Edible Amphibian Species: Local Knowledge of their Consumption in Southwest Nigeria and their Nutritional Value

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Abstract

The knowledge of the consumption of edible amphibian species in southwest Nigeria was investigated based on interviews. There were a total of 900 respondents of which 92.8% were aware of edible frogs being consumed by humans. Six hundred and sixty (73.3%) respondents had seen various individuals eating frogs. Examining the respondents themselves, 387 (43.0%) has eaten frogs. The occupation with the highest consumption of amphibian species was the farmers (64.1%) followed by the secondary school teachers (57.0%) and the least being the housewives (27.3%). *Ptychadena pumilio* has the highest protein content (19.79%) followed by *Xenopus muelleri* (19.53%). *Hoplobatrachus occipitalis* has a protein content of 19.46% and fats and oils of 1.06%. *Xenopus muelleri* has the highest fat and oil percentage while *Ptychadena pumilio* has the lowest (0.97%). Glutamic acid followed by aspartic acid was the highest concentration of amino acid in all the species. The Analysis of Variance (ANOVA) showed that there was no significant difference in the concentration of the amino acid among the three species of edible anurans at ($P > 0.05$). Frog meat serves as a good source of protein for the local inhabitants. But the unsustainable use of these edible frog species would have a detrimental effect on the ecosystem. Hence frog farming and conservation efforts must be encouraged.

Introduction

Amphibians are one of the most threatened groups of vertebrates, with at least one third of over 6,000 known species being threatened with extinction (Stuart *et al.,* 2004, 2008). Many reasons are attributed to the decline of amphibian species such as global warming, habitat destruction and modification, pollution, disease, etc. But overexploitation, being one of the major causes (Gibbons *et al.,* 2000; Halliday, 2008), is rarely mentioned while other causes have gained much research interest. Stuart *et al.* (2004), however, have mentioned that overexploitation is one of the reasons for the world wide amphibian decline.

Many species of anuran (Class Amphibia) are eaten in many parts of the world. Recently, there has been an increasing trend in the exportation of frogs from developing to the developed countries. Frog legs are a popular delicacy in Europe and eaten in countries where it is against the law to hunt them (Ashton *et al.*, 1988). A recent report by Niasse *et al.* (2004) states that utilization is the main threat for 281 amphibians species, 54% of these already listed as vulnerable, endangered or critically endangered when IUCN Red List categories are applied. The frogs are also collected for leather production and souvenirs, for pet trade and cultural reasons, including traditional medicine (Oza, 1990; Veith *et al.,* 2000; Young *et al.,* 2004; Kusrini & Alford, 2006; Gonwouo & Rodel, 2008).

In many countries including Nigeria, frogs have been collected on a local scale as an

essential source of animal protein (Angulo, 2008; Mohneke *et al*, 2009). But within the past decade, frog has become an international trading item, involving more than 30 countries, and in 1998 was valued at approximately USD 48.7 million (Teixeira *et al.*, 2001). Such exploitation without sustainability of these amphibian species would have direct and indirect impacts on the frog species and the ecosystem, respectively. For it is a well known fact that amphibians are important components in various terrestrial and aquatic ecosystems (Toledo *et al.*, 2007; Mohneke & Rodel, 2009).

The present study attempts to investigate the awareness of the populace in relation to their knowledge of edible amphibian species in southwest Nigeria. The study also investigates the nutritional content of three edible species investigated previously (Mohneke *et al.*, 2010), which serves as source of protein in the diet of many who consume it. Based on the interviews conducted in southwest Nigeria (Lagos, Ogun and Oyo States), this study aims to get an overview of the awareness of and the nutritional values of these edible amphibian species.

Materials and methods

Interview survey

The study was conducted in southwest Nigeria in the states of Lagos, Ogun and Oyo. Questionnaires were administered and interviews were conducted in six selected towns in each state. The places visited in Lagos State were Epe, Abule Ogba, Festac Town, Badore/Ajah, Ijede and Badagry; in Ogun State were Abeokuta, Ijebu-Oru, Pakoto/Ifo, Sagamu, Ishara and Odo-Jabore; in Oyo State were Eruwa, Ado-Awaye, Iseyin, Ogbomosho, Onidundun and Oyo Town. Three hundred individuals (50 from each town) were interviewed from each state totaling 900. The respondents were of various occupations comprising different ethnic groups.

The questionnaires were written in English. To avoid communication problems, all interviews were carried out with the help of field assistants speaking the local languages. In general the questionnaires comprised questions eliciting information on the knowledge/experience the interviewees had concerning the different types of amphibian species, their habitat, colour and especially their consumption.

Proximate composition of edible anurans

The parameters analyzed were the proteins, ash content, moisture, fats and oil percentages. The protein content was further analyzed to determine its amino acid profile. The detailed methods of food estimate analysis employed are as described by Krishna & Ranjhan (1980).

Moisture content. The moisture content was determined based on loss of water on drying of the specimen in the oven at temperature of 105 ^{o}C. About 5 g of the specimen sample was accurately weighed in a dry and clean porcelain dish (crucible). The porcelain dish and the content were transferred into an air-tight oven at 105 ^{o}C and were allowed to dry for about 3 h. It was transferred into a desiccator and allowed to cool and re-weighed. The difference between the initial and final weight, expressed in percentage, corresponds to the moisture content.

Ash content. The ash content was determined by weighing about 5 g of specimen sample into a dry, clean and weighed porcelain dish. The dish and content were placed over a bunsen burner flame in a fume cupboard and burned until no more soot was given off. The dish and the content were then transferred into a muffle furnace and heated at 500–550 ^{0}C until it was fully ashed after about 1 h. The ash content corresponds to the weight difference between the crucible containing the ash and the empty crucible, expressed as a percentage of the mass of sample used.

Fat and oil. Fat and oil was determined by gravimetric extraction method. About 10 g of sample was mashed and acidified at a *p*H of 2 with a 1:1 HCl solution, and was properly mixed in a beaker. The resulting mixture was transferred into a separating funnel. The mixture was shaken vigorously and extracted with 20 cm^3 of chloroform. The extraction with chloroform was repeated twice and all the extract collected in a beaker containing about 2 g anhydrous sodium sulphate. After swirling the content it was filtered into a clean, dry and weighed beaker followed by evaporation over a water bath. Increase in weight of the beaker expressed as percentage represents the fat and oil content.

Protein. The protein content was determined by the Kjeldahl digestion method. About 5 g of sample was weighed into a Kjeldahl flask and 25 l of concentrated sulphuric acid (H_2SO_4) was added to the flask. Two tablets of copper catalyst were added and the flask in an inclined form was heated gently and later strongly until the liquid became clear. The flask was cooled and anti-bumping granules (4 seeds) were added to the flask and connected to a distillation apparatus. 85 ml of 50% NaOH was added to the mixture and the liberated ammonia gas was bubbled into a 2% solution of boric acid. At the expiration of the bubbling process the resulting mixture was back titrated with a standard sulphuric acid (H_2SO_4) solution (0.05 *M*). The protein content was calculated using the expression:

$$\% \text{ Protein} = \frac{V \times 0.0014 \times F \times 100}{W}$$

where V = volume of H_2SO4 required to reach dull state colour end point, W = mass of sample used, and F = Protein factor; 6.25

Amino acid analysis. The amino acid profile in the known sample was determined using methods described by Spackman *et al*. (1958). The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon sequential multi-sample amino acid analyzer (TSM) for analysis.

Results

Knowledge of anurans

Out of the 900 respondents, only 1 had not seen a frog or toad before, constituting 0.1%. 899 of the respondents had seen an anuran. Majority (38.2%) had seen only two types of anurans while 11.0% had seen five or more types of anurans. 44.7% of the respondents observed anuran species mainly around ponds, streams and rivers. This was followed by the swamp habitat in which 28.6% of respondents observed anuran species. The least habitat in which anuran species were seen was in the town as observed by 7.3% of the respondents.

Knowledge of human dietary consumption of edible anurans

From the results of the survey, 835 (92.8%) of the respondents were aware that there were edible frogs consumed by humans whereas 65 (7.2%) were not aware of these edible anurans. 660 (73.3%) respondents have seen other individuals eating frogs, while 240 (26.7%) have not seen other individuals eating frogs. 387 (43.0%) of the respondents themselves have eaten frogs while 513 (57.0%) have not. Of the 387 respondents that have consumed these organisms, majority (53.7%) have only eaten one type of frog species (Fig. 1). As the number of frog species increased, the number of individuals eating it decreased. Only six (1.6%) respondents out of 387 ate five or more species of frogs.

From the respondents, the age group mostly associated with the eating of anuran species were 11–20 years of age (Fig. 2). Comparing the occupation of the respondents in relation to the consumption of edible frogs, the farmers were the highest consumers (64.1%) and the least were the housewives (27.3%) (Table 1). Plate 1 shows dried edible anurans on display in some markets in southwestern Nigeria

Nutritive value of edible anurans

Some of the anuran species identified as edible in previous market surveys were

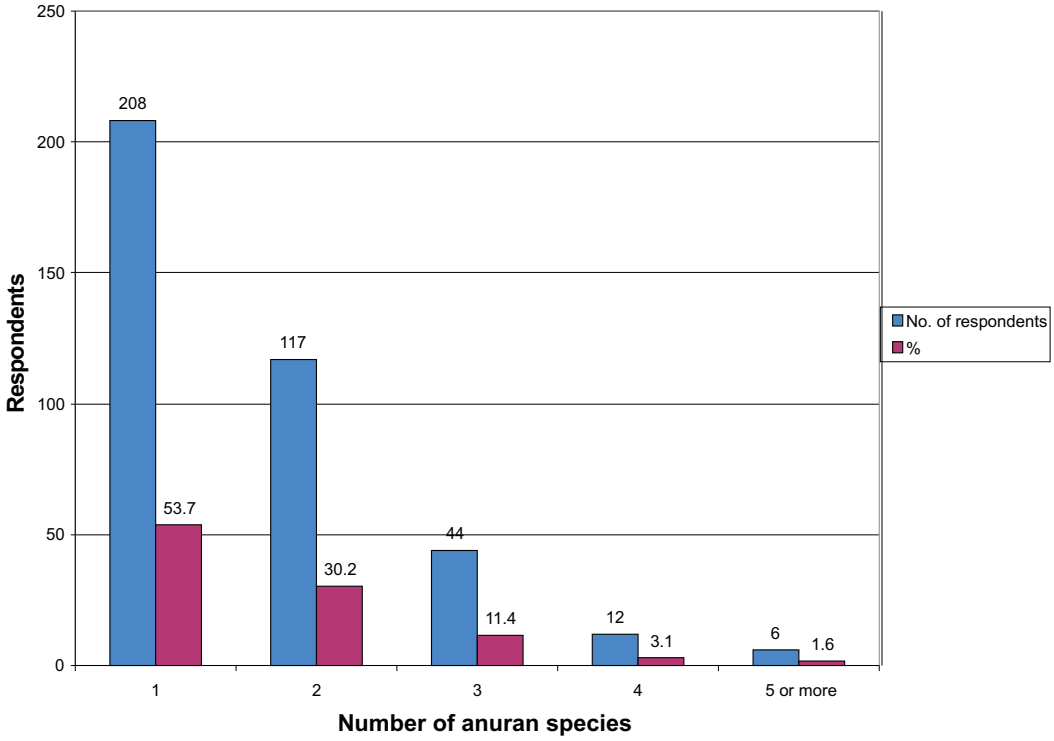

Fig. 2. Number of anuran species eaten by respondents

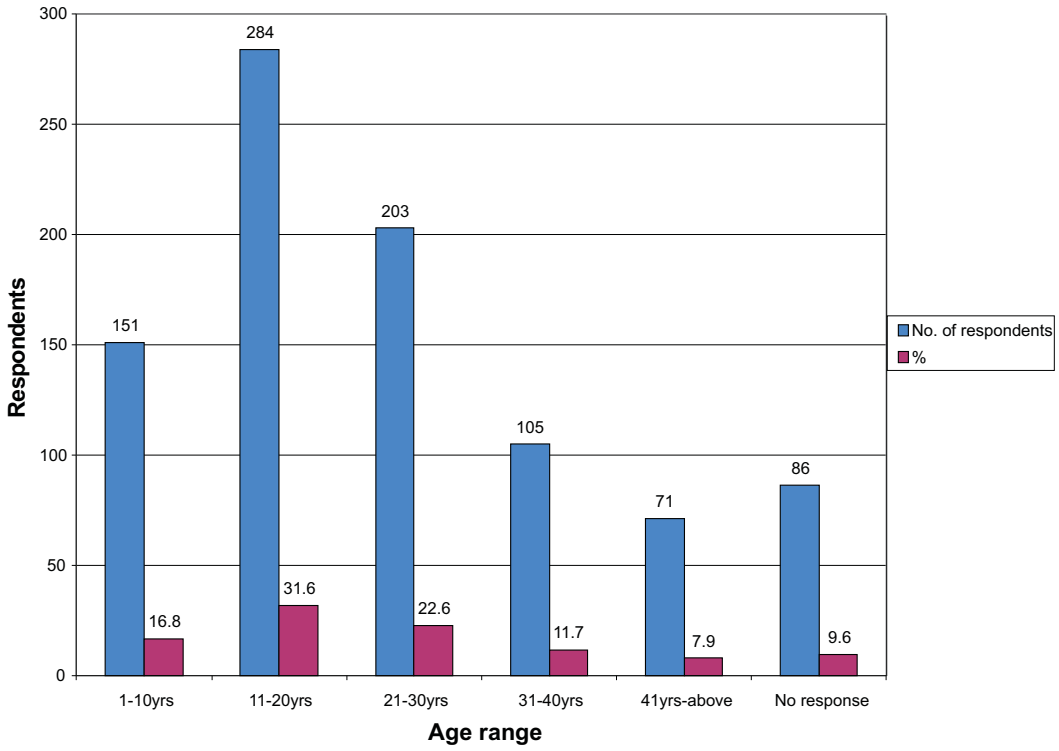

Fig. 1. Age range associated with the consumption of edible anuran species

TABLE 1
Occupation of respondents in relation to anuran consumption.

Occupation	*Individuals eating frogs*	*Percentage*	*Individuals not eating frogs*	*Percent*	*Total individuals*
Civil servants	16	36.3	28	63.6	44
Professionals	56	44.1	71	55.9	127
Housewives	3	27.3	8	72.7	11
Students	88	28.8	218	71.2	306
Teachers	61	57.0	46	43.0	107
Traders	67	49.6	68	50.4	135
Farmers	41	64.1	23	35.9	64
Artisan	55	51.9	51	48.1	106

Plate 1. Dried edible anurans on display at Badagry and Oyingbo markets, southwestern Nigeria

analyzed for their nutritive values as shown in Table 2. The highest percentage moisture content was recorded for *Ptychadena pumilio* followed by *Hoplobatrachus occipitalis,* which were 78.96% and 77.85%, respectively. From the result, *Ptychadena pumilio* has the highest protein content (19.79%) followed by *Xenopus muelleri* (19.53%). *Hoplobatrachus occipitalis* has a protein content of 19.46% and fats and oils of 1.06%. *Xenopus muelleri* has the highest fat and oil percentage while *Ptychadena pumilio* has the lowest (0.97%). Table 3 shows the amino acid components of protein from the three edible anuran species. Glutamic acid had the highest concentration of the amino acids in all the species; *Ptychadena pumilio* (14.76 g), *Xenopus muelleri* (14.39 g) and *Hoplobatrachus occipitalis* (15.37 g). This was followed by aspartic acid; *Ptychadena pumilio* (9.65 g), *Xenopus muelleri* (9.80 g) and *Hoplobatrachus occipitalis* (10.23 g).

The concentration of lysine was among the medium category in the edible anuran species. It accounted for 5.91 g in *Ptychadena pumilio,* 5.08 g in *Xenopus*

TABLE 2
Result of Proximate Analysis of Anuran Species

Parameters	*Levels detected*		
	Hoplobatrachus occipitalis	*Xenopus muelleri*	*Ptychadena pumilio*
Moisture (%)	77.85 ± 3.04	75.60 ± 4.45	78.96 ± 2.92
Protein (%)	19.46 ± 1.02	19.53 ± 1.79	19.79 ± 1.09
Ash content (%)	1.28 ± 0.14	1.17 ± 0.16	1.26 ± 0.18
Fats and oil (%)	1.06 ± 0.15	1.81 ± 0.19	0.97 ± 0.23

TABLE 3
Concentration (g/100g protein) of amino acid in three edible species of anurans

Amino acid	*Concentration g/100 g protein or g/16 g N*		
	Ptychadena pumilio	Xenopus muelleri	Hoplobatrachus occipitalis
Lysine	5.91	5.08	5.74
Histidine	2.33	2.27	2.17
Arginine	8.19	8.02	7.33
Aspartic acid	9.65	9.80	10.23
Threonine	3.03	3.11	2.81
Serine	3.14	2.71	2.82
Glutamic acid	14.76	14.39	15.37
Proline	3.15	3.25	2.84
Glycine	5.13	5.02	4.46
Alanine	3.15	3.68	3.38
Cystine	1.52	1.45	1.38
Valine	4.82	4.73	5.05
Methionine	3.51	3.46	3.82
Isoleucine	5.48	4.53	4.12
Leucine	8.11	7.73	7.29
Tyrosine	3.17	3.65	3.65
Phenylalanine	4.62	5.14	5.14

muelleri and 5.74 g in *Hoplobatrachus occipitalis.* The concentration of isoleucine and glycine also placed them within the medium category of amino acids. Concentration of amino acids in the minor category were cystine, threonine and serine. Cystine had the lowest concentration with *Ptychadena pumilio, Xenopus muelleri* and *Hoplobatrachus occipitalis,* each having a concentration of 1.52 g, 1.45 g and 1.38 g, respectively.

The analysis of variance (ANOVA) showed that there was no significant difference in the concentration of the amino acid among the three species of edible anurans at ($P > 0.05$).

Discussion

Results from the interviews revealed that anuran species are eaten by many people in southwestern Nigeria. Over 90% of the interviewees had knowledge that frogs were consumed in southwest Nigeria. About 75% of those that had knowledge of edible frogs had actually seen various individuals eating these frogs. Even 43% of the interviewees themselves admitted that they have consumed edible frog species. This supports the findings of Cully (1978) and Fugler (1983) who reported that numerous species of anurans and chelonians (Fugler, 1984) are utilized as a significant and available source of protein for the human populations of the tropical world, and a culinary delicacy in the industrialized nations.

Looking at the various occupations, the farmers were the highest consumers of edible frogs. This is due to the fact that they are usually associated with the forests, bush and farmland environments, which gives them greater access to the habitats of these frogs. In view of this, they easily collect these frogs for self sustenance on a regular basis, which makes them the highest consumers of these vertebrates. The teachers were the next highest consumers of edible frogs. Many of them ate the frogs during their youth days while growing up in rural settlements. The age group of 11–20 years was mostly associated with the eating of frogs. This may be due to the fact that they are juveniles and very active at this stage of development. In the rural areas they are usually found in the forests and farmland environments catching these frogs when these areas are being cleared for agricultural purposes. Most of these frogs are skewed on sticks and roasted over the fire. Ashton *et al.* (1988) reported that large bullfrogs are collected and roasted by local inhabitants in the hinterlands.

In addition to the economic value of anurans there was also a cultural value. Certain frog species have medicinal importance, i.e. they are used to cure specific illnesses. Traditional medication is especially important in areas where western medicine is either not available or hardly affordable (Van der Geest, 1997). Anuran species specially used for medicinal purposes were the toads, e.g. *Amietophrynus regularis* and *A. maculates*. The survey of edible anuran species in southwest Nigeria revealed that *Hoplobatrachus occipitalis, Xenopus muelleri* and *Ptychadena pumilio* were the species most sought after (Mohneke *et al.*, 2010). However, *Hoplobatrachus occipitalis,* because of its large size, was the most commercialized species followed by *Xenopus muelleri*. Nutritionally, they are very important in the diets of their consumers, serving as cheap source of protein.

The amino acid composition of frog meat can be compared to those of the *Clarias* sp. and *Tilapia* sp. worked on by Osibona (2005). Glutamic acid was the major amino acid followed by aspartic acid in both the frogs and fish. The concentration of glutamic acid in *Clarias* sp. and *Tilapia* sp. were 28.45 and 29.03, respectively, and that of aspartic acid was 18.14 and 17.85, respectively (Osibona, 2005). In this study, *Hoplobatrachus occipitalis, Xenopus muelleri* and *Ptychadena pumilio,* each had a glutamic acid concentration of 15.37, 14.39 and 14.76, respectively, and that of aspartic acid was

10.23, 9.80 and 9.65, respectively. Despite glutamic acid and aspartic acid being the 1st and 2nd highest amino acid concentration in both frog and fish, the 3rd and 4th amino acids following in concentration gradient were not similar in both organisms. Arginine and leucine were the 3rd and 4th highest amino acids in frogs while glycine and alanine were the 3rd and 4th in fish. Irrespective of this difference, both organisms are valuable source of protein for consumers.

Frog meat serves as a good source of protein diet for the low income population that cannot afford other protein food sources such as chicken, turkey, beef, sea food, etc. Sadly, these edible anuran species are being exploited from their natural habitats without being replenished. Hence, in order to have a sustainable utilization of the wild frog population, frog farming must be highly encouraged. Ideally, any harvesting of wild species should be done sustainably (Waites, 2007). On a global scale an increasing number of internationally traded frogs are produced in frog farms (Teixeira *et al*., 2001; Daszak *et al*., 2006). Whereas there seems to be efforts to set up frog farms in Central Africa (Munyuli Bin, 2002), there is no initiative in West Africa. According to data all West African amphibians used for food are from the wild (Mohneke *et al.*, 2010). Cultivation of edible frog species would not only help to secure wild populations but also offer long-term socioeconomic advantages. This will help to develop and preserve anuran populations, which are valuable biological entities in the ecosystem's structure and function.

Conclusion and Recommendation

Efforts should be made to save the valuable anuran population by educating the public about their importance in the environment. There should be less exploitation of edible anurans from the wild, and frog farming must be encouraged in order to alleviate the declining population of edible anurans. Frog farming in collaboration with conservation efforts will adequately have an effect on the unprecedented decline of the anuran population.

Acknowledgement

The authors thank Dr T. Ojobe from the Department of Zoology, University of Jos, who tirelessly conducted the processes of the proximate analysis and amino acid profile of the various anuran species. Thanks also go to Dr Nwadinigwe of the Faculty of Education, University of Lagos, who helped to validate the questionnaires.

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