Short Communication

The effects of dietary energy and protein concentrations on ostrich skin quality

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Abstract

The effects were investigated of energy and protein concentrations (with associated amino acid concentrations) in ostrich diets on leather quality of the skins of 50 ostriches. Energy concentrations were 9.0, 10.5 and 12.0 MJ ME/kg diet and protein concentrations were 130, 150 and 170 g/kg diet. The physical leather parameters that were assessed included tensile strength, elongation, slit tear strength and skin thickness. All traits were assessed in samples taken parallel or perpendicular to the spine in the butt region of the slaughter bird. The raw skin weights of ostriches consuming the diets with energy concentrations of 10.5 and 12.0 MJ ME/kg diet were respectively 19.4 and 21.8% heavier at slaughter than those of their contemporaries on the 9.0 MJ ME/kg DM diet. A corresponding trend was found for trimmed skin weight, and the increase in skin weight with diets higher in energy exceeded 10%. Differences between skin area means only approached significance, with a tendency to increase with an increased energy concentration. Leather thickness taken parallel to the spine was increased by 13% in the diet containing 12 MJ ME/kg diet, compared to the diet containing 9.0 MJ ME/kg. Dietary protein concentrations failed to influence skin weight, skin area or any of the physical leather properties. The skins of male ostriches were thicker than those of females. The study suggested that the lowest levels of energy and protein supplied, were sufficient to prevent a decline in physical leather quality.

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Leather contributes markedly to the revenue of commercial ostrich farmers. Cloete *et al*. (1998) estimated that ostrich leather contributed *ca.* 70% to the total income obtained by ostrich farmers during the mid 1990's. This contribution has declined since, with ostrich meat becoming more popular in Europe after the bovine spongiform encephalopathy (BSE) scare. However, leather is still estimated to contribute more than 50% of the total income of ostrich products, depending on product quality (Hoffman, 2005).

Ostrich leather competes in the exotic leather market, and is marketed as a luxury product (Cooper, 2001; Adams & Revell, 2003). Despite its value, little is known about its physical properties and the influence of various factors on skin traits (Sales, 1999). Skin grading of ostriches depends strongly on physical damage (Meyer *et al*., 2003b). However, industry also requires information on the influence of nutrition on ostrich leather quality. Brand *et al*. (2000) reported that dietary energy concentrations between 9.0 and 12.0 MJ ME/kg feed resulted in an increase in growth rate of slaughter ostriches, while absolute skin area was not significantly improved. Both these traits were independent of protein concentrations between 130 and 170 g/kg diet. These studies have not yet been extended to cover factors associated with leather quality. It is known that the tensile strength of leather is of paramount importance to determine whether it is suitable for usage in specific products. The aim of the present study was therefore to extend the previous work of Brand *et al*. (2000) to determine the effects of dietary treatments on physical quality aspects of ostrich leather.

Animals were obtained from the ostrich flock at the Oudtshoorn Experimental Farm. The background and origin of the population are well described (Bunter & Cloete, 2004). Ninety slaughter ostriches were randomly allocated to 18 groups at roughly four months of age, with five birds per group. These groups were randomly allocated to nine treatments in a 3 X 3 factorial design. The factors were energy concentrations of 9.0, 10.5 and 12.0 MJ ME/kg feed and protein concentrations of 130, 150 and 170 g/kg feed (with associated amino acid concentrations). The physical composition and estimated chemical analyses of the diets are provided in Table 1.

Table 1 Physical composition (expressed as g/kg feed) and calculated chemical analysis (based on table values and expressed as g/kg except energy) of the experimental diets used in the experiment

Energy (MJ ME/kg)		9.0			10.5			12.0	
Protein (g/kg)	130	150	170	130	150	170	130	150	170
Physical composition									
Lucerne	117.8	320.5	523.2	244.7	352.3	59.8	371.6	384.0	396.4
Oat bran	561.5	425.7	289.8	292.3	218.7	144.9	23.1	11.7	0.0
Maize	148.7	90.3	31.8	335.9	284.9	234.0	523.0	479.6	436.1
Soyabean meal	127.7	130.0	13.23	87.1	111.7	136.2	46.5	93.3	140.1
Dicalciumphosphate	12.9	11.7	10.5	11.5	10.3	9.0	10.1	8.8	7.5
Feed lime	20.6	11.7	2.7	18.3	12.5	6.8	15.9	13.4	10.8
Salt	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Premix*	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lysine	1.2	0.6	0.0	1.0	0.5	0.0	0.8	0.4	0.0
Methionine	0.6	0.7	0.7	0.3	0.3	0.4	0.0	0.0	0.0
Chemical composition (Estimated)									
Energy (MJ ME/kg)	9.05	9.03	9.00	10.63	10.65	10.5	12.20	12.10	12.00
Protein	122.0	141.1	160.1	121.0	140.5	160.1	120.0	140.0	160.0
Lysine	6.7	7.9	9.0	6.7	7.9	9.0	6.7	7.9	9.0
Methionine-cystine	3.7	4.3	4.9	3.7	4.3	4.9	3.7	4.3	4.9
Tryptophan	1.7	2.5	3.2	1.7	2.5	3.2	1.7	2.5	3.2
Threonine	4.0	5.4	6.7	4.0	5.4	6.7	4.0	5.4	6.7
Arginine	6.4	7.4	8.4	6.4	7.4	8.4	6.4	7.4	8.4
Crude fibre	196.5	220.8	245.1	165.2	178.8	192.5	133.8	136.9	139.9
Fat	13.7	13.7	13.7	19.4	18.8	18.2	25.1	23.9	22.7
Ca	14.0	13.0	12.0	14.0	13.0	12.0	14.0	13.0	12.0
P	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8

* Commercially available mineral-vitamin premix

The birds received the respective diets *ad libitum*, and were finished to an age of 11 months and an average (± s.d.) live weight of 94 ± 10 kg. The birds were slaughtered according to standard South African procedures (Van Schalkwyk *et al*., 2005). The skins were weighed immediately after skinning, with the subcutaneous fat still attached (raw skin weight). Trimmed skin weight was determined after the subcutaneous fat was removed. Skin area was also determined at this stage. All the skins were then processed to the chrome-crusted stage, using standard procedures (Meyer *et al*., 2003a; b). A leather sample was obtained from the most caudal part of the skin, in the middle of the back. This site is commonly referred to as the butt region in research on leather characteristics (Cloete *et al*., 2004). All samples were tested at the SA Wool Testing Bureau. Samples were assessed for tensile strength, elongation at grain break and slit tear strength on an Instron® machine, as described by Snyman & Jackson-Moss (2000). Tensile strength was defined as the force required to break a dumbbell-shaped leather sample on the Instron®. It was expressed in relation to the diameter at the narrowest part of the dumbbell-shaped piece of leather and the thickness of the sample. Elongation at grain break was determined during the test for tensile strength. It was defined as the percentage stretch of the dumbbell shaped leather sample before it broke. The test for slit tear strength involved a rectangular leather sample with a small slit cut in it. The sample was then pulled apart by a clamp attached to its base and another clamp inserted through the slit. The point at which the slit starts to tear is defined as the slit tear strength. Slit tear strength was expressed in relation to average leather thickness, by including leather thickness as a covariate in the analysis of variance. Leather thickness of each sample was measured in millimetres. Each sample was assessed in duplicate on samples that were cut either parallel to the spine or perpendicular to the spine, respectively (Cloete *et al*., 2004).

Since individual data were recorded, animals were treated as experimental units. The data were analysed as a 3 (energy concentrations) X 3 (protein concentrations) X 2 (gender – male or female) factorial design (Snedecor & Cochran, 1967). Least-squares procedures were used to account for unbalanced data (Harvey, 1990). The least significant difference method was used to discern significant differences between means. These tests were only conducted when it was protected by a significant ($P < 0.05$) F-value in the analysis of variance table (Snedecor & Cochran, 1967). Skin weight, raw skin area and physical leather characteristics were independent of the interaction between energy and protein concentrations and only main effects were tabulated. The effect of gender was mostly unimportant, and noted in the text where significant differences were found. Interactions of gender with protein or energy concentrations were also not significant. Male : female ratios on the respective dietary treatments ranged from 0.60 : 0.40 to 0.43 : 0.57.

The raw skin weights of ostriches consuming the diets with energy concentrations of 10.5 and 12.0 MJ ME/kg DM were respectively 19.4 and 21.8% heavier ($P < 0.05$) at slaughter than those of birds on the 9.0 MJ ME/kg diet (Table 2). Fat deposition increased as energy concentration increased, in agreement with results reported by Brand *et al*. (2004), using energy concentrations ranging between 7.5 and 11.5 MJ ME/kg feed. A corresponding trend was found for trimmed skin weight. The increase in skin weight ($P < 0.05$) with diets higher in energy amounted to 13.8% for the diet containing an energy concentration of 10.5 MJ ME/kg, and to 10.2% for the diet containing 12 MJ ME/kg. These trends accorded with the general pattern followed by growth rate from four to 11 months by the experimental animals (Brand *et al*., 2000). Differences between raw skin area means only approached significance ($P = 0.08$). The absolute difference in skin area between the lowest and the highest energy concentrations amounted to 4.3 dm^2 or 3.2% relative to the 9 MJ ME/kg diet. Given that the means were based on the same data, it is not surprising that the means for raw skin area reported in Table 2 were identical to those reported earlier (Brand *et al*., 2000). Brand *et al*. (2004) subsequently reported that the skin size of 12-month-old slaughter ostriches was increased by 5 dm^2 (from 135 to 140 dm^2) by an increase in dietary energy concentration from 7.5 to 9.5 MJ ME/kg feed. However, a further increase in dietary energy concentration to 11.5 MJ ME/kg feed did not result in a further increase in skin size.

Table 2 Means (± s.e.) for skin weight and skin area for ostriches consuming diets with energy concentrations ranging between 9.0 and 12.0 MJ ME/kg feed (means based on 15 – 18 observations)

Trait	Energy concentration (MJ ME/kg feed)			Significance
	9.0	10.5	12.0	
Crude skin weight (kg)	6.84 ± 0.38 [a]	8.17 ± 0.37 [b]	8.33 ± 0.39 [b]	*
Trimmed skin weight (kg)	4.48 ± 0.13 [a]	5.10 ± 0.13 [b]	4.97 ± 0.14 [b]	**
Skin area (dm^2)	133.8 ± 1.3	136.3 ± 1.3	138.1 ± 1.4	0.08

* – Significant ($P < 0.05$), ** – Significant ($P < 0.01$), [a,b] – Means in rows with different superscripts differ ($P < 0.05$)

All skin attributes were unaffected by concentrations of crude protein of between 130 and 170 g/kg feed in the experimental diets ($P > 0.20$; Table 3). Brand *et al*. (2000) correspondingly did not report any effect of these protein concentrations on skin area. In a later study, skin size of 12-month-old ostriches was once again independent of dietary protein concentration at levels as low as 80 g crude protein/kg feed (Brand *et al*., 2004). Skin area was independent of gender. Male ostriches tended to have heavier skins than females after the fat was trimmed away (4.96 ± 0.11 *vs*. 4.73 ± 0.12 kg; $P < 0.20$), a result consistent with that of Meyer *et al*. (2003a).

The means presented in Tables 4 and 5 for leather strength, elongation and slit tear strength were consistent with earlier results obtained for 11-month-old ostriches (Cloete *et al*., 2004). Corresponding means in the latter study were 19.8 N/mm^2 for leather strength, 27.9% for elongation and 93.6 N/mm for slit tear strength. An increase of 1 mm in leather thickness accounted for an increase of 7.64 ± 2.08 N in slit tear strength in samples taken parallel to the spine. The corresponding increase in slit tear strength in samples taken perpendicular to the spine was 3.81 ± 0.96 N. Leather thickness in this study (1.15 to 1.30 mm) was somewhat thicker compared to means for 11-month-old ostriches in the previous study of Cloete *et al*. (2004), where it averaged 0.95 mm.

Table 3 Means (± s.e.) for skin weight and skin area for ostriches consuming diets with crude protein concentrations ranging between 130 and 170 g/kg feed (means based on 14 – 21 observations)

Trait	Crude protein concentration (g/kg feed)			Significance
	130	150	170	
Crude skin weight (kg)	7.97 ± 0.41	7.79 ± 0.34	7.85 ± 0.39	0.79
Trimmed skin weight (kg)	4.90 ± 0.14	4.79 ± 0.12	4.86 ± 0.14	0.84
Skin area (dm^2)	135.1 ± 1.4	135.3 ± 1.2	137.8 ± 1.4	0.29

Table 4 Means (± s.e.) for physical leather attributes of ostriches consuming diets with energy concentrations ranging between 9.0 and 12.0 MJ ME/kg feed (means based on 15 – 18 observations)

Trait	Energy concentration (MJ ME/kg feed)			Significance
	9.0	10.5	12.0	
Parallel to the spine:				
Tensile strength (N/m^2)	18.1 ± 0.7	18.6 ± 0.6	18.8 ± 0.7	0.44
Elongation (%)	31.8 ± 0.8	31.6 ± 0.8	33.4 ± 0.9	0.28
Slit tear strength (N/mm)	101.2 ± 5.5	106.6 ± 5.4	98.3 ± 5.8	0.48
Thickness (mm)	1.15^{a} ± 0.04	1.17^{ab} ± 0.4	1.30^{b} ± 0.04	*
Perpendicular to the spine:				
Tensile strength (N/m^2)	20.7 ± 1.2	23.4 ± 1.2	20.7 ± 1.3	0.21
Elongation (%)	27.1 ± 0.7	26.3 ± 0.7	26.6 ± 0.7	0.77
Slit tear strength (N/mm)	90.0 ± 3.0	95.7 ± 2.9	94.8 ± 3.1	0.37
Thickness (mm)	1.18 ± 0.05	1.21 ± 0.05	1.18 ± 0.5	0.91

* – Significant (P < 0.05); $^{a\,b}$ – Means with different superscripts differ (P < 0.05) in rows

Table 5 Means (± s.e.) for physical leather attributes of ostriches consuming diets with different protein concentrations ranging between 130 and 170 g/kg feed (means based on 14 – 21 observations)

Trait	Protein concentration (g/kg feed)			Significance
	130	150	170	
Parallel to the spine:				
Tensile strength (N/mm^2)	18.3 ± 0.7	19.4 ± 0.6	17.8 ± 0.7	0.22
Elongation (%)	31.6 ± 0.9	32.7 ± 0.8	32.5 ± 0.9	0.60
Maximum force (N/mm)	105.5 ± 5.8	102.5 ± 4.9	99.4 ± 5.6	0.78
Thickness (mm)	1.24 ± 0.04	1.18 ± 0.4	1.20 ± 0.04	0.54
Perpendicular to the spine:				
Tensile strength (N/mm^2)	20.2 ± 1.3	21.4 ± 1.1	23.3 ± 1.3	0.26
Elongation (%)	25.9 ± 0.8	27.8 ± 0.7	26.2 ± 0.8	0.12
Maximum force (N/mm)	89.1 ± 3.2	96.6 ± 2.7	94.7 ± 3.1	0.21
Thickness (mm)	1.21 ± 0.05	1.16 ± 0.04	1.20 ± 0.5	0.79

Physical leather characteristics were largely independent (P > 0.20) of dietary energy concentrations (Table 4). The exception was leather thickness taken parallel to the spine, which was 13.0 % higher (P < 0.05) on the diet containing 12 MJ ME/kg diet, compared to the diet containing 9 MJ ME/kg diet. This trend was, however, not supported by results obtained when the sample was taken perpendicular to the spine. This result can be considered as coincidental, unless future studies yield the same result. Dietary protein concentrations in this study did not affect any of the physical leather characteristics (P > 0.12; Table 5). No references with regard to the effect of dietary protein and energy concentrations upon leather quality parameters in ostrich skins could be sourced. Further research on this topic is thus indicated.

Male ostriches produced skins with thicker (P < 0.05) leather than females. Means for samples cut parallel to the spine were 1.30 ± 0.03 *vs.* 1.12 ± 0.04 mm for males and female, respectively. Corresponding values for samples cut perpendicular to the spine were 1.27 ± 0.04 *vs.* 1.11 ± 0.04 mm, respectively (P < 0.05). The thicker skin thickness recorded for male ostriches in this study is consistent with results previously reported by Cloete *et al*. (2004) and Engelbrecht *et al*. (2005).

The higher energy diets caused higher levels of fat deposition, resulting in heavier raw skin weights. However, the resultant gain in saleable skin was much smaller, although it still approached significance. At the levels supplied in this study protein concentrations, with associated amino acid compositions, did not affect quantitative leather traits. The qualitative leather traits that were assessed were largely independent of the concentrations of dietary energy or protein tested. These results indicate that the lowest levels of energy and protein supplied in the present study, namely 9.0 MJ ME/kg feed and 130 g/kg feed respectively, did not compromise physical leather quality in slaughter ostriches.

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