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Original Research Article

Comparison of the nutrient composition, biogenic amines and selected functional parameters of meat from different parts of Nile crocodile (*Crocodylus niloticus*)

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ABSTRACT

The aim of the study was to compare nutritional parameters (contents of fat, protein and the individual amino acids), biogenic amines (histamine, tyramine, phenylethylamine, tryptamine, putrescine, cadaverine, spermidine and spermine) content, selected functional properties (colour and textural properties) and pH values of six parts of crocodile carcass (tail dorsal – TD, tail ventral – TV, neck – N, shoulder – S, leg – L and cheek – C). The individual parts of the crocodile carcass showed different values of nutritional parameters. TD and C had the highest values of Essential Amino Acid Index (104–126). Valine, threonine and leucine were determined as limiting amino acids in individual parts of the crocodile carcass. The content of biogenic amines was very low. These results will provide crocodile meat producers as well as consumers with new and useful information about the nutritional value of this meat and its relevance for nutrition.

1. Introduction

In the last 50 years the demand for consumption of dishes from non-traditional ingredients has been growing in developed countries. Also, the restaurants in both developing and developed countries are trying to offer their customers a wide range of specialities and delicacies. Meat from different animal species, also including the animals of *Reptilia* class, especially the representatives of Crocodilia (crocodiles, caimans, alligators, gharials), Testudines (turtles, tortoises, terrapins), Squamata (lizards, geckos, iguanas, snakes) and Sphenodontia (tuatara) is thus used as an alternative source. In addition to the traditional countries running farms for breeding these animals, such as Africa, America and Australia, new farms have also been established in Europe over the last 20 years (e.g. France and Czech Republic) (Hoffman et al., 2000; Gill, 2007; Hoffman, 2008; Magnino et al., 2009; Makanyanga et al., 2014).

Among *Reptilia*, great attention is particularly paid to crocodiles, which provide skin and meat. In some cases meat is only a by-product of getting crocodile skin. Globally, several species of crocodiles are bred on farms (mainly *Crocodylus niloticus*, *Crocodylus johnstoni*, *Crocodylus siamensis*, *Crocodylus acutus* and *Crocodylus porosus*). The most widely farmed species is *C. niloticus* (Madsen, 1996; Hoffman et al., 2000; Osthoff et al., 2010). The microbiological quality of crocodile meat and the potential risks to consumers' health have been examined in many studies, e.g. Madsen (1996), Gill (2007), Magnino et al. (2009), and Makanyanga et al. (2014). The above-mentioned studies agree on a strict application of Good Hygienic Practices (GHP), Good Manufacture Practices (GMP) and Hazard Analysis and Critical Control Points (HACCP) throughout the food chain in order to ensure safety of crocodile meat.

Despite the fact that the consumption of crocodile meat is growing, there is still not enough information in the literature about the nutritional value of this meat. One of the few studies that

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dealt with the nutritional value and slaughter parameters of the individual parts of Nile crocodile (*C. niloticus*) meat was Hoffman et al. (2000). In seven crocodiles at the age of 33–34 months, the tail, neck, torso and legs were taken in order to determine the carcass characteristics, moisture, protein, fat and ash content and cooking loss. There was no significant difference in the protein and fat content (211–229 g kg^{-1} and 29.4–91.1 g kg^{-1}, respectively) between the body parts studied. The lowest cooking loss was detected in the torso (23.2%; a percentage of the original weight). In the other parts (tail, neck and legs), cooking losses were observed within the interval of 29.6–32.1%. The content of selected amino acids, fatty acids and minerals was only determined in the tail (Hoffman et al., 2000). A few other studies only dealt with some nutritional parameters and usually only in some parts of crocodile bodies, such as basic chemical composition (*C. porosus* and *C. johnstoni*; Mitchell et al., 1995), amino acid content (*C. niloticus*, the middle of the tail; Osthoff et al., 2010), selected minerals (in the blood and organs of *C. niloticus* body; Swanepoel et al., 2000) or in the tail of *Alligator mississipiensis* body (Guillory et al., 2011).

The above-mentioned studies are primarily concerned with the tail part because it is considered to be the most valuable from a culinary point of view. However, for the food industry and gastronomy there are many more usable parts of the crocodile body, such as neck, shoulder and/or legs (Hoffman et al., 2000; Gill, 2007). Amino acid content of the individual parts of crocodiles and the biological value of their proteins are not available in the literature. Also, other properties of the individual parts of the crocodile body which are important for the consumer (e.g. texture parameters and/or meat colour) have not been found in any sources available. A good indicator of meat quality and safety can also be the content of biogenic amines and polyamines (Kalač, 2006; Buňka et al., 2013). Increased consumption of these substances could endanger the health of the consumer, especially when monoaminooxidase inhibitors, affecting detoxification metabolism, are consumed at the same time (included in antihistamines, antidepressants, etc.) (Ten Brink et al., 1990). However, the data about the content of biogenic amines and polyamines in crocodile meat have not been found in the available literature either.

The aim of this study was to compare selected nutritional indicators (mainly the content of fat, protein and the individual amino acids), the content of biogenic amines and polyamines (histamine, tyramine, phenylethylamine, tryptamine, putrescine, cadaverine, spermidine and spermine) and selected functional properties (colour and textural properties) in six parts of crocodile carcass (tail dorsal, tail ventral, neck, shoulder, leg and cheek). These results will provide crocodile meat producers as well as consumers with new and useful information about the nutritional value of this meat and its relevance for nutrition.

2. Material and methods

2.1. Crocodile samples

The samples were collected from seven Nile crocodiles (*C. niloticus*) at the age of 42–46 months from a commercial crocodile farm in the Czech Republic (Jevišovice). The crocodiles were slaughtered (in one day) by standard procedure, i.e. killed using a 0.22 calibre rifle and skinned (the same slaughter procedure was used in Hoffman et al. (2000)). In the Czech Republic, the requirements for crocodile slaughter are described in the Notice of Ministry of Agriculture No. 34/2013. Meat samples for the analysis were collected from six parts of the crocodile body (see Fig. 1): tail dorsal (TD), tail ventral (TV), neck (N), shoulder (S), leg (L) and cheek (C). After sampling, the meat was cooled down to 4 ± 1 °C and stored for 24 h until the beginning of the analysis. For

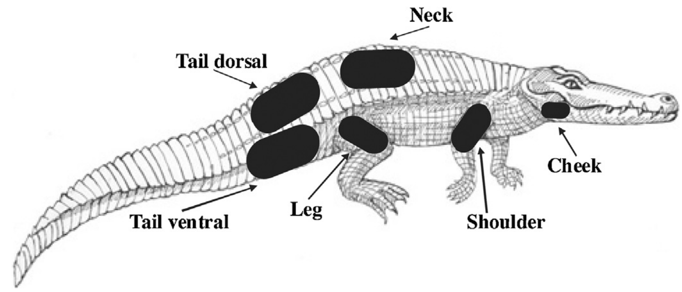

Fig. 1. A schematic presentation of sampling of the parts of the crocodile body tested (tail dorsal, tail ventral, neck, shoulder, leg and cheek).

moisture, fat and protein content analysis, texture profile analysis, colour analysis and pH measurement, the chilled samples were used directly (after tempering to 20 ± 1 °C). Prior to the analysis of amino acid and biogenic amine content, the samples were lyophilised (Christ Alpha 1–4; Martin Christ Gefriertrocknungsanlagen GmbH; Osterode am Harz; Germany) and the powdered samples were stored at −70 °C until the analysis.

2.2. Basic chemical analysis

The moisture content of the individual parts of the crocodile meat was analysed according to ISO 1442 (1997). The pH-values were measured by direct insertion of a spear electrode (pHSpear, Eutech Instruments, Oakton, Malaysia) into the samples (20 ± 1 °C). The fat and crude protein content was determined according to ISO 1443 (1973) and ISO 5983-1 (2005), respectively. All chemicals were analytical grade or higher and were obtained from Lach-Ner (Neratovice, Czech Republic). Each sample was measured at least four times (in each part of the crocodile carcass and for each crocodile).

2.3. Amino acid analysis

The lyophilised samples (~150 mg) were accurately weighed and put into 20 ml screw-capped test tubes with Teflon caps. Fifteen millilitres of 6 mol L^{-1} hydrochloric acid were added to the tubes, which were purged by means of argon for 1 min. Then the tubes were placed in a thermoblock (Labicom, Olomouc, Czech Republic) heated at 115 ± 1 °C and hydrolysed for 23 h. Sulphur amino acids (cysteine and methionine) were hydrolysed in the same way after 16-h oxidation with a mixture of 30% (v/v) hydrogen peroxide and 98% (v/v) formic acid (in the ratio of 1:9 v/v). After the hydrolysis, hydrochloric acid was evaporated (RVO 400, Ingos, Prague, Czech Republic) and the ropy residue was diluted in sodium-citrate buffer (pH 2.2) in a 25 ml volumetric flask. The mixture was filtered through a 0.45 μm pore filter and loaded into an analyser. All samples (parts of the body) from each crocodile were prepared three times. Liberated amino acids were determined by using ion-exchange chromatography (column 370 mm × 3.7 mm filled with ion exchanger Ostion LG ANG), post-column ninhydrine derivatisation and spectrophotometric detection (440 nm for proline and 570 nm for other amino acids). Amino Acid Analyser AAA400 (Ingos, Prague, Czech Republic) was used for the analysis. Sulphur amino acids were separated and quantified as cysteic acid and methionine sulphone. Each hydrolysate was analysed at least in triplicate (3 samples for hydrolysis × 3 analyses = 9 measurements of each part of the crocodile carcass and for each crocodile). The buffer system, protocols of the analysis (elution programmes) and the process of ninhydrine reagent preparation had been recommended by the manufacturer of the analyser (Buňka et al., 2009; Lazárková et al., 2011). The results were expressed for the fresh matter before