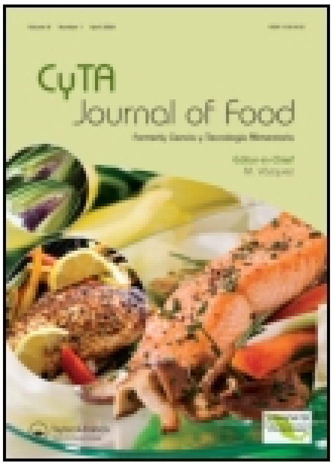

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Meat from alternative species - nutritive and dietetic value, and its benefit for human health - a review

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Meat from alternative species – nutritive and dietetic value, and its benefit for human health – a review

Carne procedente de especies alternativas – valores nutritivos y dietéticos y sus beneficios para la salud humana – uns revisión

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The aim of the current review was to shed light on the nutritional composition of meat from alternative species, including red deer, fallow deer, rabbit, horse, pigeon and ratites (mainly ostrich) by comparison with conventional meat, and their benefits for human health. One of the reasons for such interest was the occurrence, in Europe several years ago, of dioxin, Bovine Encephalopathy and foot-and-mouth disease problems in farm animals. Therefore, consumers began to look for alternative kinds of red meat from other non-traditional species. The nutritional composition of meat from alternative species by comparison with conventional meat is characterised by low levels of fat and cholesterol, relatively high concentrations of *n*-3 and iron. Therefore, the meat from alternative species may supplement the local meat market with good quality products.

Keywords: meat; nutrition; health; alternative species

El objetivo de esta revisión fue arrojar un poco de luz sobre la composición nutricional de carne procedente de especies alternativas, incluyendo ciervo, gamo, conejo, caballo, pichón y ratites (principalmente avestruz), comparándolas con carne convencional, y sobre sus beneficios para la salud en humanos. Una de las razones de este interés fue la aparición en Europa hace algunos años de casos de dioxinas, Encefalopatía Bovina y fiebre aftosa en granjas. Desde entonces, los consumidores empezaron a buscar tipos alternativos de carne roja procedente de especies no tradicionales. La composición nutricional de carne de especies alternativas se caracteriza, en comparación con la carne tradicional, por niveles bajos de grasa y colesterol, y concentraciones relativamente altas de *n*-3 y hierro. Por esto, la carne de especies alternativas puede complementar el mercado local de carne con productos de buena calidad

Palabras claves: carne; nutrición; salud; especies alternativas

Introduction

Over the last years, there has been a growing interest in meat from alternative animal species, such as red deer, fallow deer, rabbit, horses, pigeon and ratites (mainly ostrich) throughout the world (Horbańczuk, 2003; Pomianowski et al., 2009; Ramirez et al., 2005; Volpelli, Valusso, Morgante, Pittia, & Piasentier, 2003). The demand for so-called functional food has greatly increased over the last decade with greater attention paid to the quality of products consumed. Nowadays, modern consumers need to be aware of the nutrient composition of food that is bought for consumption (Poławska, Marchewka, Krzyżewski, Bagnicka, & Wójcik, 2011; Poławska et al., 2011). According to Fasone and Privitera (2002), consumption of meat from alternative species, including ostrich, is mostly performed by the medium-high cultural and professional status person, defined as the ''modern attentive consumer'' aged 41–50 years. Consumers are principally women with a purchasing behaviour essentially related to the safety of the product, nutritive value, intrinsic characteristics and taste. The second reason was the emergence of pathological manifestations in farm animals, e.g. dioxine problems, second outbreak of Bovine Spongiform Encephalitis and foot-and-mouth disease (Cooper & Horbańczuk, 2004; Horbańczuk, Tomasik, & Cooper, 2008). The consumption of conventional meat in Europe at that time was attenuated and consumers began to look for alternative kinds of meat from other non-traditional species (Horbańczuk, 2002).

The alternative species are increasingly gaining interest as livestock animals because of their potential to produce high-quality meat, and production worldwide is increasing as well as the total meat consumption. For example, New Zealand (NZ) produces over one million red deer and fallow deer annually. The volumes of NZ venison export have increased from an average quantity of 17,000 tonnes during the period 2000–2004 to over 19,000 tones in 2008 (Deer Industry New Zealand, 2009).

The market in the world for rabbit meat is also growing. Global consumption of rabbit meat in the world is highest in Malta – 7.5 kg per head, followed by Italy – 5.5 kg and France – 3.0 kg (Hernandez, Pla, Oliver, & Blanco, 2000). On the other hand, in the USA and Canada, the consumption of this meat is very low (0.15–0.20 kg), although rabbit meat is in the same price range as chicken breast and other higher valued chicken parts.

The European horsemeat market consumes some 120,000 mt/year (principally in Italy, France and Belgium). In the 15

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European Community countries, the average individual horse meat consumption is 0.4 kg/year (Martuzzi, Catalano, & Sussi, 2002).

Ostrich production has been expanding around the world from South Africa to other continents, such as America, Australia, Asia and Europe (Cooper, Horbańczuk, & Fujhara, 2004; Horbańczuk et al., 2007; Sales, Horbańczuk, Dingle, Coleman, & Sensik, 1999). Approximately 45–50 million kg of ostrich meat is available worldwide for human consumption on an annual basis. The production is, however, primarily in South Africa ranging from 300–350,000 slaughter birds (China produces 100,000 birds; Horbańczuk, 2004). In Europe, Germany consumes yearly over 5000 tonnes of ostrich meat. In the last few years, the annual export value of selling ostrich meat in Poland exceeded US$ 5.5 m (Horbańczuk et al., 2008). In some European countries, especially in Middle Europe, the price of ostrich meat and venison is relatively high, as compared to chicken fillet or turkey meat, but similar to beef (Cooper, 2007a; Horbańczuk et al., 2008). In turn, rabbit meat is the cheapest among them.

Although a positive change among meat producers to rearing alternative species has recently occurred worldwide, there is still an undervaluation of meat from alternative animals, partially due to old prejudices of some people and due to the wrong impression that this meat is of a lower nutritive value and quality than conventional meat types. Therefore, more information on the nutrient composition of meat from alternative species is required.

This article was written in an attempt to shed light on nutritional composition of meat from alternative species by comparison with conventional red (beef) and white (chicken) meat and its benefits for human health.

Nutritive value

Protein and fat

The chemical composition of farm animals' meat is mostly influenced by feeding system (Wood et al., 2007). The results of the study on animals fed on standard diets were chosen to compare protein and fat content between species. The protein content is almost constant between species (see Table 1). Meat from alternative species, mainly ostrich and venison, has an exceptionally low fat content compared with beef and chicken (Cooper & Horbańczuk, 2002). The favourable fat/protein ratio is a key characteristic of the healthy qualities of ostrich (Paleari et al., 1998) and venison meat. The low intramuscular fat content of such meat is one of the most promising characteristics included in marketing strategies. It may be useful for people trying to keep their weight under control (Cooper, 1999), but on the other hand, the lack of fat causes a loss of sustained juiciness in ostrich meat and venison during chewing (Sales & Horbańczuk, 1998).

Ostrich meat has low calorific values of ca. 390 kJ/100 g meat compared with ca. 517 kJ/100 g for beef and this makes it a useful lean meat. As recommended by World Health Organisation (WHO) (2003), only 30% of daily energy intake by human from diet should come from fat, so ostrich meat and venison seems to be a good source of protein with low calorific value.

Table 1. Protein, fat and cholesterol content (g/kg) of meat of some alternative and traditional species.

Tabla 1. Contenido de proteína, grasa y colesterol (g/kg) de carne de algunas especies alternativas y tradicionales.

Species	Protein (g/kg)	Fat (g/kg)	Cholesterol (g/kg)
Ostrich[1]	216	9–14	0.57
Rhea[2]	–	15–28	0.56–0.82
Red deer[3]	217	20	0.74–0.87
Fallow deer[4]	2.6	6	–
Reindeer[5]	236	27	–
Rabbit[6]	204	40	0.7
Horse[7]	198	66	0.61
Pigeon[8]	217	43	0.44
Beef[9,10,11]	221–281	7–38	0.38–0.67
Chicken[9,12]	213–223	11–43	0.58[13]–0.74[14]

Note: [1]Horbańczuk et al. (1998, 2003); [2]Filgueras et al. (2010); [3]Polak et al., (2008); [4]Volpelli et al. (2003); [5]Wiklund, Finstad, Johansson, Aguiar, & Bechtel (2008); [6]Fasone & Privitera (2002); [7]Badiani, Nanni, Gatta, Tokomelli, & Manfredini (1997); [8]Pomianowski et al. (2009); [9]USDA (2011); [10]Pordomingo, Garcia, & Volpi Lagreca (2012); [11]Pestana et al. (2012); [12]Zelenka, Schneiderova, & Mrkvicova (2006); [13]breast meat only (Honikel & Arneth 1996); [14]leg without skin (Honikel & Arneth 1996).

Cholesterol content

Cholesterol content in the meat of different species is presented in Table 1. It is interesting that, initially, ostrich and venison meat were thought to be almost devoid of cholesterol. Further investigations demonstrated that although the cholesterol content of ostrich meat is lower than in pork, chicken and beef, it is comparable with that in turkey meat (Horbańczuk & Sales, 1998). The cholesterol content in ostrich meat has been reported as 0.57 and 0.6–0.61 g/kg tissue (Horbańczuk et al., 1998). On the other hand, Paleari et al. (1998) refer to a lower cholesterol content of ostrich meat (0.34 g/kg tissue). Pigeon meat also has low cholesterol level (0.44 g/kg tissue; Pomianowski et al., 2009). Other meat from alternative species has a relatively higher cholesterol level: 0.74–0.87 g/kg tissue for venison, 0.7 g/kg tissue for rabbit meat and 0.56–0.82 g/kg tissue for rhea meat (Fasone & Privitera, 2002; Filgueras et al., 2010; Polak, Rajar, Gasperilin, & Zlender, 2008), similar or even higher than the meat from conventional species: 0.58–0.74 g/kg tissue for chicken and 0.38–0.67 g/kg tissue for beef (Honikel & Arneth, 1996; United States Department of Agriculture [USDA], 2011).

Fatty acids composition

Comparative data on the composition of fatty acids are given in Tables 2 and 3. Over many years, the concept of reducing saturated fatty acids (SFA) and increasing polyunsaturated fatty acids (PUFA) intake has been promoted in an attempt to attenuate the risk of coronary heart disease. Current knowledge is that the intake of SFA increases plasma levels of low density lipoprotein, which is decreased by the intake of PUFA (Whitney & Rolfes, 2002). Meat from alternative species has a good profile of fatty acids compared with beef and chicken. The PUFA's content in meat of alternative species clearly achieved higher levels (Table 2) by comparison with chicken (225–310 g/kg total FA), beef (60–67 g/kg total FA) and pork (136–213 g/kg total FA) (Crespo & Esteve-Garcia, 2002; Raj et al., 2010; Sarries, Murray, Moloney, Troy, & Beriain, 2009). Rhea meat has very high content of PUFA, up to ca. 450 g/kg of total FA (Filgueras et al., 2010), as well as fallow deer (512 g/kg of total FA; Volpelli et al., 2003).

Among PUFA, the linoleic acid (LA – 18:2 *n*-6), linolenic acid (ALA – 18:3 *n*-3), arachidonic acid (AA – 20:4 *n*-6) and especially eicosapentaenoic acid (EPA – 20:5 *n*-3), docosapentaenoic acid (DPA – 20:5 *n*-3) and docosahexaenoic acid (DHA – 22:6 *n*-3) are marked as essential in the diet due to their necessity for body metabolic, growth and renewal processes (Riediger, Othman, Suh, & Moghadasian, 2009). High concentrations of LA fatty acid is notably present in rabbit meat, ALA and DHA in ostrich meat, AA and EPA in fallow deer and rhea meat, and DPA and DHA in red deer meat (Table 3). Another important promotional feature is the relatively high total *n*-3 fatty acids content of ostrich meat (80 g/kg total FA; Horbańczuk et al., 1998) which would be advantageous for promoting these products, since the intake of *n*-3 fatty acids lowers the incidence of coronary disease, is essential for growth and development in man throughout the life cycle, and *n*-3 fatty acids have more effective antithrombotic and antiatherogenic properties than the corresponding *n*-6 PUFA (Horbańczuk, 2002). Both *n*-3 and *n*-6 fatty acids produce eicosanoids which are involved in inflammation, platelet aggregation and vasoconstriction. Both groups compete for enzymes, thus the *n*-6/*n*-3 fatty acids ratio seems to be a determining factor for the result of the enzymatic pathways (Simopoulos, 1999, 2002). According to WHO (2003) recommendations, the *n*-6/*n*-3 ratio in human diets should not exceed 4–5:1 (among all presented meats, the best *n*-6/*n*-3 ratio is present in ostrich meat); today that ratio in human diet is often over 10:1 what means that our diets are deficient in *n*-3 fatty acids. The daily intake of PUFA varies among different countries, e.g. in the USA, the average PUFA intake is only 140 mg/day for adults, whilst in Japan it is almost 1600 mg/day due to Japanese fish-eating preferences (Meyer et al., 2003). About 45% of PUFA daily intake came from meat sources, including conventional and alternative species (Howe, Meyer, Record, & Baghurst, 2006).

Table 2. Fatty acid profile (g/kg total FA) of meat of some alternative and traditional species.

Tabla 2. Perfil de ácidos grasos (g/kg ácidos grasos totales) de carne de algunas especies alternativas y tradicionales.

Species	SFA	MUFA	PUFA	*n*-6/*n*-3
Ostrich[1]	377	335	280	2.7
Rhea[2]	299–344	247–260	391–452	6.8–8.1
Fallow deer[3]	348	139	512	4.2
Red deer[4]	356–424	270–372	259–374	2.6–4.8
Rabbit[5]	357	268	374	11.5
Horse[6]	348	466	186	3.6
Pigeon[7]	344	452	204	–
Beef[8]	434–454	436–486	60–67	2.2
Chicken[9]	210–319	288–454	225–310	20.2
Pork[10]	352–407	391–510	136–213	6.1–14.3

Notes: SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; *n*-6/*n*-3, *n*-6 polyunsaturated fatty acids and *n*-3 polyunsaturated fatty acids ratio. [1]Horbańczuk et al. (1998, 2003); [2]Filgueras et al. (2010); [3]Volpelli et al. (2003); [4]Polak et al. (2008); [5]Ramirez et al. (2005); [6]Badiani et al. (1997); [7]Pomianowski et al. (2009); [8]Sarries et al. (2009), Juarez et al. (2011); [9]Crespo & Esteve-Garcia (2002), Strakova, Suchy, Herzig, Hudeckova, & Ivanko (2010); [10]Guillevic, Kouba, & Mourot (2009), Juarez et al. (2010), Raj et al. (2010).

Enhancement of the amounts of *n*-3 acids (ALA, EPA and DHA) and *n*-6 acids (AA) in food from game meat can be beneficial to man. Thus, the high nutritional merit of alternative species must be emphasised through the wide marketing promotion of their meat via special labels and consumer surveys (ALAlami & Cooper, 2007; Cooper, 2007a,b).

With regard to infant feeding/nutrition, PUFA are essential for normal embryonic growth and development. Provision at the early stages of development of DHA and AA are important given the essential usage thereof in neural tissue and deficiency thereof resulting in irreversible functional limitations (Anderson, Neuringer, Lin, & Connor, 2005; Riediger et al., 2009). During pregnancy and lactation, supplementation of the diet by *n*-3 fatty acids, particularly EPA and DHA, results in better development indices of infant development (among others, Decsi, Campoy, & Koletzko, 2005; Dunstan, Simmer, Dixon, & Prescott, 2008). However, a high content of PUFA in meat is associated with the tendency to lower the oxidative stability and other technological aspects of meat products. This issue is very important when meat has to be transported over a long distance and its shelf-life has to be maintained as long as possible, e.g. ostrich and rhea meat. To improve shelf-life thereof on different types of packing and storage, conditions may be applied what suggests the results of the studies (Filgueras, Gatellier, Zambiazi, & Sante-Lhoutellier, 2011).

Minerals and vitamins content

The mineral profiles of the meat of different species are shown in Table 4. Mineral profiles for ostrich, rabbit and horse differ

Table 3. Content (g/kg total FA) of selected fatty acids of meat of some alternative and traditional species.

Tabla 3. Contenido de ácidos grasos seleccionados (g/kg ácidos grasos totales) de carne de algunas especies alternativas y tradicionales.

Species/meat	LA	ALA	AA	EPA	DPA	DHA
Ostrich[1]	151	65	53	5	–	8
Rhea[2]	222	19	120	11	17	< 2.4
Fallow deer[3]	232	31	101	–	–	–
Red deer[4]	96–178	25–41	< 6	< 2.4	18–33	3–8
Rabbit[5]	314	32	21	–	–	–
Horse[6]	120	49	11	–	–	–
Pigeon[7]	160	4	40	–	–	–
Beef[8]	27–30	3.6–8	7.7–12	1.3–5	3.3–7.1	0.7–1.2
Chicken[9]	186–234	13–25	9–17	0.7–1.2	2.5–3.8	1.4–3.2
Pork[10]	96–190	6.5–12	2–13	0.4	1.2	0.6

Notes: LA, linoleic acid (18:2 *n*-6); ALA, linolenic acid (18:3 *n*-3); AA, arachidonic acid (20:4 *n*-6); EPA, eicosapentaenoic acid (20:5 *n*-3); DPA, docosapentaenoic acid (22:5 *n*-3); DHA, docosahexaenoic acid (22:6 *n*-3). [1]Horbańczuk et al. (1998); [2]Filgueras et al. (2010), mean of muscles: M.*Gastrocnemius pars interna* and M.*iliofibularis*; [3]Volpelli et al. (2003); [4]Polak et al. (2008); [5]Ramirez et al. (2005); [6]Badiani et al. (1997); [7]Pomianowski et al. (2009); [8]Sarries et al. (2009), Juarez et al. (2011); [9]Crespo & Esteve-Garcia (2002) , Strakova et al. (2010); [10]Guillevic et al. (2009), Juarez et al. (2010), Raj et al. (2010).

Table 4. Mineral composition (g/kg) of meat of some alternative and traditional species.

Tabla 4. Composición mineral (g/kg) de carne de algunas especies alternativas y tradicionales.

Species	Na (g/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Fe (g/kg)	P (g/kg)	Se (mg/kg)
Ostrich[1]	0.36	2.43	0.055	0.24	0.029	2.16	0.2–0.4
Rhea[2]	0.64	2.57	0.019	0.15	0.032	3.84	0.8
Deer[3]	1.11	3.33	0.07	–	0.040	–	0.10[9]
Rabbit[4]	0.37–0.47	4.28–4.31	0.027–0.093	–	0.011–0.013	2.22–2.34	0.09[9]
Horse[5]	0.74	3.31	0.038	0.22	0.038	2.31	0.10[9]
Beef[6]	0.74	2.99	0.13	0.25	0.026	1.80	0.27[9]
Chicken[7]	0.77	2.29	0.12	0.27	0.009	1.73	0.18[9]
Pork[8]	0.60	2.80	0.118		0.014	2.25	0.10–0.51[10]

Note: [1]Majewska et al. (2009); [2]Ramos et al. (2009); [3]Daniel, Thompson, & Hoover (2000); [4]Parigi Bini, Xiccato, Cinetto, & Dalle Zotte (1992); [5]Badiani et al. (1997); [6]Driskell et al. (2011); [7]Paul & Southgate (1978); [8]Tomovic, Petrovic, Tomovic, Kevresan, & Dzinic (2011); [9]USDA(2011); [10]Mahan et al. (2005).

from beef, chicken and pig meat. Meat from alternative species has lower content of calcium (0.027–0.093 g/kg) than the meat from traditional species (0.011–0.013 g/kg).

Reduced sodium intake has recently been recommended to limit arterial hypertension (Cooper, 1999). Meat, as such, is relatively low in sodium (beef – 0.74 g/kg or chicken – 0.77 g/kg). As ostrich meat has low sodium content (0.36 g/kg) compared with beef and chicken, it would be advantageous for people who have to consume a low sodium diet. Indeed, modern western diets are particularly high in sodium due to its positive influence on shelf-life and taste (ALAlami & Cooper, 2007).

The iron content is especially high in deer, horse and rhea meat compared with beef and chicken meat (Table 4). Meat of alternative species could therefore provide important quantities of iron for anaemic patients as well as for pregnant women (Cooper, 1999). Iron is an essential micronutrient in haematopoiesis and various cellular metabolic reactions and iron in meat is more biologically available than the iron in plant products (Lombardi-Boccia, Martinez Dominguez, & Aguzzi, 2002).

Infant development necessitates a good supply of micronutrients which are involved in bone mineralisation, enzymatic reactions, secretion of hormones and also protection of cells and lipids in biological membranes (Taylor, Gallagher, & McCullough, 2004). Deficiency of minerals in the infant diet can adversely influence in their later life, e.g. rickets due to inadequate calcium and phosphorus (review of Zand et al., 2011). Currently, commercially prepared foods are used in infant feeding and meat from alternative species can also be included in them specially as a good iron source.

Selenium is an essential trace mineral being a part of body's antioxidant defence system. The recent decrease in the dietary intake of selenium in highly developed countries can have negative impacts on humans' health. In humans, selenium deficiency is associated with diseases such as cardiovascular disease, muscular dystrophy, diabetes, arthritis or even cancer (review of Zhang, Xiao, Samaraweera, Lee, & Ahn, 2010). Among meats, particularly good sources of selenium are rhea (0.8 mg/kg; Ramos, Cabrera, del Puerto, & Saadoun, 2009) and ostrich (0.2–0.4 mg/kg; Majewska et al., 2009) meat by comparison with conventional meat species, such as beef (0.27 mg/kg) and chicken (0.18 mg/kg; USDA, 2011). Other meat from alternative species has lower selenium content (0.1 mg/kg) than meat from conventional species.

Vitamins, although required in extremely small quantities, play vital roles in the health of the human. Meat is an excellent source of B vitamins (Allman-Farinelli, 2007). As is shown in Table 5, the vitamin B_3 and amino acids compositions are of similar level in alternative meat species and in the meat of conventional species. Vitamin B_1 content is higher in the ostrich and horse meat (1.6 and 1.8 mg/kg edible portion, respectively) than in the meat from traditional species (less than 0.8 mg/kg edible portion). The vitamin B_2 content in meat from alternative species (1–2 mg/kg edible portion) is similar to that in beef (0.9–1.7 mg/kg edible portion) but not in chicken (0.3 mg/kg edible portion).

Table 5. Vitamin content (mg/kg edible portion) and some amino acids profile (g/kg) of meat of some alternative and traditional species.

Tabla 5. Contenido de vitaminas (mg/kg porción comestible) y perfil de algunos amino ácidos (g/kg) de carne de algunas especies alternativas y tradicionales.

Species	Ostrich[1]	Rabbit[2]	Horse[3]	Beef[4]	Chicken[5]
Vitamins[6]					
Thiamine B_1	1.6	0.5	1.8	0.1–0.8	0.4
Riboflavin B_2	1.0	1.1	2.0	0.9–1.7	0.3
Niacin B_3	45	53	73	50–65	80
Amino acid					
Lysine	16.4	21	15.7	16.9	18.1
Threonine	7.5	10.3	8.4	7.2	9.0
Valine	9.7	13.2	9.6	7.5	10.6
Methionine	5.5	7.7	4.8	2.5	5.9
Isoleucine	9.2	12.3	9.1	7.2	11.3
Leucine	17.1	21	15.2	13.9	16.0
Phenylalanine	9.4	10.2	8.2	6.4	8.4

Note: [1]Karklina & Kirila (2007); [2]Cheeke, Patton, & Templeton (1982); [3]Badiani et al. (1997); [4]Schönfeldt, Naude, & Boshoff (2010); [5]Paul & Southgate (1978); [6]Lombardi-Boccia, Martinez Dominguez, & Aguzzi (2005).

Conclusions

The nutritional composition of meat from alternative species is similar to that of conventional meat, but not in agreement according to fat content, fatty acids profile and content of some minerals.

Meat from alternatives species can be introduced, especially in developed countries, by underlying in marketing strategies its most important advantages, such as low level of fat (especially ostrich meat and venison), low level of cholesterol (pigeon and ostrich meat) and higher concentration of PUFA, namely: higher quantities of LA (especially rabbit meat), ALA and DHA (ostrich meat), and AA (fallow deer and rhea meat), high level of iron (deer, horse and rhea meat); and low level of sodium (ostrich meat). Thus, the meat from alternative species may supplement the local meat market with good quality products.

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