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Yield and composition of pirarucu fillet in different weight classes

Fabíola Helena dos Santos Fogaça[1*], Elenise Gonçalves de Oliveira[2], Samanta Eulles Quixaba Carvalho[1] and José Francisco de Seixas Santos[1]

*[1]Centro de Pesquisa Agropecuária do Meio-Norte, Empresa Brasileira de Pesquisa Agropecuária, BR 343, km 35, 64200-970, Parnaíba, Piauí, Brazil. [2]Universidade Federal do Ceará, Fortaleza, Ceará, Brazil. *Author for correspondence. E-mail: fabiolafogaca@cpamn.embrapa.br*

ABSTRACT. The fillet yield and quantity of waste generated after processing are important for planning and evaluating the growth performance of species and systems of aquaculture production in Brazil. The pirarucu (*Arapaima gigas*) is among the species with desirable characteristics for intensive fish with high market value. The objective was to evaluate the performance of pirarucu fillet in different weight classes: 7.0 to 9.0 kg (group I), 11.0 to 13.0 kg (group II) and 14.0 to 17.0 kg (group III). The fillet yield presented no significant difference between groups. The composition showed significant differences ($p < 0.05$) for moisture (77.96 to 75.04%) and ash (2.21 to 2.46%), while values of lipid and protein were similar between classes evaluated. In assessing the fat percentage per serving (loin, belly and tail) there was higher fat deposition in the ventral part and in group III. Thus, it can be lessen the pirarucu with weight ranging from 7.0 to 9.0 kg, using shorter production cycles and obtaining better quality fillets by having a lower muscle percentage of lipids.

Key words: *Arapaima gigas*, fat deposition, filleting.

RESUMO. Rendimento e composição do filé de pirarucu em diferentes classes de peso. O rendimento de filé e a quantidade de resíduos gerada após o processamento são importantes para o planejamento e a avaliação do desempenho zootécnico de espécies e dos sistemas de produção aquícola brasileiros. O pirarucu (*Arapaima gigas*) está entre as espécies com características desejáveis para piscicultura intensiva e com alto valor de mercado. O objetivo do trabalho foi avaliar o rendimento do filé de pirarucu em diferentes classes de peso: 7,0 a 9,0 kg (grupo I), 11,0 a 13,0 kg (grupo II) e 14,0 a 17,0 kg (grupo III). O rendimento de filé não apresentou diferença significativa entre os grupos avaliados. A composição apresentou diferenças significativas ($p < 0,05$) para umidade (77,96 a 75,04%) e cinzas (2,21 a 2,46%), enquanto os valores de lipídeos e proteína bruta foram similares entre as classes avaliadas. Na avaliação da porcentagem de lipídios por porção (lombo, barriga e cauda) houve maior deposição de gordura na parte ventral e no grupo III. Dessa forma, pode-se abater o pirarucu com média de peso entre 7,0 a 9,0 kg, utilizando-se ciclos de produção mais curtos e obtendo-se filés com melhor qualidade por apresentarem menor porcentagem muscular de lipídio.

Palavras-chave: *Arapaima gigas*, deposição lipídica, filetagem.

Introduction

The introduction of fish as food, as recommended by researchers and FAO (Food and Agricultural Organization), has been widely exploited by the fishing sector to enhance its product (SANTAMARIA; ANTUNES, 1998). However, the stagnation of extractive fishing highlights the growth of aquaculture, increasing its current importance in the global supply of fish (BORGHETTI et al., 2003).

Based on tilapia culture, aquaculture in Brazil shows promising results. Moreover, production of native fishes should also be encouraged, since there are numerous species with potential livestock that can contribute to meet the domestic demand for fish. For this, there is need to know the species since its acquisition, production, processing and marketing. In this sense, the pirarucu (*Arapaima gigas*) has desirable characteristics for breeding in captivity, due to its fast growth and excellent meat quality (IMBIRIBA, 2001).

Pirarucu has been studied in different cropping systems: recirculating systems (SAINT-PAUL, 1986), ponds (IMBIRIBA, 2001), cages (CAVERO et al., 2003), monoculture, polyculture or consortium (PEREIRA-FILHO; ROUBACH, 2005). Although these studies, there is still lack of results, especially in breeding and processing, and few are those related to yield and nutritional composition of the pirarucu. Such studies are essential to estimate the potential for industrialization of species (CARNEIRO et al., 2004), its production scale, meet quality and availability of resources (whole fish, fillets, steaks, processed products).

According to Ono et al. (2004), the yield of pirarucu fillets in weight classes ranges between 30-40 kg, ranging from 56.6 to 57.9%, while specimens weighing over 60 kg can reach values of up to 65% for yield of fillet with skin. In the case of fishes from captivity, the slaughter weight is lower (10-20 kg), which can reduce rates of meat yield.

To prove these results, works should assess these parameters in different weight classes, since the slaughter weight seems to be directly related to the fillet yield, which may influence the quality and value of products. According to Souza et al. (2005), weight classes do not influence the composition, but cause variations in thickness and fillet area, and consequently influences in fish industrialization, according to studies conducted in Nile tilapia. However, some species showed higher lipid deposition from a certain weight, influenced by season and age (NAKAMURA et al., 2007) according to the physiological need of the fish: growth, reproduction, or just maintenance (fattening). In the case of pirarucu, it was studied the whole fillet composition and specific parts since the species has a marked difference in terms of lipid contents between the dorsal and abdominal regions, which from the technological point of view demands more caution as the process of lipid deterioration shortens the shelf life of products (DAVIS et al., 1999).

Given the above and the small number of publications on carcass traits and growth performance of this species, the purpose of this study was to determine the yield and composition of the pirarucu fillet in different weight classes.

Material and methods

The study was conducted at the Embrapa - Parnaiba Unit Research, Parnaiba, Piauí State, between April and August 2008. A total of 15 pirarucu specimens (*A. gigas*) with approximately 18 months of age from culture in irrigation canals (DITALPI - Irrigation District Coastal Tablelands of Piaui, Parnaiba, Piaui State) were used.

Fishes caught by trawl, were stored in fiber boxes with 10 m^3 capacity and transported to Embrapa for physical measurements (weight and length), slaughter and filleting. Each fish was weighed on digital scales (model TB-6002) and measured in ictiometer to obtain the total length (cranial extremity end to end of caudal fin). Afterwards, fishes were killed by heat shock in ice and water (1:1) and bled by cutting their gills, gutted, and after the withdrawal of the head and skin, they were fillet. The filleting cut was started at the dorsal region from the cranial to the caudal extremity regions. Fishes were divided into three weight classes (five fishes/class): 7.0 to 9.0 kg (group I) 11.0 to 13.0 kg (group II) and 14.0 to 16.0 kg (group III). For each class were determined: average weight, total weight, total weight after slaughter and bleeding, weight of whole eviscerated fish, fish weight without head, skin weight, fillet weight, viscera weight, liver weight and carcass weight (Table 1). Based on data collected were calculated the following yield parameters being related to the initial weight of the whole fish (total weight):

- Fish yield after bleeding (RPS) = (weight after bleeding x 100) / total weight;
- Eviscerated whole fish yield (RPIE) = (eviscerated fish weight x 100) / PT;
- Fillet Yield (RF) = (fillet weight x 100) / Total weight.

All samples used were stored at -18°C and maintained at 5°C for 24 hours prior to analyses of composition. Fillet samples of five fishes in each weight class were removed and homogenized (AOAC, 2000), with analysis performed in triplicate. For the assessment of fillet lipid composition, samples of the loin (back), tail and belly (abdomen) areas of fillets (Figure 1) were removed and analyzed.

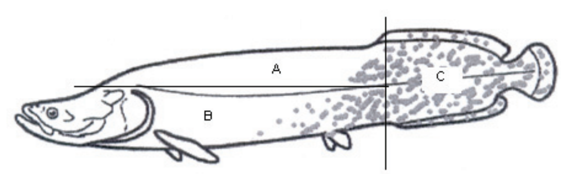

Figure 1. Details of cuts performed to assess the lipid percentage of pirarucu fillets. A = loin B = belly and C = tail.

The composition was determined by standard analytical methods (AOAC, 2000). Moisture was determined by drying a sample of 2.0 g at 105°C for 24 hours. Ashes were determined by incineration at 550ºC for 6h in muffle furnace. Lipids were determined by extraction in petroleum ether in Soxhlet apparatus. The crude protein was determined by semi-micro Kjeldahl method. The protein nitrogen conversion factor considered was 6.25.

A completely randomized design was used, with three treatments represented by the weight classes and five repetitions represented by the fishes. For lipid percentage of pirarucu fillets, a 3 x 3 factorial arrangement was used, characterized by the cuts performed and weight classes. Data were analyzed using the SAS statistical software, version 6.12 (SAS, 1997). To detect differences between means was performed the analysis of variance (ANOVA), and in cases where there was significant difference between treatments was applied the Tukey multiple comparison test ($p < 0.05$).

Results and discussion

The percentage values of fishes yield in different weight classes studied are presented in Table 1. There was no difference among groups evaluated with 48.62% average fillet yield. Usually there is direct relationship between the total fish weight and its fillet yield (SANTOS et al., 2000). In this work, we could observe that there was no such relationship in pirarucus with weights between 7.0 and 16.0 kg. It is still observed a small percentage (8%) of viscera with no differences between classes studied (Table 1).

Table 1. Mean weight and fish yield in different weight classes.

Parameter	Group I	Group II	Group III
Total weight (kg)*	7.99±0.27	12.05±0.27	15.14±0.99
Total length (cm)*	100.4±0.55	114.2±2.77	120.0±2.00
Weight after bleeding (kg)	7.91±0.23	11.96±1.97	14.89±2.33
Skin weight (kg)	0.49±0.73	0.77±1.33	1.08±1.61
Eviscerated fish weight (kg)	5.36±0.22	7.57±1.88	9.47±2.24
Liver Weight (kg)	0.06±0.01	0.07±0.01	0.10±0.01
Carcass Weight (kg)	1.12±0.06	1.64±0.20	1.92±0.22
Head Weight (kg)	1.16±0.05	1.62±0.24	1.90±0.26
Fillet Weight (kg)	3.79±0.19	5.86±1.13	7.55±1.39
Fish Yield after bleeding (%)	98.95 ± 0.47	99.29 ± 0.89	98.30 ± 2.31
Eviscerated Fish Yield (%)	92.80 ± 0.87	92.94 ± 0.96	91.25 ± 2.52
Fillet Yield (%)	47.43 ± 1.46	48.62 ± 3.00	49.79 ± 3.61

*Mean of five fishes per treatment ± Standard Deviation. Group I: 7.0 to 9.0 kg; group II: 11.0 to 13.0 kg; group III: 14.0 to 16.0 kg.

A study of performed with tilapia (*Oreochromis niloticus*), evaluating three weight classes found a direct relationship between total weight and fillet yield (SOUZA et al., 2005). In pirarucus, there is no record of studies comparing yield in different weight classes. However, the yield of pirarucu fillets in weight classes ranges between 30-40 kg is smaller than fillet yield of specimens weighing over 60 kg (ONO et al., 2004).

The fillet is considered the most commonly cut type sold, taking advantage on the consumer acceptance. Its yield depends on, beyond the cutter's dexterity, especially the anatomical shape of the fish (CONTRERAS-GUZMÁN, 1994). Since the tilapia's body has fusiform shape and pirarucu is more cylindrical, the latter provides superior yield. In general, fishes have fillet yield ranging between 30-50%. It noted therefore that pirarucu has superior yield to other species already domesticated, as the jundiá (*Rhandia quelen*) (CARNEIRO et al., 2004) and the curimbatá (*Prochilodus lineatus*) (MACHADO; FORESTI, 2009), factor that favors its production in captivity.

Regarding composition, values showed significant differences ($p < 0.05$) for moisture (77.96 to 75.04%) and ash (2.21 to 2.46%), while values of lipids and crude protein were similar between classes evaluated (Table 2). The average values of certain lipids in the fillet were low, demonstrating that the pirarucu flesh has low muscle fat content when compared to the tambaqui (*Colossoma macropomum*) (FERNANDES et al., 2010), lungfish (*Hoplias malabaricus*) (SANTOS et al., 2000) and rainbow trout (*Oncorhynchus mykiss*) (KIM et al., 1989). This could be explained because lipid composition and distribution between and within tissues in fish vary from species to species (PRASAD THAKUR et al., 2003), that can be classified according to the lipid content in: lower muscle lipid levels (fat ranging from 0.1-1.0%, confined to the liver); middle muscle lipid levels (8.0%); and fat fishes (15.0%) with higher accumulation of visceral fat (OGAWA; DINIZ, 1999).

Table 2. Mean composition of pirarucu fillets.

Group	Moisture (%)	Fat (%)	Crude protein (%)	Ash (%)
I	76.12 ± 1.75^{b}	0.63 ± 0.01^{a}	20.67 ± 1.27^{a}	2.33 ± 0.07^{ab}
II	77.96 ± 0.60^{a}	0.56 ± 0.03^{a}	19.97 ± 0.69^{a}	2.21 ± 0.08^{b}
III	75.04 ± 1.09^{b}	0.64 ± 0.02^{a}	20.13 ± 0.74^{a}	2.46 ± 0.15^{a}

Mean of five samples ± Standard Deviation, with three replicates (n = 15). Mean values followed by different letters in the same column have significant difference by the Tukey's test at 5% probability ($p \leq 0.05$).

Knowledge of the fish chemical composition is of fundamental importance for the standardization of food in nutritional and technological aspects, since it provides information to introduce them in the diet, for industrialization and fitness able to meet the needs of the market (SIMÕES et al., 2007).

Table 3 presents the analysis of variance results for the lipid fillet composition according to pirarucu cut (C) and weight classes (W). There was an effect of the cut performed in the lipid composition of fillet ($p < 0.05$).

Table 3. Analysis of variance results for the lipid fillet composition according to pirarucu cut (C) and weight classes (W).

Variation factor	F	p Value
Weight classes (W)	0.7449	0.5139*
Cut (C)	10.7405	0.0004
W x C interaction	0.7171	0.5882*
CV (%)	23.48	

*Not significant ($p > 0.05$).

Between weight classes evaluated, higher fat deposition was observed in the ventral (belly) region in animals of group III (Table 4), which gained more weight during the growing period. This could be explained because from a certain weight the animal usually reduces the protein deposition and enhances fat deposition in the carcass and fillet (MACHADO; FORESTI, 2009).

Table 4. Mean values of lipid fillet composition according to pirarucu cut.

Group	Back	Tail	Belly
I	0.30 ± 0.34^{Ca}	0.56 ± 0.77^{Bb}	1.61 ± 0.77^{Ac}
II	0.43 ± 0.24^{Ca}	0.82 ± 0.81^{Ba}	2.15 ± 2.88^{Ab}
III	0.42 ± 0.18^{Ba}	0.55 ± 0.24^{Bb}	3.14 ± 1.80^{Aa}

Analyses of five samples with three replicates (n=15). Means followed by the same letters are not different by the Tukey's test at 5% probability (lower case letters in the rows and upper case letters in the columns).

The fat percentage in wild specimens showed lower values when compared to specimens from cultivation (ARBELÁEZ-ROJAS et al., 2002). This variation may also be influenced by season and age of animals, since lipid deposits can be located in different tissues (NAKAMURA et al., 2007) according to the physiological need of the fish: growth, reproduction, or just maintenance (fattening).

Studies with curimbatá collected in the wild have found higher levels of lipid and energy into fillets of resident specimens with stationary habit in relation to stocks of migratory fishes of the same species (MACHADO; FORESTI, 2009). In this study, no specimen evaluated presented gonadal development in maturation being considered young animals in growth stage and with the same age.

All groups evaluated showed lower fat percentage in the back and higher in the belly (Table 4). This difference was also observed in African catfishes (*Pangasius bocourti)* (THAMMAPAT et al., 2010). This trend of increased lipid content in back-belly direction can be found in other studies with rainbow trout, sea bass (*Dicentrarchus labrax*) and golden (*Sparus aurata*) (TESTI et al., 2006). According to further studies, the tissue of the ventral region is composed predominantly of adipocytes that contain the highest contents of lipids and triglycerides per gram of muscle, followed by the red and white muscles in decreasing levels of intramuscular fat (NANTON et al., 2007).

Conclusion

It can be lessen the pirarucu with weight ranging from 7.0 to 9.0 kg, using shorter production cycles and obtaining better quality fillets by having lower muscle of lipid.

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