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A comparison of different roughages as ingredients in ostrich finishing rations

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The inclusion of poor quality roughage in diets for growing ostriches (*Struthio camelus* var. *domesticus*) at an age when the gut is fully functional will cheapen the diet, provide energy as volatile fatty acids (VFA) and help to sustain growth rate with less likelihood of excess deposition of body fat. In this trial, three sources of roughage were compared in growing ostriches by measuring growth rate, body fat deposition and digestibility of the diets. Thirty two ostriches aged on average 7.4 ± 0.13 months were randomly allocated to four dietary treatments (a control diet (CN) of concentrate and a legume hay, and concentrate with either veld hay (VH), Katambora Rhodes grass hay (RG) or maize stover (MS)) resulting in eight birds being allotted to each treatment to measure growth rate, metatarsal length, fat deposition and digestibility of the diets. The following mean initial liveweight per group were obtained; CN (62.6 ± 12.62 , $n=7$), VH (58.8 ± 12.34 , $n=7$), RG (61.6 ± 12.63 , $n=7$) and MS (58.3 ± 8.14 , $n=7$). There were no treatment differences ($p>0.05$) on growth rate measured by increment of metatarsal length between the four treatments. The quantities of backfat and chestfat, and backfat and abdominal fat thickness, were greater ($p<0.05$) in birds given either veld hay or Rhodes grass hay compared to those on the control or maize stover diet. There was no difference ($p>0.05$) in backfat deposition in between birds fed on the control and maize stover diets. There was no difference ($p>0.05$) in backfat deposition between birds fed on either veld hay or Rhodes grass hay diets. Crude protein appeared to be equally well digested irrespective of the source of the roughage component. The digestibility of the neutral detergent fibre was greater ($p<0.05$) for the maize stover and Katambora Rhodes grass hay diet than for the veld hay and control diet.

Keywords:

Introduction

In commercial production of ostriches for hides and meat, there is a large variation in management practices (Dzama *et al*, 1995). There is a need to develop feeding management practices for rapid growth so that acceptable slaughter weight can be reached at the age of 10-12 months. This can be achieved by feeding all on high concentrate diets in amounts close to maximum intake. Such feeding systems are costly as they make only limited use of the fermentation capacity of the bird's gut, and they supply excessive energy which is likely to lead to the deposition

of surplus body fat. Alternative diets which alleviate these effects need to be examined. The structure of the hind gut of the ostrich, with its large proximal colon and two active caeca, enables fibrous foods to be degraded by microbial fermentation which has characteristics similar to that occurring in the rumen of ruminants (Bezuidenhout, 1986).

Three roughages, all of which are of poor quality, are widely available on Zimbabwean farms. They are maize stover, veld hay and Katambora Rhodes grass hay. The inclusion of each in diets for growing ostriches at an

age when the gut is fully functional would reduce the cost of the diets. In addition, they may provide sufficient energy as volatile fatty acids from the fermentation of fibre to help sustain growth rates without excess fat being deposited. The objective of this study was to compare the three sources of roughage namely maize stover, veld hay and Katambora Rhodes grass hay in diets for growing ostriches by measuring growth rates, body fat deposition and digestibility of the diets.

Materials and methods

Birds and housing

Thirty-two ostriches aged on average 7.4 ± 0.13 months were obtained from four different farms in Zimbabwe. A mixture of twenty males and twelve females were randomly allocated to four dietary treatments to give 5 males and 3 females in each group. Three birds died during the adaptation period and a runt was excluded from the trial. The mean initial liveweight (kg) per group were, Control diet (62.6 ± 12.62 , $n=7$), Veld hay diet (58.8 ± 12.34 , $n=7$), Katambora Rhodes grass hay diet (61.6 ± 12.63 , $n=7$) and Maize stover diet (58.3 ± 8.14 , $n=7$). Four paddocks 75 m long and 12.4 m wide were used to accommodate the birds.

Diets

Three treatment diets, each containing a poor quality roughage (maize stover (MS), veld hay (VH) and Katambora Rhodes grass hay (RG)) were compared to a control (CN) diet. The control diet consisted of seven parts of ostrich grower mash and five parts of silverleaf desmodium (*Desmodium uncinatum*) hay meal. Each of the treatment diets consisted of a specially formulated concentrate (500 g/kg), yellow maize (250 g/kg) and the roughage (250 g/kg). The ingredient composition and diet chemical composition is shown in Tables 1a and b, respectively. The diets were analysed for crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL). The nutrient specifications used to design the concentrate were based on those used for raising ostriches

on a diet of nine parts of ostrich growers mash mixed with one part of veld hay and a poultry layer vitamin and trace element premix. The roughages in all four diets were milled through a 5 mm screen before mixing with the concentrate fraction.

Table 1a: Treatment diet ingredient composition.

Nutrient	Level (kg/t)
Soya bean meal	50.50
Wheat feed	407.00
Yellow Maize	250.00
Roughage (Veld hay, Katambora Rhodes grass and Maize stover)	250.00
Bone meal	18.50
Limestone Flour	16.00
Salt (fine)	3.50
Lysine	1.25
Methionine	1.25
RX10 (mineral mix)	2.00
Control diet ingredient composition	
Meat and Bone Meal	40.00
33% Sunflower Meal	70.00
Wheat Feed	477.00
Hominy Chop	270.00
Molasses	60.00
Lucerne meal	56.00
Limestone Flour EWM	18.00
Salt (fine)	4.00
Lysine	0.80
MHA Methionine	0.60
RX 36	4.00

Management

The birds were fed 2 kg/head/day throughout the trial period, given twice daily in equal amounts. Water was available at all times. The birds were weighed and condition scored at the beginning and thereafter fortnightly with condition scoring at monthly intervals. The length of the metatarsal was measured at the beginning and end of the trial. The birds were observed to see whether any display of dominance interfered with the feeding of the facile birds. The birds remained on the same dietary treatment until they reached slaughter weight. The trial lasted for six months after which the birds were slaughtered and body composition assessed. Body fat deposition was assessed

Table 1b: Chemical composition of the experimental diets containing four different roughages.

Diet	Chemical constituent (%)			
	CP	NDF	ADF	ADL
Control	15.9±0.04	49.7±0.06	32.2±0.04	11.3±0.05
Veld Hay	13.8±0.04	47.4±0.06	28.2±0.04	10.2±0.05
Rhodes Grass	15.1±0.04	50.6±0.06	15.9±0.04	5.1±0.05
Maize Stover	15.8±0.04	45.6±0.06	15.3±0.04	6.4±0.05
n	8	8	8	8

by measuring the thickness of the abdominal wall using a veneer linear calliper's at two different points; between the legs (ABFTL) and towards the tail end (ABFTT), and by removing with an ordinary knife and weighing the fat collected from two principal depots of fat, i.e. the back and chest.

Digestibility trial

Five of the heaviest birds from each treatment were selected for use in the digestibility trials. Nutrient and dry matter (DM) digestibilities of the diets were measured during weeks 17 and 18 by using chromic oxide as a marker to measure faecal output. For 14 days each bird was force-fed one gram of chromic oxide made up in a bolus of the diet daily. In the last six of the 14 days, faecal samples were collected from each bird using the grab sampling method (Kobt and Luckey, 1972) in the morning and afternoon. The samples were kept refrigerated at 0°C in air tight plastic bags until required.

Faecal sample preparation

Faecal samples were dried in the oven at 60°C for 48 hours before the chemical analysis. The morning and afternoon excreta samples were combined on an equal weight basis to make one collection for the day. The pooled excreta of each bird for each day over the collection period were combined to make one composite sample for chemical analyses. Representative samples of both faecal and diet samples were dried at 105°C overnight in a convection oven for dry matter (DM) determination, and the remainder was ground (1 mm sieve) for further analyses.

Chemical analyses

Neutral detergent fibre or cell wall contents was determined according to Van Soest and Wine (1967) and acid detergent fibre and acid detergent lignin were determined according to Van Soest and Wine (1968). Chromium in the faecal samples was determined according to Stevenson and de Langen (1960). Crude protein was determined using the Kjeldhal procedure.

Statistical Analysis

The growth rate of each bird was obtained by regressing the weights against time and using the slope to give the average rate of growth during the trial. The results were subjected to analysis of variance using the General Linear Model Procedure of SAS (1990) to test the effect of sex and dietary treatments on growth, body composition and digestibility.

Results

Behaviour

Frequent periods of observation during the trial showed that there was very little or negligent dominance or aggression by any one bird and that all birds had access to feed when it was available.

Growth

The mean growth rates and metatarsal length of the birds in each of the four treatments are shown in Table 2. There were no differences ($p>0.05$) between dietary treatments in growth rate of the birds. Sex of the birds had no effect on growth rate. The increases in metatarsal length were small for all four treatments and not different ($p>0.05$) between treatments.

Table 2: Mean growth rates (g/d) and mean increases of metatarsal length (mm) of ostriches given diets containing four different roughages. Values are means \pm SE.

Measurement	Control	Diet		
		Veld Hay	Rhodes Grass	Maize Stover
Daily gain(g/d)	170.7 \pm 23.20	228.5 \pm 25.00	230.6 \pm 23.20	205.4 \pm 23.10
n	7	6	7	7
Metatarsal length (mm)	76.7 \pm 6.01	72.5 \pm 7.90	66.7 \pm 6.52	69.3 \pm 6.60
n	7	4	6	6

Body composition

The amount of fat in the birds at slaughter as given by the amount of back fat and of chest fat, and by the thickness of the abdominal wall and the backfat is given in Table 3. The four diets fed had either a great effect ($p<0.01$) on fat deposited on the chest and back as well as on backfat thickness or an effect ($p<0.05$) on the two fat measurements taken along the abdomen. There was a difference ($p<0.05$) in backfat deposition between birds on either the veld hay or Katambora Rhodes grass hay and those on the control diet, but there was no significant difference ($p>0.05$) in backfat deposition in birds given the control and maize stover diets even though this difference was numerically large.

For all five measurements of fatness, birds' given either veld hay or Rhodes grass hay were considerably fatter ($p<0.05$) than the control birds or those given maize stover. The differences were either significant or

highly significant for weights of back fat and chest fat and thickness of back fat.

Digestibility

The nutrient digestibility of the experimental diets is shown in Table 4. There was a significant difference in CP digestibility among the diets ($p<0.05$). Maize stover diet had the highest digestibility of crude protein which differed ($p<0.05$) from that of the other three diets. There was no difference ($p>0.05$) in crude protein digestibility of CN, VH and RG diets. There were no differences ($p>0.05$) in the digestibilities of cell wall components (NDF) of the control and veld hay diets as well as between Rhodes grass hay and maize stover diets. The digestibility of acid detergent fibre in the Rhodes grass hay diet was less ($p<0.05$) than that of other three experimental diets. There were no differences in acid detergent fibre digestibilities between the control, veld hay and maize stover diets.

Table 3: Weight (g) of back fat (BFW), chest fat (CFW), thickness (mm) of backfat (BFT), thickness (mm) of abdominal wall fat between the legs (ABFTL) and of the abdominal wall fat towards the tail end (ABFTT) in ostriches given diets containing four different roughages. Values are means \pm SE.

	Control	Diet		
		Veld Hay	Rhodes Grass	Maize Stover
BFW	349.1 ^a \pm 257.0	1364.3 ^{b,c} \pm 304.4	2212.9 ^b \pm 315.8	729.2 ^{a,c} \pm 276.6
CFW	347.5 ^a \pm 176.2	854.3 ^a \pm 208.7	1788.0 \pm 216.5	691.7 ^a \pm 189.6
BFT	5.1 ^a \pm 3.4	18.8 ^{b,c} \pm 4.5	27.3 ^c \pm 4.2	14.5 ^{a,b} \pm 4.1
ABFTL	15.8 ^a \pm 5.2	39.8 ^b \pm 5.6	41.4 ^b \pm 5.7	29.5 ^{a,b} \pm 5.6
ABFTT	22.7 ^a \pm 6.4	47.3 ^b \pm 6.9	55.1 ^b \pm 7.0	37.7 ^{a,b} \pm 6.9
n	7	6	6	6

^{a-c}Denote significance of differences in rows ($p<0.05$)

Dry matter digestibilities highly depended ($p < 0.01$) on diet type. The maize stover diet had the highest and different ($p < 0.05$) digestibility from the other three diets. There were no significant differences in dry matter digestibilities between the control and veld hay diets as well as between the veld hay and Katambora Rhodes grass hay diet ($p < 0.05$).

Discussion

Ostriches at least initially avoid unfamiliar feeds in terms of contents or physical form. All ostriches adapted well to the four fibrous diets. Birds did not select against the roughage in the diet probably for two reasons. The roughages were coarsely ground and well mixed with other ingredients and the

Growth rates

Birds in the three treatment groups (Veld hay, Katambora Rhodes grass and maize stover) grew as well as those on the control diet as shown in Table 2. The mean live mass gain per day resulted in acceptable slaughter weights. The inclusion of the poor quality roughages at a level of 25 percent appears to be acceptable and may be recommended and such a recommendation is supported by the values obtained for the digestibility coefficients which tended to be higher for the three roughage diets than for the control diet. This difference is probably because the control diet contained less concentrate but more roughage (42 percent silverleaf hay) which was of poor quality. However birds on this diet grew at an appreciable rate which indicates that a higher percentage of roughage may be used.

Table 4. Nutrient digestibility of the experimental diets containing different roughages given to ostriches. Values are means \pm SE.

Digestibility (%)	Diet			
	Control	Veld Hay	Rhodes Grass	Maize Stover
DM	65.9 ^a \pm 1.30	69.7 ^{a,b} \pm 1.23	73.2 ^b \pm 1.20	80.3 \pm 1.21
CP	92.3 ^a \pm 0.61	91.7 ^a \pm 0.50	93.0 ^a \pm 0.51	95.0 \pm 0.50
NDF	59.8 ^a \pm 1.20	61.2 ^a \pm 1.11	71.4 \pm 1.10	76.4 \pm 1.12
ADF	49.2 ^a \pm 3.30	56.7 ^a \pm 3.00	33.6 \pm 3.01	50.5 ^a \pm 3.02
ADL	52.9 ^a \pm 3.10	63.8 ^b \pm 2.91	49.8 ^a \pm 2.83	68.6 ^b \pm 2.90
n	5	5	5	5

^{a-b} Denote significance of differences in rows ($p < 0.05$)

birds were given restricted amounts of the diets which were less than their voluntary intakes. In addition there was no evidence that the inclusion rate of 25 percent poor quality roughage adversely affected the acceptability of the diet or reduced food intake. Feed intake was similar for the four dietary treatments ruling out the possibilities of this as a factor accounting for differences in growth rates. Feed intakes obtained compared reasonably with those of Swart and Kemm (1985) of an average daily feed intake of 2209g / bird in a study on performance of growing ostriches within the 60–110kg weight range.

Digestibility trial

In ratites, there is a limited amount of information available in the literature relating to digestibility of nutrients (Angel, 1993). With the ostrich being a herbivore and hind gut fermenter, a considerable attempt has been directed at fibre digestibility. Swart *et al.*, (1993) found adult ostriches to digest 63 percent NDF (cell wall constituents) in a high fibre diet. Herd and Dawson (1984) found an NDF digestibility of 45 percent in emus fed a high fibre diet (36 percent NDF). The NDF digestibility value reported by Swart *et al.*, (1993) was lower than the result obtained for RG and MS but higher than that obtained for

CN and VH in this experiment. MS had the highest NDF digestibility at 76.4 percent. In comparison fibre digestibility of the chicken ranges from 6 to 9 percent (Swart, 1988).

It was anticipated that the determination of acid detergent lignin would provide an internal marker, which along with the external marker chromic oxide, would allow individual feed intakes and digestibilities to be calculated. The digestibility of the acid detergent lignin was appreciable in all diets, which indicates some change in this fibre constituent during digestion. Maize stover diet was the most digestible of all the diets except for acid detergent fibre fraction for which a higher value was found for veld hay. Use of chromic oxide showed large differences in faecal excretion of dry matter between birds in the same group, which indicated differences between individuals in feed intake. Some allowance was made for these differences and derived but approximate digestibility values were obtained.

The digestibility values indicate that a certain amount of fermentation occurred in the hind gut of the ostrich which resulted in the roughage being partly digested. Swart (1988) in an elaborate series of experiments on the growth and metabolism of ostriches confirmed the high rate of VFA production in the hind gut of the ostrich. The metabolisable and digestible energy values given for maize when fed to ruminants, pigs and poultry are very high (McDonald *et al*, 1992) which indicates that maize has a high digestibility of about 90 percent in these species. The ostrich tends to have a digestive system which can digest concentrates like cereal grains with similar efficiency. Therefore it was assumed that the ostrich is able to digest 90 percent of the maize and of the concentrate part of the diet, the calculated dry matter digestibility values for the silverleaf desmodium, veld and Rhodes grass hays and for maize stover are approximately 33, 8, 20 and 48 percent respectively. However this assumption does not take account of any interaction between this part of the diet and the roughage component since there is no evidence in the literature which supports

this for ostriches. Crude protein appeared to be equally well digested irrespective of the source of the roughage component. The high values of protein digestibility must be treated with caution because they were indirectly determined. However, coprophagy in the birds may lead to effective digestion.

Body composition

The greater quantities of fat in birds given veld hay and Katambora Rhodes grass hay suggests more channelling of metabolisable energy (ME) in these diets towards fat energy. Birds on the maize stover diet contained less fat than those given either veld hay or Katambora Rhodes grass hay diet which had lower digestibilities and contained a little less protein. This anomaly may be explained by a different pattern of fermentation in the hind gut since different diets may result in different proportions of the individual volatile fatty acids. It was anticipated that the inclusion of a poor quality roughage in the diet would reduce the deposition of body fat when compared with that of the birds given the control diet. Such an effect was not seen, in fact a reverse trend was apparent. Swart and Kemm (1985), cited by Swart (1988), reported deposition of excessive amounts of subcutaneous fat in growing ostriches even when they were fed diets high in protein and low in energy. Both from a leather quality and a productivity standpoint, ostriches should not be carrying excessive fat at slaughter. The hide from fat birds comes off the bird with a thick layer of fat. Removal of this fat is time consuming (increases labour costs) and may result in nicks and cuts if not done carefully. Salt and bactericide treatment which prevent decomposition and bacterial growth will not penetrate through the fat, and will potentially result in poor quality hide reaching the tannery. Fat deposition in the bird's body requires more feed than the deposition of muscle. This presents a loss to the producer. Health conscious markets that have developed in recent years requires the characteristic of low fat and high protein in ostrich meat.

The results obtained in this study indicate that the inclusion of poor quality roughages

which varied in fibre content may be recommended for the second phase of growth in ostriches. The high NDF digestibilities obtained in this study show that adult ostriches are capable of extensive fibre digestion and thus utilising diets with high fibre levels. It may be appropriate in future work to examine the effects of increasing the levels of poor quality roughages in diets for growing ostriches during the second phase of growth. A diet of 42 percent roughage (CN) is the one recommended to farmers and the assumption made is that silverleaf desmodium is a legume of high quality i.e. has a high content of crude protein.

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REFERENCES

- ANGEL, C.R. 1993 Age changes in digestibility of nutrients in ostriches and nutrient profiles of ostrich and emu eggs as indicators of nutritional status of the hen and chick. *Australian Ostrich Association Conference*.
- BEZUIDENHOUT, A.J. 1986 The topography of the thoraco-abdominal viscera in the Ostrich (*Struthio camelus*). *Onderstepoort Journal of Veterinary Research* **53**: 111–117.
- DZAMA, K., MUNGATE, F. AND TOPPS, J.H. 1995 Ostrich production in Zimbabwe: Summary of survey results. *Journal of Applied Science in Southern Africa* **14**: 142–147.
- HERD, R.M. AND DAWSON, T.J. 1984 Fibre digestion in the emu, *Dromaius novaehollandiae*, a large bird with a simple gut and high rates of passage. *Physiology of Zoology* **57**: 70–84.
- KOTB, A.K. AND LUCKEY, T.D. 1972 Markers in nutrition. *Nutrition Abstracts and Reviews* **42**: 813–845.
- MCDONALD, P., EDWARDS, R. A. AND GREENHALGH, J.F.D. 1992 *Animal Nutrition*. (4th ed.), Longman Scientific and Technical. Essex, England.
- STEVENSON, A.E. AND DE LANGEN, H. 1960 Measurement of food intake by grazing cattle and sheep. VII. Modified wet digestion method for determination of chromic oxide in faeces. *New Zealand Journal of Agricultural Science* **3**: 314–319.
- SAS. 1990 SAS User's Guide: Statistics. SAS Institute., Cary, NC., USA.
- SWART, D. 1988 Studies on the hatching, growth and energy metabolism of ostrich chicks. PhD. Thesis. University of Stellenbosch, Republic of South Africa.
- SWART, D., MACKIE, R.I. AND HAYES, J.P. 1993 Fermentative digestion in the ostrich (*Struthio camelus* var. *domesticus*) a large avian species that utilizes cellulose. *South African Journal of Animal Science* **23**: 127–135.
- VAN SOEST, P.J. AND WINE, R.H. 1967 Uses of detergents in the analysis of fibrous feeds. IV. The determination of plant cell wall constituents. *Journal of Association of Official Analytical Chemists* **51**: 58.
- VAN SOEST, P.J. AND WINE, R.H. 1968 Determination of lignin and cellulose in acid detergent fibre with permanganate. *Journal of Association of Official Analytical Chemists* **51**: 780.



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