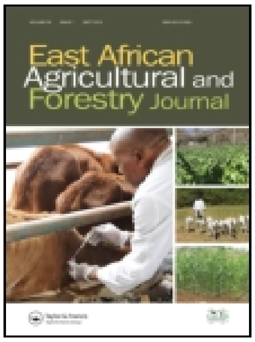

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EFFECT OF POULTRY WASTE AND GRAIN SORGHUM SUPPLEMENTS ON UTILISATION OF RANGE HAY BY SMALL EAST AFRICAN GOATS

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The main constraints to livestock production throughout the world include inadequate feed supply, animal health, genotype and livestock management. The inability of livestock producers in the tropics and sub-tropics to produce adequate and quality livestock feed is the most widespread constraint. Forage quality declines rapidly with advance in maturity, drastically reducing the effective utilisation period by ruminants. On the other hand, the low quality is accompanied by low nutrient concentration, resulting in low intake of digestible nutrients such as protein, energy and minerals. Dry plant residues constitute the only forage available to grazing animals during dry seasons. Such forages provide sub-maintenance rations and animals solely on such forages inevitably lose weight. To minimise such weight losses, interventions such as strategic supplementation of animal diets, chemical treatment of dry forages or harvesting/storage of the forage at the time of maximum nutrient content, must be integrated into grazing systems. Strategic supplementation will necessitate partial or total utilisation of non-conventional feed resources that are cheap and least competitive to replace the costly conventional supplements that are normally required for human consumption.

Although extensive research has been done on natural forages and on the attendant rangeland grazing systems with the aim of maximising their utilization in livestock production, there is paucity of information on the role of non-conventional sources of protein and energy in the nutrition of free ranging ruminants. The primary objective of this study was therefore to determine the effect of increasing levels of poultry waste and grain sorghum on intake, digestibility and performance of Small East African Goats fed low-quality range forage.

MATERIALS AND METHODS

A feeding study was conducted at the University of Nairobi, Kabete Field Station using 28 growing Small East African Goats (14-16 kg body weight) raised in the semi-arid rangelands of south east Kenya. The animals were randomly assigned to individual feeding pens (1.3 x 1 m) fitted with individual feed boxes. The pens were inside a draft-free animal shed. Before confinement, all the animals were treated against external and internal parasites every 5 weeks during the study .

Four diets were fed in a completely randomised design. The diets consisted of range hay, grain sorghum and poultry waste mixed as shown (Table I). The hay was chopped using a chaff cutter to facilitate handling and minimise selection by animals during feeding. Poultry waste was collected by placing polythene sheets under several layers' chicken cages, and allowing waste to accumulate for 4 days. The material was then sun-dried for 4 days, ground through a 5-mm hammer mill and stored in a dry place until feeding time when it was incorporated into the various rations. Sorghum (*Sorghum vulgare*) grains obtained from local shops was also ground through a 3-mm hammer mill and incorporated into the diets.

All the animals received 170 g/d of the supplemental diets and *ad libitum* quantities of hay. Feeding was done twice per day at 0800 and 1300 h. At 0800 h, animals were offered hay and 170 g of the supplement while at 1300 h, they only received additional hay. The feeding regime aimed at about 20% refusal (orts). Mineral salt lick and water were offered *ad libitum.*

The feeding study lasted 15 weeks. The first 3 weeks comprised the adjustment period during which the animals were allowed to adapt to their environment and diet. All animals were on hay only. Daily hay intake was determined by subtracting the amount offered from the amount refused. Samples of refusals and fresh batches of hay were collected separately, thoroughly mixed and sub-sampled for chemical analyses. Animal liveweights were measured every 2 weeks.

During the 8 weeks, 3 animals from each treatment were selected at random and placed in standard

TABLE I – COMPOSITION OF SUPPLEMENTARY DIETS AS FED TO GOATS

Feed ingredient	Treatment			
	A	B	C	D
Poultry waste (Pw %)	0	29	59	88
Grain sorghum (Gs %)	88	59	29	0
Molasses (M %)	12	12	12	12
	100	100	100	100

individual metabolism crates for digestibility and balance determinations. The animals were allowed 7 days to adjust to the crates. Data was collected for 7 days. During each feeding period, a sample of the test-diet was taken and stored for chemical analyses. Daily faecal and urine output from each animal was collected, weighed and representative samples of 10% (w/w) and 15% (v/v), respectively recorded. A small quantity of 1M H_2SO_4 was added to the urine collection buckets to minimise nitrogen losses through volatization. Faecal samples were collected in plastic bags and urine samples in plastic bottles and stored in a deep freezer for chemical analyses. A metabolism trial on hay alone was included in the study.

Blood urea nitrogen (BUN) was measured as an indicator of both protein intake and the nutritional status of the animals. For this, three animals per treatment were randomly selected. Blood sampling was done every 4 weeks. During each sampling, 5 ml of blood were taken from the left jugular vein of each animal. The samples were placed in glass bottles, allowed to clot and analysed for serum. Blood urea nitrogen content was determined using a spectrophotometer set at 340 nanometres (nm).

Faecal and diet samples were oven-dried at 60°C overnight and then ground through a 1-mm Wiley Mill. Dry matter, ash and nitrogen were determined according to AOAC (1980) procedures, while acid detergent fibre (ADF) and neutral detergent fibre (NDF) were determined by the procedures of Goering and Van Soest (1975). Fecal nitrogen was determined using weight samples. Frozen urine samples were thawed, thoroughly mixed and then analysed for nitrogen using the macro-kjedahl method (AOAC, 1980). Gross energy values of the diets were determined using adiabatic bomb calorimeter while minerals were assayed according to AOAC (1980) procedures. All samples were analysed in duplicates.

One way analysis of variance was done on treatment means for intake, weight gain, nitrogen balance and digestibility coefficients of the various chemical components of the treatments (Steel and Torrie, 1980). Mean separation tests were done using Duncan's Multiple Range test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

On the basis of crude protein content alone, the hay used in this study can be rated as low quality (Table II). About 7% crude protein content is the minimum level below which ruminants substituting on natural forages are not able to met their DM intake digestible requirement. Leng (1980) described roughages with dry matter and CP levels below 55 and 8%, respectively, as low quality and unable to meet the nutrient requirements of cattle and sheep. Such limitations are attributed to low intake and digestibility of the feed. The hay had high lignin and NDF content. Lignin is highly indigestible and acts as an encrusting substance which prevents rumen micro-organisms from attacking digestible feed components

To increase utilisation of poorly digestible feeds, ruminants require adequate ammonia nitrogen supply to the rumen which, enhances microbial population growth and activity. This is associated with increased rumen fermentative capacity and nutrient availability to the animals. The supplementary diets had CP levels above the critical minimum for small ruminants and low levels of lignin and thus, were expected to make up for the nitrogen deficiencies of the hay.

Dry matter intake (g/d) and liveweight gains (g/d) of the animals are presented in Table III. Although only diet C had significant ($P<0.05$) effect on DM intakes of the animals, all four diets exhibited a general increase in DM intakes with increasing levels of poultry waste and decreasing levels of grain sorghum in the diets.

TABLE II – CHEMICAL COMPOSITION (ON DM BASIS) OF HAY AND GRAIN SORGHUM/POULTRY WASTE DIETS FED TO THE GOATS

Chemical component	Diet				
	A	B	C	D	Hay
DM	86.7	86.3	87.0	86.9	91.7
CP	10.2	12.9	14.4	15.8	4.2
ASH	2.3	7.8	15.6	21.5	8.6
NDF	9.0	18.0	28.0	46.4	71.9
ADF	6.8	13.1	16.4	22.8	38.4
ADL	1.2	1.7	2.2	2.7	8.4
Ca	0.15	1.62	3.59	4.31	0.39
P	0.21	0.31	0.52	0.67	0.08
K	0.62	0.87	1.20	1.61	0.63
Mg		0.51	0.79	0.85	0.14
			PPm		
Fe	0.25	581	1119	1187	403
Zn	24	104	164	178	32
Cu	5	10	17	25	5
Na	88	367	568	722	41
		Kcal/g			
GE	4.658	4.282	4.017	3.940	3.792

Liveweight gains per day were also not significantly ($P<0.05$) affected by treatments. Increase in DM intake with increasing levels of poultry waste in the diets can be attributed to the corresponding increase in CP content of the diets resulting in an increase in nitrogen intake by the animals. Elliot and Topps (1963) observed that increasing levels of CP (from 4 to 10%) in low protein diets resulted in concurrent increase in DM intake by sheep. Ernst *et al.* (1975) reported increased DM intake of low quality hay when urea supplement was included in the diet of steers. Other studies (Elliot 1967; Fick *et al.*, 1973; Church and Santos, 1981; Delcurto *et al.*, 1990) have shown that DM intake of low quality roughages increases as a result of increased levels of nitrogen in the diet. Weston (1967) concluded that the nitrogen level in a given diet is the most important factor influencing intake of low quality roughages. Increase in DM intake with increase in supplemental nitrogen, is in line with the assertion that supplemental nitrogen responses to DM intake of low quality diets are more pronounced in diets with less than 7% crude protein (Ventura *et al.*, 1975).

The decrease in hay intake with increasing levels of dietary grain sorghum could be due to grain sorghum provided providing a more readily available source of energy to the rumen micro-organisms. This, resulted in slow breakdown, longer retention time and low rumen turnover rates. Chase and Hibberd (1987) reported that increasing levels of ground corn linearly depressed intake of low quality hay by cows. Sanson *et al.* (1990) observed a depression in hay DM intake when steers subsisting on low quality hay (4.3% CP) were supplemented with increasing levels (6-20%) of whole corn.

TABLE III – LIVEWEIGHT GAIN AND DRY MATTER INTAKE OF HAY

	A	B	C	D	SE
Liveweight gain (g/d)	28.9^{a}	22.8^{a}	28.1^{a}	21.4^{a}	2.60
Regressed LWT gain (g/d)	27.5^{a}	22.1^{a}	27.5^{a}	21.3^{a}	0.20
Intake of hay (g/d)	492.3^{a}	501.9^{a}	526.2^{b}	506.7^{a}	3.25
Intake of hay ($g/kg^{75}/d$)	11.8^{a}	12.5^{b}	12.4^{b}	12.6^{b}	0.11

Treatments means followed by same superscript within columns are not significantly ($P<0.05$) different

TABLE IV – APPARENT *IN VIVO* DIGESTIBILITY (% DM) OF DIETS

Group	DM	ASH	CP	NDF	ADF	ADL	GE
A	63.4^{a}	14.3^{a}	42.6^{a}	63.3^{a}	52.0^{a}	30.3^{a}	65.6^{a}
B	66.3^{b}	28.5^{b}	59.7^{b}	66.6^{b}	58.4^{b}	29.3^{a}	56.0^{a}
C	73.0^{c}	43.4^{c}	72.8^{c}	73.4^{c}	67.4^{c}	31.3^{a}	72.5^{b}
D	73.7^{c}	45.9^{c}	73.2^{c}	76.5^{c}	71.3^{c}	30.8^{a}	74.5^{b}
Hay	61.3^{d}	22.6^{d}	40.4^{d}	66.7^{b}	55.9^{ab}	25.0^{b}	61.2^{d}
SE	1.35	3.24	3.87	1.34	1.99	0.71	1.30

Treatments means followed by same superscript within columns are not significantly ($P<0.05$) different

TABLE V – NITROGEN BALANCE OF GOATS FED ON HAY AND SUPPLEMENTED WITH VARIOUS POULTRY WASTE-GRAIN SORGHUM DIETS

	Diets					
	A	B	C	D	Hay	SE
Ingested N g/d	5.510^{a}	6.15^{b}	6.76^{c}	6.89^{d}	2.74^{a}	0.40
$g\ kk^{-1}\ w^{.75}/d$	0.380^{a}	0.43^{b}	0.45^{b}	0.47^{b}	0.26^{c}	0.02
Faecal N/gd	3.16^{a}	2.47^{b}	1.83^{c}	1.84^{c}	1.64^{c}	0.16
$g\ kg^{-1}\ w^{.75}/d$	0.250^{a}	0.22^{b}	0.17^{c}	0.17^{c}	0.17^{c}	0.01
Urinary N/gd	0.090^{a}	0.55^{c}	0.50^{bc}	1.54^{d}	0.21^{ab}	0.14
$G\ kg^{-1}\ w^{.75}/d$	0.017^{a}	0.07^{b}	0.06^{bc}	0.15^{d}	0.04^{ac}	0.01
Total N loss g/d	3.260^{a}	3.02^{a}	2.33^{b}	3.38^{a}	1.85^{c}	0.16
$G\ kg^{-1}\ w^{.75}/d$	0.260^{a}	0.25^{a}	0.20^{b}	0.28^{a}	0.19^{b}	0.01
Retained N/gd	2.260^{a}	3.13^{b}	$4,43^{c}$	3.51^{b}	0.89^{d}	0.32
$G\ kg^{-1}\ w^{.75}/d$	0.200^{a}	0.26b	0.33^{c}	0.28^{b}	0.11^{d}	0.02
Retained N as % of N intake	52.60^{a}	60.50^{b}	73.30^{c}	59.60^{b}	42.30^{d}	1.83

Treatment means followed by same superscript within rows are not significantly ($P<0.05$) different

TABLE VI – MEAN BLOOD UREA NITROGEN LEVELS (mg/100ml) IN GOATS FED ON THE SUPPLEMENTARY DIETS

Week	A	B	C	D	SE
0	6.9^{a}	6.9^{a}	7.0^{a}	7.0^{a}	0.02
4	5.7^{a}	7.7^{ab}	9.0^{b}	9.7^{b}	0.61
48	7.3^{a}	9.2^{a}	11.2^{b}	16.0^{c}	1.00
12	8.0^{a}	9.6^{a}	11.5^{ab}	15.2^{b}	0.95
	7.0^{a}	8.3^{ab}	10.0^{b}	12.0^{c}	0.45

Treatment means followed by same superscript rows are not significantly ($P<0.05$) different

Diets A and C; and B and D gave about the same liveweight gains despite distinct differences in chemical composition. The higher liveweight gains at higher grain sorghum levels could be largely due to higher efficiency in the utilisation of ruminal metabolites such as the volatile fatty acids (VFAs). Blaxter and Wainman (1964) reported that rations containing large amounts of flaked maize resulted in a marked reduction in the molar proportion of acetic acid in sheep rumen contents. It was also shown that efficiency of metabolisable energy (ME) use in fattening animals increased as the molar proportion of acetic acid in rumen liquor decreased. It was suspected that with the 88% grain sorghum and 0% poultry waste diet, the molar proportion of acetic acid was not low enough to significantly increase the efficiency of utilisation of the rumen metabolites for liveweight gain. However, animals showed a general tendency towards increased fat deposition. The high liveweight gain with diet C could be attributed to a favourable Pw:Gs, resulting in better utilisation of the high poultry waste nitrogen content. High nitrogenous diets require readily available energy sources that match the rate of nitrogen metabolism and assimilation at the tissue level. If this requirement is not met, much of the absorbed nitrogen is lost as urinary nitrogen. This in effect reduces the energy available for weight gain as nitrogen excretion is an active process. This could also account for the low weight gains of animals on diet D which had the highest poultry waste and no grain sorghum. These animals had the highest urinary nitrogen loss.

In vivo digestibility coefficients of DM, CP, ash, NDF, ADF, acid detergent lignin (ADL) and gross energy (GE) are presented in Table IV. Except for ADL, all the other nutrients had a general increase in digestibility with increase in poultry waste content; DM, Ash, CP, NDF and ADF digestibility increased by 10.3; 31.6; 30.6; 13.3 and 19.3% units from diet a to D, respectively. Diet A, with the highest grain sorghum, had significantly ($P<0.05$) lower DM, AH, NDF and ADF digestibility than the other diets. Nutrient digestibilities were highly and positively correlated to the levels of poultry waste in the diets, i.e., DMD, $r = 0.96$; DCP, $r = 0.95$; NDF, $r = 0.95$; ADF, $r = 0.95$ and ash, $r = 0.95$. On the other hand, digestibility coefficients of individual nutrients were negatively correlated to levels of grain sorghum in the diets (DMD, $r = -0.32$; DCP, $r = -0.32$; NDF, $r = -0.68$; ADF, $r = -0.61$ and Ash, $r = -0.6$).

The increase in nutrient digestibility with elevated levels of poultry waste in the diets was attributed to the corresponding increase in the CP content of the diets. High dietary protein supplies adequate nitrogen for rumen microbial growth. This, is associated with high rumen fermentation and high overall digestibility of the ingesta. Similar results have been reported by Cottrial *et al.*, 1982; Mehrez and Orskov (1978) and Sultan *et al.* (1992). Church and Santos (1981) reported that addition of NPN or soya bean meal to wheat straw, improved CP, DM and ADF digestibility in heifers. Pathak and Sharma (1991) observed an increase in digestibility of poor quality wheat straw with increase in CP content of goat diets. Delcurto *et al* (1990) demonstrated that DM and NDF digestibility increased with increase in supplemental crude protein content of steer diets. At 59 and 88% poultry waste level, there was no significant ($P<0.05$) increase in nutrient digestibility, indicating that nitrogen was no longer the main limiting factor. This is in agreement with the work of Church and Santos (1981) who observed that with supplemental nitrogen, feed digestibility increased up to a certain level and then levelled off.

The negative correlation between nutrient digestibility and increase in dietary energy content is in agreement with the studies of Delcurto *et al.* (1990) and Sanson *et al.* (1990) who observed that DM, NDF and ADF digestibility declined with increase in energy. Energy supplements of high calorific density cause starch-digesting micro-organisms to produce chemical factors that inhibit digestion of plant cell wall components (Church and Pond, 1988). However, this effect is alleviated by addition of protein supplements to the diets (Mehrez *et al.*, 1978; Sultan *et al.*, 1992).

The higher NDF and ADF digestibilities in diets C and D compared to diet A and B could not be entirely attributed to the effect of protein on nutrient digestibility but also to the positive interaction between the fibre fraction of the hay and the poultry waste. Highfill *et al.* (1987) observed that digestibility of low quality hay was not depressed when a higher fibre supplement was included in the diet. Such supplements enhance complementary digestive interactions among the fibre components of the whole diets. The marginal increases in the digestibility of NDF and ADF in this study, (0-29% Pw) compared to hay alone, could be attributed to decreased digestibility of the fibre portion of the hay as a result of preferential breakdown of grain sorghum starch by the rumen micro-organisms. Thus, the rumen micro-organisms derived most of their energy from the sorghum starch. This is in agreement with El-Shazly *et al.* (1961) who observed no significant increase in the digestibility of NDF and ADF components of diets by micro-organisms supplemented with starch *in vitro*. This phenomenon was attributed to substitution of more digestible for a less digestible energy source by rumen micro-organisms.

Table V shows the nitrogen balance status of the animals relative to the level of poultry waste and grain sorghum in the diets. Fecal nitrogen losses (g/d) generally increased with increase in dietary grain sorghum from 1.8 to 3.2 g/d. Diets A and B showed significantly ($P<0.05$) higher fecal nitrogen losses than diets C, D and hay alone. This could be attributed to tannins in the sorghum. Tannins bind nitrogen in feedstuffs, making it inaccessible to rumen micro-organisms. This is in agreement with the findings of Hulse *et al.* (1980) who observed that tannin content is inversely related to nitrogen digestibility.

Total nitrogen loss (g/d) was significantly higher in all treatment diets than in hay alone. Treatment D, with highest poultry waste content lost the highest daily total nitrogen . However, there was a general increase in retained nitrogen with increase in ingested nitrogen. The highest nitrogen retention was in animals fed on poultry waste-rich diets combined with grain sorghum (energy) supplement. This indicated that availability of energy is critical to increased nitrogen retention. Mehrez and Orskov (1978) and Pathak and Sharma (1991) observed an increase in nitrogen retention by animals when dietary nitrogen was increased through supplementation. Sultan *et al* (1992) asserted that high energy diets with adequate protein resulted in higher nitrogen retention than low energy diets with inadequate protein. Thus, lack of energy could be a limiting factor to nitrogen metabolism and retention in animals on diet D, leading to increased urinary nitrogen losses.

The mean blood urea nitrogen (BUN) generally increased with increasing levels of poultry waste and decreasing levels of grain sorghum in the diet (Table VI). Diet D, with the highest poultry waste content of 88% significantly ($P<0.05$) increased BUN than to all the other diets. Assimilated dietary nitrogen is stored and/or transported around the animal's body in form of blood urea. Thus, increase in BUN concentration with an increase in poultry waste can be directly attributed to the concurrent increase in nitrogen intake by the goats. These results agree with those of Pathak and Sharma (1991) who reported high (Repp *et al.*, 1955; Webb *et al.*, 1972; Bartley *et al.*,

BUN in goats fed on poor quality roughages supplemented with high nitrogen diets. Other studies 1976) have shown that BUN is directly related to the amount of nitrogen ingested by animals.

Blood urea nitrogen levels are parallel to weight gain and efficiency of nitrogen utilisation by animals (Preston *et al.*, 1978). This relationship has been used to estimate dietary nitrogen intake by livestock (Preston *et al.*, 1965; Pitts *et al.*, 1992). Goats that received 59 and 88% poultry waste diets had 10 mg/100 ml and 12.0 g/100 ml of BUN concentration, respectively, implying an adequate protein intake. This is in line with the findings of Preston *et al.* (1965) indicating that at least 10.0 mg of BUN/100 ml of blood represent adequate protein intake in small ruminants. Goats that received 88% poultry waste diet without grain sorghum (energy) supplement had 20% more BUN than those on 59% poultry waste. This elevated BUN could be attributed to an energy deficit which in turn, resulted in correspondingly high urinary nitrogen losses. Pitts *et al.* (1992) observed that high protein intakes require correspondingly high energy intakes to maintain BUN levels constant.

Results of this study indicate that a combination of poultry waste fed and a suitable energy source, significantly improved the plane of nutrition of animals on low-quality natural forages. Thus, in the agro-pastoral areas where farmers, in addition to domestic ruminants, keep traditional poultry, integration of poultry waste into the conventional ruminant feeding systems is feasible, particularly during the dry season. This can enhance the overall livestock productivity and hence the gross incomes of the farmers.

SUMMARY

A 12 week feeding study was conducted to evaluate the effect of various dietary levels of poultry waste and/or grain sorghum on dry matter intake (DMI), *in vivo* dry matter digestibility (IVDMD), nitrogen balance (NB), blood urea nitrogen (BUN) and liveweight gains (LWG) of Small East African Goats. The basal diet comprised low-quality range hay supplemented with poultry waste (Pw)/grain sorghum (Gs) diets. Twenty-eight goats weighing 14-16 kg were randomly assigned to four treatments of Pw and Gs rations as follows A 0:88; B 29:59; C 59:29 and D 88:0. Molasses was included at a constant rate of 12% to improve the palatability and reduce the dustiness of the feed. Hay was offered *ad libitum* while the supplemental diets were offered at 170 g/d/animal for 12 weeks. One way analysis of variance was used to compare treatment means.

Increasing levels of Pw (0-88%) in the diet, significantly ($P<0.05$) increased hay intake from 11.8 to 12.6 g of DM/kg/$W^{.75}$/day. Digestion coefficients of DM, CP, NDF, ADF and GE significantly ($P<0.05$) increased with increasing levels of Pw. Nitrogen

balance and BUN increased significantly with increase in Pw from 2.26-4.43 g/d and 7-12 mg/100 ml, respectively. Treatments had no significant effect on the animals LWG. However, animals on the higher Gs levels generally had higher weight gains than those on the lower end. Results of this study indicate that Pw fed in conjunction with a suitable energy source, can improve the plane of nutrition of animals on low quality natural forages. In the agro-pastoral areas where farmers, in addition to domestic ruminants, keep traditional poultry, addition of poultry waste to the conventional ruminant low-quality forages, particularly during the dry season can significantly improve their utilisation. This can enhance the overall livestock productivity and the income levels of the farmers.

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