Carcass traits, nutrient composition and technological quality of monitor lizard (*Varanus exanthematicus*) meat produced in captivity in Benin

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Abstract
Varanus exanthematicus (Bosc, 1792) is the most consumed reptile as bushmeat among wildlife species in Benin. The study aimed to characterize the functional properties and the nutritional values of its meat producer in captivity. Therefore, ten Varanus exanthematicus were slaughtered and their thigh and back muscles were used for the physic-chemical analyses. It comes out from the study that the total length, snout-vent length, the tail length, the wingspam length, the neck length, the tail circumference, the thorax depth and the thorax width were respectively 123 cm, 52 cm, 74cm, 34 cm, 11 cm, 16 cm, 4 cm and 8.5 cm. The live weight of the monitors, the weight of the hot carcass and the yield of the hot carcass are respectively 1920g, 1700g and 88.54%. The arms, the thigh and the tail represent respectively 15.58%, 20.58% and 25.88% of the hot carcass weight. Functionally, the pH value recorded at 24 hours post-mortem, the luminance, the red index, the yellow index and the water holding capacity were respectively 6.37; 44.18; 14.7; 16.18 and 28.1% for the thigh meat and were respectively 6.58, 45.61; 10.22; 16.18 and 26.4% for the back meat sampled without skin.
Nutritionally, the dry matter, total ash, water, organic matter, fat and total nitrogen content of the meat are respectively 28%; 1.6%, 72%, 26.4%, 3.1% and 22.9%. It would be interesting to encourage the domestication trials of this species currently underway in Benin to not only promote food security through the use of unconventional resources, but also to reduce pressure on wildlife.
Key words*: Benin, bushmeat, quality, food security, Varanus exanthematicus.*

1. Introduction

In West African countries, where an ever-increasing populations are undernourished (FAO, 2018; Tougan et al., 2020), the local production of meat, milk and eggs remains under the existing demands (Hoffman et al., 2012; 2018). The low disposable incomes of the household in this region and the worldwide economic crisis increase food insecurity rate. Therefore, the need to intensify meat production has lead West African countries to improve the productivity of domestic animal species and unconventional animal species, (Hoffman, 2016; Tougan et al., 2021). Other valuable non-wood forest products (NWFPs) such as fish, insects, caterpillars, larvae, snails (Bikoue et al., 2007), and the wild species were considered in the further strategies of food security (Kurttila et al., 2018). Furthermore, the increasing pace of animal product demand and the expensive cost of conventional meat and meat products obliged the households to exploit wildlife animal species as bushmeat (Cawthorn and Hoffman, 2015; Nasi and Fa, 2015; Tougan et al., 2021). The wildlife species consumed as bushmeat range from antelopes to monkeys, rodents, monitor lizards and other reptiles and a range of invertebrates including snails (Stiévenaert, 1992; Tougan et al., 2021), caterpillars (Malaisse and Latham, 2014), termites (Malaisse, 2019) and bark beetles.
In Benin, Bushmeats are largely consumed in preference to domestic animals (Tougan et al., 2021). The grasscutter, *Thryonomys swinderianus* (Temminck, 1827) and the monitor lizards, mainly *Varanus exanthematicus* (Bosc, 1792) are the most consumed species (Baptist and Mensah, 1986; Tougan et al., 2021).
The present study aims to characterize the carcass traits, the functional properties and the nutritional values of the meat of *Varanus exanthematicus* kept in captivity in Benin.

2. Materials And Methods

2.1. Description of the study area

The study was carried out sequentially at the Faculty of Agonomy of the University of Parakou and the Laboratory «Quality and Safety of Agro-Food Products» of Gembloux Agro-Bio Tech, University of Liège in

Belgium, from 1 May 2017 to 30 September 2020. Parakou is located in the Department Borgou (2º39-2°53 East Longitude and 9°6-9°21, North Latitude). The climate is of Sudanese type with an alternation of a rainy season (May to October) and a dry season (November to April). The annual average rainfall is of 1125 mm recorded from 1994 to 2008 and the average annual temperature varies between 26 and 27°C.

2.2. Methodology

2.2.1. Morphological characterization of monitor lizard

The Total length (TL) from the tip of the snout to the tip of the tail and Snout-vent length (SVL) from the tip of the snout to the cloaca, the tail length, the wingspam length, the neck length, the tail circumference, the thorax depth and the thorax width were measured using a soft measuring tape and Digital Vernier Caliper 150 mm.

2.2.2. Lizard Slaughtering process and carcass traits evaluation

Ten terrestrial monitor lizards of 18-month-old reared in captivity in ditches and galleries were purchased were used for the study. These reptiles were slaughtered after 8 hours of feed withdrawal in accordance with the rules of the ethics committee of the University of Parakou. The slaughtered monitor Lizard were then manually skinned in hot water (70°C) and cleaned. After slaughtering process, the legs were severed at the tibio-tarsus-metatarsal joint and the head was separated from the neck at the skull-atlas junction. The organs of the abdominal and thoracic cavities were removed, as well as abdominal fat. The weights of the hot carcass, as well as those of the offal (head, legs, neck, heart, liver, lung, tongue) were determined. A cutting of each carcass was used to determine the weights of the different carcass components.

2.2.3. Functional properties evaluation of the monitor Lizard meat

The back and thigh muscles were used for the measures of pH, color (CIE L*, a*, b*), the juice loss, the cooking loss and the water holding capacity.

- **pH and color (CIE L*, a*, b*)**

The pH was measured at 1hour and 24 hours post mortem in the back and thigh muscles muscles at 2 cm depth (Raach-Moujahed et al., 2011; Tougan et al., 2016) using a calibrated pH-meter (Hanna Instruments Inc., model HI99161).

Color parameters were evaluated using a CR400 colorimeter, according to definitions proposed by the Commission Internationale de l'Éclairage (Pathare et al., 2012; Tougan et al., 2016). The value L* or luminosity indicates the product brightness or darkness and varies from 0 (black) to 100 (white). The value of a* (chromaticity coordinate) represents an indicator of green (-) and red (+). The value of b* is an indicator of blue (-) and yellow (+). The hue values were calculated using a* and b* values according to the following formula: hue = $\tan^{-1}(b^*/a^*)$. Chroma (C*) represents the color saturation. Chroma value was calculated according to the following formula: $C^* = (a^{*2} + b^{*2})^{1/2}$. The measurements were performed in duplicate, with the calibrated equipment, using 5 samples of each type of muscle.

- **Water Holding Capacity**

The Water Holding Capacity was determined by cooking loss. A sample of 10 grams of back or thigh cuts were weighed and cooked in vacuum-package bags (COPVAC 17025, Vigoclima S.L., Vigo, Spain) in bain-marie (Memmert GmbH + Co, GK, Germany) until the meat core temperature reached 70°C (Tougan et *al*., 2013). The core temperature was controlled using a digital thermometer (Testo AG, Lenzkirch, Germany) during the cooking process. After cooking the samples were removed, cooled to room temperature, and reweighed. The Water Holding Capacity was calculated as the loss of weight during the boiling process and was expressed as a percentage (Tougan et *al*., 2013) as follows:

$$\text{Water Holding Capacity } (\%) = \frac{\boldsymbol{Weight\ loss}}{\boldsymbol{Initial\ fresh\ meat\ weight}} \times \mathbf{100}$$

- **Texture analysis**

The texture analysis was evaluated using TA.XT Plus Texture analyzer (Lloyd Instrument), equipped with a cell charge of 25 kg (Tougan et al., 2013). Cylindrical uniform and homogeneous samples, with diameters and heights equal to 10 mm, were removed from random points in the cooked meat samples. The sampled meats were kept at room temperature (21 °C). The texture value in Newton was obtained by a compression test of the meat cylinder, using a cylindrical compression probe of 75 mm diameter at a constant speed of 2.0 mm s-1. 5 independent replicates were produced for each type of meat sample.

2.2.4. Nutrient composition evaluation

Overall, nutrient composition assessment was performed according to the standard procedures recommended by (AOAC, 2000). The moisture content was determined gravimetrically according to standard NF V 04-401 of April 2001 by kiln drying at 105 °C until constant weight. The total mineral content was assessed by calcination in muffle furnace according to the standard NF V 04-2018 of October 1989 (Tougan et al., 2013). The cheese fat content was determined by using the method described by Folch (1957). The total protein content was estimated by the Kjeldal method (Tougan *et al*., 2013, 2016) by using the standard NF V 04-407of September 2002. The factor used in conversion from nitrogen to total protein was 6.25. Analyses were performed in triplicates.

2.3. Statistique Analysis

The data collected on the carcass composition of the five genetic types of chicken were suggested to descriptive statistics by using the software SAS (Statistical Analysis System, 2006). The means were calculated using the procedure *proc means* while the frequencies were calculated using the procedure *proc freq*.

3. Results

3.1. Morphometric traits of monitor lizard carcasses

The table1 presents the morphometric traits of monitor lizard carcasses. It appears that the total length, snout-vent length, the tail length, the wingspam length, the neck length, the tail circumference, the thorax depth and the thorax width were respectively 123 cm, 52 cm, 74cm, 34 cm, 11 cm, 16 cm, 4 cm and 8.5 cm. The live weight of the monitors, the weight of the hot carcass and the yield of the hot carcass are respectively 1920g, 1700g and 88.54%.

Table 1: Morphometric traits of monitor lizard carcasses

Variables	Mean	Standard Error
Total length (tip of snout- tip of tail) (cm)	123	1.02
Snout-vent length (cm)	52	0.6
Tail length (cm)	74	0.3
Wingspam length (cm)	34	0.22
Neck length (cm)	11	0.18
Tail Circumference (cm)	16	0.32
Thorax depth (cm)	4	0.08
Thorax width (cm)	8.5	0.12

3.2. Carcass yield and composition

The table 2 presents the carcass traits of monitor lizard. It appears that the live weight of the monitors, the weight of the hot carcass and the yield of the hot carcass are respectively 1920g, 1700g and 88.54%. About the different cut pieces, the arms, the thigh and the tail weigh respectively 265g, 350g and 440g and represent respectively 15.58%, 20.58% and 25.88% of the weight of the hot carcass. The head of the neck, the rest of the carcass, the heart, the liver, the lungs, and the tongue weigh respectively 95g, 80g, 377g, 8g, 48, 22g, and 15g.

Table 2: Carcass yield and composition

Variables	Mean	Standard Error
Live weight (g)	1920	15.9
Carcass weight (g)	1700	12.6
Carcass yield (%)	88.54	0.25
Arms weight (g)	265	4.75
Thigh weight (g)	350	4.23
Tail weight (g)	440	2.39
Arms (%)	15.58	0.42
Thigh (%)	20.58	0.28
Tail (%)	25.88	0.28
Head (g)	95	1.02
Neck (g)	80	1.81
Carcass rest (Back) (g)	377	4.5
Heart (g)	8	0.42
Liver (g)	48	0.6
Lung (g)	22	0.77
Tongue (g)	15	0.26

3.2. Functional and nutritional quality of monitor lizard meat

The table 3 presents the functional properties of monitor lizard meat. The table 4 shows the nutritional quality (macronutrients contents) of monitor lizard back meat. Overall, the pH24, the luminance, the red index, the yellow index and the water holding capacity of the thigh are respectively 6.37; 44.18; 14.7; 16.18 and 28.1%. At the level of the arm, they are respectively 6.58, 45.61; 10.22; 16.18 and 26.4%. The dry matter, total ash, water, organic matter, fat and total nitrogen content of the back meat are respectively 28%; 1.6%, 72%, 26.4%, 3.1% and 22.9%.

Table 1 : Functional attributes of monitor lizard meat

Variables	Mean	Standard Error
Thigh meat		
pH24	6.37	0.04
L*	44.18	1.69
a*	14.7	0.7
b*	16.18	8.03
Water Holding Capacity (%)	28.1	1.41
Back meat		
pH24	6.58	0.02
L*	45.61	0.89
a*	10.22	1.12
b*	16.18	0.67
Water Holding Capacity (%)	26.4	1.16

4. Discussion

The results of this study show that *Varanus exanthematicus* meat has many advantages. Its crude protein content is higher than that of indigenous chicken and cattle meat (Salifou et al., 2013; Tougan et al., 2013). This finding clearly justifies its valorization in culinary recipes in Benin and in the West African countries and the pressure exerted on this lizard species as bushmeat. Indeed, wildlife is a food resource perceived as an alternative to food security in West Africa. The importance of bush meat in the diet of West Africans is well documented (Buffrenil and Hemery, 2007; Bennett and Robinson 2000; Wilkie et al. 2005; Nasi et al. 2011; Tougan et al., 2021). Among reptiles, varans are the most consumed species in Benin, Côte d'Ivoire and Burkina Faso (Tougan et al., 2021).

According to Nasi and Fa (2015), foods of animal origin, such as wildlife, are rich in energy, protein and micronutrients, which are more bioavailable than plant sources. However, some evidence indicates a close causal link between bush meat consumption and human nutrition (Neumann et al., 2003). In a study of children under 12 in the rural northeast of Madagascar, lack of access to bushmeat has led to an significant increase (29%) in the number of children with iron deficiency anemia and a tripling of anemia cases among children in poorer households (Golden et al., 2011). If food security is intended to provide healthy, nutritionally sufficient and healthy food, available consistently throughout the year and available to households in sufficient quantities for active and healthy living (Maxwell and Wiebe, 1999; Pinstrup-Andersen 2009), the contribution of wild lizard as bush meat to human nutrition in sub-Saharan Africa is very important.

In addition, Starkey (2004), Cawthorn and Hoffman (2015) and Nasi and Fa (2015) also reported that wildlife observed as observers are an important source of income for rural populations and play an important role in the practice of traditional medicine. Schulte-Herbrüggen et al. (2013) have shown that bushmeat is an important resource in the livelihoods of many rural communities in sub-Saharan Africa and can be an essential safety net for the most vulnerable households, especially in times of economic hardship. In addition, trade in non-timber forest products has non-financial benefits that are generally overlooked (Shackleton and Shackleton, 2004).

It would therefore be interesting to encourage the trials of domestication of this species currently underway in Benin in order not only to promote food security through the use of unconventional meat resources, but also to reduce the pressure on wildlife.

5. Conclusion

This study shows that the meat of *Varanus exanthematicus* has nutritional assets that deserve to be valued for food security. The protein value of this lizard meat is higher than that of chicken, Borgou, Zébu Peuhl breed beef raised in Benin. It's a very low-fat meat. The pH, luminance, red index, yellow index and water-holding capacity of the meat indicate that the meat of *Varanus exanthematicus* is a red meat with good processing and preservation attributes by smoking and drying.

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7. CONFLICTS OF INTEREST

The authors declare that they have no conflict of interests.

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