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The ostrich meat – an updated review.
II. Nutritive value*

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Ostrich meat is a niche product gaining popularity among consumers especially in Europe. Nutrient composition of this meat considering protein, amino acids, fat, cholesterol, fatty acids, minerals and vitamins was henceforth assessed. Ostrich meat is characterized by low intramuscular fat content, a favourable fatty acids profile (PUFA/SFA and n-6/n-3 ratios), a high content of iron and vitamin E and low of Na. Thus, it can be considered as a high quality product of high nutritive and dietetic value. It may thus be a valuable component of human diet.

KEY WORDS: cholesterol / fatty acids / meat / minerals /ostrich / vitamins

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Introduction

Ostrich meat is recognized as a valuable product of high nutritive and dietetic value making these birds important for many livestock industries [Sales *et al*. 1999, Horbańczuk 2002, Cooper *et al.* 2004, 2008, Cooper and Horbańczuk 2004]. Demand for such products in Europe has recently increased especially also among consumers who pay a greater attention to the quality of consumed products [Cooper *et al*. 2007, Horbańczuk *et al*. 2007, 2008]. Nowadays, the modern consumer wants to be sure of the nutrient composition of food that is bought for consumption. According to Fasone and Privitera [2002] a consumer of ostrich meat is a medium-to-high cultural and professional status person, defined as a "modern attentive consumer" aged 41-50, principally women, with a purchasing behaviour essentially related to nutritive value, safety of the product, intrinsic characteristics and taste. It should be emphasised that nowadays consumers also appreciate "naturalness" and safety of ostrich meat produced from birds with almost natural methods, excluding the use of technologies such as intensive fattening or antibiotics administration. It is important also for them that ostriches are usually kept in sustainable production systems with consideration of high animal welfare standards. However, ostrich meat in Europe is still a niche product unknown by many people, but it is appreciated by most of consumers who tasted it. Unfortunately, until now the current knowledge of the nutritive value of this meat is still limited. Therefore, the present review was prepared in order to compile scientific data about nutritive value of ostrich meat including its benefits for human health.

Nutrients of ostrich meat

According to Hoffman *et al.* [2005] meat from ostriches fed a standard diet contains 21.65, 1.95 and 1.2% protein, fat and ash, respectively. Similar values regarding especially to protein and ash were recently reported by Majewska *et al.* [2009]. In their studies 10 different muscles were compared and all of them had similar content of dry matter (23.3-24.5%), protein (20.6-21.7%) and ash (1.07-1.17%). In turn, fat content is more differentiated among muscles (0.90-1.34%) – Table 1 (selected muscles) – being lower than in other species (beef – 4.6% or chicken – 4.3% [Sales 2002]). It should be noted that in a study by Sales [2002] the fat content of ostrich meat was lower and varied from 0.2 to 0.71g/100g of edible meat, but as emphasized by Majewska *et al* [2009] the lipid content depends on the method of the analysis, with different solvents used for extraction causing different results [Jensen 2004].

Additionally, according to Sales [2002] meat from older ostriches (10-12 months at slaughter) contains more fat and dry matter than from respective younger ones (8 months), especially with regard to *m. ambiens, m. iliofibularis* and *m. iliotibialis lateralis*.

Table 1. Chemical composition (g/100 g edible portion) of ostrich meat [Sales, 2002 and Majewska *et al.* 2009] as influenced by muscle and birds' age

Component (%)	Muscle	Age (months)			
		Sales [2002]			Majewska *et al.* [2009]
		8	10	12	10-12
Dry matter	*gastrocnemius*	22.27	22.23	22.43	23.3
	femorotibialis medius	22.39	22.80	22.89	23.0
	ambiens	23.84	24.33	24.18	24.1
	iliofibularis	22.21	22.48	22.63	22.8
	iliotibialis lateralis	23.41	24.09	24.27	23.8
	iliofemoralis	24.30	24.99	25.09	23.8
Protein	*gastrocnemius*	20.63	20.44	20.72	21.3
	femorotibialis medius	20.34	20.71	20.42	20.8
	ambiens	21.55	21.23	21.51	21.3
	iliofibularis	20.05	21.85	20.99	20.7
	iliotibialis lateralis	21.07	21.36	21.37	21.4
	iliofemoralis	21.53	22.22	21.94	20.7
Fat	*gastrocnemius*	0.26	0.20	0.21	0.90
	femorotibialis medius	0.33	0.33	0.28	0.95
	ambiens	0.35	0.53	0.47	1.34
	iliofibularis	0.39	0.42	0.50	1.10
	iliotibialis lateralis	0.33	0.36	0.45	1.21
	iliofemoralis	0.71	0.66	0.66	1.22
Ash	*gastrocnemius*	1.15	1.21	1.17	1.10
	femorotibialis medius	1.09	1.06	1.20	1.15
	ambiens	1.10	1.16	1.11	1.09
	iliofibularis	1.09	1.16	1.11	1.07
	iliotibialis lateralis	1.20	1.20	1.24	1.17
	iliofemoralis	1.10	1.23	1.19	1.14

The amino acids composition of ostrich meat in comparison to beef and chicken meat is shown in Table 2. As regard either essential or non-essential amino acids content in ostrich meat is generally similar to other meat types except for histidine and serine.

The intramuscular fat content is one of the most important factors influencing consumers' choice with regards to meat type. In other species, e.g. in pigs, the last thirty years of breeding was dedicated to improve the quality of meat by lowering its fat content [Kouba *et al.* 1999, Pascual *et al.* 2007, Raj *et al.* 2010]. Ostrich meat is "naturally improved" meat because of its low content of intramuscular fat. This type of meat is recommended for overweight people and for those who suffer from coronary heart disease. On the other hand, low fat content is related to lowered juiciness of meat [Cooper 1999]. Thus, during cooking, the fat content increase and causes decrease in moisture [Sales *et al*. 1996].

The most important factor affecting fat content of meat is feeding. From studies on other species it is known that not only composition of a diet and addition of fat to the diet influences fat content of meat. Also the level of energy and protein (amino

Table 2. Amino acids content (g/100 g edible portion) of ostrich meat compared to beef and chicken [based on Sales 2002]

Item	Ostrich meat	Beef	Chicken meat
Essential amino acids			
threonine	0.76	0.92	0.90
isoleucine	0.92	0.95	1.13
leucine	1.70	1.56	1.61
lysine	1.65	1.74	1.82
methionine	0.55	0.54	0.59
phenylalanine	0.94	0.82	0.85
histidine	0.39	0.72	0.66
valine	0.97	1.02	1.06
Non-essential amino acids			
tyrosine	0.61	0.70	0.72
arginine	1.36	1.32	1.29
alanine	1.06	1.26	1.17
aspartic acid	1.90	1.91	1.91
glutamic acid	2.51	3.15	3.20
glycine	0.82	1.14	1.05
serine	0.59	0.80	0.74

acids, especially lysine) can change its content. This was similarly concluded by Sales [1997] who fed ostriches with a high-energy and low-protein diet and found that high energy/protein ratio leads to elevated fat content of meat.

Cholesterol content and fatty acids composition

At the beginning ostrich meat was recognized as a meat almost "free" of cholesterol. However, further research showed, that its cholesterol content is similar to that of beef and chicken meat (59 and 57 mg/100 g, respectively). Cholesterol content of ostrich meat has been reported as 57 mg/100 g tissue [Sales and Oliver-Lyons 1996], 65-68 mg/100 g [Horbańczuk and Sales 1998, Horbańczuk *et al*. 1998] and 83 mg/100 g [Cooper 1999]. The cholesterol content differed among the types of fat. Horbańczuk *et al.* [2004] found much higher level in backfat (74.33 mg/100 g) than in breast fat (49.50 mg/100 g). Probably the initial conclusion was made due to the low intramuscular fat content of ostrich meat which content is poorly correlated to cholesterol content. Cholesterol is mainly situated in cell membranes as structural components. After information, that cholesterol is stored in some blood vessels of persons suffering from arteriosclerosis and thus contributes to heart infarct cholesterol phobia is a common phenomenon especially in the developed countries.

By comparison with other species, e.g. chicken and beef, ostrich meat shows a beneficial fatty acids profile [Sales and Horbańczuk 1998], with differences in the fat type therein. The highest content of saturated fatty acids (SFA) was affirmed of abdominal fat (46.7%) – Hoffman *et al*. 2005], lower in muscles (<39.8%) – Horbańczuk *et al.* 1998, Hoffman *et al*. 2005 and the lowest in backfat and breast fat

Table 3. Fatty acids profile (% of total fatty acids) of ostrich muscles according to different authors

Acid	*Musculus iliofibularis*			*Musculus gastrocnemius*	
	Hoffman *et al.* [2005]	Horbańczuk *et al*. [1998]	Giorlami *et al*. [2003]	Horbańczuk *et al*. [1998]	Giorlami *et al*. [2003]
14:0	0.75	1.23	0.70	0.97	0.48
16:0	21.73	20.57	22.89	22.35	17.48
18:0	14.08	13.15	8.87	13.66	11.02
Total SFA	39.73	35.18	33.31	37.24	29.88
16:1 n-7	3.51	4.67	7.20	5.62	5.84
18:1 n-9	21.15	30.97	31.58	33.25	29.36
Total MUFA	27.27	35.57	39.05	39.09	35.52
18:2 n-6	18.06	15.61	16.24	14.18	16.63
18:3 n-3	5.76	5.68	2.14	1.55	1.50
20:4 n-6	6.15	5.62	6.50	5.81	11.34
20:5 n-3	1.21	0.42	0.28	0.35	0.54
22:5 n-3	-	0.86	0.74	0.92	1.40
22:6 n-3	1.22	0.73	0.21	0.83	0.39
Total PUFA	32.99	26.93	27.64	23.65	34.60
P/S	0.83	0.77	0.83	0.64	1.16
n-6/n-3	3.02	3.16	7.57	7.38	8.31

SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; P/S – PUFA to SFA ratio; n-6/n-3 – PUFA omega 6 to PUFA omega 3 ratio.

(31.8-32.2% of the total FA) – Horbańczuk *et al*. [2004]. Opposite order was reported within polyunsaturated fatty acids (PUFA), although all types of fat showed very high PUFA content (23.5-38.6%). Ostrich meat has a beneficial PUFA/SFA ratio, which is above 0.5 and riches very high values, even 1.2 (Tab. 3). WHO [2003] recommends the ratio of above 0.4, so ostrich meat and fat with its values can be considered pro-healthy. Also the n-6/n-3 ratio is usually on the level recommended by WHO [2003] – below 4. The relatively high total n-3 fatty acids content of ostrich meat (above 8 %), would thus be advantageous in promoting the product, since intake of n-3 fatty acids reduces incidence of coronary disease and are essential in growth and development of man throughout the life cycle and seem to be more effective in their antithrombotic and antiatheorgenic properties than the corresponding n-6 polyunsaturated fatty acids.

Hoffman *et al.* [2005] revealed that the *iliofibularis* muscle in the ostrich has a high content (%) of palmitic (21.73), oleic (21.15), linoleic (18.06) and stearic acid (14.08). Also Horbańczuk *et al.* [1998] reported high content of palmitic (25.93-27.11%), oleic (25.02- 28.33%), linoleic (10.09-10.58%) and linolenic acid (16.75-22.17%) of ostrich meat. Similar results were reported by Horbańczuk *et al.* [1998] and Giorlami *et al.* [2003] in *m. gastrocnemius*, although they revealed a higher content of oleic acid (29.36-33.25%). In ostrich meat, the contents (per cent) of acids important from the consumer point of view (arachidonic – AA, eicosapentaenoic– EPA and docosaheksaenoic – DHA) were found higher than in ostrich fat (6.15 *vs* 1.95, 1.21 *vs* 0.16, 1.22 *vs* 0.21, respectively [Hoffman *et al*. 2005]. However, in both cases the

content was much higher than in other meats, *e.g*. pork [Enser *et al*. 1996]. Giorlami *et al.* [2003] found difference between g*astrocnemius* and *iliofibularis* muscle in content of AA (11.34 *vs* 6.50%), EPA (0.54 *vs* 0.28%) and DPA (1.40 *vs* 0.74%).

Further research is required explaining the metabolism of fat and fatty acids in the ostrich digestive tract as well as metabolism of fatty acids on the cellular level. This can be closely linked with histo-morphological analyses, selective staining and protein marker evaluations. The role of the hepatic and biliary system in the processing of lipids is also integral to such studies.

Minerals

Meat in human diet is considered an important source of protein and minerals, especially iron and zinc. In the research of Lombardi-Boccia *et al.* [2002], Karklina and Kivite [2007] and Majewska *et al.* [2009] raw ostrich meat was found to be rich in total iron (2.32- 4.02 mg/100 g). In general, ostrich meat has the highest content of iron from all meat sources available for humans, e.g. beef or chicken (1.93, 0.4-0.7 mg/100 g, respectively). Thus, it can be an important source of iron for anaemic patients as well as for pregnant women [Cooper 1999] and complements metabolic and cellular processes including activities in leukocytes. Iron is essential for haematopoiesis.

Zinc levels of raw ostrich meat evaluated by Lombardi-Boccia *et al.* [2005] varied between different carcass cuts: 3.1 mg/100 g of leg and significantly less in sirloin and fillet (2.5 and 1.96 mg/100 g respectively). These levels were still higher than in other poultry meats: 1.71, 0.65, 2.47, and 1.08 mg/100 g of chicken thigh, chicken breast, turkey thigh and turkey breast, respectively. However, zinc concentrations in beef sirloin and beef fillet were higher: 4.09 and 4.01 mg/100 g, respectively. Levels of zinc in ostrich meat evaluated by Majewska *et al.* [2009] varied between 2.02 and 4.30 mg/100 g in different muscles.

Copper levels determined in raw ostrich meat by Majewska *et al*. [2009] ranged from 0.103 to 0.187 mg/100 g. In other species levels of copper were lower: 0.07-0.09, 0.05 and 0.06 mg/100 g of beef, chicken and turkey, respectively. In turn, calcium reached a maximum value of 5.62 mg/100 g of meat comparable to 6 mg/100 g recorded for beef, but considerably lower than chicken meat (12 mg/100 g of edible meat).

Very low sodium content of ostrich meat (32-36 mg/100 g) compared to beef (63 mg/100 g) or chicken (77 mg/100 g) would be advantageous for people who have to consume a low sodium diet, for example those suffering from hypertension [Cooper 1999].

Majewska *et al.* [2009] evaluated mineral content of meat samples collected from ten different ostrich muscles. The selected results are presented in Table 4. Compared to other species ostrich meat is more similar to beef than to chicken meat.

Table 4. Minerals of selected ostrich muscles compared to beef and meat of chicken

Minerals (mg/100 g)	Ostrich meat[1]			Beef[2]	Chicken meat[2]
	m. gastrocnemius	*m. obturatorius*	*m. iliofibularis*		
Macroelements					
calcium	5.45	5.15	5.62	6	12
potassium	243	244	240	358	229
magnesium	24.3	25.3	23.8	23	25
sodium	36.1	38.7	32.6	63	77
phosphorus	216	224	210	201	173
Microelements					
iron	2.88	3.04	2.32	2.2	0.9
copper	0.116	0.162	0.108	0.08	0.05
zinc	3.55	2.29	2.43	4.4	1.5
manganese	0.012	0.017	0.012	0.01	0.02

[1] Majewska *et al*. [2009]. [2] Sales and Oliver-Lyons [1996].

Vitamins

Information about the content of vitamins in ostrich meat is still very limited. There are only some incomplete data on this area and there is a need, therefore, for research aiming at the elaboration of the profile of vitamins of the ostrich meat.

Table 5. Vitamin content of ostrich meat compared to beef and chicken [Karklina and Kivite 2007]

Vitamin (mg/100 g)	Ostrich meat	Beef	Chicken meat
B_1	0.220	0.178	0.140
B_2	0.098	0.087	0.066
B_5	11.45	10.60	8.32
B_6 (mg/kg)	0.225	0.125	1.5
B_{12} (µg/kg)	12.5	0.100	0.05
E (mg/100g)	9.1	6.2	7.5

Levels of vitamins (Tab. 5), especially of group B, were determined in ostrich meat and compared to other species by Lombardi-Boccia *et al*. [2005] and Karklina and Kivite [2007]. Thiamine (vit. B_1) levels were found higher in ostrich than in beef or chicken meat. Riboflavin (vit. B_2) and pantothenic acid (vit. B_5) levels occurred similar in ostrich meat and in beef, while chicken meat was lower in vitamins B_2 and B_5. Also niacin (vit. B_3) content of ostrich meat was found similar to that of beef, while chicken meat contained more of this vitamin. Level of pyridoxine (vit. B_6) in ostrich meat was found twice as high as in beef or in chicken. The marked difference was noticed in the case of cobalamine (vit. B_{12}), the content of which was over 10 times higher than in beef, and even more when compared to chicken. In conclusion, ostrich meat as a source of B group vitamins is generally comparable to beef, with a much higher level of vitamins B_6 and B_{12}.

Another important factor found in meat is vitamin E, considered one of the most effective natural antioxidants. As determined by Karklina and Kivite [2007], content

of vitamin E was highest of ostrich meat (9.1 mg/100 g), followed by chicken meat (7.5 mg/100 g) and beef (6.2 mg/100 g).

Conclusion

Ostrich meat is a niche product characterized by a low intramuscular fat content, favourable fatty acids profile (PUFA/SFA and n-6/n-3 ratios) and high content of iron and vitamin E. The lack of a culinary tradition and relatively high price are reasons for which ostrich meat will not replace beef, pork or chicken as a staple meat in Europe. It may, however, as a high quality product, be a valuable supplement of human diet.

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