

FROG TAIL: A SOURCE OF PROTEIN TO FEED THE FUTURE

Andre Muniz AFONSO¹, Ana Beatriz Monteiro FONSECA², Carlos Adam CONTE-JUNIOR¹,
Eliane Teixeira MÁRSICO¹, Mônica Queiroz de FREITAS¹, Sergio Borges MANO¹

ABSTRACT

The aim of this study was to produce a nutritious food, in short-time period, of final low cost, based in frog matrix. Tadpoles obtained from natural fertilization were reared for 100 days and then transported to industrial processing plants, where two primary products were elaborated, the frog tail fillet (FTF) and the non-edible part (NEP). Two canned preserves were developed from the FTF (frog tail fillet in oil/FTFoil; frog tail fillet in tomato sauce/FTFtomato) and from the NEP a flour was produced (tadpole flour/TF). The five products were subjected to physical-chemical analysis. Those elaborated from the tail presented chemical composition values close to the frog meat, while NEP and TF showed values of protein, lipid and ash compatible with by-products and ingredients normally used in the animal feed industry. The two canned preserves were subjected to acceptance test and purchase intent test, with emphasis on the FTFOil, which obtained an acceptance rate of 77% from the evaluators. The method of food production proposed proved to be satisfactory fully reaching the objectives stated. It also can be used in anti-hunger programs, as well as by human and animal industries, improving the quality of the products developed.

Key words: frog meat; frog farming; bullfrog; *Rana catesbeiana*.

CAUDA DE RÃ: UMA FONTE PROTEICA PARA ALIMENTAR O FUTURO

RESUMO

Objetivou-se a produção de um alimento nutritivo, em curto espaço de tempo, de custo final baixo, utilizando-se como matriz a rã. Girinos obtidos a partir de fertilização natural foram criados durante 100 dias e transportados para plantas processadoras, onde foram elaborados dois produtos, o filé da cauda de rã (FTF) e a parte não-comestível (NEP). Duas conservas enlatadas foram desenvolvidas a partir do FTF (filé da cauda de rã em óleo/ FTFOil; filé da cauda de rã com molho de tomate/FTFtomato) e da NEP, uma farinha foi produzida (farinha de girino/TF). Os cinco produtos foram submetidos à análise físico-química. Àqueles elaborados a partir do FTF apresentaram valores de composição química próximos à carne de rã, enquanto que NEP e TF apresentaram valores de proteínas, lipídios e cinzas compatíveis com coprodutos normalmente usados na indústria de alimentação animal. As duas conservas enlatadas foram submetidas a testes de aceitação e intenção de compra, destacando-se o FTFOil, que obteve uma taxa de aceitação de 77%. O método de produção de alimentos proposto mostrou-se satisfatório alcançando plenamente os objetivos estabelecidos. Os produtos propostos podem ser utilizados em programas de combate à fome, bem como pelas indústrias de alimentos, nas mais diversas formas.

Palavras-chave: carne de rã; ranicultura; rã-touro; *Rana catesbeiana*.

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¹Programa de Pós-graduação em Medicina Veterinária (Doutorado em Higiene Veterinária e Processamento Tecnológico de Produtos de Origem Animal) da Faculdade de Veterinária da Universidade Federal Fluminense (UFF) – Rua Vital Brazil Filho, 64, CEP 24230-340, Niterói (RJ/Brasil) - (corresponding author) andremunizafonso@gmail.com.

²Instituto de Matemática e Estatística – Universidade Federal Fluminense (UFF)

INTRODUCTION

Scholars of food safety predicted that the human population will reach 9 billion people by the year 2050, which has forced some farmers and researchers to develop fast crops (ASH *et al.*, 2010), especially in developing countries, whose number of undernourished people already passed 1 billion (FEDOROFF *et al.*, 2010). Another issue is that in developing countries, as people's purchasing power has been improved, they began to feed on larger amounts of animal protein, which has created a huge debate in society, because it is known that much of the cropland in the world are intended to produce food, directly or indirectly, for the livestock. This debate has made some scholars conclude that people need to eat less meat, which could mean more farmlands for vegetables (STOCKSTAD, 2010).

In other hand, the world seafood production has shown consistent growth over the last five decades at a rate of 3.2% per year, which doubles the global population growth rate, kept in 1.6% per year. Apparent consumption per capita grew from 9.9 kg/inhabit./year in the 1960s to 20.1 kg/inhabit./year in 2014. The global fish production reached 167.2 million tons in 2014, with aquaculture accounting for 73.8 million tons (44.14%) of this total (FAO, 2016b). Seafood has superior nutritional profile and benefits, like high biological value protein, essential amino acids and omega-3 fatty acids, vitamins, minerals and trace elements, when compared to terrestrial meat products (TACON and METIAN, 2013).

VOGEL (2010) stated that the future of food production goes beyond personal choices, it needs to be based on public policies, as some scientists think while studying the possibility of using the insects' proteins as food additives or even as food itself, which is a very common habit in many societies around the world. However, TACON and METIAN (2013) asserted that in a world where nearly 30% of humanity suffers from malnutrition and over 70% of the planet is covered with water, aquatic foods represent an essential component of the global food basket to improve the nutrition, health and well-being for the humanity.

The rearing of frogs, named as frog culture or frog farming, is one of the world's aquaculture components (FAO, 2016a) and their creation can be a way to provide important nutrients in countries that suffer from malnutrition without an ecological

damage (EFENAKPO *et al.*, 2015). In 2015, the frog culture completed 80 years of existence in Brazil. Its peak was reached between the 1980s and 1990s and currently the activity undergoes a remodelling phase, following the integrated production process, as occurs in poultry and swine industries. Although this is a small production chain, their products and by-products reach high sale value in the market, in addition, their chemical composition is commonly associated with direct benefits to human health (AFONSO, 2012). Its larval stage, characterized by the rearing of the tadpoles, usually takes three to four months. It can be performed in artificial tanks, such as masonry, plastic canvas, fiberglass and similar or in natural tanks (earthen ponds), which is capable of generating animals larger and more resistant to the production process (CRIBB *et al.*, 2013).

The aim of this study was to produce a nutritious food, in short-time period, of final low cost, based in frog matrix.

METHODS

Facilities and rearing methods

In order to obtain a homogeneous matrix for the preparation of food products, the initial concern was linked to the method of raising the animals. Thus, it started in a frog farm located in the municipality of Cachoeiras de Macacu (Rio de Janeiro, Brazil). The species chosen was the American bullfrog (*Lithobates catesbeianus* Shaw, 1802), the only one allowed for frog farming by the country laws (BRASIL, 1998), according to the methodology of rearing frogs stated by CRIBB *et al.* (2013), with some modifications as described. The eggs were obtained by natural fertilization in 1 m² masonry tanks with 15 cm of depth. Twelve hours after mating, the eggs were collected using small fishnets and transferred to 6 m² masonry tanks with 80 cm of depth. These tanks were filled by neutral pH water, with an oxygen concentration ranging from 3 to 5 mg L⁻¹ and temperature between 21 and 25°C, obtained from a natural source existing in the same farm. The tadpoles hatched within 36 hours after the transfer. The water was renewed daily at a rate of 5%, for the next seven days, until the animals began to search for exogenous food. The diet of the animals was

based on a commercial feed supply composed by 45.69% of carbohydrates, 30.4% of crude protein, 12.5% of moisture, 7.67% of ashes, and 3.74% of crude fat, besides the natural plankton formed in the tanks walls. The rate of feeding was 3 times per day (8, 11 and 14 h), based on 10% of the total biomass weight, offered in haul to form a single layer in the water surface. With 40 days of life, the tadpoles were transferred to earthen ponds containing 19 m³ of water capacity (same 80cm of depth), in a proportion of 5 animals per liter of water, where they remained until reaching 100 days of life, receiving the same feed supply, based on 15% of the total biomass weight for the first 30 days and 5% for the last 30.

Slaughtering

The slaughter process was based in the slaughter and processing methodology developed by AFONSO *et al.* (2016) for bullfrog's tadpoles. First, it was subdivided into two major steps, the pre-slaughter steps, which comprehends the procedures until the animals reaches the processing plant (fasting, harvesting and transportation); and the slaughter procedure itself, from depuration to distribution.

Development of the canned preserves

For the development of canned preserves, frozen packed frog tail fillets obtained at slaughter were placed in isothermal boxes containing potable ice, maintained at a temperature of 4 ± 1°C, and sent to the food processing plant of Bioprocess Center of the National Industrial Education Service (SENAI), located in the municipality of Vassouras, state of Rio de Janeiro, Brazil.

The fillets were packed in coated epoxy varnish cans, with 170g capacity, in two formulations, as shown: frog tail fillet in oil (FTFoil), composed by 95g of frog tail fillets (62.1%), 55g of sunflower oil (35.95%) and 3g of salt (1.96%); and frog tail fillet in tomato sauce (FTFtomato), composed by 95g of frog tail fillets (62.1%), 28g of tomato pulp (18.3%), 20g of extra virgin olive oil (13.07%), 7g of chopped garlic (4.58%) and 3g of salt (1.96%).

The cans were preheated to 80°C, passed through an exhausting tunnel, double sewn and heat treated in a steam steady vertical autoclave (120 L - Tecnifood®), using the binomial time-temperature

of 120°C for 15 minutes, a value that resulted in F₀ of 8.89 minutes, monitored by a data logger in every 10 seconds (0.1 °C - Extech® data logger model SD 200).

Development of the tadpole flour

The tadpole flour (TF) was developed by milling and drying, in a conventional oven, the non-edible parts obtained in the slaughtering process, according to the methodology proposed by MONTEIRO *et al.* (2014).

Physical-chemical analysis

In order to know the physical-chemical properties of the frog tail fillet (FTF) and non-edible part (NEP) of the tadpoles, after the storage procedure, 2 kg of each material were collected and transported in isothermal boxes with potable ice at 4 ± 1°C to the Laboratory of Physical-chemical analysis at the Veterinary Faculty of the Federal Fluminense University, located in the municipality of Niterói, state of Rio de Janeiro, Brazil. Samples were analyzed (n=6) for their content of moisture (gravimetric method), protein (Kjeldahl method), fat (Soxhlet method), ash (oven at 550°C) and carbohydrate (calculated by simple difference, i.e. 100% - % of moisture, ash, protein and lipids).

The calorific value was calculated using the equation [(protein × 4 kcal g⁻¹) + (lipid × 9 kcal g⁻¹) + (carbohydrate × 4 kcal g⁻¹)/Final composition %]. The pH values were measured after homogenization of each 10 g of sample in 90 mL of distilled water, with a digital pH meter (Instrutherm® model 03423), equipped with an electrode (Instrutherm® model 03663).

All methodologies are considered standardized, being normally used in quality control of meat products and were conducted according to the procedures outlined by AOAC (2012). Six analytical replicates were performed for each treatment.

The analysis of the tadpole flour followed the same steps for the raw material previously described, as well as that of the canned preserves, except for the values of pH and that the oil content was almost totally drained (30 seconds drainage) from the frog tail in oil cans (FTFoil), before the analysis took place.

Microbiological analysis

The microbiological analysis was based on the commercial sterility test for low-acid canned food, as described by BRASIL (2003).

Sensory evaluation of the canned preserves

For the sensory evaluation, we used the acceptance test in a nine-point hedonic scale (1- disliked extremely and 9- liked extremely), in addition to the purchase intent test, also in a nine-point hedonic scale (1- ate if forced and 9- ate if available). The tests were performed by 100 consumers in individual booths, in the Laboratory of Food Sensory Analysis of the Federal Fluminense University (Faculty of Veterinary). The samples were coded with three-digit numbers and presented in white disposable plastic dishes, in monadic form and randomly. The evaluators were oriented to fill out a form containing personal data (name, sex and age) and product appearance (product in the can), aroma, flavor, texture, overall acceptance and purchase intent, according to the methodology proposed by STONE and SIDEL (1993). The samples were accompanied by a biscuit, which served as a vehicle, plus a glass of water to rinse mouth.

Statistical analysis

The Kruskal-Wallis test was used for the comparison between treatments, while the Mann-Whitney U test was used for the evaluation of their difference. All the data were analyzed using the program SPSS Statistics for Windows, version 17.0 (SPSS Inc., Chicago, Illinois, USA), at a significance level of 5%. Acceptance and purchase intent rates were treated statistically using the computer program XLSTAT version 2015.2.02 (Addinsoft, Paris, France) software. The analysis of variance (ANOVA) were used for the F test to make evaluation on whether or not a difference between the results obtained with the samples at a significance level of 5%, followed by a Tukey's HSD (honest significant difference) test ($p < 0.05$).

RESULTS

The facilities, the type of food, the feed rate and

the overall management used in this study proved to be efficient, producing tadpoles in 100 days (60 in the earthen ponds) with an average weight of 15.98 ± 2.65 g (Figure 1).

The total processing time - from pre-stunning to quick freezing step - was 2 minutes. The non-edible parts weighted 11.99 ± 2.17 g, which corresponds to $74.87 \pm 2.4\%$ of the total weight, while the tail fillets weighted 4 ± 0.63 g, which corresponds to $25.14 \pm 2.4\%$ of the total weight. The total cost of production and processing to obtain 1 kg of frog tail fillet was US\$ 0.95.

The total cost of production (field costs + industrial costs) of the FTFoil was US\$ 1.10 (each 170g can) and of the FTFTomato was US\$ 1.26 (each 170g can) (Figure 2). The TF's production process occurred as expected, resulting in a final product with $2.08 \pm 0.06\%$ of moisture.

The proximate composition of the five products derived from this work are shown in Table 1.

The six cans of each formulation that were incubated for the test did not present any kind of oil leak or deformity due to the production of gas, associated with *Clostridium* spp. The material collected from the cans did not present the normal characteristics of microbial growth in the tubes containing specific growth mediums.

The sensory evaluation of the canned preserves is shown in Table 2. For the purchase intent, 77% of the evaluators showed interest in consuming FTFoil, while for FTFTomato this figure was only 46% (Figures 3 and 4).



Figure 1. Example of a bullfrog tadpole used to produce the tail fillet.



Figure 2. Frog tail canned preserves before the preheating and the exhausting processes.

Table 1. Mean proximate composition* (g/100g) \pm SD, energy value (Kcal/100g) and pH of the frog tail fillet, non-edible part, frog tail canned preserves and tadpole flour.

Parameters	FTF	FTFoil	FTFtomato	NEP	TF
Moisture	84.81 \pm 0.12 ^a	76.52 \pm 0.2 ^b	69.14 \pm 8.26 ^b	77.18 \pm 1.84 ^b	2.08 \pm 0.06 ^c
Protein	15.24 \pm 0.67 ^a	15.39 \pm 2.08 ^a	18.54 \pm 1.11 ^a	8.51 \pm 0.78 ^b	38.59 \pm 0.65 ^c
Lipid	0.06 \pm 0.05 ^a	4.09 \pm 0.35 ^b	4.26 \pm 0.32 ^b	7.77 \pm 3.24 ^b	24.39 \pm 0.45 ^c
Total Carbohydrate	-	2.71 \pm 2.25 ^a	6.89 \pm 8.7 ^{ab}	1.92 \pm 4.08 ^a	13.73 \pm 0.57 ^b
Ash	0.94 \pm 0.27 ^a	1.29 \pm 0.16 ^a	1.17 \pm 0.68 ^a	4.62 \pm 1.16 ^b	21.21 \pm 0.19 ^c
Kcal	61.51 \pm 2.36 ^a	98.5 \pm 10.9 ^b	112.77 \pm 4.35 ^b	104 \pm 29.05 ^b	374.43 \pm 3.67 ^c
pH	7.25 \pm 0.12	-	-	7.54 \pm 0.78	-

* $n=6$;

FTF (Frog Tail Fillet); FTFoil (Frog Tail Fillet in Oil); FTFtomato (Frog Tail Fillet in Tomato Sauce); NEP (Non-edible part); TF (Tadpole Flour);

Different letters in the same line indicate significant differences ($p < 0.05$).

Table 2. Mean values* of the attributes presented in the acceptance test and the purchase intent test of the Frog tail fillet in oil and the Frog tail fillet in tomato sauce (both evaluated in a nine-point hedonic scale).

Products	Appearance	Aroma	Flavor	Texture	Overall acceptance	Purchase intent
FTFoil	5.76 ^a	6.99 ^a	7.29 ^a	7.53 ^a	7.17 ^a	6.43 ^a
FTFtomato	5.14 ^b	5.69 ^b	6.18 ^b	6.83 ^b	5.94 ^b	5.19 ^b

* $n=100$ (61 women/39 men) (average age of 26.85 years old);

FTFoil (Frog Tail Fillet in Oil), FTFtomato (Frog Tail Fillet in Tomato Sauce)

Different letters in the same column indicate significant differences ($p < 0.05$).



Figure 3. The image shows the preserved canned foods developed in the study, the frog tail fillet in oil (left) and the frog tail fillet in tomato sauce (right).



Figure 4. The image shows one of the preserved canned foods developed in the study (frog tail fillet in oil), as presented for the sensory evaluation.

DISCUSSION

According to CRIBB *et al.* (2013), earthen ponds can be used for rearing bullfrog tadpoles, in a density of 3 liters of water per animal, resulting in animals weighing an average of 8g at 90 days of life. SEIXAS FILHO *et al.* (2011) worked with bullfrog tadpoles using a diet with 28% crude protein and a density of 1 animal per liter, obtaining maximum weight of approximately 5.28g for tadpoles with 75 days of life. HAYASHI *et al.* (2004) worked with different stocking densities for bullfrogs' tadpoles and concluded that with lower densities were obtained larger tadpoles and more uniform batches with better survival rate, which shows that the smaller animal density by area proposed in this study (i.e., 5 L animal⁻¹) explains the large difference in the final weight obtained.

The method of slaughter and processing operation for bullfrog tadpoles proposed in this study was in accordance with the methodology settled to obtain frog legs and fish and fishery products (BRASIL, 2000; CODEX ALIMENTARIUS, 2011, 2013).

The time-temperature binomial used (15'/120 °C) was considered satisfactory for the commercial sterility procedure described in national (BRASIL, 1952) and international (FAO, 2011a; FDA, 2016) standards as for the acceptance tests. The fasting, harvesting and transportation steps avoids welfare and technologic problems, by preventing faecal contamination, stress and short-time products' shelf life (POLI *et al.*, 2005; BRASIL, 2007; VARGAS *et al.*, 2013; LINES and SPENCE, 2014). The pre-stunning step (ice slurry immersion), followed by the decapitation (decerebration) combines different methods of killing, which is stated by POLI *et al.* (2005) as a good strategy for both animal welfare and product quality. Also, the CODEX ALIMENTARIUS (2011), stated that the killing should be done immediately after stunning in such a manner that either the head is severed from the body or the brain is destroyed by pithing. The tadpole noble part (tail fillet) do not differ significantly to the frog noble part (frog legs), which corresponds to 30% of the total weight (AFONSO, 2012).

The two formulations proposed in this paper, tail fillet in vegetable oil and tail fillet in tomato sauce, are described in the Brazilian legislation for fishery products (BRASIL, 1952) and their preparation followed the idealized parameters for canned preserves, where the main product must

be present in a proportion of 30% of the total. For both formulations was used 62.1% of the main product, namely, "frog tail fillet". All parameters were constantly measured using data loggers and temperature and pressure sensors as stipulated by the Code of Federal Regulations (FDA, 2016).

The time and sterilization temperature were measured every 10 seconds with a confidence interval of 0.1°C, in accordance with the maximum limit of 0.5°C stipulated by the Code of hygienic practice for low acidified low acid canned foods (FAO, 2011a). PIZATO *et al.* (2012) worked with tilapia canned preserves using two procedures for commercial sterilization, 15 and 30 minutes at 121°C, and both were analyzed for their microbiological and sensorial characteristics with satisfactory final results. TORREZAN *et al.* (2013) working with a canned brazilian hybrid freshwater fish, known as cachapinta, and obtained satisfactory results for commercial sterility using the time-temperature binomial of 20 min at 115°C. The broud-snout caiman canned meat was also submitted to acceptance and commercial sterility tests, being considered satisfactory after thermal processing at 116°C for 45 minutes, the same time recommended in the Brazilian legislation for tuna (AZEVEDO *et al.*, 2009).

The TF's final moisture value is in accordance with national standard, whose maximum recommended is 10% (BRASIL, 1952). However, according to the same pattern, the protein content was below the value recommended for the first-grade flour (minimum of 60%). This occurred due to the manufacturing process (MONTEIRO *et al.*, 2014), which not comprised the pressing step, normally resulting in a production of a fish oil. The TF also obtained a greater lipid content than the national standard (maximum of 8%). If a pressing step was included in the elaboration process, the value of the protein would be higher while the lipid content would be lower, fitting the standard described for national fish and fishery processing plants (BRASIL, 1952).

The mean values of protein in the three products designed for human consumption obtained in this study not statistically differ from each other ($p > 0.05$) and are similar to other protein values found for frog meat 16.52% (NOLL and LINDAU, 1987); 15.99% (MELLO *et al.* (2006b); 16.60% (GONÇALVES and OTTA, 2008); 14.81% (COSTA *et al.*, 2011); and 16.40% (USDA, 2016). FTF's dry matter content is composed by 93.84% of protein. This value makes the FTF richer

than other animal protein concentrated products' dry matter, like the fish protein concentrate (FPC) made by the wastes of the tilapias' filleting, with 64.14% (VIDAL *et al.*, 2011); the FPC of bycatch species, ranging from 57 to 77% (MURUETA *et al.*, 2007); the dried earthworm protein powder (*Eisenia foetida*), with 65.5% (ROMERO *et al.*, 2010); and skimmed whey protein concentrate (WPC) from cheese whey, ranging from 65 to 70% (DAMODARAN, 2011) - but similar to some commercial and semi-commercial brands of whey protein concentrate, isolate and fractions, ranging from 80.25 to 95.39% (HOLT *et al.*, 1999).

The high moisture combined with a pH close to neutral obtained in the FTF allow optimal environment for microbial growth, which could mean losses in nutritional and sensory attributes, as well as compromising safety (BRASIL, 2003; FAO/WHO, 2010; FAO, 2011a, b). The thermal treatment used in this study was conducted in order to ensure the safety of products supplied to the consumer and to meet the national (BRASIL, 1952) and international (FAO, 2011a) standards for fish and fishery products.

The content of lipids and carbohydrates presented in the FTF, as well as the protein content, showed the hypocaloric profile of this food matrix. Some authors found similar profile for frog meat: lipids 0.31% and 68.87 kcal 100g⁻¹ (NOLL and LINDAU, 1987); lipids 0.16% and 65.40 kcal 100g⁻¹; (MELLO, 2006b); lipids 0.3% and 73 kcal 100g⁻¹ (USDA, 2016).

Comparing the two canned preserves elaborated (FTFoil vs. FTFtomato), there were no statistical difference ($p > 0.05$) between the lipid and caloric content. The FTFtomato acquired average fat content slightly higher than FTFoil due to the fact that the latter is usually drained before the consumption. It is considered a normal practice for home consumers for fish and fishery products offered in oil, while the same kind of products with tomato sauce are directly incorporated to other foods at the time of consumption without prior drainage.

One of the most fishes used in canned preserves, the herring or atlantic sardine (*Clupea harengus*), has, after drainage, lipid composition of 11.45% and total energy of 208 kcal 100g⁻¹ (USDA, 2016). PIZATO *et al.* (2012) found lipid composition values equal to 32.75% and total energy of 343.55 kcal 100g⁻¹ for canned preserves of tilapia in oil. Also, AZEVEDO *et al.* (2009) developed canned preserves with broad-snouted caiman meat in oil and obtained 12.8% of

lipid composition and 173.2 kcal 100g⁻¹. The FTFoil, after drainage, reached a mean value of 4.09% of lipid content and 98.5 kcal 100g⁻¹ of total energy, therefore being more suitable for a hypocaloric human diet. The FTFtomato reached a similar composition of lipid content (4.26%) and of total energy (112.77 kcal 100g⁻¹) and also is considered better when compared to traditional canned preserve fishes in tomato sauce, like the pacific sardine (*Sardinops spp.*) with 10.45% and 185 kcal 100g⁻¹, respectively, for low caloric diets (USDA, 2016).

For both prepared preserves, carbohydrates' values varied considerably, although the previous homogenization for the analysis has been done correctly. There is a lack of data in the literature on the carbohydrate values for canned fish preserves, which makes it difficult to compare with other products.

The mineral content in the ash was not analyzed in the present work for any of the products elaborated. It is known that the frog meat has significant quantities of certain bioavailable minerals such as calcium (MELLO *et al.*, 2006a, b; USDA, 2016), and it is believed that the frog tail fillet and the non-edible parts of the tadpole may represent good source of this and other minerals.

The non-edible part (NEP) presented reasonable contents of protein, lipids and minerals. The moisture was considered high and the pH was above neutral, so, as to FTF, an immediate thermal treatment was indicated to ensure food safety, resulting in the production of a tadpole flour (TF), suitable for animal feeding.

TF showed protein value similar to those found by STEVANATO *et al.* (2008) (38.41%), who made a tilapia head flour (THF), and PETENUCCI *et al.* (2010) (40.8%), who made a tilapia carcass flour (TCF). The ash content showed the same pattern for the three products, 21.21%, 19.38% and 18.3%, respectively. The TF protein value was a little lower when compared to the tilapia head and carcass flour prepared by MONTEIRO *et al.* (2014). TCF and TF also showed similarity with the lipid content, 25.3% and 24.39%, respectively.

EFENAKPO *et al.* (2015) evaluated the chemical composition of three species of frogs, which are commonly captured, desiccated and sold in Nigeria and found mean values of crude protein equal to 48.23%, 52.83% and 49.22% for *Hoplobatrachus occipitalis*, *Hildebrandtia ornate* and *Ptychadena pumilio*,

respectively. The drying process of the whole frog enables a highest percent of crude protein when compared to TF, whose process keeps the viscera, the skin and the head of the tadpoles, but not their main muscle groups, located in the tail.

By representing a mean value of 74.87% (NEP) of the total weight of the tadpole, the excellent nutritional profile presented by TF turns it a great by-product to be traded by the industry, making it strategically to ensure business profitability, as occurs in contemporaneous fish processing plants (CAMPOS, 2012).

The commercial sterility test for low-acid canned preserves, described by BRASIL (2003), shows possible problems in the manufacturing step, like can seam defects and growth of thermophilic pathogenic microorganisms such as *Clostridium* spp. and *Bacillus* spp., for example. The results presented in this study enabled the use of the canned preserves for the sensory evaluation tests.

The mean values of the evaluated attributes of acceptance and purchase intent for FTFoil were higher and statistically different ($p < 0.05$) from those of FTFTomato. The only attribute with an average score below six for FTFoil was the appearance, which was the first attribute to assign a grade in the evaluation chart. However, all the others had averages between the 6-9 ranges, representing a potentially saleable product.

The FTFTomato showed no attribute value below the midpoint (5), but only the attributes of taste and texture showed values between 6 and 9, which shows lower trade potential compared to FTFoil.

FURTADO and MODESTA (2006) developed an acceptance test of shredded frog meat in tomato sauce, using a hedonic scale structured in seven points, and the vast majority of the evaluators (> 90%) said they like the aroma, appearance and color of the sauce, while 91% liked the taste and the texture of the product and 66% the consistency of the sauce. About 64% of the evaluators said they would buy the product, which was lower than the value obtained for FTFoil. GONÇALVES and OTTA (2008) developed a frog meat burger and by an acceptance test obtained an acceptability rate of 88.4% by the consumers. ASSIS *et al.* (2009) conducted a sensory evaluation using smoked frog meat added or not to rosemary (*Rosmarinus officinalis*) and obtained good acceptance of the products developed.

Historically, pre-hispanic civilizations like the Aztecs and their neighbors had the habit of consuming tadpoles, known as "atotócatl", "atepocate" or "tepocate" (ANDREU, 2004) and it persists nowadays in Mexico and Guatemala (ALMOLOYA DEL RÍO, 2016; GARCÍA, 2016; GUATEMALA TRAVEL GUIDE, 2016), as well as in some African countries, such as Cameroon (ALTHERR *et al.*, 2011.).

Though not widely diffused, the frog meat demonstrated good acceptability when subjected to acceptance tests, which allows us to speculate that one of the major problems linked to its marketing is the lack of advertising on its sensory attributes, as well as its health benefits.

CONCLUSIONS

The proximate composition of the FTF makes it an important source of nutrients to be exploited commercially, either as direct food, becoming a deli item or even associated with anti-hunger programs - or as a food ingredient - supplementing a products' final protein content. The method proposed in this study can be an important animal protein production tool based in the frog matrix, made with few financial resources and in a short-time period, which can be applied in many food production programs for the present and the future. The canned preserves produced proved to be innocuous and showed good final protein values and low total energy, which can be incorporated into low-calorie diets for humans. The flour produced showed good values for protein, lipids and ash, which can become an interesting product for the animal feed industry.

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