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Ostrich (*Struthio camellus*) Carcass Yield and Meat Quality Parameters

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ABSTRACT

This article aimed at compiling recent studies on the main factors that influence ostrich meat quality and carcass yield. Few articles investigated the effect of subspecies, which generally are not even mentioned. There are important dietary effects, particularly those caused by dietary protein to energy ratio. *Rigor mortis* follow-up studies showed that there are no losses in meat quality when carcasses are hot-deboned. Age at slaughter influences some meat quality traits, such as tenderness and lipid content. Few effects of gender have been observed, and at the same age at slaughter, both male and female present the same meat quality traits.

INTRODUCTION

Ostrich production was initially developed in South Africa for feather production, and later for leather. However, ostriches have been raised on other countries around to world to produce meat. The development of this sector opens the market for ostrich meat, and one of its attractive characteristics is its novelty. This meat is novel not only for consumers, but also for those involved in production – from geneticists and farmers to animal production researchers. The future of ostrich production is based on the idea of providing ostrich meat as an alternative for the consumption of traditional meats.

This article proposed to review some studies carried out in the last few years on the factors that influence ostrich carcass yield and meat quality.

Carcass yield

The optimal age for slaughtering ostriches is 12 to 14 months for the African Black subspecies, and 10 to 12 months for the subspecies Red Neck, Blue Neck, as well as for crossbred ostriches. This is the time when these birds present the best meat, leather, and feather quality (Pollok *et al.,* 1997a).

According to Cooper & Horbanczuk (2002), the effect of subspecies on carcass yield and meat quality has generated controversial opinions, as many studies do not mention which subspecies was evaluated. Although some subspecies effects limiting commercial performance have been detected, meat quality is usually overlooked.

Cold carcass yield is approximately 51%, and there are no differences between males and females when birds have similar age and weight (Balog *et al.,* 2006a). Parts yield may reach up to 42%, depending on genetic background, rearing system, and slaughter techniques (Morris *et al.*, 1995a; Fisher *et al.*, 2000; Nitzan *et al.*, 2002).

As the ostrich is a runner bird, the absence of keel in the sternum and the reduced muscle mass in the wings, providing it with a reduced breast muscle mass, and therefore saleable carcass parts are concentrated in the posterior limbs (Mellet, 1994; Cooper & Horbanczuk, 2002).

Carcass utilization is mainly limited to the back, thighs, and legs. Parts correspond to each muscle that composes these regions. Muscle fascia, which extend from tendons and aponeuroses, allow clear identification of muscle limits (Budaxé, 2003).

Carcass yield still requires further studies, and its improvement will allow the enhancement of ostrich production. There are few studies on this subject, resulting in low or virtually no genetic selection focused on carcass yield and uniformity (Kyle, 1994; Pollok *et al.,* 1997a; Wotton & Sparrey, 2002; Balog *et al.,* 2006a). Therefore, there is little consistency between the results presented by literature and those observed under commercial conditions.

Chemical Composition and Nutritional Value

The introduction of ostrich meat in the current competitive global markets implies in providing guarantees of adequate nutritional level for a specific niche of consumers in some countries (Jones *et al*., 1994). Therefore, strategies for the introduction of new products must focus on the superior quality of the meat, both from the nutritional perspective and in terms of texture, which are determined by the meat chemical composition (Swart, 1981; Jones *et al*., 1994; Sales, 1997).

Several studies were conducted to establish the effect of subspecies on the chemical composition of different muscles, and most of these differences are related to lipid composition, and only recently some research is being carried out to determine amino acid and mineral profiles (Sales & Hayes, 1996). However, these studies have produced contradictory results, particularly as to lipid content (Sales, 1994, 1996; Sales & Hayes, 1996; Sales, 1998; Horbanczuk *et al.,* 1998). In some muscles, such as the *Gastrocnemius pars interna* and *Iliofibularis*, there are no differences in lipid content in the subspecies Red Neck and Blue Neck (Horbanczuk *et al.,* 1998), but these are different from the subspecies African Black (Sales & Hayes, 1996; Horbanczuk *et al.,* 1998).

Intramuscular lipid content in ostrich meat is significantly lower than that observed in mammals and other commercially produced poultry (Paleari *et al.,* 1998). However, low lipid content reduces meat juiciness during mastication, an important characteristic required to introduce the product in the market, as it is related to meat tenderness (Sales & Oliver-Lyons, 1996; Resurreccion, 2002).

Ostrich meat is extremely lean, with low levels of intramuscular fat (2.3% in average), and most of it, approximately 2/3, consists of easily digestible unsaturated fat (Sales, 1996; Paleari *et al.,* 1998; Matosses, 1999). In addition, carcass leanness is also due to the easy separation of fat during processing, as most fat is subcutaneous or located in cavities (Cooper & Horbanczuk, 2002).

Ostrich meat has lower levels of monounsaturated fatty acids (MUFA) and higher levels of polyunsaturated fatty acids (PUFA) as compared to other meats (Horbanczuk *et al.,* 1998; Paleari *et al.,* 1998; Sales, 1998; Raes *et al.,* 2003). However, ostrich meat qualities and benefits are not determined by its high PUFA levels, but rather by its significantly high content of ù3.

Oleic acid (C18:1) is the most abundant fatty acid in ostrich meat, followed by palmitic acid (C16:0) and linoleic acid (C18:2n-6) (Sales, 1994; Horbanczuk *et al.,* 1998; Paleari *et al.,* 1998; Sales, 1998; Hoffman & Fisher, 2001). In the study carried out by Sales (1998) with African Black ostriches, it was observed that individual fatty acid profile varies among muscles. When the SFA:MUFA:PUFA ratio was examined, low levels of saturated fatty acids (SFA) (C16:0, C18:0) and high PUFA percentage were observed in the *Iliofibularis*, whereas high levels of MUFA were found in the *Ambiens* (Sales, 1998). Other authors also detected differences in the fatty acid profile of muscles in Red Neck and Blue Neck ostriches (Horbanczuk *et al.,* 1998).

The chemical composition of meat is influenced by poultry nutrition (Van Schalkwyk *et al.,* 2002; Hoffman & Mellet, 2003; Lanza *et al.,* 2004; Van Schalkwyk *et al.,* 2005), particularly by the energy:protein ratio (Van Schalkwyk *et al.,* 2002), and energy is main responsible for the carcass fatty acid profile (Lanza *et al.,* 2004).

Hoffman & Fisher (2001) and Sabbioni *et al*. (2003) studied the effect of slaughter age on the fatty acid profile of ostrich meat, and found that birds slaughtered at 10-11 months of age presented higher PUFA and lower MUFA levels.

The meat of young animals usually presents lower lipid levels as compared to older animals. However, some researchers (Hoffman & Fisher, 2001; Girolami *et al.,* 2003; Sabbioni *et al.,* 2003) studied lipid content in the carcasses of animals slaughtered at different ages and did not find significant differences as to lipid content, but differences in lipid quality. Older animals presented an increase in saturated to unsaturated fatty acid ratio.

Sabbioni *et al.* (2003) did not find any differences in lipid, cholesterol, and fatty acid content in different ostrich muscles. However, it must be stressed that this study considered only the total percentage of monounsaturated, unsaturated, and polyunsaturated fatty acids.

In literature, results are contradictory as to cholesterol levels in the different ostrich muscles. Whereas Sales (1998) found differences between the muscles *Gastrocnemius pars interna* and *externa* and *Iliofibularis*, Horbanczuk *et al.* (1998) and Girolami *et al.* (2003) did not observe these differences when evaluating the same muscles, as well as no differences among subspecies. Girolami *et al.* (2003) found that cholesterol, differently from fatty acids, does not change according to age at slaughter.

The average mineral level of 1.29% in ostrich meat is optimal from the nutritional point of view, and it is higher than in chicken meat (1.17%) (Balog *et al.,* 2006b). Iron content does not vary among ostrich muscles, but the observed values (12.25mg/100g edible matter, in average) are high as compared to other meats (Sales, 1996; Budaxé, 2003; Balog *et al.,* 2006b). Hay consumption increased total mineral content in ostrich meat as compared to birds fed only concentrate (Nitzan *et al*., 2002).

Protein levels are high in ostrich meat, of about 28% in average, and the most frequent amino acid is creatine (Sales & Hayes, 1996).

Physical Characteristics

Ostrich meat is characterized by high ultimate pH, as measured 24 hours *post-mortem.* Muscle glycogen undergoes glycolysis, producing lactic acid, which promotes rapid pH drop. Meat quality traits related to muscle pH drop *post-mortem* are color, moisture content, and shelf life.

Average values of ultimate pH in ostrich meat allow to classify it as an intermediate meat, between regular (pH<5.8) and high (pH>6.2) pH values higher than 6.2 cause meat to be darker, and decreases its water holding capacity.

Stress is considered as a possible cause of muscle glycogen depletion, and therefore a cause of high meat pH. However, modern slaughter techniques have not been able to minimize this.

Some authors have observed that muscles, such as the *Gastrocnemius pars interna*, *Femorotibialis complex*, *Iliotibialis lateralis*, and *Iliofemoralis*, present a normal pattern of pH decline, whereas in the muscles *Ambiens*, *Iliofibularis*, and *Obturatorius medialis* there is rapid pH decline up to 2 hours *post-mortem*, and then a considerable increase up to its stabilization (Morris *et al.,* 1995b; Sales & Mellett, 1996; Balog *et al.,* 2006a).

The sensorial properties of ostrich meat are attractive to the consumer, and different from those of beef. These traits result from is high ultimate pH and low intramuscular fat content. The muscle *Gastrocnemius pars interna* has been identified by sensorial panels as having a milder flavor as compared to the other muscles, whereas the *Obturatorius medialis* has been considered as the muscle with the strongest flavor. Studies carried out to evaluate the effects of slaughter method, deboning, and bird age did not find differences in meat flavor (Morris *et al.,* 1995a; Sales & Horbanczuk, 1998; Wotton & Sparrey, 2002; Botha, 2005).

Both aroma and flavor depend on the chemical substances present in small concentrations in proteins and particularly in fat. Therefore, as ostrich meat has very low far content, it has a very peculiar flavor, characteristic of this species, being very tasty and mild. According to Paleari *et al.* (1998), its taste is similar lean beef cuts, but it is slightly sweet due to its higher muscle glucose content.

Flavor of different muscles is similar, but it is possible to recognize a stronger flavor in the internal parts, such as *Iliofemoralis* and *Obturatorius medialis*, whereas external parts, such as *Gastrocnemius pars interna* and *externa*, present a mild flavor.

The low lipid content in ostrich meat confers low palatability to sausages and cured product. In addition, ostrich meat resistance to cathepsins B, B+L, and H, as well as to enzymes that act on proteins and improve tenderness, makes it a good candidate to curing processes, particularly when nitrates sodium chloride, and ascorbic acid are used (Van Jaarsveld *et al*., 1998).

Tenderness is the most appreciated ostrich meat characteristic. This is due to its low levels of saturated fat and its collagen to protein ratio, which are part of the connective tissue, and are responsible for meat texture, making it easy to digest and to chew. In addition to the low collagen level (0.44% in average), the arrangement of the muscle fibers, which are transversally oriented, may also explain its tenderness (Balog *et al.,* 2006a).

Due to differences in cooking methods, temperatures, and tools used to obtain objective measures of tenderness, it is difficult to compared results from different studies. There is a wide variation in average tenderness values measured by the Warner-Bratzler Shear Force methods in different ostrich meat parts (2.0 to 4.5). However, independent of the applied methodology, ostrich meat tenderness values are consistently lower than those observed in beef (4.5 to 6.0) a similar to those obtained in poultry meat (1.9 to 3.0) (Lawrie, 1998). Instrumental assessment, used by most authors, indicates that the muscle *Iliofibularis* is the most tender, with lower collagen content, whereas the muscle *Fibularis longus* is the least tender, characterized by a higher concentration of insoluble collagen, whereas the *Iliotibialis* presents intermediate tenderness (Pollok *et al.*, 1997b; Cooper & Horbanczuk, 2002; Girolami *et al.,* 2003).

According to Balog *et al.* (2006a), muscle water content also influences meat tenderness. Ostrich meat does not loose much water during cooking, which ensures better texture (low shearing force) and juiciness. However, long cooking times should be avoided, as they promote water depletion, making the meat drier and less juicy.

Literature studies show that age at slaughter may also change meat tenderness. Sales (1994) and Girolami *et al.* (2003) evaluated ostriches slaughtered at 8, 10, 12, and 14 months of age and did not find effect of age on meat tenderness when using instrumental methods; however, sensorial panels identified differences among ages.

The characteristic red color of ostrich meat can be explained by its high pigment content (22 mg Fe/g). Pigment content varies among different ostrich muscles, with *Flexor cruris lateralis*, *Iliofibularis*, and *Iliotibialis cranialis* presenting more intense color.

Meat color is also influenced by water holding capacity, as higher water content results in higher absorption of radiation and lower reflection, making the meat darker.

Despite being poultry meat, ostrich meat is intensely red, and may be darker, depending on feeding methods and slaughter procedures. Ostriches fed exclusively concentrates present higher luminosity (L*). When studying the effect of dietary energy on meat quality, Nitzan *et al.* (2002) and Lanza *et al.* (2004) observed that dietary energy and protein levels influenced cooking loss, drip loss, and color.

Ultimate pH is a meat characteristic that determines its microbiological quality, and therefore, its shelf life. Ultimate pH values around 6 favor the proliferation of microorganisms, which eventually cause foul odor. Although time improves meat tenderness, it may potentially increase bacterial load, consequently reducing shelf life. According to microbiological quality assays, which establish anaerobe plate cultures with >6log/cm^2 as unacceptable, the quality of vacuum-packed ostrich fillets stored under refrigeration for 14 days was impaired, and unacceptable after 21 days (Pollok *et al.*, 1997a).

Slaughter process must be taken into consideration when evaluating meat quality, particularly stunning and bleeding procedures, as well as evisceration, as the use of air for skin removal has significant influence on meat microbiological quality. It has been shown that the use of ozone for carcass chilling reduces its microbiological load.

Results observed during the development of *rigor mortis* indicate that ostrich carcasses can be hot-deboned with no losses in terms of shelf life or meat quality (Hoffman & Fisher, 2001).

CONCLUSIONS

Today, there is not a stable and significant demand for ostrich meat products, mostly due to lack of knowledge and offer. However, ostrich meat offer has recently increased, and therefore, prices have been reduced, and consumption increased. The trend is to stabilize the demand for this meat, establishing its place in the meat market, as final consumers are increasingly concerned with food nutritional quality.

The sensorial characteristics of ostrich meat, such as texture, juiciness, and a flavor very similar to beef – which a strong cultural habit among Brazilians – are attractive to consumers, in addition to its low fat and cholesterol levels, which characterize it as a healthy food.

Ostrich meat production has grown, allowing the establishment of genetic improvement programs and specific legislation, thereby ensuring higher productivity and promoting its trade.

However, variations in meat quality traits observed in research studies must be taken into account, as well as differences in carcass yield, generally resulting from different slaughter methods and from different analysis methodologies, particularly as to lipid and collagen determination.

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