Natural Resource Management Plan (Mamirauá, 1996). Figure 1 displays a map showing these locations. The animals were harvested in August and September during decrease water level season. A few number in the lakes and more intensity in the canals surround community.

The animals was captured at the night, between 10 p.m. and 2 a.m., by the local fishermen, were measured from the tip of the snout to the posterior edge of the cloaca, obtaining the snout-vent length (SVL) measurement, which corresponds to approximately half of the total length of the animal (Da Silveira and Thorbjarnarson, 1999). The animals were weighed using an analog scale (Pesola ®) of different capacities according to the animal size. They were determinate the sex by exposition of the penis in the males. Thus, the size, live weight and sex of the animals were determined. At 6 a.m. the slaughtering was initiated. The animals were washed, stunned by concussion, and the bleeding was performed by cutting the occipital region of the skull sectioning the occipital sinus. The animals were hung upside down to allow the blood to drain out and for skinning, removal of the head and feet, and evisceration. The carcasses

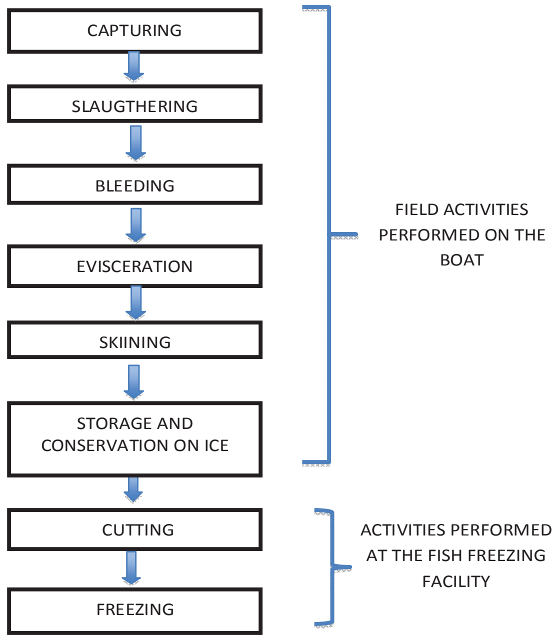

Figure 2. Flowchart of black caiman meat processing.

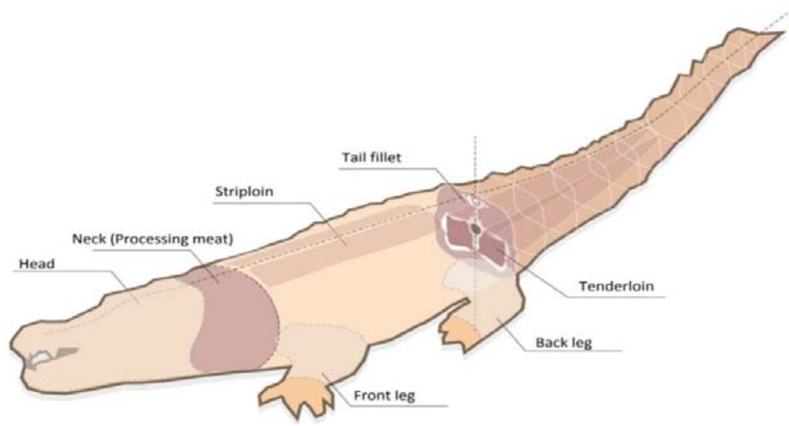

Figure 3. *M. niger* carcass components.

were washed with chlorinated water and weighed using Pesola ® scales. The clean carcasses were sent to an isothermal container of a fishing boat and kept on ice at temperatures between 0 and 1°C. After capturing and slaughtering, the carcasses were transported, 36 h, to a fish facility and submitted to cutting into parts two days after slaughtering. A flowchart outlining the experimental procedures is shown in Figure 2. To better use and to establish Brazilian patterns for *M. niger* meat, the carcasses were performed in cuts: neck (processing meat), front legs, back legs, boneless back legs, striploin, T-Bone, ribs, tail, tail fillet, tenderloin, and tail steaks (darnes) (Figures 3 to 5), based on the Australian Standard Cuts of *Crocodylus porosus* (Quensland, 1996).

In addition to measuring the carcass weight, the individual weights of each cut was measured using a 15 kg capacity electronic scale; when the cut exceeded this weight, weighing was performed using an analog Pesola ® scale. The cuts were frozen in a freezing tunnel at -45°C. Cuts from ten randomly chosen animals were homogenized and analyzed in triplicate for moisture content, protein, lipids, and ash, according to the AOAC (2005). The carcass yield (%) was determined by the ratio between the final weight of the carcass and the live weight of the animal; the cut yield was determined by the ration between the final weight of the cut and the live weight of the animal, as follows:

$$\frac{\text{Carcass weight} \times 100}{\text{Live weight}} = \text{carcass yield (\%)}$$

$$\frac{\text{Cut weight} \times 100}{\text{Live weight}} = \text{Cut yield (\%)}$$

The results were tabulated and analyzed statistically. Analysis of variance was used to evaluate the proximate composition, and a significant difference was observed. The carcass and cut yield data were subjected to the Tukey's test at a significance level of 5%. The linear relationship between SVL (cm) and the cut yield (%) and also between SVL (cm) and the cut weight (kg) was verified by the

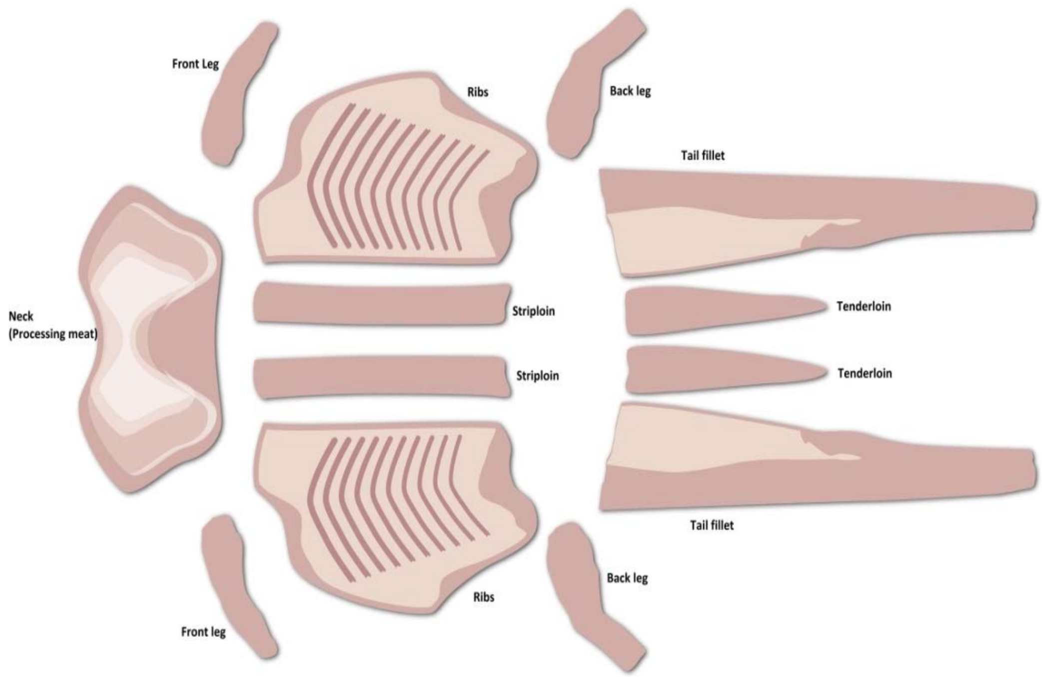

Figure 4. *M. niger* separated cuts.

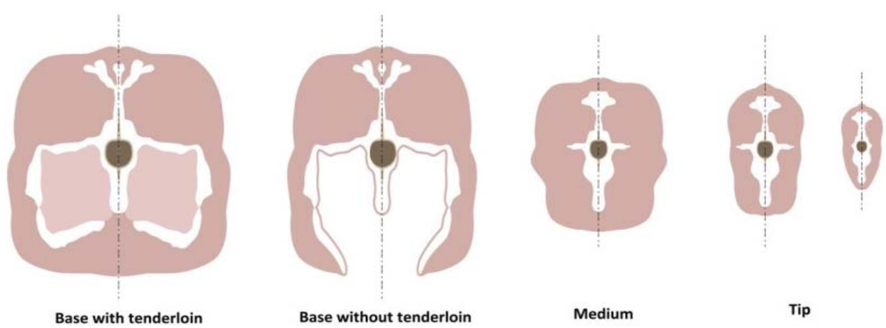

Figure 5. Cross sections of the tail: from the base of the tail to the tail tip.

Pearson's correlation coefficient (r); the Student-t test was used to determine the statistical significance. The linear relationship coefficients were determined by the method of least squares. The analysis was performed using the R statistical software (R Development Core Team, 2011). Lattice graphics were implemented in Sarkar (2008).

RESULTS AND DISCUSSION

The proximate composition data of some cuts are showed in Table 1. The average values for proximate composition of *M. niger* were: moisture content 78.17%, protein 19.23 g%, and lipids 1.09 g%. The mean levels found were similar to those of other studies conducted on other species of crocodilians, as shown in Table 2. Different values were observed for other animal species commonly found in butcher shops, for example, beef (beef for stewing): moisture 71.9 to 72.5%, protein 21.4 to 21.8 g%, lipids 4.6 to 5.3% (West et al., 2014); chicken meat: moisture 72.9%, protein 17.1 g%, and lipids 9.8 g% (NEPA-UNICAMP, 2011); pork: moisture 67.7%, protein 22.6 g%, and lipids 8.8 g% (NEPA-UNICAMP, 2011). Special attention should be paid when comparing the results of this study with those of other species of crocodilians since the animals used in the present study were captured in their natural environment (Table 2). Vicente et al. (2006) reported the proximate composition of captive-bred animals, with controlled environmental and feeding conditions, different from those of the caimans in the Amazon region. The samples in the present study showed lower lipid content than that of captive-bred animals because lipid content can vary with seasonal changes, type of feeding, and animal's exercise intensity. This hypothesis is supported by the findings of

Table 1. Proximate composition of different cuts of black caiman (p < 0.05).

Cut description	Proximate composition variables (%)			
	Moisture	Protein	Lipid	Ash
Tail fillet	77.4±0.39	20.68±0.2	0.63±0.07	0.8±0.03
Tenderloin	78.87±0.1	19.22±0.12	0.75±0.2	0.73±0.02
Strip loin	78.42±0.26	17.79±0.41	1.75±0.12	0.88±0.05
Boneless ribs	77.44±0.57	18.87±0.22	1.44±0.15	0.96±0.26
Neck	77.23±0.3	20.94±0.35	1.74±0.007	0.63±0.15
Boneless back legs	78.52±1.76	18.63±0.78	0.57±0.06	0.6±0.11
Boneless front legs	79.28±0.3	18.47±1.01	0.75±0.26	0.49±0.11

Table 2. Comparison between carcass yield and proximate composition of different species of crocodilians and regular meats.

Meats	Carcass yield %	Proximate composition (g%)			
		Moisture	Protein	Lipid	Ash
Crocodilians					
Melanosuchus niger	57.02	78.17	19.23	1.09	0.73
Caiman latirostris[a]	54.00	74.00	16.90	4.39	1.00
Cayman yacare[b]	59.50	74.49	21.88	2.98	1.17
Crocodilus niloticus[c]	56.50	71.64	22.08	6.23	0.51
Alligator mississipiensis[d]	62.35	75.50	21.45	1.22	1.30
Regular meats					
Beef	53.2[e]	72.4[f]	21.6[f]	5.5[f]	1.00[f]
Pork	59[g]	67.7[f]	22.6[f]	8.8[f]	1.00[f]
Chicken	73.3 to 74.5[h]	76.4[f]	17.8[f]	4.9[f]	0.9[f]

(a) Cossu et al. (2007); (b) Romanelli and Felicio (1999); (c) Hoffman et al. (2000); Moody et al. (1980); (e) Spanguero et al. (2004); (f) NEPA-UNICAMP (2011); (g) Fortin et al. (2003); (h) Kokoszynski and Bernacki (2008).

Almeida et al. (2008). They observed tambaquis (*Colossoma macropomum*) and reported that nature animals had between 42 and 48% less fat than farmed animals. Horna et al. (2001) report that *M. niger* are predators to suit a wide variety of prey, feeding almost anything that moves around. However, they observed a positive relationship between a mean proportion of snails and fish in the diet and the black caiman size, and a negative relationship between insects larvae and the animals size. Therefore, Da Silveira and Magnusson (1999) observed a higher amount of fish in stomachs of *C. crocodilus* during the rising and decrease water level season of the Rio Negro (26 m > 20 m) in animals captured in canals, demonstrating increased availability of fish in these stations and environment. In our work the *M. niger* samples were harvested in canals in August and September, with the water level between 30 and 25 m. These animals were captured with the best possible body status. However, it is important to repeat the experiment in other seasons to check the body status and carcass yield.

Table 3 shows the average weight and carcass and cut yield (%) of *M. niger*. The carcass yield values were satisfactory when compared to those of meat animals: bovine 53.2% (Spanghero et al., 2004), bubaline 52.6% (Spanghero et al., 2004), swine 59% (Fortin et al., 2003), ovine 53.16% (Bueno et al., 2000). The results obtained were significantly lower than the existing data of broilers, 73.3 to 74.5% (Kokoszynski and Bernacki, 2008), animals with considerable genetic improvement and bred with high feeding technology, use of good management practices, and intended for meat.

All of the cuts had a positive correlation between weight (kg) and SVL (cm) (p < 0.0001), with a correlation coefficient r greater than 0.80. The average SVL was 109.99 ± 15.55 cm, including animals from 59.50 to 151.10 cm, and the average live weight of 40.90 kg ±18:22, including animals of 14.00 to 96.00 kg. This is an expected exponential relationship, as shown in Figure 6, amongst all animal species considering that animals gain muscle mass with growth. The carcass yield of *M. niger* obtained in the present study was higher than those found by Cossu et al. (2007), 54.0% for *Caiman latirostris* and *Caiman yacare* and 56.5% for *Caiman niloticus* (Hoffman et al., 2000). On the other hand, the carcass yield of *M. niger* obtained here was lower than those found by

Table 3. Cut weight and cut yield and correlation between weight and SVL of black caiman.

Component	n	Cut weight (kg)	Yield (%)	Cut weight – SVL		Yield – SVL	
				r	p	r	p
Empty carcass weight	15	23.26 ± 9.75	57.02 ± 6.20	0.93	0.0010	0.10	0.7285
Commercial cuts total	163	18.29 ± 8.74	44.80 ± 5.77	0.93	0.0000	0.17	0.0326
Tail	51	5.11 ± 1.25	19.61 ± 1.80	0.89	0.0001	-0.12	0.3840
Tail steaks (darnes)	68	7.30 ± 3.92	14.85 ± 6.82	0.51	0.0001	-0.18	0.1427
Tail fillet	66	6.16 ± 3.15	13.82 ± 3.68	0.77	0.0001	-0.01	0.9163
Ribs	184	4.72 ± 2.49	11.53 ± 3.64	0.78	0.0001	0.07	0.3233
T-bone	19	3.46 ± 1.81	8.28 ± 2.04	0.91	0.0001	-0.19	0.4319
Neck (processing meat)	181	1.92 ± 1.16	4.69 ± 1.34	0.84	0.0000	0.33	0.0000
Back legs	184	1.72 ± 0.74	4.20 ± 0.42	0.92	0.0001	-0.20	0.0060
Striploin	159	1.25 ± 0.60	3.05 ± 0.60	0.91	0.0000	0.13	0.1058
Boneless back legs	91	1.30 ± 0.59	3.00 ± 0.45	0.90	0.0001	-0.15	0.1620
Tenderloin	125	1.31 ± 0.48	2.77 ± 0.37	0.92	0.0000	-0.21	0.0203
Front legs	184	0.60 ± 0.28	1.46 ± 0.27	0.89	0.0001	0.07	0.3169

SVL= Snout-vent length; n= number of samples.

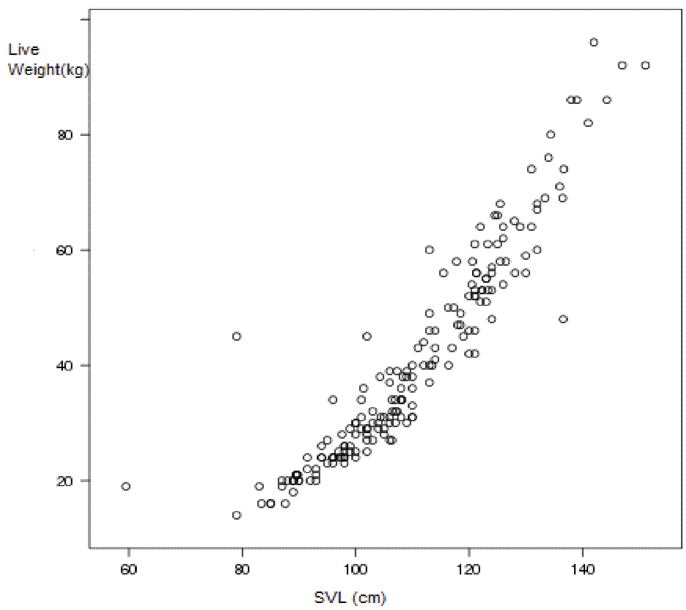

Figure 6. Live weight-SVL relationship.

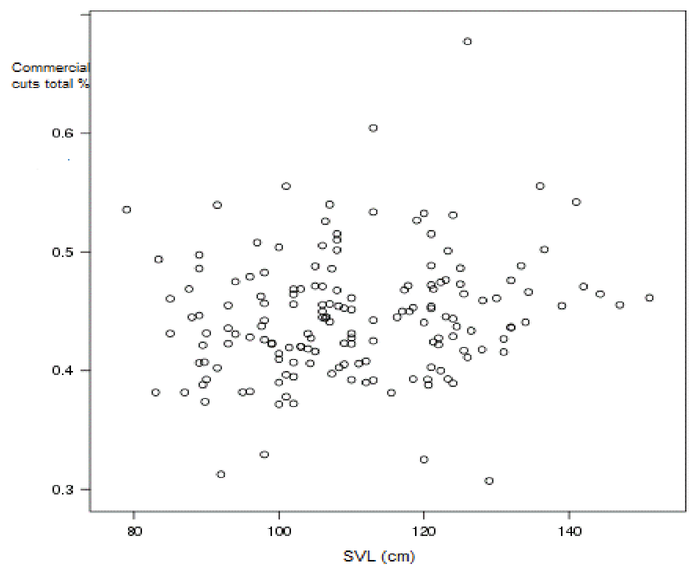

Figure 7. Dispersion of the relationship between commercial cuts total (%) and SVL (cm) data.

Romanelli and Felicio (1999), 59.5% for *C. yacare* and by Moody et al. (1980), 62.35% for *Alligator mississippiensis.* The reasons for these differences may be based on gender, food availability, hormonal changes, and handling techniques during cutting, according to Hoffman et al. (2000). In our work, even larger variation was possible, considering that those studies were conducted with captive-bred animals with standard group, and the animals analyzed in the present study were captured in their natural environment. Despite of the crocodilians phenotype similarity, it is hard to make a comparison with other authors considering that they used different cutting patterns and farmed animals. A positive or direct correlation between yield (%) and SVL (cm) was observed for the cut "neck" ($p<0.0001$), and a negative or inverse correlation was observed for the cuts "bone-in back legs" and "tenderloin" ($p<0.0402$). However, the correlation coefficient r was below 0.35 in all cases. Therefore, these correlations are considered weak or not statistically significant. No correlation was observed between yield (%) and SVL (cm) for carcass yield, commercial cuts total (Figure 7), and for the cuts: front legs, boneless back legs, ribs, striploin, T-Bone, tail, tail steaks, and tail fillet ($p > 0.1427$).

Conclusions

M. niger is an excellent source of animal protein found in the Amazon region. The results obtained demonstrate that the black caiman meat can be considered an important nutritional resource compared with other animal's meat. The proximate composition and carcass yield of *M. niger* are similar to those of other crocodilians analyzed in different regions in the world. Our findings suggest that the size of the animal not affect carcass yield economically significant. Thus the choice of the size classes of *M. niger* for slaughter is not necessary based on this variable. On the other hand, more studies are necessary to establish texture, color, flavor standards and other variables that may influence sensory or economically the meat of black caiman.

Conflict of Interest

The authors have not declared any conflict of interest.

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