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Carcass yield and proximate composition of bullfrog (*Lithobates catesbeianus*)

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ABSTRACT. This work evaluated five classes of weight of bullfrog (*Lithobates catesbeianus*) seeking to define the ideal slaughter weight for the species. We used 79 bullfrogs, distributed in a completely randomized design (class 1 < 100 g (n = 10); class 2 from 101 to 150 g (n = 17); class 3 from 151 to 200 g (n = 24); class 4 from 201 to 250 g (n = 14); and class 5 >251 g (n = 14)), which were euthanized, weighted and gutted. For the carcass yield, we weighed the clean torso, thighs, liver, skin and head. The clean torso was subjected to chemical composition analysis. The carcass yield was, on average, 49% with no difference between weight classes ($p > 0.05$). The yield of posterior thighs was significantly higher for the lower weight class, which also presented higher percentage of paws (28.37 ± 0.63 and 9.33 ± 0.21, respectively) ($p < 0.05$). The percentages of visceral fat and skin showed a progressive increase along with the weight of the animals; the class with individuals weighing 201-250 grams showed the higher values ($p < 0.05$). The chemical composition indicated that individuals above 251 grams showed lower values of ether extract and higher values of crude protein (0.99 ± 0.14 and 15.80 ± 0.64, respectively) ($p < 0.05$). So, it is recommended the slaughter of bullfrogs weighing more than 201 grams, because of better yield and meat quality.

Keywords: exotic species, meat processing, raniculture.

Rendimento de carcaça e composição centesimal da rã-touro (*Lithobates catesbeianus*)

RESUMO. O objetivo do trabalho foi comparar cinco diferentes classes de peso de rã-touro (*Lithobates catesbeianus*), buscando definir o peso ideal de abate para a espécie. Foram utilizados 79 exemplares de rãs-touro, distribuídas em um delineamento inteiramente casualizado (classe 1 <100 g (n = 10); classe 2 de 101 a 150 g (n = 17); classe 3 de 151 a 200 g (n = 24); classe 4 de 200 a 250 g (n = 14), e classe 5 > 251 g (n = 14)), que foram eutanaziados, pesados e eviscerados. Para o rendimento da carcaça foram pesados: tronco limpo, coxas, fígado, patas, pele e cabeça. O tronco limpo foi submetido à análise de composição centesimal. O rendimento de corpo limpo foi em média 49%, sem diferença entre classes ($p > 0,05$). O rendimento das coxas posteriores foi significativamente maior para a menor classe de peso, e essa classe também apresentou maior porcentual de patas (28,37 ± 0,63 e 9,33 ± 0,21, respectivamente) ($p < 0,05$). As porcentagens de gordura visceral e pele apresentaram um aumento progressivo concomitante ao peso dos animais, sendo que a classe com indivíduos de 201 a 250 g apresentou os maiores índices ($p < 0,05$). Na composição centesimal observou-se que indivíduos acima de 251 g, apresentaram menores valores de extrato etéreo e maior valor de proteína (0,99 ± 0,14 e 15,80 ± 0,64, respectivamente) ($p < 0,05$). Para melhor aproveitamento é recomendado que rãs-touro sejam abatidas com peso superior a 201 g, pois apresentam melhores rendimentos e características da carne.

Palavras chave: espécie exótica, processamento de carne, ranicultura.

Introduction

Among the problems of the fishing industry is the lack of standardization of fisheries. This factor has encouraged studies aimed at improving this sector; however studies on frog meat are scarce and concentrated in the processing area (Assis et al., 2009; Gonçalves & Otta, 2008; Mello et al., 2006a; Mello, Silva, Mano & Franco, 2006b). There are large gaps in technological research on this species, particularly for obtaining a more uniform raw material, as this provides the use of new technologies such as automated slaughtering, reducing costs with labor, seeking to make better use of fisheries and intending to reduce the losses to the final processing.

The barriers in bullfrog production of bullfrogs include the lack of researches, publications and failures in the basic production chain. Among the problems are factors that hinder the marketing of this

product flow: lack of marketing directed to the final consumer and the merchant, and variation in the supply, due to the off-season.

Bullfrog (*Lithobates catesbeianus*) is native to North America, but can be found in more than 41 countries (Laufer, Canavero, Núñez & Maneyro, 2008). It is very resistant to climatic variations and can support up to negative temperatures, besides being very resistant to management. For this reason, it has been introduced in several countries for commercial purposes (Barrasso, Cajade, Nenda, Baloriani & Herrera, 2009).

Carcass of bullfrog consists of thighs and torso. Thighs have a high commercial value, while the torso, which accounts for nearly half-carcass weight, receives a lower value because it contains a relatively large amount of bones. Frog meat has a high protein content with adequate balance of amino acids, low lipid content and high percentages of polyunsaturated fatty acids (Noll & Lindau, 1987), providing carcass with low-fat and cholesterol (Casali, Moura & Lima, 2005). The differentiated composition and nutritional value of this meat attract consumers, compared to other animal foods, since they have beneficial characteristics in treating certain diseases and physiological disorders (Rodrigues et al., 2014).

In Brazil, frogs are sold whole (without skin and viscera), while in the international market, frog meat is more abundant in the form of fresh or frozen thighs, at higher prices (Mello et al., 2006a; Ramos, Gomide, Ramos & Peternelli, 2004), its main products are the meat and the skin.

Aiming at the standardization in cuts and processing of bullfrog, analyzing husbandry qualities and especially the attributes that bullfrog meat offers, this study compared five different bullfrog weight classes, in an attempt to define the ideal slaughter weight for the species.

Material and methods

The study was conducted in the Laboratory of Fish Technology, State University of Western Paraná – Unioeste, Campus de Toledo. Bullfrog (*Lithobates catesbeianus*) individuals (n = 79) were purchased live in a commercial frog farm in the municipality of Toledo, Paraná State. Frogs were maintained in concrete pens with water layer and given 14 mm-commercial feed, with 36% crude protein twice per day. Animals were divided into five weight classes as follows: Class 1: <100 g (n = 10); Class 2: 101-150 g (n = 17); Class 3: 151-200 g (n = 24); Class 4: 200-250 g (n = 14), and Class 5: > 251 g (n = 14), and before stunning, frogs were fasted for 24 hours.

In laboratory, frogs were stunned individually in ice water (thermonarcosis), and subsequently euthanized by cranial concussion and section of the cervical spinal cord (AVMA, 2001), using sharp scissors, then each animal was weighed on a semi-analytical scale (Animal Ethics Committee Protocol 8691). After pre-washing, sections were made from the ends of the paws, collar risk, cross-sections of the abdominal skin and around the vent to facilitate removal of the skin. Subsequently, a longitudinal section in the abdomen was made to remove viscera and cut the head. Each of the different parts obtained from the processing of frogs [clean torso (gutted, without skin, head and paws) and posterior thighs] was weighed to calculate the individual percentage of each fraction. Liver, paws, head and visceral fat were also weighed to calculate the indices of each body part: [(organ weight/total weight)*100]. Finally, a final wash of the clean carcass was made to be packed in plastic bags and frozen (-20°C) for later analysis of proximate composition.

For the proximate composition analysis, it was used five frogs from each weight class. Samples were ground and homogenized for determination of moisture percentage, mineral matter and ether extract and crude protein (Silva & Queiroz, 2002). For this analysis, it was used the clean carcass with bones.

Data of carcass yield and chemical composition were tested for the assumptions of homoscedasticity (Levene test) and normality of residuals. Then, data were subjected to analysis of variance (5%) and Tukey test at 5% significance level using the software Statistica 7.0®.

Results

There were significant differences between bullfrog weight classes for the percentage of posterior thighs, fat, paws and skin ($p < 0.05$). On the other hand, the values of clean carcass, torso, liver and head did not differ statistically ($p > 0.05$) (Table 1).

The overall mean value of clean carcass yield remained around 49% independent ($p > 0.05$) of the classes. The yield of the posterior thighs represented about 27% of the total weight; the animals weighing between 151 to 200 g presented lower values (25.94 ± 0.38%) ($p < 0.05$) than the others. The percentage of visceral fat has gradually increased according to the increase of animal weight, and the individuals with 201-250 grams had the highest levels ($p < 0.05$). For the percentage of skin, there was an increase similar to that found for visceral fat. Significant differences were observed between the classes, in which the lowest percentage of skin (7.84 ± 0.15%) was verified for frogs weighing less than 100g and the highest for the class of 201 to 250 g (9.98±0.17%).

Table 1. Percentage yield of meat cuts and waste of bullfrog (*L. catesbeianus*) in different weight classes.

	Weight classes					
Variables	<100 g	101 - 150 g	151 – 200 g	201 – 250 g	>251 g	p
Clean carcass %	49.81 ± 0.79	49.40 ± 0.60	48.97 ± 0.46	49.96 ± 0.48	49.65 ± 0.62	0.71^{ns}
Post. legs %	28.37 ± 0.63^{a}	26.95 ± 0.50^{ab}	25.94 ± 0.38^{b}	26.75 ± 0.47^{ab}	25.66 ± 0.76^{ab}	0.04★
Ant. legs %	5.68 ± 0.43	5.52 ± 0.53	4.90 ± 0.22	4.50 ± 0.14	4.59 ± 0.12	0.05^{ns}
Torso %	25.28 ± 3.54	22.41 ± 0.50	20.81 ± 0.37	23.11 ± 0.55	23.94 ± 0.72	0.51^{ns}
	Weight classes					
Variables	<100g	101 - 150 g	151 – 200 g	201 – 250 g	>251 g	p
Liver %	3.33 ± 0.20	5.16 ± 1.90	3.75 ± 0.13	3.65 ± 0.11	3.63 ± 0.24	0.69^{ns}
Fat %	3.39 ± 0.26^{a}	4.41 ± 0.25^{a}	5.49 ± 0.22^{b}	6.74 ± 0.14^{c}	6.20 ± 0.24^{bc}	0.00★
Skin %	7.92 ± 0.16^{a}	9.01 ± 0.18^{b}	9.42 ± 0.12^{bc}	9.98 ± 0.17^{c}	9.54 ± 0.19^{bc}	0.00★
Head %	11.45 ± 0.22	11.09 ± 0.42	10.55 ± 0.38	9.61 ± 0.32	10.57 ± 0.40	0.06^{ns}
Paws %	9.33 ± 0.21^{a}	9.01 ± 0.18^{ab}	8.64 ± 0.12^{ab}	8.73 ± 0.14^{ab}	8.42 ± 0.13^{b}	0.01★

Post. legs: posterior legs; Ant. legs: anterior legs. Data represented by means ± standard error; ★ Indicates significant difference ($p < 0.05$); ^{ns} Indicates non-significant difference ($p > 0.05$); Different letters in the same row indicate significant differences between weight classes.

Paws accounted for about 8.5% of the animal weight. In frogs with more than 251g, these forelimbs represent 8.42 ± 0.13% of the total weight and are significantly lower when compared to frogs with 100 g (9.33 ± 0.21). This result indicates that according to the growth of the animals, paws become less representative in the body percentage. The same trend was observed for the weight of the head, which showed a lower percentage for animals over 251 g compared animals with less than 100 g (10.57 ± 0.40 and 11.45 ± 0.22, respectively), but without significant difference.

In relation to the proximate composition of the bullfrog meat, moisture had an average of 80% for all classes, without significant difference ($p > 0.05$) between classes. Moreover, the higher the content of ether extract, the lower the crude protein content (Table 2). Individuals over 251 g exhibited a lower fat deposition in the meat (0.99 ± 0.14%), on the other hand, they had higher crude protein (15.80 ± 0.64). Also, bullfrogs with more than 201 g showed lower values of mineral matter ($p = 0.00$), meaning that, from 201 g, frogs develop least the skeleton and start to accumulate more meat.

Discussion

Bullfrog can be fully used after slaughter. Posterior thighs are the main product marketed and, in this study, they represented on average 26% of the marketable part of this animal; however, according to Mello et al. (2006a), other products can be obtained from mechanically separated meat (CMS) as frogburguer, pates and canned products. These products can be easily obtained through the extraction of CMS from the torso or anterior thighs, which together represent approximately 30% of the clean carcass, according to the results of the present study. These parts have small bones, which hinder their marketing. Furthermore, the waste (liver, paws, skin, fat and head), which in this work accounted for about 30% of the total weight, can be processed into meal for subsequent formulation of feed. The fat can be processed further, for oil extraction. Fat can be further processed for oil extraction. Skin is used in the manufacture of garments. According to Lopes, Dantas and Cunha (2010), skin, guts and fat are the focus of scientific research aiming applicability in the pharmaceutical industry.

The main product obtained from bullfrogs is the thigh cut, and in this study frogs with less than 100 grams had the highest yield, but animals with this weight range have small thighs, which can be a limiting factor on the consumer market. The results also showed that despite the individuals of this weight class have higher yield of thighs, they demonstrated higher percentages of head and paws (11.45 ± 0.22%, 9.33 ± 0.21%, respectively) than the other weight classes. The proximate composition was disadvantaged in that class, as it presented high contents of mineral matter (3.45 ± 0.09%), intramuscular fat (1.40 ± 0.08%) and low content of crude protein (13.19 ± 0.44%), when compared to larger individuals.

Frog skin is a highly valued product in the market, as it turns into leather through the tanning process and can be used for making belts, bags, shoes and other accessories. In this sense the results

Table 2. Proximate composition of different weight classes of bullfrog, *L. catesbeiana*.

	Weight classes					
Variables	< 100 g	101 - 150 g	151 – 200 g	201 – 250 g	> 251 g	p
Moisture %	80.51 ± 0.25	80.02 ± 0.40	78.80 ± 0.26	80.47 ± 0.32	79.41 ± 0.48	0.05^{ns}
Ether extract %	1.40 ± 0.08^{a}	1.26 ± 0.04^{ab}	1.35 ± 0.03^{ab}	1.11 ± 0.07^{ab}	0.99 ± 0.14^{b}	0.02★
Mineral matter %	3.45 ± 0.09^{ab}	3.41 ± 0.07^{ab}	4.03 ± 0.25^{a}	3.06 ± 0.15^{b}	3.23 ± 0.13^{b}	0.00★
Crude protein %	13.19 ± 0.44^{b}	14.40 ± 0.38^{ab}	15.18 ± 0.16^{ab}	14.50 ± 0.27^{ab}	15.80 ± 0.64^{a}	0.00★

Data presented as means ± standard error; ★Indicates significant difference ($p < 0.05$); ^{ns} indicates non-significant difference ($p < 0.05$); Different letters in the same row indicate significant differences between classes.

of this study were important because they showed that skin percentage is directly proportional to the weight of the animals, where class 4 showed the highest result (9.98 ± 0.17%), followed by classes 3 and 5 (9.42 ± 0.12, 9.54 ± 0.19, respectively).

Visceral fat differed between treatments, and the results were proportional to weight, where the frogs of the class 4 had 6.74 ± 0.14%, while in frogs of the class 1, the percentage was 3.36 ± 0.23, almost half of that found in heavier animals. There was a trend toward greater accumulation of visceral fat in animals over 151 g, which indicates that the liposomal index varies according to age, because Castro, Barboza, Silva and Pires (2008) found a similar value for animals with 100 g; in the present study, from 150 g, this index doubled when compared to the lower weight classes. Differences between the liposomal index in frogs also have been associated with reproductive activities (Loumbourdis & Kyriakopoulou-Sklavounou, 1991) that is, the use of energy reserves for maturation of the reproductive tract.

Additionally, the crude protein content is one of the most important parameters to determine the quality of meat, as it is responsible for the growth and maintenance of the integrity of body structures and their functions. In this study, the values were lower than those found by Gonçalves & Otta (2008); Nóbrega, Ataíde, Moura, Livera and Menezes (2007) (19.4 and 16.6%, respectively).

In contrast, the amount of fat in muscle verified in the analysis of the ether extract of meat was higher than commonly found in the species. In all classes evaluated this parameter was greater than 0.99%, while in other studies in the literature, the lipid content ranged from 0.8% (Gonçalves & Otta, 2008; Mello et al., 2006a) to 2.27% (Assis et al., 2009).

Regarding the moisture found in all samples, about 80%, it was similar to that found by Mello et al. (2006b), (79.18%). On the other hand, data relative to mineral matter were higher (from 3.06% to 4.03%) compared to those described by Gonçalves and Otta (2008), in which ash (mineral matter) was 0.20% in fresh meat. This difference is explained because, in the present study, analyses were performed using meat with bones, while the other study used deboned meat.

Our findings point out that the ideal is to slaughter individuals over 200 g, since they have smaller percentages of head and paws, considered waste. The composition of animals over 200 g demonstrates higher quality than smaller frogs, because they show higher content of crude protein, while the values of mineral matter and intramuscular fat are lower. Given the versatility of waste from frog slaughter, it is important to improve techniques and perform more studies to generate income to producers, and consequently less waste and higher value.

Conclusion

Bullfrogs slaughtered with weight above 200 g have better yield and meat quality.

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