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≪Research Note≫

Chemical Composition of Edible Ostrich Offal

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The offal (hearts, stomachs, and livers) of 24 African ostriches (*Strutio camelus var. domesticus*) from Polish farms were used in this study. Offal were taken directly from the production line; they were weighed and their water, fat, protein, ash and total collagen contents were determined. Ostrich hearts and stomachs were found to have high protein (18.1% and 19.0%, respectively) and low fat content (2.0% and 0.9%, respectively), typical of lean meat. Thus, the offal could be used in processed offal products or in pet food. Ostrich livers had slightly lower protein content (16.6%) and significantly higher and diverse fat content (4.4–28.4%). Heavier livers had significantly ($P<0.05$) higher fat and lower protein, water, and ash content. The utilization of ostrich liver should be preceded by classification of its fat content.

Key words: heart, liver, offal, ostrich, stomach

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Introduction

Many edible by-products, such as livers, hearts, and stomachs, are generated through the slaughter of poultry (Murawska, 2013; Toldrá *et al*., 2014). They can either be sold for household culinary purposes or processed into meat products. Taste and chemical composition are factors determining the utilization of such products (Fernandez-Lopez *et al*., 2004). The possibility of using offal in meat products has long been known by butchers. Traditional, well-known meat products in which offal is the main ingredient are pâtés (Fernandez-Lopez *et al*., 2004; Estevez *et al*., 2005; Dalmas *et al*., 2011), which get their specific flavor from the addition of liver. Liver can also be an ingredient in meat products such as liverwurst or liver sausage, and in black puddings. Hearts and stomachs are used in the production of various types of head cheese. Dishes made of fried or stewed liver and various types of heart and stomach goulash are also popular (Liu and Ockerman, 2001; Majewska *et al*., 2016; Toldrà *et al*., 2016). Poles eat 4 kg of offal per person annually, which constitutes approximately 6% of the overall meat consumption, and is higher than the consumption of beef.

Ostrich meat has notable taste and nutritional values (Watkinson *et al*., 2004; Rødbotten *et al*., 2004; Brenesselová *et al*., 2015), which are a result of its high protein content, optimum composition of fatty acids, and low cholesterol content (Hoffman *et al*., 2014). There is little information concerning edible ostrich offal, and its use in the industry is occasional. The work of Fernandez-Lopez *et al*. (2004) is one of the few studies showing the possibilities of using ostrich offal, suggesting its potential use in the production of pâtés. However, in this work, no offal characterization was done. Lack of information related to the quality of ostrich offal leads to its ineffective use in the meat processing industry. Understanding the chemical composition, especially compared to the commonly used turkey offal, may allow for widespread use of ostrich offal in meat production and pet food by increasing the efficiency of breeding and processing (Florek *et al*., 2012). The aim of this study was to determine the chemical composition of edible ostrich offal (hearts, livers and stomachs) and to compare this to turkey offal.

Materials and Methods

Offal Sample Preparation

Offal (hearts, stomachs and livers) were obtained from 24 African ostriches (*Strutio camelus var. domesticus*), aged 1.5 to 2 years, which were raised under different nutrition and farming conditions on Polish farms (12 males and 12 females). Animals were kept in a slaughter plant for a minimum of two hours for a pre-slaughter rest period. Slaughter and post-slaughter processing stages included mechanical stunning, sticking and bleeding with a pipe knife, manual feather removal, cutting off the head and legs, mechanical skinning, evisceration, veterinary examination and carcass cleaning (e.g. external fat removal). The offal samples were

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obtained after veterinary examination and prior to chilling. Liver samples were taken directly from the production line. Blood clots were removed from hearts and ingested matter and internal mucous membranes were removed form stomach samples. Next, the offal was weighed on a scale (Axis A6000, Poland, accuracy 0.1 g), packed into polyethylene bags and cooled at 2–4℃. After 24 hours had passed post-slaughter, offal samples were ground twice in a laboratory grinder (ZM Mesko AL2-1, Poland) through a 3-mm plate. The reference material used was turkey offal (24 pieces of each type). This choice was dictated by their popularity and availability in the Polish market and the fact that turkeys are the largest birds slaughtered in the industry. To ensure diversity of the reference material, turkey offal was purchased at different locations. Preparation of turkey offal samples was the same as that of the ostrich offal.

Basic Chemical Composition

Water, fat, protein, and ash content were determined in the samples (AOAC, 2000). The moisture content was determined by drying the samples at 105℃ (SUP-65 dryer, Wamed, Warsaw, Poland). The ash content was determined by ashing the samples at 550℃ for 24 hours in a muffle furnace (P.E.M.-2, Prodryn, Wodzisław Śląski, Poland). The protein content was determined using the Kjeldahl method (Velp Scientifica UDK 129 Destillation Unit, Poland). The fat content was determined by soxhlet extraction (Büchi Extraction System B-811, Donserv, Poland). For stomachs, the total collagen content was determined based on the hydroxyproline content according to ISO 3496 (2000), assuming a conversion factor of 8 (EC 13) and by using a colorimetric assay with the HITACH-U-1100 spectrophotometer (Hitachi Corporation, Ltd. Tokyo, Japan).

Statistical Analysis

Results were subjected to statistical analysis using STATISTICA 12 PL (Stat Soft. Inc., Tulsa, USA). The mean equality hypothesis was checked using a Student's t-test or analysis of variance (Tukey's HSD test) assuming a level of significance $\alpha=0.05$. The dependencies between the weight of ostrich offal and basic chemical composition were analyzed using Pearson's (linear) correlation.

Results and Discussion

Weights of Selected Edible Ostrich Offal

Livers had the largest average weight, 1586.4 g, among the analyzed ostrich offal (Table 1). The average weight of stomachs was 1087.7 g and that of hearts was 899.7 g. A broad range of weights was observed in the edible ostrich, especially in the liver samples which had a range from 998.5–2055.8 g (1057.3 g difference). Stomach and heart samples had maximum weight differences of 509.3 g and 228.8 g, respectively. Differences in the weight of obtained ostrich livers may be the result of a difference in age, sex and weight of the slaughtered birds (Harris *et al*., 1993). Literature values also show a broad range of stomach weights, from 3140–4550 g, (van Schalwyk *et al*., 2005; Naseva *et al*., 2010) which may be attributed to different breeding methods and techniques of removing ingested matter and membranes. Similar weights of ostrich hearts have been reported by Tadjalli *et al*. (2009), at 1054 g, and Naseva *et al*. (2010), at 1010 g.

In comparison to offal weights from other slaughtered animals, pig livers were found to be most similar in weight, ranging from approximately 1400 g to over 1800 g (Fornias, 1996; Seong *et al*., 2014). The weight of turkey offal is 10–12 times lower than ostrich offal. According to Murawska (2013), turkey heart weights range from 40.1–65.0 g, livers range from 114.8–184.3 g, and stomach weights range from 60.3–127.2 g, all of which are dependent on the birds sex.

Chemical Composition of Selected Edible Ostrich Offal

Ostrich stomachs and hearts were found to have similar water content, 79.5% and 78.6%, respectively. Significantly ($P<0.05$) lower water content was determined for livers (Table 2). Livers also had a significantly ($P<0.05$) lower protein content than hearts and stomachs. Collagen constitutes over 11% of ostrich stomach protein (Table 3). Its overall amount of collagen was within the range 1.62–2.51%. The fat content in edible ostrich offal was low in stomachs and hearts at 0.9% and 2.0%, respectively. Significantly ($P<0.05$) higher fat content (14.3%) was determined for livers. A lower fat content, 6.5%, and higher water and protein content, 69.5% and 19.4%, respectively, in the ostrich liver was reported by Fernandez-Lopez *et al*. (2004). The considerably higher fat content of the liver observed in this study was most likely the result of differences in bird nutrition. In terms of fat content, the analyzed livers were very diverse with values ranging from 4.4–28.4%. According to Majewska *et al*. (2016), fat from ostrich liver contains more SFA (saturated fatty acids) and MUFA (monounsaturated fatty acids) and less PUFA (polyunsaturated fatty acids) compared to fat from turkey liver, implying that ostrich liver may be less nutritious. Fat content in liver is a derivative of the amount of energy supplied along with the feed. Its surplus leads to a fatty liver which is used in the production of "foie gras". Ash content in the analyzed edible ostrich offal was 1.1–1.2% (Table 2).

From a histological point of view, ostrich hearts and

Table 1. **Weight of selected edible ostrich offal**

Edible offal ($n=24$)	Mean value	SD	Range
Heart (g)	889.7	107.2	725.2–1118.5
Liver (g)	1586.4	301.2	998.5–2055.8
Stomach muscle (g)	1087.7	163.4	909.0–1418.3

Table 2. **Comparison of the chemical composition of selected edible ostrich and turkey offal**

Components of edible offal	Ostrich (n=24)			Turkey (n=24)		
	Mean value	SD	Range	Mean value	SD	Range
Water (%)						
Heart	78.6[b]	0.8	77.7–80.0	78.8[b]	1.1	76.8–79.8
Liver	64.2[a]	6.4	53.5–71.6	75.2[a]*	1.7	71.7–76.3
Stomach muscle	79.5[b]*	0.5	78.6–80.2	77.7[b]	0.2	74.3–80.0
Protein (%)						
Heart	18.1[b]	0.7	17.1–19.3	18.5[b]	0.9	17.4–19.6
Liver	16.6[a]	2.1	13.0–19.5	19.1[b]*	0.7	17.9–20.0
Stomach muscle	19.0[b]*	0.7	18.2–20.5	17.1[a]	0.7	15.8–17.7
Fat (%)						
Heart	2.0[a]*	0.4	1.6–2.8	0.7[a]	0.1	0.5–0.8
Liver	14.3[b]*	8.2	4.4–28.4	3.1[b]	1.0	2.3–4.9
Stomach muscle	0.9[a]	0.2	0.6–1.3	3.2[b]*	1.5	1.3–5.5
Ash (%)						
Heart	1.2[a]*	0.1	1.1–1.4	1.1[b]	0.1	1.0–1.2
Liver	1.1[a]	0.1	0.8–1.3	1.3[c]*	0.04	1.2–1.3
Stomach muscle	1.1[a]*	0.1	1.0–1.3	0.9[a]	0.1	0.7–1.0

[a–c] — within column, values followed by different letters are significantly different ($P<0.05$).
* — within same row values followed by * are significantly different ($P<0.05$).

Table 3. **Total collagen content in ostrich stomach muscle**

	Mean value	SD	Range
Total collagen (%)	2.21	0.25	1.62–2.51

stomachs consist of muscle cells and so their chemical composition is similar to that of lean meat (Watkinson *et al*., 2004; Viljoen *et al*., 2005; Kuzelov *et al*., 2012). The chemical composition of ostrich meat depends on the birds nutrition, especially on the energetic value to protein content ratio (Hoffman and Mellet, 2003; Lanza *et al*., 2004; van Schalkwyk *et al*., 2005), and on the birds age (Hoffman and Fisher, 2001; Girolami *et al*., 2003; Sabbioni *et al*., 2003). These factors may also influence a variety of other chemical components of the analyzed offal. Tomović *et al*. (2016) found significant differences in the mean values of the protein, fat and water content of the edible by-products from Saanen goat male offspring.

The chemical composition of ostrich offal was compared to that of turkey offal, widely available in the market. It was suggested that the selection be guided by the size of the bird (the smallest variation in weight). Ostrich hearts were characterized by significantly ($P<0.05$) higher fat content (Table 2) than those of turkeys. Other chemical components in ostrich and turkey hearts were on a similar level. In the case of stomachs, bigger differences between ostriches and turkey were observed. Ostrich stomachs had significantly ($P<0.05$) higher water, protein, and ash content and significantly ($P<0.05$) lower fat content. The fat content in ostrich stomachs was more balanced with a range of 0.6–1.3% compared to turkey stomachs which had a range of 1.3–5.5%. The opposite was observed in the comparison of ostrich and turkey livers. Ostrich livers were characterized by significantly ($P<0.05$) higher fat and lower water, protein, and ash content. In a comparison of ostrich and turkey meat, Poławska *et al*. (2013) found that ostrich meat had higher protein and water content and lower fat content; similar results were obtained for the analysis of the stomachs.

The basic chemical composition of ostrich livers was correlated with their weights (Table 4). Heavier livers had higher fat content ($r=-0.87$) and lower water ($r=-0.88$), protein ($r=-0.86$) and ash ($r=-0.77$) content. The fat content in liver is especially influenced by the energetic value of the feed.

No significant correlations were found between weight and chemical composition for ostrich hearts. For ostrich stomachs, it was observed that there was a correlation between the weight and fat content, with lighter stomachs having higher fat content ($r=-0.72$). However, this dependency was of a different character than in case of livers, with heavier livers having higher fat content ($r=0.87$).

In conclusion, in comparison to turkey offal, ostrich offal had a notably different basic chemical composition. Ostrich

Table 4. **The effect of ostrich edible offal weight on its chemical composition**

Components of edible offal	Correlation coefficient
Heart	
Water	−0.19
Protein	−0.29
Fat	0.40
Ash	0.50
Liver	
Water	−0.88*
Protein	−0.86*
Fat	0.87*
Ash	−0.77*
Stomach	
Water	−0.27
Protein	0.12
Collagen	0.17
Fat	−0.72*
Ash	0.23

* indicates a statistically significant difference ($P<0.05$).

hearts and stomachs were characterized by high protein and low fat content, characteristic of lean meat. As such, they could be used in processed offal products (i.e., liverwurst) or pet food. Ostrich livers, however, were characterized by slightly lower protein and significantly higher and diverse fat content. The chemical composition of the liver correlated with its weight; heavier livers had higher fat and lower protein, water, and ash content. The use of ostrich livers should be preceded by fat content analysis.

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