ARTÍCULO DE REVISIÓN

Studies on ostrich (*Struthio camelus*) meat – Review

Estudios en carne de avestruz (*Struthio camelus*) -Revisión

Lili Dóra Brassó[1], *István Komlósi*[2]

[1] Doctoral School of Animal Science, University of Debrecen. Debrecen, Böszörményi Street 138.
brasso.dora@agr.unideb.hu

[2] Department of Animal Science, University of Debrecen. Debrecen, Böszörményi Street 138.
komlosi@agr.unideb.hu

Recibido: 04/11/2021 Aceptado:22/12/2021

Como citar este artículo:
Brassó L.D., Komlósi I. (2021). Studies on ostrich (*Struthio camelus*) meat – Review. Revista Ciencias Agropecuarias 7(2): 83-91

Abstract

Globally, ostrich meat is considered a gourmet product, as high-nutritive-value red meat, it fits into the diet. This study aimed to gather the most significant information on ostrich meat quality and characteristics based on the literature. We also made a comparison between an ostrich, beef, poultry, and pork meat. Meat quality is influenced by many genetic, environmental, management, and processing technological factors which can be different in respect of farms and countries. Meat quality measures include color, pH, nutritional composition, technological parameters, and organoleptic value. Ostrich meat has a dark red color similar, to but slightly darker than beef. The pH at 24 hours post mortem (pH_{24}) is moderately acidic, between 5.8 and 6.2. The ostrich meat is rich in protein (18-22 %) similar to pork but richer than poultry and beef. Ostrich has lean meat with low-fat content (1-4.5 %) compared to other domestic species. The ostrich meat is rich in unsaturated fatty acids, also the saturated fatty acid content is lower compared to other species. The technological losses are higher compared to beef and pork. The organoleptic value is average, but regarding flavor and tenderness, we can find statistical differences between the meat parts.

Keywords: ostrich *(Struthio camelus)*, slaughter value, meat quality, meat composition, meat organoleptic characteristics.

Resumen

La carne de avestruz es considerada un producto gourmet a nivel mundial, ya que como carne roja de alto valor nutritivo, encaja en la dieta. El presente estudio tuvo como objetivo recopilar la información más significativa sobre la calidad y las características de la carne de avestruz con base en la literatura. También hicimos una comparación entre la carne de avestruz, res, ave y cerdo. La calidad de la carne está influenciada por muchos factores tecnológicos genéticos, ambientales, de manejo y de procesamiento que pueden ser diferentes con respecto a las granjas y los países. Las medidas de calidad de la carne incluyen color, pH, composición nutricional, parámetros tecnológicos y valor organoléptico. La carne de avestruz tiene un color rojo oscuro similar, pero ligeramente más oscuro que la carne de res. El pH a las 24 horas post mórtem (pH_{24}) es moderadamente ácido, entre 5,8 y 6,2. La carne de avestruz es rica en proteínas (18-22 %) similar a la del cerdo pero más rica que la de las aves y la ternera. El avestruz tiene carne magra con bajo contenido de grasa (1-4,5 %) en comparación con otras especies domésticas. La carne de avestruz es rica en ácidos grasos insaturados, además el contenido de ácidos grasos saturados es menor en comparación con otras especies. Las pérdidas tecnológicas son mayores en comparación con la carne de res y cerdo. El valor organoléptico es medio, pero en cuanto a sabor y terneza podemos encontrar diferencias estadísticas entre las partes de la carne.

Palabras clave: avestruz (*Struthio camelus*), valor de sacrificio, calidad de la carne, composición de la carne, características organolépticas de la carne.

Introduction

Ostrich meat is not a regular meat type found on the market, so it is considered special and due to its high price, it is qualified as a gourmet product. Regarding its rich nutritional value, ostrich meat can be an alternative meat source for other domestic species (poultry, pork, beef) [1]. Primarily, meat is the main product of ostrich all over the world, though the skin, feather, oil, and eggs are also used for different purposes. South Africa leads the global meat market, the second-biggest producer is the USA and the followings are Australia, Spain, Poland, and the Middle East. Export products include fresh meat, hamburger meat, steak, and dry meat [2].

The economically optimal slaughter age of ostriches is 12 to 14 months when the slaughter value (57-58 %), the meat, and skin quality are the best [3,4]. Later, at the age of 18 months, the slaughter value decreases to

51 % [2]. The most valuable meat parts can be found on the thigh and back, the wings are useless from this point of view, and regarding that ostriches have a flat sternum, the breast is also poor in meat [5,6]. In Hungary, the meat parts called a fan, outside strip, medal, oyster, and the tip are considered the most valuable lean meats. Hungary slaughters several hundred kilograms of ostriches annually and exports them mainly to France and live animals are usually transported to Belgium.

The study aims to reveal the most important characteristics of ostrich meat, regarding its nutritional, technological, and organoleptic value. Our object is to make a deeper overview of ostrich meat quality compared to other species, based on the international literature.

Meat color and pH

The color is a quite interesting parameter from the consumers' point of view. The darker the meat is, the more iron content it should contain. But many other factors influence meat colors, such as the species, breed, bird age, sex, nutrition, rearing, meat part, storage time, and pH [7].

The pH of meat has an impact on the drip loss, processability, and shelf life of products [8-10]. In general, ostrich meat has a pH_{24} (at 24 hours post mortem) of between 5.8 and 6.2 but significant differences can be found among meat parts [11,12]. For example, the pH of the inside leg is 6.2 [12], 6.00 for the oyster [2], and 5.81 for the fan [11].

Nutritional composition of ostrich meat

Dry matter content and macronutrients

Meat quality and composition are influenced by the birds' age, sex, nutrition, slaughtering method, storage time, and storage temperature [13].

Ostrich meat can be characterized by 23-26 % of dry matter, 18-22 % of protein, and 1-4.5 % of fat content [2,12,14]. It can be stated that the protein content of ostrich meat is similar to that of pork but higher than beef and poultry [15,16]. The fat content is lower than beef, pork, and even poultry meat [15,16]. The low fat and cholesterol content and high protein content provide a good dietary characteristic for ostrich meat. Hydroxyproline makes up most of the collagen which molecule determines the tenderness of the meat. Meat tenderness is an important organoleptic factor. The average hydroxyproline content of ostrich meat is between 0.01 and 0.09 % [2,17].

Micronutrients

Amino acids

Amino acids play a key role in human nutrition as being the building blocks of body proteins. Essential amino acids can not be produced by our organism, so they should be taken by the diet. Conditional amino acids can not be synthesized in every organism or they are necessary at a certain stage of development. The content of amino acids in ostrich outside strip is 0.15-3.33 g/100 g of meat. This meat part contains the most essential amino acids (8.68 g/100 g of meat), 6.18 g of conditional amino acids, and 4.69 g of non-essential amino acids in 100 g of meat [2].

The table 1 shows amino acid content in ostrich, beef, and chicken determined by different authors. The amino acid composition of beef and chicken was similar. In the case of serine, threonine, glutamine, leucine, alanine, phenylalanine, tyrosine, lysine, and histidine values of beef and chicken were closer to the findings of Brassó et al. [2] on ostrich compared to that of Sales et al. [18].

Table 1.
Amino acid composition of ostrich meat compared to the meat of different species

Amino acid/ Content (%)	Ostrich[1]	Ostrich[2]	Beef[3]	Chicken[4]
	(g/100 g outside strip)	(g/100 g mixed meat)		
ASP	1.94	-	-	-
THR	1.00	0.76	0.92	0.90
SER	0.83	0.59	0.80	0.74
GLU	3.33	2.51	3.15	3.20
PRO	0.88	-	-	-
GLY	0.82	0.82	1.14	1.05
ALA	1.18	1.06	1.26	1.17
CYS	0.15	-	-	-
VAL	1.00	0.97	1.02	1.06
MET	0.54	0.55	0.54	0.59
ILE	0.98	0.92	0.95	1.13
LEU	1.62	1.70	1.56	1.61
TYR	0.74	0.61	0.70	0.72
PHE	0.85	0.94	0.82	0.85
HIS	0.86	0.39	0.72	0.66
LYS	1.84	1.65	1.74	1.82
ARG	1.00	1.36	1.32	1.29

Sources: [1] (2), [2,3,4] (18).

Fatty acids

Unsaturated fatty acids and mainly the n-3 fatty acids are significant nutrients in human nutrition and health [19]. Ostrich meat is rich in unsaturated fatty acids, but we can find differences among muscles. The PUFA content of ostrich meat is 27.54 % [2], while the fan contains 28.79 % and the leg shows 23.78 % [20]. The MUFA content of ostrich meat is 37.37 %, and the total unsaturated fatty acid content of ostrich meat is 64.90 %. The saturated fatty acid content is 35.10 % which is lower compared to the PUFA content [2]. The ratio of n-6/n-3 fatty acids in the meat is between the healthy 1-10:1 range, being 3.91 for the outside strip [2] and 7.55 for the fan [20].

Minerals

The table 2 demonstrates the minerals in a valuable ostrich meat part compared to meat parts of similar characteristics from beef, chicken, and pork.

Table 2 also shows that the Ca, K, Mg, Na, and P content of ostrich outside strip (334.94±7.02, 3455.67±47.123, 265.46±2.92, 516.51±10.91 and 2489.12±18.45 mg/kg) excelled regarding the evaluated minerals. When choosing species and meat parts to make a comparison with ostrich outside strip, we aimed to select domestic species of significant market value and meat parts. Comparing ostrich outside strip to beef tenderloin and sirloin, the Ca, Fe, Mn, and Zn content of ostrich meat was greater than those of beef. The higher Fe content supports the fact that ostrich meat

Table 2.
Minerals in the ostrich outside strip compared to other species

Minerals	Ostrich (mg/kg)	Beef tenderloin/ sirloin (mg/kg)	Chicken thigh (mg/kg)	Pork loin (mg/kg)
Ca[1]	334.94±7.02	28.18±3.30	109±0.60	6.08±0.21
Cu[2]	2.27±0.06	2.00±0.11	0.67-0.80	1.00±0.01
Fe[3]	48.32±0.59	17.40±0.41	30.4-55.4	3.30±0.26
K[4]	3455.67±47.12	4280±37.8	1040.0-3665.0	1266±0.41
Mg[5]	265.46±2.92	272.00±1.50	855.0-995.0	97.8±0.23
Mn[6]	0.43±0.01	0.10±0.06	0.013-4.9	0.00±0.00
Na[7]	516.51±10.91	494±6.00	265-486	47±2.00
P[8]	2489.12±18.45	2245±15.1	132.00-160.00	907.00±0.29
Zn[9]	35.19±0.78	3.49±0.63	1.29-8.38	14.7±0.03

Sources: *Ostrich*: (2), *Beef*: (21)[1,6]; (22)[2]; (23)[3,4,5,7,8,9]; *Chicken*: (24)[1,4,7]; (25)[2,6]; (26)[3]; (27)[3,5,7,8,9], (28)[8,9]; *Pork*: (29)[1-9].

is considered darker red than beef and the meat of all other presented species. In comparison with chicken thigh, the P, Na, Ca, Zn and Cu content was greater or slightly greater than that of chicken thigh. However, the ostrich outside strip composed less than one-third of chicken thigh in Ca and the Fe content was similar in content. In the case of chicken thigh, values were shown as ranges in the literature. On the one hand, some minerals were referred to by different authors. On the other hand, the authors presented data as ranges in the case of chicken thigh. The quantity of all measured minerals in the ostrich outside strip was greater when compared to the results for pork loin [29].

Paleari et al. [30] declare that ostrich meat is richer in phosphorus, manganese, and iron, but poorer in sodium than beef and turkey meat. According to Nitzan et al. [31], hay supplement increases the iron content of meat. Akram et al. [17] declared that the content of P, Zn, and Ca in ostrich meat is 9.02±0.03, 2016.63±0.68, and 1.05±0.02. The iron content of ratites meat is significant and should be highlighted. Horbańczuk and Wierczbicka [32] found iron content to exceed 4 mg/100 g against 0.4-0.6 mg for chicken and 0.1-2 mg for beef expressed in 100 g meat. The content of Ca in emu and ostrich meat is 5.4 -7 mg/100 g, respectively. The content of Mg and Na is 28.8 mg and 43 mg in 100 g of meat, respectively. The Selenium content is 0.04 mg in 100 g of meat.

Shear force and technological specificities

The sheer force indicates the tenderness of the meat. The lower the value is, the more tender the meat is. The more tender meat is required on the market because it tastes better. According to the literature, the shear force of ostrich meat is between 2.90 and 3.42 [2,33].

The drip loss of ostrich meat ranges between 2.85 and 5.88 % [2,11,17], while the drip loss of beef is between 0.71-1.05 % [34] and for pork, it is below 3 % [35]. The cooking loss of ostrich meat is generally between 21.18 and 41.23 % [2,17] and the thawing loss is between 3.88 and 4.48 %. The cooking loss of beef ranges between 23.5 and 25.1 % and the thawing loss is between 0.26 and 3.6 %.

Organoleptic value

Organoleptic characteristics generally include smell, taste, the presence of aftertaste, tenderness, juiciness, and texture. Organoleptic evaluation can be made on either a five-scale or a nine-scale hedonic scale. On a five-scale hedonic scale the smell, taste, the presence of aftertaste, tenderness, juiciness, and texture of ostrich meat got 3.09, 3.14, 1.91, 3.41, 2.69, and 2.84 values [2]. On a nine-level scale, the meat tenderness, juiciness, and flavor scored 7.17±0.06, 7.38±0.12, and 6.80±0.05 [17]. Regarding both scales, os-

trich meat has an average organoleptic value. Differences between meat parts can be found in flavor and tenderness, as the tip and the outside strip are the tastiest and the outside leg is the most tender meat part [2]. The smell and flavor of meat were typical of game animals and more aromatic and sweeter, than the meat of the main domestic species (chicken, pork, beef) as experienced and reported by consumers. Óváry et al. [36] declare that we can differentiate between water-soluble and fat-soluble molecules. The smell is influenced by the former molecules and flavor is mainly determined by the latter ones. The authors claim that tenderness and juiciness have a close relationship, as juicier meat is considered more tender from the consumer's point of view. Hoffman and Mcmillin [37] concluded that ostrich meat is less juicy (3.38 %), compared to pork (4.60), lamb (4.68 %), beef (3.25 %), or chicken (2.89 %). The authors state that the characteristic of ostrich meat as being drier can be attributed to the lower fat content. Al-Khalifa and Al-Nasser [38] noted that ostrich meat is tougher than beef due to its lower collagen content (0.41 % compared to 0.63 %). Aftertaste (fish-like, metallic, unfavorable, which does not resemble a characteristic of meat) was not detected by the panelists [2].

Conclusions

Ostrich meat is a good source of nutrients and minerals, as characterized by high protein, unsaturated fatty acid, Ca, Mg, P, Fe, Zn, and Mn content compared to beef, poultry, and pork. Due to its advantageous dietary composition, it is optimal for athletes, children, and those who have to follow a low-fat diet. The higher pH than usual increases the water-holding capacity, moderates the drip loss, but decreases the shelf-life of meat. From this point of view, the evaluation of the impact of pH and storage time on shelf-life would be interesting and could be suggested.

References

[1] Brassó, D.L., Béri, B., Komlósi, I. Studies on Ostrich (Struthio camelus) – Review. Acta Agr. Debr. 2020; 1: 15-22.

[2] Brassó, D. L., Szabó, V., Komlósi, I., Pusztahelyi, T., Várszegi, Zs. Preliminary Study of Slaughter Value and Meat Characteristics of 18 Months Ostrich Reared in Hungary. *Agric.* 2021; *11*(9): 885.

[3] Pollok, K. D., Hale, D. S., Miller, R. K., Angel, R., Blue-Mclendon, A., Baltmanis, B., Keeton, J. T. Ostrich slaughter and by-product yields. Am. Ost. 1997; 4: 31-35.

[4] Hoffman, L., Botha, S.S., Britz, T. Sensory properties of hot-deboned ostrich (Struthio camelus var. domesticus) Muscularis gastrocnemius, pars interna. Meat Sci. 2006; 72, 734–740.

[5] Mellett, F.D. Ostrich production and products, in: Maree, C. & Casey, N.H. (Eds) Livest. Prod. Sys., Princ. and Pract. (Pretoria, Agri Development Foundation) 1993; 187-194.

[6] Cooper, R.G., Horbańczuk, J.O. The anatomical and physiological characteristics of ostrich (Struthio camelus var.domesticus) meat determine its nutritional importance for man. An. Sci. J. 2002; 73, 167-173.

[7] Naveena, B., Sen, A., Muthukumar, M., Girish, P., Kumar, Y.P., Kiran, M. Carcass characteristics, composition, physico-chemical, microbial and sensory quality of emu meat. Br. Poult. Sci. 2013; 54, 329–336.

[8] Thomas, A.R., Gondoza, H., Hoffman, L., Oosthuizen, V., Naudé, R.J. The roles of the proteasome, and cathepsins B, L, H and D, in ostrich meat tenderisation. Meat Sci. 2004, 67, 113–120.

[9] Fernández-López, J., Jiménez, S., Sayas-Barberá, E., Sendra, E., Pérez-Alvarez, J.A. Quality characteristics of ostrich (Struthio camelus) burgers. Meat Sci. 2006, 73, 295–303.

[10] Li, J., Yang, C., Peng, H., Yin, H., Wang, Y., Hu, Y., Yu, C., Jiang, X., Du, H., Li, Q., et al. Effects of Slaughter Age on Muscle Characteristics and Meat Quality Traits of Da-Heng Meat Type Birds. Animals 2019; 10, 69.

[11] Yucel, B., Taskin, T. Animal Husbandry and Nutrition. Intech Open: London, UK, 2018; 202. ISBN 978-1-78923-420-6.

[12] Poławska, E., Marchewska, J., Cooper, R., Pomianowski, J., Strzałkowska, N., Horbańczuk, J., Sartowska-Żygowska, K. The ostrich meat - An updated review. II. Nutritive value. An. Sci. Pap. Rep. 2011; 29, 89–97.

[13] Sabbioni, A., Superchi, P., Sussi, C., Quarantelli, A., Bracchi, P.G., Pizza, A., Barbieri, G., Zanon, A., Zambini, E.M., Renzi, M. Factors affecting ostrich meat composition and quality. Ann. Fac. Medic. Vet. di Parma 2003; 28: 243-252.

[14] Majewska, D., Jakubowska, M., Ligocki, M., Tarasewicz, Z., Szczerbińska, D., Karamucki, T., Sales, J. Physicochemical characteristics, proximate analysis and mineral composition of ostrich meat as influenced by muscle. Food Chem. 2009; 117, 207–211.

[15] Bodnárné, S.E., Bodnár, K. The main chemical composition parameters of pork (review). Rev. on Agric. and Rural Dev. 2012; 1, 2, 534-540.

[16] Hamed, H., Ma, M., Damaka, A., Elkhedir, A., Jin, G. Effect of Freeze and Re-freeze on Chemical Composition of Beef and Poultry Meat at Storage Period 4.5 Months (SP4.5). J. Food Process. Technol. 2019; 10, 5.

[17] Akram, M.B., Khan, M.I., Khalid, S., Shoaib, M., Hassan, S.A. Quality and Sensory Comparison of Ostrich and Goat Meat. SSR Inst. Int. J. Life Sci. 2019; 5, 2168–2175.

[18] Sales, J. Ostrich meat research: An update. In Proceedings of the World Ostrich Congress, Warsaw, Poland, 26–29 September 2002; 148–160.

[19] Burlingame, B., Nishida, C., Uauy, R., Weisell, R. Fats and Fatty Acids in Human Nutrition: Introduction. Ann. Nutr. Metab. 2009; 55: 5–7.

[20] Horbañczuk, J., Sales, J., Celeda, T., Celeda, A., Ziêba, G., Kawka, P. Cholesterol content and fatty acid composition of ostrich meat as influenced by subspecies. Meat Sci. 1998; 50, 385–388

[21] Somogyi, T., Holló, I., Csapó, J., Anton, I., Holló, G. Mineral content of three several muscles from six cattle genotypes. Akadémiai Kiadó, Budapest, Acta Alim., 2015; 44: 1: 51–59.

[22] Cabrera, M.C., Saadoun, A. An overview of the nutritional value of beef and lamb meat from South America. Meat Science 2014; 98, 435-444.

[23] Czerwonka, M., Szterk, A. The effect of meat cuts and thermal processing on selected mineral concentration in beef from Holstein–Friesian bulls. Meat science 2015; 105, 75-78.

[24] Andersen Maj-Britt, S., Frydenvang, J., Henckel, P., Rinnan, Å. The potential of laser-induced breakdown spectroscopy for industrial at-line monitoring of calcium content in comminuted poultry meat. Food Cont. 2016; 64, 226-233.

[25] Probst, Y. Nutrient Composition of Chicken Meat. Rural Ind. and Dev. Corp. 2009; 1-83.

[26] Probst, Y. Nutrient Composition of Chicken Meat. Rural Ind. and Dev. Corp. 2009; 1-83.

[27] Kokoszyński, D., Bernacki, Z., Stęczny, K., Saleh, M., Wasilewski, P.D., Kotowicz, M., Wasilewski, R., Biegniewska, M., Grzonkowska, K. Comparison of carcass composition, physico-chemical and sensory traits of meat from spent broiler breeders with broilers. European Poult. Sci. 2016; 80.

[28] Bohrer, B. M. Review: Nutrient density and nutritional value of meat products and non-meat foods high in protein. Trends in Food Sci. & Techn. 2017; 65, 103-112.

[29] Halter, J.M. Nutrient composition of selected pork loin cuts. Master of Science, Texas Tech University, Texas, 2012.

[30] Paleari, M.A., Camisasca, S., Beretta, G., Renon, P. Corsico, P., Bertolo, G., Crivelli, G. Ostrich meat: Physico-chemical characteristics and comparison with turkey and bovine meat. Meat Sci. 1998; 48, 205-210.

[31] Nitzan, R., Barkai, D., Nitsan, Z., Serge Yan, L. Intake, growth and carcass characteristics of young ostriches given concentrates with and without pasture. An. Sci. 2002; 74, 71-79.

[32] Horbańczuk, O., Wierzbicka, A. Technological and nutritional properties of ostrich, emu, and rhea meat quality. Vet. Res. 2016; 60, 279-286.

[33] Poławska, E., Lisiak, D., Jozwik, A., Pierzchala, M., Strzalkowska, N., Pomianowski, J., Wójcik, A. The effect of the diet supplementation with linseed and rapeseed on the physico-chemical and sensory characteristics of ostrich meat. An. Sci. Pap. and Rep. 2012; 30, 65-72.

[34] Jama, N., Muchenje, V., Chimonyo, M., Strydom, P., Dzama, K., Raats, J.G. Cooking loss components of beef from Nguni, Bonsmara and Angus steers. Afr. J. Agr. Res. 2008; 3, 416-420.

[35] Żelechowska, E., Przybylski, W., Jaworska, D., Santé-Lhoutellier, V. Technological and sensory pork quality in relation to muscle and drip loss protein profiles. Europ. Food Res. and Techn. 2012; 234, 883-894.

[36] Óváry, M., Holló, G., Ábrahám, Cs., Csapó, J., Seenger, J., Holló, I., Szűcs, E. Az íz szerepe a hús élvezeti értékében (Irodalmi áttekintés). Acta Agr. Kap. 2003; 7, 63-74.

[37] Hoffman, L.C., McMillin, K.W. Improving the meat quality of venison and other exotic game. Improving the Sensory and Nutritional Quality of Fresh Meat, Woodhead Publ. Ser. in Food Sci., Techn. and Nutr. 2009; 447-475.

[38] Al-Khalifa, H; Al-Naser, A. Ostrich meat: Production, quality parameters and nutritional comparison to other types of meats. Appl. Poult. Res. 2014; 23, 784-790.