UTILIZATION OF AGRICULTURAL BY-PRODUCTS AS LIVESTOCK FEEDS IN AFRICA

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METHODS OF ESTIMATING NUTRITIVE VALUE OF FIBROUS RESIDUES

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ABSTRACT

The present methods of estimating nutritive value were discussed including chemical analysis such as crude fibre, acid and neutral detergent fibre, lignin and soluble carbohydrates and biological measurements such as in vitro and in vivo determination of digestibility and determination of rate and extent of digestion using the nylon bag method. It was shown that the chemical analyses were very poor predictors of differences in nutritive value between different types of fibrous residues, between different varieties of straws and also in estimating improvements occasioned by chemical treatment. Only biological measurements estimated utilization with any degree of accuracy, and of the biological measurements, the nylon bag method of describing rate and extent of degradation was by far the best predictor and better than in vivo digestibility determined in restricted fed animals.

Development of laboratory methods to estimate nutritive value of feeds has been the goal of many research workers in the past. Numerous equations have been developed relating chemical analysis to nutritive value. For concentrate feeds developments of chemical methods to predict nutritive value have on the whole been very successful. This in part is due to the fact that they usually contain very little fibre and the starch sugar or fat they contain are virtually completely digestible. Estimating fibre digestibility for ruminants has been fraught with many more problems. The method used for many years was the Weende system developed in Germany to measure crude fibre, crude protein, ether extractive and ash. The apparent credibility of this system was due to the fact that the feeds used to develop the equation varied greatly in nutritive value, due mainly to different stages of maturity of the plants investigated.

The use of biological measurements to estimate nutritive value of forages was introduced particularly by development of the in vitro system by Tilley and Terry (1963) in which substrate disappearance was measured after laboratory incubation in rumen fluid. This was a spin-off from development of easy methods of fistulating ruminant animals and thus obtaining rumen fluid. The problem, however, with the in-vitro system is that it assumes that the conditions in the incubators remain similar to rumen content for 48 hours in spite of the accumulation of end products. It also depends on maintenance of constant temperature in the laboratory incubation. Power failures will render the results void and power failures are not unusual in developing countries.

Development of equations to estimate in vivo digestibility from any parameters, chemical or biological, assumes that the in-vivo digestibility gives the true value of the feed. It is now increasingly recognized that even the *in vivo* value is by no means constant. It varies mainly due to differences in rumen retention time, but can also vary according to the rumen environment. This infers that the value to be predicted is not static, but is itself dynamic.

This is best illustrated by describing the course of digestion, for example of straw, as in Fig. 1. This relationship can be described by the formula

$$p = a + b\,(1 - e^{-ct})$$

where a, b and c are constants, p is degradation at time (t) and e is the natural logarithm (Ørskov and McDonald, 1979). This type of equation is chosen because it gives some biological meaning to the constants insofar that a is the intercept or the immediately soluble fraction, b is the insoluble but potentially degradable material and c is the rate constant of b. It follows that a + b is the maximum potential digestibility of the feed. If an accurate measure could be obtained of these parameters it would assist greatly in predicting not only digestibility but intake as well.

In Fig. 1 it can be seen that the maximum potential, or the asymptote, is reached only after more than 90 hours of fermentation. The rumen retention time, however, is seldom as high as that. Mean retention time with straw is likely to vary from 36 to about 60 hours. This variation however implies that one measurement *in vivo* is only a point on the graph, and may not represent the *in vivo* situation in which it is to apply. In other words the use of sheep fed at maintenance level of feeding may give values quite different from cattle given a high level of feeding. The difference is not likely to be constant either, but will depend on the shape of the degradation curve, i.e. its a, b and c values. The *in vivo* estimates are likely to differ most from the maximum potential in feed with a high b value and a low rate constant c.

What is then the best description of nutritive value of fibrous residues? A description of degradation as in Fig.1, using nylon bags and a rumen environment in which cellulolysis is optimal, is no doubt more informative than one *in vivo* value of digestibility. In fact determination of *in vivo* digestibility can be used subsequently as a means of learning whether the diets are being utilized adequately, which in turn can lead to further studies to investigate reasons why if this is not the case.

Although the use of nylon bags in rumen cannulated sheep is a robust tool and does not fail due to failure of power supply etc., it would still be of great value if chemical analysis could identify some differences in nutritive value of fibrous feeds.

In a recent experiment (Ramanzin *et al*. 1986) studied whether chemical analysis could identify differences in quality of straw and differences in quality conferred by ammonia treatment. It is clear from the results presented in Table 1 that there was no relationship between ADF and nutritive value within leaves

Table 1. Effect of variety and component of straw on chemical analysis of acid detergent fibre (ADF), neutral detergent fibre (NDF), crude protein (CP) and degradation of dry matter during 48 hrs.

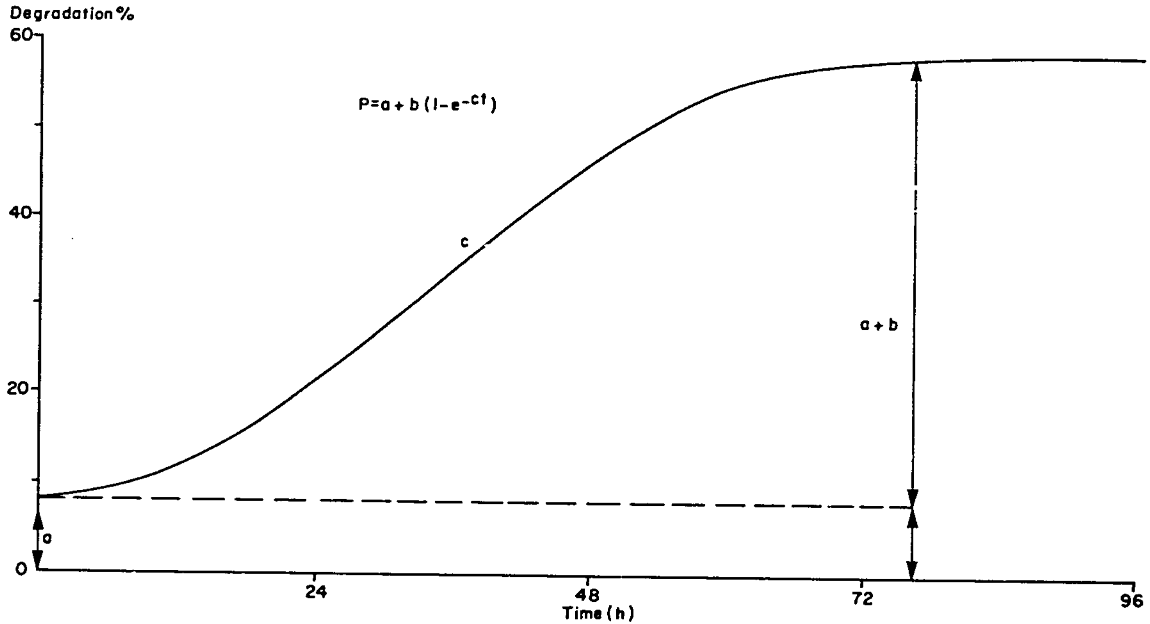
Variety	Component	Treatment	ADF (%)	NDF (%)	CP (%)	Degradation in nylon bag for 48 hr.	72 hr.
Corgi	leaves	untreated	45.2	83.2	4.4	76.0	85.9
Corgi	leaves	NH_3 treated	47.4	77.7	-	83.5	90.1
Gerbil	leaves	untreated	49.3	84.5	4.4	70.8	80.3
Gerbil	leaves	NH_3 treated	47.5	79.7	-	74.4	86.2
Corgi	internodes	untreated	61.4	93.0	2.1	53.3	58.8
Corgi	internodes	NH_3 treated	62.0	90.7	-	59.1	66.3
Gerbil	internodes	untreated	62.1	93.7	3.0	37.5	44.1
Gerbil	internodes	NH_3 treated	62.7	94.4	-	51.5	57.2

Table 2. Effect of variety and type of straw on chemical analysis of acid detergent fibr (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), cellulose digestibility (NCD) and degradation measured by *in vitro* or by nylon bag incubation.

Variety	Treatment	ADF	NDF	ADL	NCD	OMD	Degradation in nylon bags for:	
						In vitro	48 hr	72 hr.
Gerbil	Untreated	57.9	87.5	9.0	24.6	27.6	32.2	36.1
	NH_3 treated	55.5	84.0	8.3	35.2	37.8	47.4	53.4
Igri	Untreated	55.4	86.4	7.7	29.3	29.5	36.7	41.4
	NH_3 treated	55.4	84.1	8.0	34.0	37.5	44.3	49.8
Corgi	Untreated	51.2	84.0	6.3	34.4	39.0	46.8	50.9
	NH_3 treated	50.0	81.0	6.1	47.3	54.1	61.6	63.6
Golden Promise	Untreated	55.5	85.0	7.3	33.5	36.4	43.5	50.5
	NH_3 treated	52.3	79.9	6.9	44.5	45.6	53.1	57.8
Wheat	Untreated	52.0	80.7	8.0	31.5	31.7	42.1	44.5
	NH_3 treated	48.8	75.5	7.0	42.9	44.8	51.3	57.4

Preliminary and unpublished results from Rowett Institute and North of Scotland College of Agriculture.

Figure 1. *Description of degradability of fibrous residues.*



and within stems although there were clear differences in degradability due to variety, confirmed also in voluntary intake and in vivo digestibility studies. However ADF was clearly different between stems and leaves.

In later unpublished work (C.W. Reid, M. Kay and E.R. Ørskov) we have made some comparisons of chemical and biological methods (Table 2). It can be seen again that ADF and lignin content did not distinguish between nutritive values of type and varieties of straw and could not predict increases in nutritive value due to ammonia treatment. On the other hand it can be seen that both incubation with cellulase enzymes and in vivo in rumen fluid distinguished between variety, types and ammonia treatment.

It can be asked quite legitimately, if the chemical analyses do not predict nutritive value, why use resources to measure them? It is clear that differences between nutritive values of straws could not be predicted from chemical analysis developed so far.

The available evidence suggests that while gross chemical composition may be interesting, only biological measurements can presently provide sufficient information about the nutritive value of fibrous feeds or residues. We need to search for laboratory methods which can identify the factors controlling accessibility of bacteria to the substrate and the rate at which it can occur. These factors are more likely to be found in surface chemistry of cell walls rather than in gross chemical composition.

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INTAKE AND DIGESTIBILITY OF UREA-TREATED GAMBA (*Andropogon gayanus*) HAY BY CATTLE

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ABSTRACT

Intake and digestibility of urea-treated gamba (*Andropogon gayanus*) hay with or without urea supplementation was studied. Organic matter intake was improved from 57.5 to 72.8 g/kg 0.75/d while organic matter digestibility was improved from 564 to 699g/Kg. Results indicate no significant differences in the utilization of all hays containing urea either as feed additive or for treatment. All treatments involving the addition of nitrogen gave positive nitrogen retention. It is concluded that urea supplementation at the rate of 1 percent of total dry matter intake sprayed on hay at feeding time would elicit similar improvement in utilization as would urea treatment.

INTRODUCTION

Nigeria has about 140 million hectares of natural range which serves as the major source of forage for livestock, supplemented in a few places by sown pasture, grazing reserves and crop residues. Nomadic communal grazing involving migration of herds and families is gradually being replaced by limited transhumance, in which extensive grazing both in the range and in government approved grazing reserves is practised. Under this system, animals rely almost totally on natural forages. Crop residues become available after harvest, at the onset of the dry season.

The Fulani pastoralists and agro-pastoralists together control about 90 percent of the national herd. Recently, because of the realisation that land development and expansion of crop farming activities will continue to reduce the available grazing land, efforts are being made to encourage the settlement of pastoralists and to integrate them with the non-pastoralists. The implication of this is that economic feeding systems must be developed, especially for dry season feeding. This would eliminate the need for migration in search of feed and water and limit the cyclical weight gain/loss of livestock.

Most of the 90 genera and 300 species of grasses found in Nigeria are members of the Paniceae and Andropogoneae tribes. One natural feed resource on which feeding systems can be based in Nigeria is the Gamba grass, Andropogon gayanus. Gamba grass is available in abundance in almost all ecological zones in Nigeria. The problem with gamba like other tropical grasses is the rapid decline in crude protein and soluble carbohydrate with age. This is coupled with a progressive increase in crude fibre and lignin (Agishi 1985; de Leeuw 1979). Consequently, tropical grasses are low in voluntary intake and digestibility after maturity (Obioha and Ndukwe 1976; Adu and Adamu 1982). It is therefore well established that significant alteration of plant composition occurs and decreases their nutritive value and adversely affects animal performance (Zemmelink 1973).

Mature fodder plants could be improved by alkali treatment. Urea treatment of crop residue is not new (Sundstol et al. 1977). Improved utilization of low quality tropical hays by treatment with urea, ammonia, sodium and ammonium hydroxide has been reported (Sherma et al. 1972: Sundstol 1981: Buettner et al. 1982; Green halgh 1984; Nwakatundu and Owen 1974; Utley et al 1978; Umunna 1982).

Preliminary trials at Napri, Shika in Nigeria, have shown significant improvement in the rumen degradation of urea-treated gamba hay when 40g urea was dissolved in 600g of water and sprayed on 1kg of hay sealed in polythene bags for 20 days (Lufadeju, et al. 1986).

The objective of the study reported here was to compare the utilization of untreated and urea-treated gamba hay, with or without feed grade urea supplementation as the sole diet for Friesian/Bunaji dairy heifers.

MATERIALS AND METHODS

Animals

Three Friesian/Bunaji heifers approximately 18 months old and weighing 194 ± 10kg liveweight were used. They were fitted with permanent rumen cannulas with an internal diameter of 50mm. The animals were kept in individual pens to facilitate separate collection of faeces and urine.

Experimental diets and treatment arrangement

The heifers were allocated at random to receive ad libitum diets of (A) Untreated gamba alone; (B) Untreated gamba plus urea; (C) Urea treated gamba alone; (D) Urea-treated gamba plus urea in four experimental periods, so that each animal received each diet once in random order. By this arrangement four different rumen environments were created, which contained varying amounts of nitrogen.

Feed preparation

The hay used in this experiment was cut in February, during the dry season. Two tons of untreated mature gamba hay containing 5.5 gN/kg DM, and two tons of urea-treated gamba were used as the sole diet. The hay was treated with 40g of urea, dissolved in 600g of water per kg hay. The stack was covered with a polythene sheet in a pit and left to stand for 20 days. After the polythene was removed, the stack was allowed to aerate for 2 days to eliminate volatile ammonia before animal feeding commenced.

Feeding and management

For diets containing supplementary urea, 12.5g urea/kg DM intake (maximum 50g Urea/head/day) were dissolved in water (50:50 W/V) and sprayed on the hay at feeding time. The heifers were fed twice daily at 8.00 and 16.00 hours. The animals were fed to appetite with each receiving 5kg DM hay per day, for 28 days for each treatment. Bone meal, trace minerals, sodium sulphate, salt licks and vitamin premix were mixed with the urea solution or water before being sprayed on the hay. Sodium sulphate was added to give a calculated 10:1 N to S ratio. Fresh water was available at all times. Voluntary intakes were recorded daily and the animals were weighed weekly.

During the last 7 days of each period, total faeces and urine were collected, faeces from the gutter behind the animals, and urine was collected in plastic buckets through transparent polythene tubes 15 cm diameter glued around the vulva, in a manner similar to that described by Cowan et al (1981). Urine was kept acid by adding 50ml of 4 M-H_2SO_4 (ph 2-3) to the 15 litre bucket for preservation.

Daily collections of faeces and urine were weighed, mixed thoroughly and a 10 percent subsample of each was taken. Samples of urine were stored at -16°C, and faecal samples dried immediately at 70°C for 48 hours and stored. At the end of the collections, samples were bulked, mixed thoroughly and sub-samples of urine analysed for nitrogen and of faeces for dry matter, nitrogen, neutral and acid detergent fibre and ash.

Feed and faeces were analysed for dry matter by oven drying at 105° for 24 hours; for nitrogen by micro-kjeldahl technique, using Markham micro-distillation apparatus; and for neutral and acid detergent fibre by the methods of Van Soest and Wine (1967).

RESULTS

Treatment of gamba hay with urea significantly ($P<0.01$) improved the nitrogen content from 0.55 to 1.78g/100g (Table 1); there were no significant differences in the proportions of other components. Prolonged exposure after the treated stack was opened did not affect chemical composition or rumen degradation (Table 2).

The intakes and digestibilities of all treatments containing urea, whether supplemented or from treatment were not significantly different from each other, and all significantly exceeded the figures from untreated hay ($P<0.05$, Table 3).

Table 1. Chemical composition of untreated versus urea-treated gamba hay.

Item	Untreated	Treated
	Percent	
Dry matter	90.3	89.8
Cellulose	44.0	47.2
NDF	76.4	75.9
ADF	56.2	60.5
Nitrogen	0.55	1.78
Ash	5.4	5.6
48-hr. Rumen degradation	45.8	54.1

Table 2. The effect of prolonged exposure of treated Gamba hay on the chemical composition and rumen degradation.

Item	Days after stack opening	
	22-28	108-114
Dry matter	88.70	90.98
Cellulose	47.07	47.51
NDF	76.82	75.03
ADF	60.69	60.39
Nitrogen	1.79	1.77
Ash	5.53	5.80
48-hr. Rumen degradation	52.9	55.4

Significantly higher ($P<0.05$) urinary nitrogen excretion was observed in animals fed treated compared with untreated hay (Table 4). The amount of nitrogen apparently absorbed differed among all treatments (Table 4), increasing with increased dietary concentration of nitrogen; it was negative for the untreated unsupplemented hay.

Apparent nitrogen retention did not differ significantly between treatments using the treated hay, and exceeded those figures recorded from the untreated hay. There were no significant differences between treated hay alone and untreated urea supplemented hay. The control hay gave a negative nitrogen balance (Table 4). Similar proportions of absorbed nitrogen were retained in the treated diets despite differences in dietary nitrogen concentration.

Table 3. Voluntary intake and digestibility of cattle given untreated and urea-treated Gamba hay with or without supplementary urea.

Item	Treated + Urea	Treated alone	Untreated + Urea	Untreated alone	SED
Intake of DM g/kg $W^{0.75}$/d	80.2[a]	75.2[a]	77.8[a]	61.1[b]	5.42
Dry matter digestibility g/kg	680[a]	640[a]	663[a]	536[b]	26.02
Intake of organic matter g/kg $W^{0.75}$/d	74.5[a]	70.1[a]	73.8[a]	57.5[b]	5.00
Organic matter digestibility g/kg	697[a]	639[a]	673[a]	564[b]	26.14
Neutral detergent Fiber digestibility g/kg	770[a]	736[a]	750[a]	636[b]	24.10
Acid detergent Fiber digestibility g/kg	714[a]	675[a]	675[a]	568[b]	22.98

Means with identical superscript within each row are not significant at 5% level.

Table 4. Apparent nitrogen absorption and retention by cattle given untreated and urea-treated Gamba hay with or without supplementary urea.

Item	Treated + Urea	Treated alone	Untreated + Urea	Untreated alone	SED
N intake g/d	94.0[a]	67.0[b]	44.3[c]	16.6[d]	2.09
Faecal N g/d	35.5	25.5	21.5	21.5[NS]	7.48
Urinary N g/d	21.2[a]	15.2[a]	4.1[b]	4.4[b]	4.13
N apparently absorbed g/d	58.5[a]	41.5[b]	22.8[c]	-4.9[d]	6.03
N apparently retained g/d	37.3[a]	26.3[ab]	18.7[b]	-9.3[c]	7.63
Apparently retained N (% apparently absorbed)	63.7	63.3	82.0	-	-

Means with identical superscript within each row are not significant at 5% level.

DISCUSSION

The urea treatment of gamba hay in this study enhanced its nitrogen content threefold. This extent of increase in nitrogen has been reported previously (Orskov et al. 1983). Urease enzyme present in plant material, converts urea to ammonia at high temperature and moisture. Ammonia then penetrates plant material. Exposure of hay for 2 days after plastic cover removal allowed excess ammonia to escape and the pungent odour of ammonia to disappear. However, the amount of nitrogen which penetrated plant material did not change significantly with prolonged exposure. This is similar to the finding of Gordon and Chesson (1983).

The in vivo dry matter digestibility reported here for treated hay varied from 64 to 68 percent, similar to values of Greenhalgh (1984) and Fahmy and Orskov (1984). Urea supplementation of treated hay slightly but non-significantly improved dry matter intake and digestibility. However, significant improvements of 28 and 25 percent in intake and digestibility respectively were obtained when untreated hay was supplemented with urea. This level of improvement falls within the range reported by Sharma et al. (1972). There were no significant differences between treated and untreated hay supplemented with urea in either intake or digestibility. This observation raises fundamental economic questions about the efficiency of urea treatment in view of the requirement for labour and water, a question even more relevant to arid areas where water for human consumption is scarce. The degree of improvement in animal performance from urea treated forage resulting from the combined effects of higher digestibility and additional nitrogen has been reported to be similar to those of urea supplemented untreated hay (Verma and Jackson 1984). Under dry tropical conditions, nitrogen not energy has been identified as the first nutrient limiting animal performance (Verma and Jackson 1984). The lack of significant differences in nitrogen retention from treated or urea supplemented treated hay indicated that the nitrogen in treated hay was adequate for the amount of energy available from its fermentation, and further urea supplementation of treated material was of no benefit in the absence of additional energy. Animals fed untreated unsupplemented hay in this study had negative nitrogen retention, as did the sheep of Adu and Adamu (1982) which were fed three low crude protein tropical grass hays; the poor utilization of these grasses was attributed to low energy availability and inadequate nitrogen supply.

CONCLUSIONS

A consideration of the economic rearing of cattle requires the use of cheap fodder, either grass, legume, browse or crop residues. With regard to mature tropical grass of poor quality, one way their utilization can be enhanced is through urea supplementation either as feed additive or for treatment. The choice of method of supplementation depends on availability of labour and water. Addition of urea supplements to urea-treated roughages appears wasteful unless supplementary energy can be provided. Urea supplementation at the rate of 1 percent of total dry matter intake sprayed on hay at the time of feeding would elicit similar improvements in intake and digestibility as would urea-treated hay.

It is tentatively suggested that urea supplementation of hay would enhance its utilization, reduce the need for concentrate supplementation, and limit animal weight loss during the dry season.

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THE PROSPECT OF UTILIZING UREA TREATED MAIZE STOVER BY SMALLHOLDERS IN KENYA

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ABSTRACT

In the last two decades, a large part of the small holder sector in Kenya has been transformed from a traditional subsistance oriented sector into a more commercialized system. In 1981, the small holder sector produced 75% of the total milk output, 65% of the total beef production, and a substantial amount of eggs and chicken. However, the major constraint in ruminant livestock production is the quantity and quality of available feed. The average land per caput, as per 1982 estimates, by the small holders in two of the highly populated districts, Kakamega and Kiambu, is 0.26 and 0.25 ha respectively. Within these small hectarages there is a severe competition on the available land for food and feed crops.

Amongst the productive areas of research in alleviating the above problem is the enchanced utilization of arable farm by-products such as maize stover, millet and sorghum stovers, and other home offals. In recent years studies have been undertaken to improve the nutritive value of stover and straws. Of probable practical significance for the small holders is the use of urea solution for treating maize stover, the most abundant by-product on their holding. Some work on urea treatment is reviewed in this paper. Urea treatment improved both intake, digestibility and liveweight gain by cattle and sheep.

Other alternatives to treatments are chopping the stovers and supplementing them with maize bran and/or molasses. The use of forages as dual purpose legumes either in pure stands or as inter-crop fodder will increase both the utilization and availability of feeds and improve soil nitrogen, albeit at probable variable reduced yields of the main food crops. However, other studies have reported improved main crop yields.

The Kenyan Smallholder

Smallholders have emerged as an important and a distinct sector in the overall agriculture production in Kenya. Apart from the traditional smallholdings, of pre-independence and now, the attainment of independence in 1963 saw accelerated efforts by the Kenya Government to resettle the "landless" on former "Scheduled" areas which were European farmed. On the eve of independence in 1961 a "Million Acre Settlement Scheme" was started for purchasing 1.2 million acres of largely mixed farming land. Post independence, many other settlement schemes were undertaken in collaboration with the former colonial administration (Said 1985). The change in land ownerships also continued through private individuals and land owners cooperatives that would normally subdivide the bought land into small units to settle many families.

Their Agricultural Activities

Crops

It is estimated that the total numbers of smallholders in six of the eight provinces in Kenya is 2.437 million (Table 1). Average agriculture land per household and per caput in the six provinces is also given in Table 1. Table 2 gives agriculture land per household and per caput in four divisions in Kiambu and Kakamega; two of the highly populated and intensively farmed districts in Kenya. It is estimated that about 75 percent of the land per holding is under arable cropping and at the most only 25 per cent is available for livestock and livestock feeds.

The major agricultural activity on almost all the smallholders is arable cropping with maize forming the major crop. Maize stover is therefore the most abundant arable by-product on all the smallholdings. Except for plantation crops such as tea, coffee and sugar cane, arable farming is mainly for subsistence. In some areas excess food crops are sold to generate cash for the family. In Western and Nyanza Provinces, a substantial number of smallholders grow sugar cane as a major cash crop and sell it as contracted outgrowers to the sugar cane estates. In Kisii tea and coffee are the major cash crops. In Kericho and Nandi Hills tea is also the major cash crop while in Kiambu and Meru tea, coffee and potatoes are the major sources of income; variable with the ecozones within the divisions. Smallholders on irrigation schemes grow cotton, rice, and other horticultural crops for cash. Converted into value of marketed production smallholders generated between 54.8 and 51.2 percentage share of the total marketed production in Kenya between the years 1978 and 1983 (Statistical Abstract 1984).

Animal Production

Dairying is the major animal production enterprise. In 1985 the total dairy cattle population in Kenya was estimated at 2.278 million; 80 percent of which were found on smallholdings (Bartilol 1986). Out of the estimated national marketable milk production of 595 million litres, the small-scale holders produce 476 million litres or 80% of the national figure. Only 119 million litres are produced by the large-scale farmers. In 1986 the total number of dairy cattle in Kakamega District was estimated as 48,558; 11.9% of the total cattle population of 405,697 for the whole District (Said 1986b). In Kiambu District, another heavily populated smallholder farming area, there are 89,437 dairy cattle which form 78% of the total cattle population of 114,586 for the District. The remaining 25,149 head are the indigenous Zebu cattle (Said 1986b).

In Western Kenya and in parts of Eastern Province smallholders use a substantial amount of draught power either on their own holdings or for hiring to the other holders who may not have any.

Other minor ruminant livestock enterprises of the smallholders are sheep and goats, used for ceremonial purposes and sometimes to provide extra cash income. In 1976 it was estimated that out of the total 8.3 million sheep and goats in Kenya, 4.4 million or 53% were reared on small farms (FAO 1976). Mburu (1986) gives the total numbers of sheep and goats in Kenya in 1984 as 13.27 million. Assuming that 50% of these are reared by the smallholders there would have been 6.64 million small ruminants on small farms.

Over the last four years the Ministry of Agriculture and Livestock Development (MALD), in collaboration with Winrock International, have been implementing a project, Small Ruminants-Collaboration Research Support Project (SR-CRSP) to introduce dairy goats/dual purpose to smallholders in Western Kenya and in Nyanza Provinces.

Feed Constraints

As will be clear from tables 1 and 2 the major constraint to ruminant livestock production, apart from available capital for bought in feed and other logistics, is the severe competition on the available land for food crops and fodder for livestock. There is also competition on the available farm manure and compost between food crops and fodder crops for zero grazed dairy production. It is imperative that with the passing of time this situation will be worsened in that the smallholdings will be broken down further due to increasing population growth and the traditional systems of land tenure/inheritance. In the cropped semi-arid dryland areas in Machakos, Kitui and Kibwezi in Eastern Province, increased population pressure will mean even scarcer fodder for the livestock in those areas (Thairu and Tessema 1985).

In almost all the smallholder areas, from the high potential areas of Western and Central Provinces and parts of Rift Valley Province, to the medium and semi-arid areas of the Rift Valley, Eastern and Coast Provinces, maize is the main food crop. It is logical therefore to nationally look at how best the maize stover, the major bulky by-product, easily and cheaply available to the farmers, can be utilized to feed the ruminant livestock especially during the dry season when there are no green fodders either from within the small land holdings or from the road side no man's patches. Both the Department of Animal Production, University of Nairobi and the MALD/FAO Dryland Farming Research and Development Project at Katumani, Eastern Province, are looking at maize stover and other aspects of feed resources for the smallholders. Amongst the other research stations actively involved on other feed resources for the smallholders are the Kenya Agricultural Research Institute (KARI), Muguga and Embu Agricultural Research Station and (SR-CRSP) at Maseno, Nyanza Province.

Table 1. Numbers of smallholders and available agricultural land per caput in 6 of the 8 Provinces in Kenya (Extracted from Jaetzold and Schmidt 1982 and 1983)

PROVINCE	NUMBERS OF HOUSEHOLD	PEOPLE PER HOUSEHOLD	AGRIC LAND PER HOUSEHOLD (Ha)	AGRIC LAND PER CAPUT (Ha)
WESTERN	331856	5.63	2.30	0.43
NYANZA	355866	5.36	2.36	0.42
RIFT VALLEY	624506	4.94	12.32	2.43
CENTRAL	466720	5.09	2.16	0.43
EASTERN	472859	4.01	10.78	1.99
COAST	186181	5.19	31.26	6.24
TOTAL	2437988			
MEAN FOR THE 6 PROVINCES	406331	5.04	10.2	2.0

Table 2. Smallholder Agricultural land, households and hectarage per caput in Kiambu and Kakamega Provinces of Kenya. (Recalculated from Jaetzold and Schmidt, 1982 and extracted from Said, 1986b).

DIVISION	TOTAL AREA (100 ha)	AGRIC.LAND (100 ha)	NUMBERS OF HOUSEHOLDS	PERSONS PER H/H	AGRIC.LAND PER H/H	AGRIC.LAND PER CAPUT	MEAN Ha PER H/H AS AS PER SURVEY
GATUNDU	386	309	27.523	5.52	1.12	0.20	1.46
KIAMBAA	189	150	21.785	4.74	0.69	0.15	1.88
LIMURU	461	229	23.954	4.58	0.96	0.21	1.68
KIKUYU	167	119	21.300	5.10	0.56	0.11	1.04
KIAMBU DISTRICT	1935	1422	142.181	4.80	1.00	0.21	
BUTERE	344	277	25.962	4.81	1.06	0.22	1.64
VIHIGA	367	286	47.739	5.33	0.59	0.12	0.99
KABRAS	450	367	16.638	6.12	2.21	0.36	5.67
LUGARI	354	474	10.660	6.40	4.45	0.68	6.05
KAKAMEGA DISTRICT	3111	2548	197.882	5.18	1.29	0.26	

+ Jaetzold and Schmidt, 1982. Farm Managment Handbook of Kenya Vol. II Part B. Central Kenya. MALD, Kenya.

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Utilization of Maize Stover

Production levels

Accurate figures for the maize grain and stover generated by the smallholders are not available as most of the grain crop is used for domestic use or sold at the local open air markets. Fairly exact statistics are easier to get for the cash crops that are organized and handled by statutory boards. Said (1982) estimated that in 1978 the total amount of maize stover in Kenya, generated by both the smallholders and by the large-scale farmers, was 5 million metric tonnes. He used a residue grain ratio of 2:1. Kayongo-Male (1984) in a study on techniques for inventory-taking on crop wastes established a maize stover grain ratio of 2.03:1.

Fairly accurate hectarage and maize grain yields were estimated by aerial photography and by air borne digital photometers in only 8 maize growing districts in Kenya (KREMU 1985). Within the 8 districts, covering a total of 36,160 km², of Bungoma, Kakamega, Nandi, Nakuru, Uasin Gishu, West Pokot, Elegeyo, Marakwet and Trans Nzoia grain yield was estimated as 703,279 metric tonnes. Using a ratio of residue to grain 2:1 the amount of stover generated would be about 1,407 million metric tonnes. Most of the land in these 8 districts is occupied by smallholders. Jaetzold and Schmidt (1982 and 1983) estimated that percentages of smallholder land under maize is variable within the districts and within the agricultural ecozones. It ranges from 50 percent downwards. Other food crops, in some areas, such as cash crops take the rest of the land. A small percentage of the holding, in some areas, is under pasture or fodders. Yields of maize grain are also variable depending on the ecozones and management factors. It is therefore difficult under these conditions, to estimate accurately the amount of stover that would be generated. However, it is not incorrect to state that maize stover may be the major if not the only roughage available to the smallholders during the dry season.

Limitations of maize stover

Smallholders use maize stover for cooking to save on expenses for fire wood and for charcoal. Some stover is left on the fields or put on terraces to conserve soil. However, a substantial amount of the stover in the high potential smallholder areas is used as an important feed resource both for cattle, sheep and goats. In Western Kenya and in parts of Eastern Province maize stover may be the only roughage available to the oxen used for draught power. In both cases, where it is used as a feed, it is fed as whole stalk and leaves without chopping. Wastage is therefore very high and intake level low.

Like many other high lignin arable farm by-products maize stover has low digestibility. The high lignin inhibits microbial digestion of cellulose and hemicellulose. The low content of nitrogen and defficiency of readily available carbohydrates also limit microbial activity in the rumen.

Musimba (1980) and Tubei (1981) reported protein level of 2.31 percent and 6.29 percent respectively of maize stover. Said (1979) gave a protein content of maize stover at 2.76 percent. Thairu and Tessema (1985) found that maize stover of early maturing variety had a crude protein content of 2.59 percent; NDF, ADF and ADL levels were 69.55, 60.34 and 9.92 percent respectively. Dzowela (1985) reported a protein level of maize stover in Malawi at 5.43 percent and a ME value of 1.09 Mcal/kg DM; marginally below the ME of 2.00 Mcal/kg DM; a threshold value to meet maintenance requirements by beef cattle (NRC 1976). Kevelenge et al. (1983a,b,c) reported that green maize stalk has low levels of calcium and phosphorus. The crude protein level in the green maize stalk ranged from 8.5 to 8.8 percent DM.

Maize stover research in Kenya

The earliest documented work on maize stover in Kenya was by Mulder and Waweru (1973) who looked into the use of maize stover as a supplement on rations used for intensive beef production on smallholder. Musimba (1980) reported that NaOH and Magadi* treated maize stover were higher *in - vitro* organic matter digestibilities at 70.6 and 80.3 percent respectively in comparison to 48.8 percent in the untreated material. Said (1981) reported that NH_3 treated maize stover increased *in-vivo* organic matter digestibility from 56.1 percent for untreated stover to 60.9 percent, intake of organic matter increased from 22.4 $g/kgW^{0.75}$ to 27.0 $g/kgW^{0.75}$ per day and average liveweight gain by sheep in the 13 weeks experimental period was 61.8 g for the untreated stover and 88.7 g for the NH_3 treated stover.

Said (1981) showed that NaOH treated maize stover was about equal to *Chloris gayana* hay in its nutritive value when fed to wether sheep. He also reported that NH_3 treated maize stover fed to steers was apparently better than *Chloris gayana* hay, and at 26 percent silage DM replacement level, it was only slightly inferior to sorghum silage. A review of treatment methods tried in Kenya and their limitations was given by Said et al (1982).

Thairu and Tessema (1985) showed that urea treated maize stover fed to sheep and goats with either *leucaena leucocephala* or pigeon pea (leaves and stems) gave better liveweight gains compared to feeding untreated maize stover with leucaena and with pigeon pea. Treatment was with 5 percent urea solution sprinkled on the chopped stover and left in air tight bins.

Work is in progress in the Department of Animal Production, University of Nairobi, on urea treated wheat straw fed to wether sheep (Alayu 1985), and on the dacron bag digestion of urea treated maize stover (Said and Wanyoike 1986). Another study on the utilization of urea treated maize stover supplemented with varying levels of oil cakes is about to be started (Chepkitony and Sundstol 1986).

(*Magadi - natural sodium bicarbonate complex deposit at lake Magadi, Kenya).

Advantages of Urea Treatment

Under Kenyan conditions urea is cheaper compared to NaOH and NH_3, the two most effective treatment chemicals. It is easily available as a fertilizer grade urea in small packs of 2 kg. It is not hazardous to use compared with NaOH and NH_3 and it has the added advantage of increasing the nitrogen content of the roughage in form of NPN, which could be used by the rumen microflora to synthesize microbial protein; other conditions in the rumen being right.

Saadullah et al (1981) reported that crude protein content of rice straw increased from 2.9 percent in untreated straw to 5.9 percent after 20 days ensilage with 5 percent urea. Khan and Davis (1981) reported significantly increased dry matter intake and increased liveweight gain and increased total milk production from urea treated rice straw at 5 percent urea and ensiled for seven days only.

Recommended Package

Based on the present knowledge for urea treatment, it is recommended that smallholders in Kenya should use maize stover in a urea treated ensiled form by the method described by Khan and Davis (1981). Depending upon the available resources farmers can either use a hand-operated chaff cutter to chop the stover or they can use ordinary methods of chopping it into smaller pieces, 1-2 cm lengths.

Batches of 10 kg chopped stover should be sprinkled with urea solution made up of 0.5 kg urea dissolved in 10 litres of water. The treated stover should immediately be put in polyethylene (500 gauge) bags measuring 70 cm x 120 cm. Alternatively ordinary polyethylene bags that come with fertilizers can be used. Bamboo baskets or papyrus baskets can be used but they should be plastered with a mixture of mud and cow dung and lined with banana leaves. Ordinary silage pits can also be used successfully. Recommended size is 4 x 3 m and about 1.5 m deep. The pit should be lined with banana leaves (Saadullah et al. 1981) and the top should be covered with banana leaves or polyethylene sheet, on top of which should be put about 30 cm of soil.

In both cases ensiling should be for two weeks. Khan and Davis (1981) successfully ensiled rice straw for seven days and Hossain and Rahman (1981) reported that there was no advantage in prolonging treatment time beyond two weeks. The ensiled maize stover should be ready for feeding either plain or ideally with a green fodder supplement, molasses or with concentrates by farmers on commercial dairy enterprise.

Alternative Feed Resources

An important characteristic of the Kenyan smallholders who keep cattle as well as grow food crops and/or cash crops is the distinction between those smallholders who are actively engaged in commercial dairy production from improved dairy cattle and those to whom milk production from the local zebu cattle is, at the very best, providing milk for home consumption and a little surplus for the local markets. In the second setting the main uses of the cattle are for draught power and/or a source of cash income when the need arises. The need and urgency for alternative feed resources are accordingly variable. The recent thrust on introduction of dual purpose dairy goat within the smallholders in Western Kenya by SR-CRSP/MALD may also provide new incentives for alternative feed resources. Almost all the smallholders in Kenya that keep sheep and goats make no special efforts to provide additional feeds for them. They are either tethered around the homesteads or are expected to scavenge around.

Potter (1985), Abate et al (1985), Thairu and Tessema (1985), Mukhebi et al (1985) and Onim et al (1986) looked at various aspects of alternative feed resources for smallholders in Kenya. Said (1986a,b) reviewed feed constraints and strategies in two of the highly populated, intensively farmed districts in Kenya; Kiambu and Kakmega. Dzowela (1985) reviewed the role of legume forages in improving the utilization of maize stover by smallholders in Malawi. In their Technical Note No. 1 KARI (1985) gave results of their work on Bana grass, integration of maize and livestock production and on the use of poultry waste in cattle rations. Saleem (1984) reviewed the role of forage legumes in agropastoral production systems within the subhumid zones of Nigeria.

Based on our own assessments and the quoted works the following are suggested as alternative feed resources for smallholders:

Bana/Napier grass: Assuming that there is an economic incentive by the smallholder to grow fodder on the very limited available land, results have shown that Bana/Napier grass used on a "cut and carry" method would be a possible crop to consider. The extra labour required would be compensated by the manure that would be obtained from the animals. Extension efforts should be on establishing "bulking plots" of Bana/Napier grass for distribution to the farmers. It is estimated that 1 ha will yield enough bulking material for 30 ha.

Dual purpose fodder/food crops and/or intercropping: Intercroping fodder crops with food crops and/or planting dual purpose food crops such as pigeon peas, lab lab, cassava, and cow peas. Other dual purpose crops such as <u>Sesbania sesban</u> and <u>Leucaena leucocephala</u> would provide forage and fire wood. Some legume crops and/or pasture legumes could be intercropped with maize.

Maize defoliation: Recent studies on the use of green maize leaves derived by defoliating the growing plant have shown that it is possible to obtain up to 1 tonne of forage dry matter per hectare over a three month period without adversely reducing grain yield. However, this innovation needs to be restudied in various ecozones as responses on the grain yield; the main crop by the smallholders may be different in different ecozones. In some cases defoliation has been observed to increase lodging.

Use of other arable farm by-products: These include sweet potato vines, bean haulms, banana leaves and peelings, cassava leaves and peelings and other home offals.

Fodder conservation: Grass and other fodders from the road side or from no man's-land could be conserved into silage or hay. Ensilage could be made in polyethylene bags or pits. Small-scale hay making could be made as per innovation devised by the SR-CRSP/MALD method. It consists of a simple wooden box, a grass cutting sickle and sisal twine. One family can make 10 bales each of 20 kg in one month on part time basis or 4 bales a day on full time basis.

Stovers and fodder legumes: Chopped maize, millet or sorghum stovers will give better performance if fed with forage legumes or with molasses by smallholders in the sugar cane belt. Small holders nearer the urban areas may have the incentive to feed the stovers with some concentrates to increase intake and digestibility.

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EFFORTS TO ENHANCE MAIZE STOVER UTILIZATION FOR SMALLHOLDER LIVESTOCK PRODUCERS IN MALAWI

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ABSTRACT

An attempt to boost the smallholder livestock farmer feed resourses qualitatively and quantitatively through the integration of improved forages in maize crop production systems is discussed. Where the testing of different forage systems undersown in maize was done on smallholder dairy farms, the Rhodes grass-silverleaf desmodium appeared to make a better contribution to the overall forage production.

On station, the time of sowing/undersowing the forage legumes in a maize crop had no effect on all components of yield except forage legume yield which was depressed by delayed planting. Signigicant differences were obtained between the different forage systems and maize stripping intensities. There was a tendency for the climbing forage legume species to enhance the crude protein value of the maize stover component.

INTRODUCTION

Recent estimates by Mkamanga (1986) on national cereal grain production in Malawi puts the hectarage devoted to maize production at 1,145,100 ha with a total grain production of 1,355,200 tonnes. This production figure is 4.6 times the documented purchases of this crop by the Agricultural Development and Marketing Corporation (ADMARC) (Dzowela 1985). The reason for this discrepancy is that the major portion of the national production is used directly for consumption by the farm families themselves, maize being the stable cereal crop.

Alongside this large cereal grain production, there is an estimated 1.5 million tonnes of maize stover. This maize stover is a readily available feed resource to smallholder livestock producers which is utilized by livestock in situ, after the maize ears are removed, or cut and stall-fed. Maize stover per se as a feedstuff for livestock is inferior when compared to other locally available feed materials (Table 1).

The most limiting factor to animal performance fed on maize stover appears to be that of dietary protein. Protein supplementation alleviates the deficiency but a majority of protein supplements may be too expensive for the smallholder producers to afford on a regular basis. The most logical way of getting round this problem would be to incorporate tropical forages in the maize cropping systems (Dzowela, 1985). After the maize ears have been removed, the forage legume component, especially the climbing types could make an important contribution to maintaining adequate protein levels in the maize stover-based diets. The legume component could act as a source of protein above the

7% threshhold and also in promoting increased intake of the associated maize stover.

Table 1. Comparison of maize stover with various other feed stuffs available on smallholder dairy farms in Malawi.

Feedstuff	No.of Samples	%CP	Range	%CF
Madeya (Maize bran)	4	10.7	(10.6-10.9)	5.5
Groundnut haulms	5	11.2	(10.9-11.6)	39.9
Maize stover with leaves	3	3.2	(2.8- 4.9)	30.6
Rhodes grass hay	9	4.5	(3.5- 5.2)	36.2
Maize silage	11	6.6	(5.2- 9.1)	36.2

Dzowela (1985) outlined some of the chemical-based technologies for increasing the nutrient availability from maize stover. These methods include ammonia treatment and soaking in a solution of sodium hydroxide. This paper focusses on the work currently undertaken by the Pastures Commodity Research Team of the Ministry of Agriculture in attempt to integrate improved forages with maize cropping systems in Malawi.

MATERIALS AND METHODS

Smallholder based work

Using the adaptive on-farm research approach, some smallholder dairy farmers participated in an integrated maize crop-forage improvement programme in the Kasungu Agricultural Development Division. The pasture intervention was based on four systems, namely:

a. Pure Rhodes grass

b. Rhodes grass in association with silverleaf desmodium (*Desmodium uncinatum*)

c. Rhodes grass in association with Common Centro (*Centrosema pubescene*)

d. Rhodes grass in assotiation with a "Shotgun" mixture involving Silverleaf desmodium, Common Centrosema, *Neonotonia wightii* and Joint vetch (*Aeschynomene americanum*).

All these pasture systems were undersown to maize after the first weeding operation before the maize crop was knee high.

A similar approach was adopted in the 1984/85 season, in which the maize crop-improved pasture integration was done on three smallholder farms as a pre-fallow exercise. During the 1985/86 season a quantification of the forage production in both the newly established four pasture systems and those established in the 1984/85 season was done.

Station Based Work

This work was undertaken for a second season at Chitedze Agricultural Research Station during the 1985/86 season. The object was to generate simple technologies geared towards the integration of forage in cereal grain production of smallholder dairy producers. Four pasture systems were tested, namely;

a. Maize - common Centrosema (C. pubescens)

b. Maize - Neonotonia wightii

c. Maize - Centrosema pascuorum

d. Maize - Silverleaf desmodium.

These four forage legume systems were either sown at the same time the maize (MH12) was planted in November, 1985 or undersown after the first weeding of the maize crop when the maize plants were 30cm high. In both cases the forage legumes were drilled on top of the ridge in between the maize planting stations which were 0.90m apart.

Based upon similar work in the previous year (Dzowela 1985), the maize leaves below the maize cob were stripped at weekly intervals from the silking/anthesis physiological development stage for seven weeks. The stripping of the lower maize leaves which serve no useful purpose in maize grain filling (Loomis 1935; Stickler and Pauli 1961; Hoyt and Bradfield 1962; Chaudhry 1969; Tanaka and Yamaguchi 1972; Soza et al 1975), could provide a cheap feed resource of high nutritive value to dairy animals on smallholder farms (Dzowela 1985). In the current study, results of this work are presented.

RESULTS AND DISCUSSION

On-farm Research

A quantification of the pasture systems sown the previous (1984/-85) season revealed that the silverleaf desmodium - Rhodes grass system produced the largest amounts of forage dry matter (Table 2); being 38 per cent more than the pure Rhodes grass pasture system. The Rhodes-Centrosema system resulted in 11 per cent more forage than the pure Rhodes system. The silverleaf botanically accounted for more than 40 per cent of the sward, based on visual estimates, whereas Centrosema was less than 20 per cent.

Table 2. Second year's forage DM yields from the three pasture systems

Pasture system	DM yields in kg/ha
Pure Rhodes system	3805
Rhodes + Silverleaf	6110
Rhodes + Common Centro	4213
Mean	4709
SE	±660*

For the pasture systems established established in the 1985/86 season the forage DM yield data are shown in Table 3.

Table 3. Forage DM yields of the pasture intervention systems in 1985/86 season

Pasture Systems	Pasture Components	Forage DM yield in kg/ha
Maize-Rhodes	Maize stover	3834
	Rhodes grass	1430
Maize-Rhodes with silverleaf	Maize stover	4440
	Rhodes grass	1016
	Silverleaf	433
Maize-Rhodes with shotgun mixture	Maize stover	3808
	Rhodes grass	1149
	Legume mixture	152
Maize-Rhodes with Centrosema	Maize stover	2903
	Rhodes grass	2910
	Centrosema	123
SE (Pasture systems)	Stover	±380*
	Rhodes grass	±242**
	Legumes	±225*

The Rhodes grass - Centrosema pasture system was the best intervention from the point of view of total forage production even though the very low maize stover yields in this system was below average. The system contributed 104 per cent more forage over and above the maize stover, but of the forage production only 4 per cent was contributed by the Centrosema component. The Rhodes-silverleaf system which produced comparable forage yields to the pure Rhodes system had a 30 per cent silverleaf contribution to the overall forage production of the pasture intervention over and above maize stover. The Rhodes-shotgun mixture system on the other hand, gave lower forage yields than the pure Rhodes intervention; the legume component in this system contibuted 12 per cent to the total forage production over maize stover.

All systems were able to contribute significantly towards feed resources of the smallholder livestock producers over and above the maize stover production. The forage production from the pasture intervention system had a higher crude protein content of well above the minimum recommeded value of 7.0 per cent, whereas the maize stover alone is less than 5.0 per cent in crude protein content (Dzowela 1985).

Station Research

Maize grain yield was not affected by the forage legume sowing/undersowing time and both the forage legume system and maize stripping intensity treatments did not have any effect on grain yield either. The fact that there were no sifnificant grain yield reduction as a result of maize leaf stripping confirms what is already known about the physiology of the maize plant (Loomis 1935; Stickler and Pauli 1961; Hoyt and Bradfield 1962; Chaudhry 1969; Tanaka and Yamaguchi 1972; Soza et al. 1975). Maize stover yields were also not affected by legume sowing/-undersowing time, forage legume systems or maize leaf stripping intensity (Table 4). With respect to forage dry matter yields as affected by the stripping of the different maize leaves, there was no interaction with time of undersowing. But the forage systems resulted in significant differences in the amounts of stripped leaf forage DM produced. The least amount came from the Neonotonia forage system (P<0.05) as shown in Table 5. There was a significant progressive increase in the amount of forage DM produced the more the plant leaves were stripped (P<0.01).

The total forage yields from all the leaves below the cob indicate the potential of using such a feed resource for ruminant feeding which is otherwise a useless component in maize grain filling processes. Use of these leaves below the cob for forage puposes is a practice in Guatemala, Eygpt and Kenya (Soza 1975; Abate et al, 1985). It is a feed resource of high quality with a crude protein content of no less than 12 per cent (Dzowela 1985). Delay in sowing/undersowing of the forage legume from the time of planting maize to after the first maize weeding operation resulted in a significant reduction in forage yields from the pasture systems (P<0.01) as shown in Table 6. This reduction is a reflection of the smothering effect of the maize canopy on the early development of the forage legumes.

The forage legume component contribution to overall forage production in the different interventions was not affected by time of sowing/undersowing. The least amount of forage was contributed by Neonotonia which for two years now has indicated to be slow in establishment and hence most smothered in association with a maize crop (Dzowela 1985). The largest amount of forage came from the Pascuorum followed by the Silverleaf system (Table 7). There was a tendency for the legume forage DM to increase with maize leaf tripping intensity as a manifestation of improving light relationship underneath the maize canopy.

Table 4. Maize grain and stover yields from the four forage legume systems and maize leaf stripping intensities.

Pasture System		Maize leaf stripping 1	2	3	4	5	6	7	Means
Maize-Common Centrosema:	Grain	6415	7760	7857	7387	6761	6257	6127	6922
	Stover	8504	9309	9230	8633	7771	7955	7711	8445
Maize-Neonotonia:	Grain	5992	5503	6490	5284	6566	6340	6869	6149
	Stover	8188	7951	9359	8235	8463	7481	8005	8249
Maize-Pascuorun Centrosema:	Grain	6424	5206	7117	5593	5832	6581	4818	5939
	Stover	8649	6888	8116	7847	8463	8879	7279	8017
Maize-Silverleaf	Grain	6680	7370	6553	7416	6884	6689	6125	6816
	Stover	7150	8952	7847	8163	8561	8232	7109	8002
Means:	Grain	6378	6460	7004	6420	6510	6465	5960	
	Stover	8123	8275	8638	8220	8314	8137	7526	
S.E. Pasture	Systems:								
	Grain		$\pm$202NS						
	Stover		$\pm$288NS						
S.E. Stripping	Intensity:								
	Grain		$\pm$355NS						
	Stover		$\pm$342NS						

Table 5. Stripped maize leaves and forage DM yields from the different Pasture systems and position of the stripped leaf below the cob

Pasture System	Leaf Position 1	2	3	4	5	6	7	Total Means	Forage kg/ha
Common Centrosema	243	226	317	477	515	481	544	400	2803
Necnotonia	162	223	326	384	523	471	512	372	2601
Pusecuorum Centrosema	178	232	351	497	514	569	533	411	2876
Silverleaf	178	199	306	437	488	534	522	381	2664
Means	190	220	325	449	510	514	528		

S.E. of Pasture systems means ± 8.2*
S.E. of leaf position means ± 173***

Table 6. Forage legume DM yield in kg/ha in response to time of sowing per undersowing

Forage System		Stripping Intensity 1	2	3	4	5	6	7	Means
Maize-Common Centrosema	T_1	324	448	681	377	253	200	380	353
	T_2	146	274	271	207	221	163	188	210
Maize-Neonotonia	T_1	23	211	98	59	130	86	71	97
	T_2	23	41	22	45	46	67	32	39
Maize-Pascuorum	T_1	738	1044	739	576	740	656	866	764
	T_2	222	364	392	350	497	340	475	377
Maize-Silverleaf	T_1	801	478	563	653	522	719	318	579
	T_2	248	280	363	224	465	358	402	334
Means	T_1	472	545	518	417	535	428	364	468
	T_2	159	240	262	207	308	232	274	240

S.E. (T. Means) ± 85***

Table 7. Forage DM Yield in kg/ha of the legume components in the different systems

Forage System	Maize leaf stripping intensity 1	2	3	4	5	6	7	Means
Maize-Centrosema	235	260	476	293	188	207	194	269
Maize-Neonotonia	22	125	60	52	88	76	61	68
Maize-Pascuorum	480	704	560	463	619	498	670	571
Maize-Silverleaf	525	379	463	439	494	538	360	457
Means	315	392	390	312	470	330	319	

S.E. (Pasture systems) ± 61 **

S.E. (Stripping intensity) ± 42 ***

Table 8. Crude protein percentages (on DM basis) of the maize stover from the four pasture systems

Forage System	Maize leaf stripping intensity 1	2	3	4	5	6	7	Means
Maize-Centrosema	7.07	8.24	7.16	6.34	6.42	6.88	5.99	6.91
Maize-Neonotonia	6.97	7.88	6.88	5.92	6.81	5.54	5.04	6.43
Maize-Pascuorum Centrosema	6.46	7.94	6.91	5.94	4.69	4.88	4.13	5.85
Maize-Silverleaf	5.25	5.48	4.94	4.00	4.92	4.50	3.71	4.69
Means	6.44	7.46	6.47	5.55	5.71	5.45	4.72	

S.E. Pasture System Means ±0.202 **

S.E. Leaf Stripping Intensity Means ±0.351 ***

Qualitatively, maize stover crude protein content was not appreciably affected by the forage legume sowing/undersowing time. The inclusion of the climbing forage legumes (Centrosema Neonotonia and Pascuorum) resulted in a maize/legume and stover product higher in crude protein content than the silverleaf-based stover (P<0.01) (Table 8). The climbing forage legumes were intact on to the stover at the time of harvesting the stover and contributed to the high CP contents. The silverleaf desmodium, on the other hand being determinate in its growth habit was not attached to the maize stover at the time of cutting.

There was a tendency for the maize stover crude protein content to decrease with the maize stripping intensity (Table 6). Maize stripping as such is a physical removal of the component of the maize plant that is more nutritive than the stem. However, the fact that the stripped leaf material when stripped before senescence is a product of high quality (Dzowela, 1985) which could be fed to animals fresh or dried, may more than compensate for the reduction in the CP content of stover *per se*.

CONCLUSION

These sets of data appear to demonstrate the potential for intergrating improved forage technology in maize cropping systems of smallholder livestock producers. It helps to improve the feed resources of such smallholder livestock producers quantitively and qualitatively. Once adopted they could have an enhancing effect on the utilization of crop by-products such as maize stover and some of the otherwise wasted products from the maize plant.

The potential of climbing forage legume species ought to be explored further, especially those that stay green longer after the maize crop has dried up.

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MAIZE STOVER AND COBS AS A FEED RESOURCE FOR RUMINANTS IN TANZANIA

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ABSTRACT

Maize is the most important crop in Tanzania and total grain yields amount to 2 million tons annually, accompanied by the production of residues (stover and cobs) exceeding 4 million tons. Maize stover is largely grazed *in situ* and maize cobs used as fuel in small scale farms. The nutritive characteristics of both residues were studied through digestibility studies of diets formulated to contain 35 - 70% residues followed by production feeding trials on the most promising diets. It was shown that diets containing proportions of maize stover and maize cobs could support reasonable growth rates and milk yields.

The application of research results on farms is being investigated in a follow up project. It is obvious that the use of maize cobs as a ruminant feed is limited to large scale farms where adequate quantities are produced and grinding mills are available. In the case of maize stover, the major constraints to application of better feeding strategies is bulkiness which renders storage and transportation difficult. Further research is still required to elucidate the specific roughage x energy supplement interactions.

INTRODUCTION

Crop residues have been estimated to account for about 25 percent of the total feed energy suitable for ruminant livestock in both developed and developing countries (Kossila 1985). In 1981, maize was considered the leading crop in providing crop residues that could be utilized as a livestock feed (Table 1).

In Tanzania maize is the most important cereal crop grown for human food production (Table 2). Using a ratio of 1:2 between grain and amount of crop residues produced, suggests that about 4 million tonnes of maize stover and maize cobs are produced annually. In some areas the high potential maize producing areas have high cattle populations as well, while in other areas maize is grown in marginal rainfall areas and does not overlap with high cattle populations.

Both maize stover and maize cobs contribute significantly as ruminant livestock feed particularly during the dry season. Some of the major constraints that limit efficient utilization of maize stover and/or maize cobs are as tabulated below:

Atributes and disadvantages of using maize stover/cobs as livestock feed.

	Maize stover	Maize cobs
1. Present use	Mostly grazed *in situ*	Used as firewood in small scale farms, wasted on large scale farms
2. Availability as livestock feed	Available	Available on large scale farms only
3. Collection	Has to be collected from the field	Produced at homesteads
4. Transportation	From field to homestead	No need (cobs shelled at homestead or at granary)
5. Storage	Bulky, preferably baled	Medium density
6. Baling/grinding	Applicable but not necessary	Has to be ground and output is good
7. Mixability with other ingredients	Difficult	Easily mixed after grinding

Table 1. Global production of fibrous crop residues from different crops in trillion tonnes, 1981.*

Crop	Amount of crop residue (trillion tonnes)
Maize	1.0
Wheat	0.5
Rice	0.5
Pulses, each	0.5
Sorghum	0.3
Barley	0.2
Sugarcane	0.2
Roots and tubers	0.17
Millets and nuts each	0.13
Fruit and berries	0.11
Vegetables	0.08
Oats	0.06
Rye	0.05

* FAO Animal Production and Health Paper 50 FAO Rome - 1985.

Table 2. Food Crop production estimate in Tanzania 1984/1985 season ('000 tons)

Region	Food crops							
	Maize	Millets	Paddy	Beans	Wheat	Cassava	Banana	Sweet Potatoes
Arusha	127	33	3	13	52	5	12	2
Coast	11	4	32	1	–	88	10	1
Dodoma	23	84	2	1	–	5	–	–
Iringa	367	11	3	45	23	10	–	10
Kagera	68	49	11	82	–	22	268	22
Kigoma	73	10	3	47	3	3	13	3
Kilimanjaro	60	7	12	18	4	3	220	3
Lindi	22	36	21	12	–	135	18	–
Mara	31	44	1	4	–	19	70	19
Mbeya	240	38	48	38	5	18	75	18
Morogoro	110	10	80	4	–	1	3	1
Mtwara	22	39	26	9	–	4	–	4
Mwanza	76	68	37	19	–	78	–	78
Rukwa	160	50	12	25	–	2	1	2
Ruvuma	142	23	21	27	4	125	–	–
Shinyanga	286	267	61	52	–	92	25	92
Singida	23	126	2	1	–	11	–	11
Tabora	166	128	45	23	–	37	–	37
Tanga	60	–	5	17	–	1	58	1
TOTAL	2067	1018	425	438	93	1921	773	304

* Marketing Development Bureau, Dar es Salaam R 4/85.

The practice of in situ grazing is wasteful and inefficient (French 1943). Where the animals have to be fed indoors, the bulk factor becomes as important constraint as this increases transportation and storage costs. Grinding of maize cobs on the other hand increases wear and tear on the hammer mills.

COMPOSITION & NUTRITIVE VALUE OF MAIZE COBS & STOVER

Several studies were conducted at Morogoro, Tanzania with the overall objective of assessing the nutritive value of maize crop residues with a view of developing feeding packages for farmers. Results involving alkali treatment have been omitted since the technology can no longer be justified because of the prohibitive costs of alkalis. Data on chemical composition, derived from work carried out at Morogoro and Kabete, in Tanzania and Kenya respectively, are given in Table 3, and Table 4 presents the formulation and digestibility of several diets based on maize cobs and stover.

Table 3. Chemical composition of maize cobs and stover (% DM)

	Maize stover Hybrid 631/32 (Musimba 1980)	Maize stover Ilonga composite (Biwi 1986)	Maize stover Ilonga composite (Urio 1981)	Maize cobs Ilonga composite (Urio 1981)
Dry matter (DM)%	93.4	-	90.6	88.1
Ash	12.1	8.1	6.0	3.9
CP	2.3	3.5	2.4	2.2
CF	45.3	39.4	-	-
EE	1.8	0.6	-	-
NFE	38.4	48.4	-	-
NDF	-	80.7	-	-
Ca	-	0.32	-	-
P	-	0.28	-	-
GE,MJ/kg DM	-	16.6	16.3	17.3

The results indicate that maize stover and/or maize cobs can successfully be incorporated in ruminant rations and that such rations have relatively high digestibilities.

With rations 1 and 2 (Table 4) the replacement of cottonseed cake by urea as a source of protein did not affect digestibility, although Kategile (1978) observed a slight depression in voluntary feed intake when urea was used at 0.5 percent with no further effect when urea was increased above 0.5 percent. There was no significant difference in digestibility between diets 3 and 4 when urea was used as a source of protein in place of cottonseed cake. Other sources of protein such as leucaena can be used effectively with maize stover as shown in diet 5. The comparatively low digestibility coefficient noted with diet 6 is probably due to the fact that digestibility was determined at *ad libitum* level of intake and that the roughage constituted a much higher percentage of the ration.

Table 4. Digestibility coefficients of diets based on maize stover/cobs

Ingredients (percent of ration)	Diets					
	1	2	3	4	5	6
Maize stover	-	-	-	-	38.3	78.8
Maize cobs	59.8	67.0	45.0	35.0	-	-
Leucaena	-	-	-	-	16.1	-
Molasses	19.0	20.0	24.0	24.0	-	3.6
Cassava	-	-	15.0	-	18.5	-
Maize bran	-	-	-	-	17.3	5.9
Urea	1.0	3.0	3.0	-	1.2	-
Cottonseed cake	18.0	8.0	10.0	37.5	7.4	10.6
Bone meal/Maclik*	2.0	2.0	2.5	2.5	1.2	1.1
Salt	0.2	-	0.5	0.5	-	-
Digestibility coefficients (*In vivo*)						
DM	61.3	61.1	68.8	69.8	64.7	56.5
OM	59.9	62.6	69.3	72.3	67.8	59.7
CP	-	-	81.5	83.5	71.7	-
CF	70.2	-	66.8	68.3	69.6	-
NDF	-	52.9	-	-	-	-
EE	-	-	78.4	78.9	-	-
NFE	-	-	71.1	71.1	-	-
DM intake g/kg$W^{0.75}$	60.5	43.7	28.5	28.0	93.6	61.1
	Kategile (1978)		Mangazeni (1982)		Biwi (1986)	Urio (1981)

* Maclick - Coopers Ltd, Kenya.

Both maize stover and maize cobs are high in lignocellulose content and would probably require a source of readily available carbohydrate for optimum utilization. Preliminary studies (Table 5) have shown that cassava combines well with both stover and cobs, but more so with stover (Kategile 1981), producing substantial increases in dry matter digestibility. Further work is required on the utilization of available sources of readily available cabohydrate in the production of rations with these maize residues.

Table 5. The effects of sources of readily available carbohydrates on digestibility coeeficients.*

Ingredient %	Diets			
	1	2	3	4
Maize cobs	58.0	58.0	-	-
Maize stover	-	-	58.0	58.0
Molasses	20.0	-	20.0	-
Cassava	-	20.0	-	20.0
Sunflower/cottonseed cake	20.0	20.0	20.0	20.0
Bone meal/salt	2.0	2.0	2.0	2.0
<u>Digestibility coefficients</u>				
DM	62.6	68.7	55.3	74.0
OM	68.9	69.7	58.4	76.8
CP	53.1	43.9	79.1	67.2
EE	79.2	80.7	68.8	84.4
CF	64.1	61.3	46.9	70.0
NFE	70.2	79.0	59.8	80.5
DM intake $g/W^{0.75}$	44.5	45.2	43.9	44.3

* Kategile (1981)

PERFORMANCE OF LIVESTOCK FED ON MAIZE STOVER/MAIZE COBS

After obtaining results on the potential of maize stover/cobs as a livestock feed, complete rations were formulated and tested using various classes of livestock (Table 6). The rations promoted reasonable rates of production even at high levels of residue inclusion. Diets 1, 4, 5 and 6 constituted complete rations while diets 2 and 3 were used as supplementary rations for grazing steers.

The above results indicate that maize stover/cobs is a potentially valuable feed resource for ruminants, whose efficient utilization can result in appreciable production improvement in various livestock classes. Dry seasons in Tanzania as well as in many other tropical countries are marked with periods of feed shortages resulting in general retardation in animal growth and production. Maize stover/cobs contribute significantly in reducing the dry season feed stress. This contribution could probably be increased if the following improvements could be made:

Improving handling and transportation of maize stover by reducing bulkiness and transport costs by baling or other processes to minimize wastages.

2. Studying optimum ration formulations both as a means of improving feed quality as well as formulating a least cost ration.

3. Where technology allows, grinding of maize cobs provides opportunity of utilizing a feed resource which is otherwise wasted, and ground maize cobs could form a major component in basal rations for steers for which feedlots could easily be established near large scale maize farms.

Table 6. Performance of livestock fed on maize stover/cobs based diets

Ingredients (percent of ration)	Diets					
	1	2*	3*	4	5	6
Maize cobs	60.8	45.0	35.5	50.8	-	-
Maize stover	-	-	-	-	78.8	38.3
Molasses	19.0	24.0	24.0	8.4	3.6	-
Cassava	-	15.0	-	-	-	18.5
Urea	1.0	3.0	-	-	-	1.2
Maize bran	-	-	-	13.8	5.9	17.3
Leucaena	-	-	-	-	-	16.1
Cotton/sunflower seed cake	17.0	1[illegible].0	37.0	24.6	10.6	7.4
Bone meal	2.0	2.5	2.5	2.4	1.1	1.2
Salt	0.2	0.5	0.5	-	-	-
ANIMAL PERFORMANCE						
Species	Heifers	Steers	Steers	Goats	Sheep	Lactating cows
Numbers	6	10	10	6	6	6
Initial weight (kg)	170.1	251.3	251.2	15.2	30.3	-
Final weight (kg)	195.3	297.2	299.5	18.5	38.5	-
Daily gain g/day	412	511	533	33.2	80.7	-
Daily milk yield kg/day	-	-	-	-	-	7.6
DM intake $g/kgW^{0.75}$	104	-	-	45.6	61.1	93.6
Feed DM/kg gain	13.2	-	-	13.0	11.7	-
	Kategile 1979		Mangazeni 1982	Urio 1981	Urio 1981	Biwi 1986

* Supplementary rations for grazing steers, others are complete diets.

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CATTLE FATTENING ON BASAL DIETS OF MAIZE STOVER AND GROUNDNUT TOPS IN MALAWI

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ABSTRACT

Maize stover is the most abundant crop residue in Malawi followed by groundnut tops. Both of these crop residues are widely used for grazing and stallfeeding cattle. Maize bran is the main supplement fed to stallfed cattle whilst cottonseed cake and leucaena (L. leucocephala) are sometimes fed with maize bran. A review of the utilization of crop residues for stallfed cattle revealed that composite maize have about 2.5% crude protein (CP) higher than that of hybrid maize and groundnut tops contain almost twice the CP content of maize stover. Adequate liveweight gains by cattle can be achieved by supplementing a maize stover and restricted (3.6kg) maize bran diet with either groundnut tops, cottonseed cake or leucaena. Large gross margins can be obtained by fattening cattle on crop residues and the stall-feeding of cattle is likely to increase as land pressure continues to increase.

INTRODUCTION

Maize (Zea mays) and groundnut tops (Arachis hypogaea) are major food crops in Malawi. Approximately 59 and 24% of the total area cropped by smallholder farmers is devoted to maize and groundnut production respectively (Manda et al., 1985). The corresponding production of crop residues from these crops in 1985 was 2.71 and 0.7 million tonnes for maize and groundnuts, respectively (Munthali and Dzowela 1985). The majority of these crop residues are grazed in situ while variable quantities are either burnt, ploughed into the soil or stallfed to cattle. Hence crop residues constitute a major feed resource for cattle during the dry seasons.

This paper gives the scope for the utilization of crop residues in Malawi and a review of the research findings aimed at improving animal performance from feeding crop residues, mainly maize stover and groundnut tops.

Scope for utilization of maize stover and groundnut tops

Utilization of crop residues in Malawi is optimal on smallholder farms where both crops and cattle are raised. Smallscale zero grazing commercial livestock production, based on one to four dairy cows or steers, is being practised. Increased land pressure (Table 1) is likely to result in increased intensive livestock production. Zero grazing is already popular in Malawi not only because of immediate cash benefits from the sale of milk or fattened cattle, but also because of the large quantities of organic manure produced in the feeding pens. The manure is widely used in the production of cash crops such as tobacco and maize.

The production of milk and high quality beef from fattened steers makes a tremendous saving on imports of animal products by the country.

Table 1. Per capita land availability by smallholder farmers in Malawi

Year	Population (x 100)	Land availability (ha)
1966	4031	1.65
1970	4441	1.50
1974	4916	1.35
1978	5723	1.16
1982	6410	1.04
1986	7017	.95

The traditional stallfeeding diets are maize stover and/or groundnut tops supplemented with maize bran. Animal production from these diets is very variable. Research on the utilization of maize stover and groundnut tops as basal diets for stallfed cattle has been conducted since the early 1970's (Anonymous, 1972-1979). The main objective of such studies were to determine the production levels that could be achieved by feeding various quantities of these roughages with various supplements.

RESEARCH ON THE UTILIZATION OF CROP RESIDUES

Yield and chemical composition of common crop residues

Up until now, crop residues are being fed to cattle without any regard to varietal differences in their quality. For example, there are several varieties of maize grown in Malawi which can broadly be categorized into hybrids and composites, whose residues might have different nutritive value. Thus a survey of common crop residues was carried out at Chitedze Research Station to find out if large varietal differences in quality exist and to estimate their yields. Samples were collected from maize agronomy, groundnut breeding and sweet potato (Ipomea batatas) breeding trials. The maize crop was given 105 kg N/ha while groundnuts were sprayed with Daconil 2787 W 75 at the rate of 3.6 kg/ha. Sweet potatoes did not receive any fertilizer. Crop residue samples were collected from the fields soon after harvesting. The results of their nutritive value and dry matter production are given in Table 2. The composites (local and UCA) tended to have more crude protein than hybrid maize (NSCM 41 and MH 12). The acid detergent fibre (ADF) was high in all maize stovers which is consistant with other studies (Holloway et al. 1977; Berger et al. 1979; Oji and Mowat 1979; Butterworth and Mosi 1986).

Dry matter yields of maize stover were also higher for the composites than for the hybrids used. In a mixed farming system (crops and livestock) commonly seen on smallholder farms composites could be more attractive than hybrids for cattle feeding; based the chemical analysis and dry matter production.

Table 2. Nutritive value and dry matter production of some common crop residues in Malawi

Crop residue	%DM	%CP	%ADF	Dry matter Production (kg/ha)
Maize stover				
Local	93.1	8.9	49.7	5864
UCA	92.8	8.6	45.5	6260
NSCM 41	92.08	6.5	48.4	4748
MH 12	93.0	6.0	41.4	4945
Groundnut tops				
Chalimbana (untreated)	91.8	14.0	40.7	2528
Chalimbana (treated)[1]	93.7	16.3	37.3	3062
Mawanga (untreated)	90.9	14.0	36.7	3030
Mawanga (treated)[1]	92.5	14.0	29.9	3607
Mani Pintar (untreated)	94.5	12.4	39.5	1897
Mani Pintar (treated)[1]	94.5	12.0	33.4	2871
Chitembana (untreated)	93.9	13.0	39.6	1777
Chitembana (treated)[1]	92.7	13.4	37.1	2619
RGI (unteated)	92.9	6.5	37.6	-
RGI (treated)[1]	91.4	10.0	36.4	-
Sweet potato vines				
Kenya	90.7	5.0	38.6	7532
Yoyela	91.6	7.1	36.2	5554
LRS 407	90.1	4.2	38.6	7156
Kamchiputu	89.4	4.2	33.7	872

1 = Treated with Daconil.

Differences in CP content amongst groundnut tops were also observed (Table 2). RG1, a rosette resistant variety, was the poorest in CP content whilst Chalimbana (the most susceptible variety to rosette) had the highest level of CP. The differences in CP between the sprayed and unsprayed groundnut tops was negligible except for RG1 in which the sprayed crop had a high CP. The ADF content was similar amongst the groundnut tops although the sprayed crop tended to have lower ADF content. The application of Daconil increased dry matter production which could be beneficial to livestock feeding. Potato vines had similar CP and ADF contents except vines from Yoyela which had a high level of CP.

Groundnut tops had the highest content of CP whilst potato vines had the lowest. Maize stover had the highest levels of ADF, characteristic of most crop residues from cereals. Groundnut tops might be used to supplement maize stover to raise its CP content, and its composite maize is likely to produce better animal production if fed with groundnut tops.

Stallfeeding experiments

The most abundant crop residue is maize stover and it is commonly stallfed to cattle in combination with maize bran. Experiments have been conducted to determine the level of feeding of these ingredients and the expected animal performances. Table 3 summarizes results of such trials. Feeding ad libitum quantities of maize stover with restricted amounts of maize bran produced lower daily liveweight gain than ad libitum maize bran; indicating that most of the liveweight gain was due to maize bran. The consumption of maize bran increased by 44 and 78% when it was fed ad libitum with ad libitum or restricted maize stover respectively. Daily liveweight gain was increased by corresponding 70 and 84%. As maize bran becomes more expensive (than the present MK0.02* per kg) ad libitum maize stover and maize bran would become more popular than just ad libitum maize bran.

* 1 US$ = 2.23 Malawi Kwacha

Table 3. Effect of supplementing maize stover with maize bran to beef cattle

Method of feeding: Maize stover	Maize bran	Maize bran consumed (kg/d)	Liveweight gain (kg/d)
Ad libitum	Restricted	3.6	0.37
Ad libitum	Ad libitum	5.2	0.63
Restricted	Ad libitum	6.4	0.68

In cognizance of the limitations of a maize stover/maize bran diet for fattening cattle, trials were carried out to find out if nitrogen supplementation would improve daily liveweight gains beyond the maximum of 0.68 kg/day (Table 3). Table 4 gives the results of feeding maize stover and maize bran with different sources of nitrogen.

Table 4. Effect of supplementing maize stover and maize bran with different sources of nitrogen to steers

Crop residue: Type	Crop residue: Feeding	Supplement: Type	Supplement: Consumption (kg/d)	Daily gain (kg/d)
MS[1]	Ad lib.[3]	Maize bran	3.6	0.37
MS+GNT[2]	Ad lib.	Maize bran	3.6	0.68
MS	Ad lib.	Maize bran + CSC[4]	3.5	0.75
MS	Ad lib.	Maize bran + Leucaena (4:1)	4.2	0.77

1 = maize stover, 2 = groundnut tops, 3 = ad libitum, 4 = cotton seed cake.

The supplements were fed to give similar levels (18.5% CP in supplement) of CP intake. When groundnut tops were fed with restricted (3.6 kg) amount of maize bran, daily gain by steers almost doubled (Table 4), and that was similar to daily liveweight gains obtained by feeding ad libitum (5-6 kg) amounts of maize bran (Table 3). Feeding cottonseed cake or leucaena (*Leucaena leucocephala*) with maize bran produced similar average daily liveweight gains but slightly higher than those obtained with feeding groundnut tops. This indicated that CP was indeed a limiting nutrient in promoting liveweight gains of steers fed a maize stover/maize bran diet.

Another experiment was conducted to determine the effect of feeding groundnut tops as a sole roughage with either plain miaze bran or maize bran with leucaena. Leucaena was fed to ascertain if additional CP would be required when groundnut tops are fed with maize bran. Two breeds of steers, Malawi Zebu (MZ) and Friesian (F) x MZ, were used. They were divided into two groups and fed either ration A (maize bran + salt) at the rate of 5 and 6.5 kg/head/day for the MZ and F x MZ, respectively, or ration B (maize bran + leucaena (4:1) + salt) at similar rates to those fed in ration A. Groundnut tops and water were given ad libitum. The results are given in Table 5. There were no differences ($P<0.5$) in both total and daily liveweight gain between the rations for both breeds. The FxMZ steers gained more liveweight and consumed more DM than MZ steers ($P<.01$). There were no differences within breeds in feed conversion between rations, but feed conversion efficiency was higher in F x MZ than in MZ steers. The results indicate that feeding groundnut tops to appetite would provide enough nutrients to offset any deficiencies found in maize bran. Similar results were obtained by Addy and Thomas (1976) who also reported breed differences between MZ and F x MZ in rate of gain and feed consumption.

Table 5. Effect of feeding groundnut tops with maize bran or maize bran leucaena (4:1) to steers

Item	Ration A MZ[1]	Ration A (FxMZ)[2]	Ration B MZ[1]	Ration B (FxMZ)[2]
Initial liveweight, kg	301.0a	382.7b	307.8a	404.3b
Final liveweight, kg	368.8a	483.4b	377.5a	504.4b
Days on test	80	80	80	80
Total gain, kg	67.8a	100.[illegible]b	69.7a	100.1b
Daily gain, kg	0.9a	1.3b	0.9b	1.3b
Conc.DM[3] intake/day, kg	4.5	5.[illegible]	4.5	5.9
Roughage DM intake/day,kg	3.0a	3.7b	3.2a	4.5b
Total DM intake/day, kg	7.5a	9.5b	7.7a	10.4b
Kg DM intake/kg gain	8.9a	7.6b	8.9a	8.3b

[1]Malawi zebu; 2 Friesian x MZ, [3]Dry matter; a,b figures with the same subscript are not sufficantly different.

Although groundnut tops have consistently been found to be better than maize stover in promoting liveweight gain of steers, the quantities available in Malawi are far lower than maize stover (Munthali and Dzowela 1975). Hence farmers frequently feed it in unknown combinations with maize stover. A trial was conducted to determine the best combination of maize stover and groundnut tops in stallfed animals. Unchopped maize stover and groundnut tops were fed ad libitum in five combinations as shown in Table 6. Maize bran was fed at the rate of 4 kg/steer daily on as is basis. Results of the experiment are given in Table 6. Daily liveweight gains and cold dressed weights increased ($P<0.05$) with increased groundnut tops ratios in the diet. Total dry matter intakes were similar for all diets even though steers tended to consume more groundnut tops than maize stover. Butterworth and Mosi (1986) reported improvements in DM intake when 0 to 50% trifolium (T. tembense) was fed with maize stover. Lack of improvements in DM intake in the present study was due to the poorer quality of groundnut tops than trifolium; 9.2 and 20.1% CP for groundnut tops and T. tembense respectively. The best combination of maize stover and groundnut tops in promoting liveweight gain of steers was as 50: 50 ratio (Table 6). This study confirmed that ad libitum maize stover and restricted maize bran is not adequate to finish steers, but that groundnut tops could be useful in improving daily gains.

Table 6. Performance of steers fed different combinations of maize stover and groundnut tops

Component	Maize stover to groundnut tops ratio				
	100:0	75:50	50:50	25:75	0:100
Initial liveweight, kg	202.0	201.5	198.5	214.5	202.6
Final liveweight, kg	234.2	248.5	266.3	260.6	
Days on test	90	90	90	90	90
Total gain, kg	32.2	46.9	64.0	51.8	58.0
Daily gain, kg	0.36c	0.52d	0.58de	0.66de	
Cold dressed weight, kg	118.0c	129.7d	141.3e	141.3e	140.5e
Dressing percentage	50.4	52.2	53.8	53.2	53.9
Roughage DM intake,kg/day	4.6c	4.8c	5.2c	5.0c	4.7c
Maize bran DM intake,kg/day	3.7	3.8	3.8	3.8	3.8
Total DM intake, kg/day	8.3c	8.6c	9.0c	8.8c	8.5c
DM intake/kg gain	23.1	16.5	12.7	15.3	12.9

c,d,e, Figures within the same row but having different subscripts are statistically different ($P<0.05$).

Prospects for Future Utilization of Crop Residues

The picture of land availability presented in Table 1 indicates that little cultivable land will be available for arable crop production, let alone the production of forages for animal production. Improvements in plant breeding and husbandry might increase both crop and by-products yields per unit area generating feed for livestock. A farmer's choice to raise cattle will depend upon their importance in the overall farming system (manure and draft) and the demand for milk and meat.

Economic analyses of feeding crop residues were conducted by I. H. Proverbs (unpublished) and A.P. Mtukuso, R.C. Graaf and D.W. Pervis (unpublished), and both reports showed favourable gross margins. An economic analysis based on data in Table 5 is given in Table 7. The cost of feed is strikingly low under smallholder conditions where crop residues are used at very low cost and maize bran is obtained by batter with salt. The cost of maize bran was estimated at MK 0.02/kg while the price of a steer was MK 0.46/kg liveweight and the carcass (first grade) was valued at MK 1.35/kg. The gross margins are higher for producer feeders than for those steers issued on loan, mainly because of the cost of servicing the loan. Stall feeding is likely to remain profitable in Malawi so long as family labour is not costed and as long as the cost of crop residues and by-products remains low.

Table 7. The potential profitability of stallfeeding of steers using groundnut tops as the sole roughage

Item	Ration A		Ration B	
	MZ[1]	(FxMZ)[2]	MZ[1]	(FxMZ)[2]
Grade at start	Feeder A	Feeder A	Feeder A	Feeder A
Grade at finish	Choice	Choice	Choice	Choice
Liveweight at start, kg	301.0	382.7	307.6	404.3
Liveweight at finish, kg	368.8	483.4	377.5	504.4
Carcass weight, kg	230.0	283.0	232.0	276.0
Carcass value at	310.5	382.1	313.2	372.6
Variable Costs:				
Producer stallfeeder				
Steer at MK 0.46/kg Liveweight	138.5	176.0	141.6	186.0
Concentrate consumed, kg	410.0	533.0	410.0	533.0
Cost of concentrate MK[3]	6.2	8.0	10.7	14.0
Transport to abbatoir MK	5.2	5.2	5.2	5.2
Insurance at 1.25% cdw[4],MK	3.2	3.9	3.2	3.8
Total variable costs, MK	153.1	193.1	160.7	209.0
Gross margin, MK	15.4	189.0	152.5	163.6
Feeder issued on credit				
Steer at MK 0.46/kg liveweight	138.5	176.0	177.7	232.0
20% interest, insurance and transport, MK	27.7	35.2	35.5	46.4
Concentrate cost, MK	6.2	8.0	10.7	14.0
Total variable costs, MK	172.4	219.2	223.9	292.4
Gross margin, MK	138.1	162.9	89.3	80.2

[1]Malawi Zebu
(FxMZ)[2] = Friesian x MZ
[3]Malawi Kwacha (1 US$ = 2.23 MK)
[4]Cold dressed weight

CONCLUSION

Adequate animal gains can be achieved by feeding either maize stover with ad libitum amounts of maize bran, or maize stover and restricted amounts of maize bran supplemented with nitrogen. The source of nitrogen can either be groundnut tops, leucaena or cottonseed cake. It is still profitable to fatten steers on crop residue in Malawi and stallfeeding is likely to increase in future due to an increase in land pressure.

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RICE STRAW AND RICE HULLS IN FEEDING RUMINANTS IN EGYPT

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INTRODUCTION

Rice straw represents an important summer crop by-product in Egypt. About 3.5 million tons of rice straw and 0.5 million tons of rice hulls are produced every year from the rice fields and rice milling process respectively. There is no practical use for these by-products, up till now, except for fuel. This paper reviews some research results relevant to the use of rice straw and rice hulls as feeds for ruminants in Egypt. The chemical composition of these materials is given in Table 1, showing the limiting factors for their utilisation by ruminants are low crude protein, high fibre and low available energy contents.

Table 1. Chemical composition of rice straw and rice hulls.

Ingredient	Dry Matter %	% on DM basis					
		Ash	Crude fibre	Crude protein	Ether extract	Nitrogen free extract	Total Digst. Nutr.
Rice straw	90.93	20.32	35.39	4.62	1.14	38.53	40.0
Rice hulls	96.40	20.51	48.55	1.79	0.83	28.32	21.4

METHODS FOR IMPROVING THE NUTRITIVE VALUE

Physical treatments

Grinding

Grinding of straw increases its intake and leads to a higher digestible energy intake by some 30% (Jackson 1978). Grinding usually decreases digestibility, but at the same time increases net energy content. The effect of grinding is much less to nil when straw comprises 50% or less of the diet (Jackson 1978).

Steam processing

Steam-processing of low quality roughages has been recommended to increase energy availability (Bender et al. 1970), and in

Table 2 some results are presented of the effect of such treatment on the in vitro digestibility of dry matter and volatile fatty acid production. Steam treatment had no effect on in vitro DMD of rice straw, but effectively increased DMD of maize cobs, bagasse and pith (Abaza et al 1981).

Table 2. Effect of steam treatment on *in vitro* dry matter digestibility (%) of rice straw compared with other roughages.

Item		Rice straw	Maize Cobs	Bagasse	Pith
Control	DMD	33.6	20.5	23.5	17.5
	VFA	26.7	31.0	24.6	27.7
Steam treated					
	DMD	34.0	32.5	33.1	27.4
	VFA	29.1	41.4	32.3	33.6

Alkali treatment

Four methods of applying NaOH to rice straw (Nour *et al* 1987), were compared in order to select the optimum method to be used in the small farms in Egypt. Chopped rice straw was treated with NaOH by the methods of Torgrimsby (1971), Boliden (as described by Jackson 1978), Jackson (1977) and Wilson and Pigden (1964). Treated straws were compared with untreated rice straw in a feeding experiment with sheep fed a resticted amount of concentrate mixture. The results in Table 3 show that NaOH treatment of rice straw increased feed intake and digestibility of DM of rice straw, which was calculated by difference. The methods of Torgrimsby and Boliden appeared to be more effective than the other methods evaluated.

Table 3. Effect of different methods of NaOH treatment on the feed intake, dry matter digestibility and on TDN content of rice straw (calculated by difference)*

	Without treatment	Method of NaOH treatment			
		Torgrimsby	Boliden	Jackson	Wilson & Pigden
Dry matter intake (kg/ head/day)	0.59	0.81	0.76	0.70	0.60
%Dry matter digestibility	46.8	74.1	71.1	55.9	51.9
% TDN	44.6	71.2	63.6	49.2	46.5

* Source : Nour *et al* (1987)

Abou Raya *et al*. (1983) showed that boiling rice straw for one hour in water or in 0.2% Ca $(OH)_2$, or in 0.2% NaOH greatly improves the nutritive value of rice straw (Table 4).

Table 4. Effect of short time alkali treatment of rice straw on its nutritive value *

	Without treatment	Treated rice straws		
		boiled in water	boiled in 0.2% Ca $(OH)_2$	boiled in 0.2% NaOH
DE Kcal/100g	191	225	206	215
SV %	21.5	29.8	28.6	35.5
TDN %	42.4	49.7	49.9	56.5
DP %	-1.35	0.15	0.10	-0.24

* Source : Abou Raya *et al*. (1983).

Ammonia treatment of rice straw, increased digestion coefficients of organic matter, crude protein, ether extract and crude fibre (Fahmy 1985). TDN content was also increased to 52.6 which represents a 10% improvement (Table 5). Ammonia treatment has the advantage in increasing both crude protein content and digestibility. When limited amounts of concentrates were added to rice straw the nutritive value of treated and untreated rice straw was improved (Table 5). Fahmy (1985) reported that alkali treatment resulted in increased water consumption and urine volume by some 2.5 - 3.0 fold.

Table 5. Effect of alkali treatment on feed intake digestibility coefficients and nutritive value of rice straw when fed with or without concentrates *

	DM intake $g/kg^{0.75}$	Digestibility coefficient %					
		OM	CP	EE	CF	NFE	TDN
Rice straw alone:							
Without treatment	11.2	63.5	-	5.8	75.2	59.3	47.8
NaOH treated	12.9	79.5	-	16.7	94.4	63.8	51.8
NH_3 treated	13.4	66.4	70.6	78.7	77.7	55.8	62.2
Rice straw + concentrates:							
Without treatment	46.6	68.3	73.1	92.8	53.3	72.9	64.1
NaOH treated	33.5	66.8	65.3	94.9	52.2	67.3	63.2
NH_3 treated	44.7	70.1	78.8	92.4	45.0	71.1	65.4

* Adapted from Fahmy (1985).

Microbiological treatment

Ensiling rice straw (whether treated or not) with berseem (Trifolium alexandrinum) resulted in a clear improvement in the performance and daily liveweight gain of fattening sheep (Table 6). This method of rice straw treatment exceeded in its beneficial effect any alkali treatment (N. Esmaiel 1983).

Mohsen et al (1983) showed that ensiling of rice straw with 6% molasses with or without monensin (5 ppm) increased its digestibility and nutritive value. The TDN% values were 55.03 and 52.83% when rice straw was ensiled with molasses and monensin or molasses respectively. Monensin is a biologically active compound that has been shown to alter silage fermentation.

Table 6. Feed consumption, daily liveweight gain and efficiency of feed utilisation by lambs maintained on rations containing treated or untreated rice straw and silage.

	Diet No:			
	1	2*	3	4*
Average feed consumption (kg DM/head/day)				
Rice straw	0.39	0.32	-	-
Berseem silage	0.25	0.24	-	-
Silage of rice straw and berseem (1:1)	-	-	0.55	0.55
Concentrate mixture	1.17	1.17	1.18	1.18
TDN consumption	1.24	1.29	1.31	1.19
Number of animals	8	8	8	8
Experimental period (days)	95	95	95	95
Initial weight (kg)	36.68	38.62	38.68	38.68
Final weight (kg)	50.56	52.02	58.08	56.00
Daily gain (kg/head/day)	0.12	0.12	0.20	0.18
Feed efficiency (kg TDN/kg gain)	10.33	9.21	6.55	6.61

* Rice straw in diets 2 and 4 was previously treated with 5% NaOH.

SUPPLEMENTATION WITH THE DEFICIENT INGREDIENTS AND INCLUSION RATES OF RICE STRAW/HULLS

Badr and Abou Akkada (1965) reported that feeding ground rice hulls with 1st cut berseem, improved the digestibility of nutrients in sheep. (Results in Table 7 indicate that feed intake is improved by the addition of molasses and urea).

Shehata and Nour (1986) showed that straw fed with concentrates has a superior feeding value than concentrates alone. Results in Table 8 indicate that increasing the percentage of rice hulls in the diet increases the contents of ash and crude fibre, and decreases crude protein, ether extract and nitrogen free extract. Nour and El Shazly (1981) showed that coefficients of digestibility, nutritive value and nitrogen balance were higher for rations containing 35 and 40% rice hulls than those containing 60 or 70% rice hulls. The highest depression in measured parameters occurred when rice hulls was increased in the diet from 60 to 70%. Therefore, it is possible to include rice hulls in pelleted diets at the 60-70% level for maintenance and at 35-40% level for production. The presense of rice hulls in the diet improved the average daily liveweight gain of bulls (Table 9). No significant differences were found between the different groups in dressing percentage, carcass bone/muscle ratio.

Table 7. Effect of addition of molasses and urea on feed intake, nutritive value and cost of rice straw as a feed for ruminants.

	Treatment		
	Rice straw alone	Rice straw + 5% molaases	Rice Straw + 5% molasses 2% urea
Feed intake (kg DM/day)	0.86	0.86	1.30
Nutritive value %			
TDN	38.70	39.70	44.30
DP	0.00	0.07	3.77
Cost (LE/ton)			
DM	38.7	39.7	44.3
TDN	97.3	96.7	92.3

* Adapted from Nour, 1986.
1 US$ = 0.70 LE

Fahmy *et al* (1968) reported that the presence of rice hulls in a diet improved the utilisation of feed constituents. The addition of sand to a diet high in concentrates stimulated better utilisation of the ration (Gooley and Burroughs 1962). The relatively high silica in rice hulls may have produced a similar effect in the experiments of Fahmy *et al* (1968) and in the present experiment.

The review of the results indicates that rice straw and rice hulls are deficient in protein, energy, and minerals and their nutritive values are quite low. Physical, chemical and microbiological methods have been investigated to improve the digestibility and nutritive value of these by-products.

Supplementation with energy, protein, minerals and vitamins resulted in improving the utilisation of the roughages.

Table 8. Composition (%) of the feed mixtures used throughout the fattening experiment using diets containing rice hulls *

Ingredients	Mixture No:				
	1	2	3	4	5
1. Composition %					
Rice hulls	70	50	10	-	-
Cottonseed cake	-	8.5	22.5	24	48
Rice bran	-	-	12	10	7
Wheat bran	10	10	10	29	19
Yellow maize	10	20	38	29.5	20
Molasses	6	6	3	3	3
Urea	-	1.5	1.5	1.5	-
Calcium carbonate	3	3	2	2	2
Sodium chloride	1	1	1	1	1
2. Chemical analysis %					
Dry matter	92.36	92.37	91.55	91.98	91.71
% Dry matter					
Crude protein	4.00	13.75	21.72	17.72	17.51
Crude fibre	39.48	24.54	13.61	11.41	16.98
Ether extract	12.92	4.65	7.42	5.87	5.12
Ash	14.47	11.77	9.32	8.79	7.98
Nitrogen free extract	38.13	45.29	51.68	56.19	52.41

* Source = Nour *et al* (1986).

CONCLUSION

It could be concluded that improving the utilisation of rice straw and rice hulls may be achieved through:

1. Pelleting of roughages after supplementation with concentrates (maize, molasses, rice or wheat bran, cottonseed cake) urea, minerals and vitamins to produce optimum complete diets suitable for feeding ruminants on large scale farms.

2. Ensiling of rice straw or rice hulls after urea treatment and mixing with berseem or any other legume forage - this method is recommendable to the small scale farms in Eygpt and perhaps elsewhere where rice straw and rice hulls are available.

Table 9. Growth rate and efficiency of feed utilisation in fattening cattle fed on the experimental diets indicated.

	Period No. A			Period No. B		
	Diet No. I	Diet No. II	Diet No. III	Diet No. I	Diet No. II	Diet No. III
Animal number	10	10	9	9	9	9
Experimental period (days)	91	91	91	63	63	63
Av. Initial weight (kg)	234.8	237.4	235.8	329	327.1	334.3
Av. Final weight (kg)	333.8	322	319.7	391.8	397.3	383.7
Liveweight gain (kg)	99	84.8	84.1	62.8	70.2	49.4
Av. daily gain (kg/day)	1.01	0.93	0.92	1.00	1.11	0.78
DM intake/day						
a. roughage (kg/day)	3.92	4.74	3.89	3.29	3.31	3.34
b. concentrate (kg/day)	8.53	8.24	8.09	7.07	7.37	7.31
	12.45	12.98	11.98	10.36	10.68	10.65
Feed efficiency:						
Kg DM intake/kg gain	12.33	13.96	13.02	10.36	9.62	13.65

Period A) I. Rice straw plus mixture 5. in table 8
II. Mixture 1 plus mixture 5. in table 8
III. Rice straw plus mixture 3. in table 8

Period B) I. Rice straw plus mixture 5. in table 8
II. Rice straw plus mixture 2 + mixture 5 in table 8
III. Rices straw plus mixture 4 in table 8

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EFFECT OF LEVEL OF CANE MOLASSES IN FATTENING DIETS ON PERFORMANCE OF BEEF STEERS AND HEIFERS.

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ABSTRACT

The performance in feedlot of 100 each 18 month-old steers and heifers, one half of which comprised Sussex x Africaner and the other half Hereford x Mashona x Sussex breeds, was determined in a 2 x 5 factorial trial. Five groups of 18 animals (mean starved body weight 280 kg) for each sex were balanced for breed and body weight and randomly allocated to one of five dietary treatments containing 0, 10, 20, 30 or 40 per cent. molasses respectively. The animals were fed <u>ad libitum</u> for 90 days and slaughtered. The results show that molasses can be included in fattening diets up to a maximum level of 30 per cent. without any adverse effects on body and carcass weight gains, efficiency of feed-use and carcass grades. There was little difference in feedlot performance between steers and heifers.

INTRODUCTION

The practice of fattening cattle on maize-based high energy diets has become uneconomical due mainly to the high cost of maize grain relative to beef producer prices in Zimbabwe. In an earlier trial a less expensive diet than the conventional maize-based fattening diet was achieved by using cane molasses, a by-product of the sugar industry (Chakanyuka, Sibanda, Grant and Mlilo, 1987). Molasses was incorporated into this diet at the rate of about 20 per cent, equivalent to replacing 23 per cent of the maize, with no adverse effect on the performance of cattle in feedlot.

Molasses cannot fully replace maize due to handling problems and possible toxic effects if it is fed at very high levels (Van Niekerk 1981). However, since it is cheaper than maize grain, as much of it as possible should be included in fattening diets. It was therefore necessary to determine the maximum level of molasses which could be used in cattle fattening diets without adversely affecting performance. This study was carried out to investigate the relationship between the level of molasses in the diet and the performance in feedlot of both steers and heifers over a 90 day feeding period.

MATERIALS AND METHODS

A total of 100 eighteen month old steers and heifers, 50% Sussex x Africaner and the other 50% Hereford x Mashona x Sussex crossbreds, with an average starved body weight of about 280 kg were used. Animals of each sex were divided into 5 equal groups of 18 animals each balanced for breed and body weight.

A 6th group of 10 animals for each sex was slaughtered at the start to estimate the initial carcass weight of the remaining 5 groups for each sex, which were randomly allocated to one of five dietary treatments, the first a conventional high energy diet containing no molasses, and the other four containing increasing proportions of molasses; their formulations are shown in Table 1.

Table 1. Formulation and chemical composition (% air fresh) of cattle fattening diets.

	Level of molasses (%)				
	0	10	20	30	40
Snap corn	92.6	75.2	54.3	33.4	20.0
Molasses	0	10.0	20.0	29.4	40.1
Cottonseed hulls	2.2	8.0	17.2	25.1	24.0
Cottonseed meal	2.4	4.0	6.2	8.0	10.0
Urea	1.70	1.70	1.70	1.70	1.70
Limestone flour	0.80	0.70	0.60	0.40	1.80
Monocalcium phosphate	-	-	-	2.00	2.40
Coarse salt	0.30	0.20	-	-	-
Chemical composition (as fed)					
Crude protein	12.5	12.5	12.5	12.5	12.5
Crude fibre	11.0	11.8	13.6	15.2	13.3
Fat	2.90	2.54	2.12	1.70	1.34
Ash	3.77	4.11	4.36	4.89	8.87
Sulphur	0.26	0.24	0.21	0.17	0.14
TDN	74	70	65	60	55
ME (MJ/kg)	11.1	10.5	9.7	9.0	8.2

Each group was divided into 3 sub-groups of 6 animals comprising the heaviest, medium and lightest animals balanced for breed. The 6 animals in each sub-group were housed in one pen and group-fed ad libitum for a period of 90 days. The animals were weighed fortnightly and food intake was calculated weekly. At the end of the feeding period the animals were slaughtered and carcass measurements taken.

The following measurements were taken: initial and final starved body weight (no food and water for 24 and 15 hours, respectively), initial and final cold dressed carcass weight, total food intake, efficiency of food conversion and carcass grades.

Differences between treatments were determined by analysis of variance with initial starved body weight as a covariate for all the variables, except carcass grades where only means are presented.

RESULTS

Body weight changes

The body weight changes are shown in Table 2. There was no significant difference between the steers and heifers, although the heifers had marginally smaller body weight changes than the steers. There was a significant ($P<0.05$) quadratic effect of level of molasses on body weight changes with the rate of increase falling with increasing level of molasses. Body weight changes for the animals on 10, 20, and 30 per cent molassses were similar and higher ($P<0.05$) than the zero and 40 per cent molasses groups. The 40 per cent molasses diet gave the lowest body weight change but this was not significantly lower than that of the conventional zero molasses diet. Initial body weight as a covariate of body weight change and the interaction between sex and diet were not important.

Carcass weight changes

The initial carcass weights of the feedlot cattle were estimated from equations based on data derived from 10 each of steers and heifers slaughtered at the start of the experiment. Regression equations (1) and (2) were used for steers and heifers, respectively:

$$CW = 133.2 \ln BW - 613.6 \quad (r = 0.823) \text{ ---- } (1)$$

$$CW = 305.8 - 1.723\, BW + 0.004\, BW^2 \quad (r = 0.978) \text{ ---- } (2)$$

where CW is cold dressed carcass weight (kg), BW is the initial starved body weight (kg) and ln is the natural logarithm. The carcass weight changes of heifers and steers were similar (Table 3). There was a significant ($P<0.05$) quadratic effect of level of molasses on carcass weight change, as the rate of increase decreased with the higher levels of molasses. The mean carcass weight change of the conventional zero molasses animals was lower ($P<0.05$) than those of all the other dietary treatments. The diets containing 10, 20, and 30 per cent molasses produced similar gains which were higher ($P<0.05$) than those of the zero and 40 per cent molasses diets. The highest mean carcass weight changes were achieved by the animals on the 20 per cent molasses diet for both sexes. As with body weight gains, initial body weight as a covariate of carcass weight change and interaction between sex and level of molasses was not important.

Food intake and efficiency of food conversion

There was little difference between the two sexes in total food intake (Table 4), but intake increased as the level of molasses increased, reaching a peak at 30 per cent molasses. The efficiency of food conversion for body and carcass weight gain was the same for steers and heifers (Table 4). The efficiency of conversion for body weight gain exhibited a linear relationship with the level of molasses in the diet as the rate of decrease continued to increase with higher levels of molasses, but the decline became very marked ($P<0.05$) at 40 per cent molasses. The rate of decrease in efficiency of food-conversion decreased

Table 2. Body weight changes (kg) of cattle fattened on diets with different levels of molasses.

	Level of molasses (%)						
	0	10	20	30	40	Mean	$SE\bar{Dx}$
Initial starved body weight							
Steers	279.4	278.9	279.2	278.6	279.2	279.1	
Heifers	280.3	281.8	280.6	278.8	280.3	280.4	
Mean	279.8	280.4	279.9	278.7	279.8		
Final starved body weight							
Steers	402.2	419.9	414.4	417.1	396.7	410.1	
Heifers	400.1	417.3	425.4	404.3	396.2	407.8	
Mean	401.2	418.6	419.9	410.7	396.4		
Body weight change							
Steers	122.8	141.0	135.2	138.5	117.5	131.0	
Heifers	119.8	135.5	144.8	125.5	115.9	128.2	3.46
Mean	121.3[ab]	138.3[c]	139.9[c]	132.2[bc]	116.7[a]		
$S\bar{Dx}$			5.45				

Means in the same row or column in the same part of the table with different superscripts are significantly different ($P<0.05$).

Table 3. Carcass weight changes (kg) of cattle fattened on diets with different levels of molasses.

	Level of molasses (%)						
	0	10	20	30	40	Mean	SED$\bar{x}$
Initial carcass weight							
Steers	136.4	136.2	136.3	136.0	136.2	136.2	
Heifers	133.4	134.2	133.7	132.8	133.8	133.6	
Mean	134.9	135.2	135.0	134.4	135.0		
Final carcass weight							
Steers	212.5	233.0	233.9	233.5	221.4	226.8	
Heifers	212.1	227.9	236.0	223.8	218.8	223.6	
Mean	212.3	230.4	234.9	228.6	220.1		
Carcass weight change							
Steers	76.1	96.8	97.6	97.5	85.2	90.6	
Heifers	78.7	93.7	102.3	91.0	85.0	90.0	2.00
Mean	77.4[a]	95.2[c]	100.0[c]	94.2[c]	85.1[b]		
SED$\bar{x}$			3.15				

Means in the same row or column in the same part of the table with different superscripts are significantly different ($P<0.05$).

Table 4. Total food intake (kg/head, air-fresh) and efficiency of food-conversion for body weight gain (kg food/kg body weight gain) and carcass weight gain (kg of food/kg carcass weight gain) of cattle fattened on diets with different levels of molasses.

	Level of molasses (%)						
	0	10	20	30	40	Mean	SED$\bar{x}$
Total food intake							
Steers	933.7	1147.7	1212.8	1259.5	1288.6	1168.5	
Heifers	965.4	1215.9	1316.3	1297.5	1267.5	1212.5	
Mean	946.6	1181.8	1264.6	1278.5	1278.0		
ME intake (MJ)	10540.6	12408.9	12266.6	11506.5	10479.6		
Efficiency of food-conversion for body weight gain							
Steers	7.86	8.60	9.05	9.26	11.23	9.20^{p}	
Heifers	8.78	9.50	9.29	10.67	11.13	9.86^{q}	0.310
Mean	8.31^{a}	9.04^{ab}	9.17^{ab}	9.95^{b}	11.18^{c}		
SED$\bar{x}$			0.487				
Efficiency of food-use for carcass weight gain							
Steers	12.7	12.4	12.5	13.1	15.6	13.3^{r}	
Heifers	12.8	13.3	13.0	14.6	15.2	13.8^{r}	0.363
Mean	12.7^{m}	12.8^{m}	12.8^{m}	13.8^{m}	15.4^{n}		
SED$\bar{x}$			0.570				

Means in the same row or column in the same part of the table with different superscripts are sifnificantly different ($P<0.05$).

as the level of molasses increased. However, there was no significant difference between the efficiency of food-conversion for carcass weight gains of the zero, 10, 20 and 30 per cent molasses animals. The 40 per cent molasses diet produced a significantly ($P<0.05$) lower efficiency of food-conversion for carcass weight gain than all the other diets. There was no interaction between sex and diets and similarly initial body weight as a covariate of efficiency of food-conversion for carcass and body weight gain was not important.

Carcass grades

The fleshing and fat grades awarded at slaughter are shown in Table 5. The fleshing index is based on the ratio of carcass weight to length. Classes 1 and 2 depict animals with adequate fat cover, class 3 would be underfat and class 9 overfat. The last two classes carry some form of penalty. Overall the highest fleshing grades were obtained with the 20 per cent molasses diet, whilst the conventional zero molasses diet produced the lowest grades. The fleshing grades for heifers fell more markedly than those for steers at molasses levels higher than 20 per cent. There was little difference between the treatments in fat grades, although heifers tended to be fatter than steers.

DISCUSSION

The results of this study agree with earlier trials carried out in this laboratory (Chakanyuka et al. 1987) and elsewhere (Lishman 1967; Elliot and O'Donovan 1973; Van Niekerk 1981). They indicated that molasses can make up to 30 per cent of fattening diets without adversely affecting animal performance.

The diets containing molasses up to and including 30 per cent, produced higher body and carcass weight gains than the conventional maize-based diet with no molasses. This confirms the results of the earlier work in which a diet containing 20 per cent molasses produced marginally higher carcass weight gains than the conventional high maize diet (Chakanyuka et al. 1987).

The reason for the better performance of cattle on molasses diets compared to the conventional high maize diets is thought to be the creation of a more suitable rumen environment for the microbial population (Hatch and Beeson 1972). This would mean that animals on molasses diets would have fewer digestive problems and would take a shorter time to adapt to the diets. In the present trial in took up to three weeks before the animals on the conventional zero molasses diet stopped scouring, while those on the molasses diets did not scour at all.

Since the level of metabolisable energy (ME) decreased with the increase in the level of molasses it would seem that total food intake was controlled by the level of ME. On as fed basis all molasses diets produced lower efficiency of food-conversion, a finding which confirms earlier studies in this country (Elliot and O'Donovan 1973; Chakanyuka et al. 1987) and elsewhere (Van Niekerk and Voges 1976; Van Niekerk 1981).

Table 5. Carcass grades (%) of cattle fattened on diets with different levels of molasses.

	Level of molasses (%)														
	0			10			20			30			40		
Fleshing grades	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Steers	16.7	72.2	11.1	72.2	22.2	5.6	88.9	11.1	-	88.9	11.1	-	44.4	50.0	5.6
Heifers	22.2	66.7	11.1	76.5	17.6	5.9	88.2	11.8	-	64.7	29.4	5.9	29.4	70.6	-
Mean	19.4	69.4	11.1	74.4	19.9	5.8	88.6	11.4	-	76.8	20.2	3.0	36.9	60.3	2.8
Fat grades	1	2	9	1	2	9	1	2	9	1	2	9	1	2	9
Steers	77.8	22.2	-	88.9	11.1	-	77.8	22.2	-	100	-	-	77.8	22.2	-
Heifers	94.4	5.6	-	100	-	-	94.1	-	5.9	94.1	5.9	-	100	-	-
Mean	86.1	13.9	-	94.4	5.6	-	86.0	11.1	3.0	97.0	3.0	-	88.9	11.1	-

However, the diets containing 10, 20, 30 and 40 per cent molasses had 5.4, 12.2, 18.9 and 25.7 per cent, respectively, less ME than the conventional diet. Therefore, the ME in the diets containing 10, 20, 30 and 40 per cent molasses was utilised more efficiently than that of the conventional diet by 4.4, 11.2, 7.1 and 4.5 per cent, respectively. These results are in agreement with the last trials when the ME in the diet containing 20 per cent molasses was utilised with 5.5 per cent higher efficiency than the conventional diet (Chakanyuka et al. 1987).

The results of the carcass grades are also in favour of molasses-based diets. While the conventional diet may exhibit a higher efficiency of food-conversion the returns from it are likely to be lower due to the resultant smaller carcass and lower grades.

It has been customary to assume that heifers were less efficient than steers in feedlot. The results of the present trial show that there was no difference between steers and heifers in efficiency of food-conversion for carcass weight gain. However, the fat grades indicate that heifers may tend to get fatter. It may be advisable to slaughter heifers earlier than steers of similar size.

CONCLUSION

Molasses can be included in fattening diets by up to 30 per cent without any marked detrimental effects on performance. This would result in relatively cheaper diets, provided the molasses was available and continued to be cheaper than maize grain. These results apply to both steers and heifers, although heifers may need to be slaughtered earlier to prevent them from getting overly fat.

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FEEDLOT PERFORMANCE OF YEARLING STEERS PREVIOUSLY MAINTAINED ON DIFFERENT CROP RESIDUE/SUPPLEMENTATION REGIMES

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ABSTRACT

Forty two Bunaji and Friesian/Holstein crossbred yearling steers averaging 192 kg liveweight were randomly assigned to 6 Phase I treatments: dry grain sorghum stover; dry grain sorghum stover plus groundnut cake; dry grain sorghum stover plus urea-molasses; untreated grain sorghum stover silage; untreated grain sorghum stover silage plus groundnut cake and urea-molasses treated grain sorghum stover with additional urea-molasses supplement. After the treatment study lasting 56 days all the steers were placed on a Phase II feedlot diet, consisting of dry grain sorghum stover and a concentrate mixture, for 42 days.

In Phase I ensilage significantly (P<0.01) improved dry matter intake per head per day but there was no economic advantage in overall performance. Supplementation with limited quantities of groundnut cake or urea-molasses maintained liveweight.

In Phase II the steers, in their respective groups, maintained their relative and significant differences (P<0.05) in feed intake per head/day but when expressed in intake per metabolic liveweight the differences were not significant. There were no significant differences in liveweight gains between groups. The applicabilty of the results to the agro-pastoralist system of cattle production and to fattening enterprises is discussed.

INTRODUCTION

Over seventy percent of Nigeria's national herd is located within the Sudan and Sahel zones. The transhumant ruminant livestock in these areas derive about 69% of their annual dry matter intake from upland savanna (including browse material), 13% from flood plains and 18% from crop residues. In terms of nutritional availability, the critical months of the year are December, January, February, March and April when cattle obtain 91, 113, 79, 130 and 112 gram/day digestible crude protein respectively from their total feed intake (Van Raay et al, 1974). A summary of reports (Adegbola and Onayinka 1968; Egunjobi 1970; Akinola 1974 and 1983; de Leeuw 1977; Fricke 1979; Awogbade and Famoriyo 1982) on range and feed resources inventory suggests that under the existing level of grassland management there is inadequate feed to sustain the present ruminant population of about 14.5 million animal units (A.U.). Table 1 gives the area of grazing land, herbage yield and carrying capacity of Nigerian Savannah. However, there is a tremendous potential from cereal and legume crop residues which Reddish and Scarr (1986) estimated to be about 50 million

Table 1. Grazing lands, herbage yields and carrying capacity of Nigerian Savanna.

Vegetation Zone	Estimated grazing land area (Km^2x1000)	Annual rainfall (mm)	Herbage dry matter yield (t/ha)	Grazing period (days)	Carrying capacity (ha/A.U.)*
Derived Savanna	38.30	1275-2030	6.0-18.0	300-330	0.4-0.83
Southern Guinea Savanna	97.41	1140-1520	2.0- 6.5	270-300	1-4
Mambilla Plateau	4.74	1800	4.0- 7.0	360	2-4
Northern Guinea Savanna	106.3	1020-1270	2.0- 4.5	210-240	3-5
Jos Plateau	8.53	1140-1450	1.5- 4.0	240	6-9
Sudan Savanna	161.4-180.4	510-1020	0.7- 2.5	120-160	8-12
Sahel Savanna	46.62-27.62	300-650	0.5- 1.5	90-120	10-14

I Animal Unit = 300 kg liveweight requiring a daily herbage dry matter intake of 7.5 kg (at 2.5 kg per 100 kg body weight).

tonnes annually. Most of this material is presently wasted through burning, improper feeding and termite attacks.

The nutritive value of the crop residues could be enhanced through physical and/or chemical treatment and/or supplementation with concentrate agro-industrial by-products or forage legume. But the quantity and quality of feed should satisfy the requirement for the type of production (maintenance, growth, lactation or draft) and the feeding regime imposed should be based on economic advantage.

In some cases it might be economically justifiable to offer sub-maintenance diets to non-producing animals during the dry season and accept loss of liveweight, if the cost of supplementary feeds is not economical.

The objective of the study was to look at effective utilization of sorghum stover, a common by-product in the agro-pastoralist farming system, and to assess the carry over effect at the fattening phase using sorghum stover and a concentrate mixture.

MATERIAL AND METHODS

The study was carried out at the National Animal Production Research Institute (NAPRI), Zaria, Nigeria located in Northern Guinea Savanna on latitude 11° 11'N and longitude 7° 38'E. The average annual rainfall is 1050 mm falling between June and September.

Forty two Zebu x Friesian/Holstein crossbred steers, average age 24 months and 190 kg liveweight, were randomly assigned to 6 treatments of 7 animals each based on age and liveweight; using balanced group continuous trial methods as described by Lucas (1974). The study covered two phases - maintenance and fattening. The 6 treatments imposed in the first trial are given in table 2.

The steers were individually penned and fed *ad libitum* twice daily at 0800 hrs and 1500 hrs. Records of voluntary feed intake were kept during the 14-day preliminary and experimental periods. All the steers were weighed weekly. At the end of the experimental period of 60 days, a digestibility study of the 6 diets was conducted using the total collection technique.

The second phase of the study was carried out on the steers from the phase one experiment to monitor their performance on better feeding under feedlot management. This simulates the situation in the dry Sudan and Sahel zones where a feedlot operator purchases animals of different body weight from differently managed herds. The forty two steers, retained in their previous groups, were allowed free grazing and exercise for 7 days before the commencement of the second phase. They were fed in individual pens to appetite for an adjustment period of 14 days and subsequently for 60 days on a concentrate mixture and dry, untreated sorghum stover as the only roughage (Table 5). Water and mineral salts were offered *ad libitum*. Daily voluntary feed intake and

Table 2. Composition of the 6 experimental diets fed in Phase I

Treatment No.	Experimental Diets
1.	Ad libitum sorghum stover + Mineral Lick.
2.	Ad libitum sorghum stover + 0.45 kg groundnut cake + Mineral Lick.
3.	Ad libitum sorghum stover + 1% Molasses + 0.5% Urea + Mineral Lick.
4.	Ad libitum untreated sorghum stover silage + Mineral Lick.
5.	Ad libitum untreated sorghum stover silage + 0.45 kg groundnut cake + Mineral Lick.
6.	Ad libitum Urea - Molasses treated sorghum stover silage + 0.5% Molasses + 0.25% Urea + Mineral Lick.

weekly liveweights were recorded. A digestion trial of the experimental diets was conducted with wether sheep.

RESULTS AND DISCUSSION

The chemical composition of the experimental diets in Phase one is given in table 3. In the Phase I trial, (Table 4) it was found that ensilage significantly (P<0.01) improved dry matter intake per head per day by 26%, but intake per metabolic body weight improved by 41 percent. This could be attributed to a faster rate and better digestion of stover silage compared to dry stover possibly due to a better rumen ecosystem resulting from the attributes of microbial products of ensilage.

Supplementation with groundnut cake (treatments 2 and 5) resulted in a significant (P<0.05) improvement in dry matter intake. This was expected as energy and nitrogen supplied could have been used to meet part of the rumen microbial requirements, and concomitantly those of the host animal in the form of microbial and escape protein (Van Soest 1982). Although addition of nitrogen and energy in the form of urea and molasses (treatments 3 and 6) depressed dry matter intake per head per day by 8% (Table 4), their influence appeared to have a significant associative (P<0.05) effect on feed efficiency. The depressant influence on dry matter intake of urea-molasses supplement was comparatively higher on dry sorghum stover-based diet (which consistently had the lowest intake-Table 4) than on ensiled sorghum stover. This suggests a positive associative interaction between the basal diet and urea-molasses supplement probably due to ensilage effect. However, significant superiority of ensilage observed in dry matter intake had no corresponding effect

Table 3. Composition of experimental diets in Phase one. (% Dry Matter)

	TREATMENT No's					
	1	2	3	4	5	6
Dry Matter	92.81	80.00	76.00	56.90	67.22	54.10
Crude Protein (N x 6.25) %	4.75	8.20	6.76	4.43	7.50	6.57
NDF %	82.82	62.57	65.99	82.63	74.68	63.94
Non-CWC %	17.18	37.48	34.01	17.32	25.32	36.06
Hemicellulose %	28.75	24.43	24.22	28.68	27.22	22.00
ADF %	54.07	38.07	41.77	54.00	47.46	41.94
Cellulose %	46.36	32.16	35.81	45.98	40.29	35.83
Lignin %	7.72	5.91	5.96	8.01	7.17	6.11
Ash %	6.11	13.12	7.01	8.22	10.77	7.71

Table 4. Performance of steers fed six experimental diets in Phase I

	TREATMENT No's						
	1	2	3	4	5	6	S.E.D.
Total DM Intake/Head/Day (kg)	2.76	3.55	2.32	3.48	4.87	3.16	0.091
Voluntary DM Intake g/$KgW^{0.75}$/Day	49.31	71.29	44.52	69.67	92.02	65.40	1.881**
Mean Daily Liveweight change (kg)	-0.059	0.590	0.671	0.404	0.114	-0.236	0.286*
Feed efficiency (Feed/gains)	-0.997	2.436	1.624	5.984	-4.062	1.03	2.108**
DM digestibility (in vivo)	52.36	48.43	30.10	52.36	60.54	45.33	
Crude fibre digestibility (in vivo)	67.20	40.66	35.77	73.70	54.32	63.09	

* significant at 5% level

** significant at 1% level

on liveweight gain. The same trend was observed in the associative effects of ensilage and sources of energy/nitrogen.

Considering the labour and other inputs required in making silage from sorghum stover, ensilage does not appear to offer either biological or economic advantage. Supplementation of dry sorghum stover with either urea-molasses or limited amount of oil cake could support liveweight maintenance and some productivity during the dry season when rangeland is dry, bare and burnt.

In Phase II study, which was intended to simulate a situation where animals previously under different feeding regimes and management were purchased for feedlot operation, there were significant ($p<0.05$) differences in the overall dry matter intake per head per day in favour of treatments 2, 5 and 1 which, apart from group 2, had the lowest intake in Phase I. Mayer et al (1965) obtained relative higher intake of high energy feed in animals that had previously been placed on restricted feeding. However, when the same data were expressed on intake per unit metabolic body weight, there was no significant difference over the whole period. Treatments 3 and 6 which suffered depressed influence of urea-molasses supplementation during Phase one continued to show lower dry matter intake per head per day but intake per metabolic body weight was just slightly lower in the fattening phase as well and had the best feed conversion rates (table 6). This suggests that those treatments which in the earlier study had reduced intakes, continued to have reduced feed consumption during the fattening phase as well as achieving similar or better results. A similar observation was made by Ledger (1973) but under a restricted intake of balanced diets.

There was no significant difference in average daily liveweight gain between treatment groups except for treatment one which had superior ($P<0.05$) liveweight gain over the remaining treatments. It is possible, as was observed by O'Donovan (1984) that under-nourishment previously suffered by this group probably resulted in a compensatory liveweight gain when later fed <u>ad libitum</u> on a high energy diet (Table 6). However, the overall average daily liveweight gain was similar to that reported in the same environment under feedlot management (Olayiwole et al, 1973; 1981). By implication, the economic advantage and increased meat output are significant. Thus it can be hypothesized that if about 698,000 out of about 1.2 million cattle slaughtered anually in Nigeria are put on feedlot diets their body weights could be increased by 100 kg per head over a period of 110 days. This would result in an increase of about 69,800 tonnes of beef annually.

On the basis of ratio of liveweight gain per unit feed intake (reciprocal of feed efficiency), the two treatments (1 and 4) on basal diets appear to have had the best biological and economical advantage followed by treatments 6, 2, 3 and 5 in that order.

Studies on ruminant livestock ownership profile in the Sudan and Sahel zones (Fricke 1979) showed that 61.5 and 35% of the

Table 5. Chemical composition (%DM) and digestibility coefficients of the ration fed for the 60 days fattening period

	DM	CP	EE	CF	NFE	ASH
Concentrate Mixture*	74.10	21.48	9.01	9.43	56.45	3.63
Sorghum Stover	90.70	2.76	1.09	38.25	52.94	4.96
In vivo digestion coefficients	71.25	70.04	88.90	54.71	77.10	-

* Mixture of sorghum grain (41%), groundnut cake (15%) and undelinted, undecorticated cotton seed cake.

Table 6. Feedlot performance of steers fed sorghum stover and a concentrate mixture (given in Table 5)

	TREATMENT No's						
	1	2	3	4	5	6	S.E.D
Voluntary DM Intake/Day (Kg)	5.50	5.68	5.31	5.39	5.58	5.34	0.132*
Voluntary DM Intake g/KgW $^{0.75}$/Day	100.72	106.83	101.44	104.39	102.27	101.87	2.750
Mean daily liveweight gain (kg)	1.498	0.904	0.744	1.090	1.097	1.159	0.241*
Total liveweight change (Kg)	49.57	40.29	44.57	45.86	40.14	40.86	5.133
Mean final liveweight (kg)	228.29	219.43	216.71	213.42	227.00	211.00	12.069
Mean Initial liveweight (Kg)	178.71	179.14	172.14	167.57	186.86	170.14	9.893
Feed efficiency (Feed/gain)	4.24	4.75	2.85	5.60	6.72	2.81	1.957
Gain/Feed ratio	0.27	0.16	0.15	0.21	0.14	0.22	0.046**

* Significant at 5% level

** Significant at 1% level

total population are in the hands of sedentary agro-pastoralists in the rainy and dry seasons respectively. This integrated crop and livestock production system ensures a reasonable tonnage of crop residues. Hence, supplementing these with agro-industrial by-products is one of the cheap and convenient ways to at least maintain body weight and a marginal productivity in the dry season. A feedlot operator who buys his cattle at the end of the dry season when the animals are at their lowest weight and poorest condition, would benefit both in reduced time and food consumption from compensatory growth.

The results of the trials indicate that the weight losses incurred during the maintenance phase do not adversely affect the animal performance of the feed lot stage. It may be inferred from the results obtained that steers could be maintained on sorghum stover with added limited quantities of protein and energy sources under intensive or semi-intensive management. There should also be adequate and regular supplies of water and mineral salts.

It is uneconomic for a grazier to sell his animals at the end of the dry season when they are in the poorest condition; he should take advantage of compensatory gain and economic efficiency. On the other hand, a fattener would capitalise on both the biological and economic advantage in buying his animals for fattening during and at the end of the dry season in these regions.

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PRACTICAL UTILIZATION OF AGRO-INDUSTRIAL BY-PRODUCTS IN A FEEDLOT IN MALAWI

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ABSTRACT

The paper gives brief background information on the siting of the Feedlot in Shire Valley where the supply of the various by-products used in the formulation of the feeds are within easy access. Molasses, bagasse, cottonseed husks, cotton seed cake, whole cottonseed, rice husks, wheat offals and hominy chop (maize germ and bran meal) are used successfully.

Combinations of some of the above ingredients are used to produce rations which when fed to local steers aged 18 months to 3 years produce daily liveweight gains approximating 1kg with a conversion rate of 10:1 over an average feeding period of 95 days. Dressing percentages are on the average 52%, with very good carcass grades. Some dairy formulations are also compounded for sale to other farmers.

INTRODUCTION

This paper is based on the practical utilization of agro-industrial by-products as experienced in the feedlot. The availability of suitable by-products, together with an assured supply of feeders were the main reasons for locating the feedlot in the Shire Valley. At that time, early 1978, there was an ample supply of whole cottonseed from ADMARC[1], Bungula, and molasses and bagasse from SUCOMA[2]. With the addition of urea, salt and vitamin A we were able to produce a complete fattening ration at low cost. Unfortunately the supply of whole cottonseed dwindled as more was used for extracting the oil. We therefore had to look at other available feedstuffs to produce equally efficient or better rations at reasonable costs. Over the past eight years we have tried nearly all by-products which are available in quantity in Malawi. Those we have used successfully are reported on below. (Refer to Appendix 1 for the standards used in ration formulation).

MOLASSES

A by-product of sugar successfully included at rates of up to 58% of fattening rations. A palatable feed which improves feed intake, especially initially. It also has the advantage of reducing the incidence of laminitis in high energy fattening rations. Can be used in dairy, pig and sheep feeds and liquid and solid maitenance feeds. I mentioned maintenance feeds as the feedlot unit has its own holding grounds where steers are grown out to feeding stage.

[1]ADMARC - Agriculture Development Marketing Corporation
[2]SUCOMA - Sugar Corporation of Malawi

Molasses has been fed as a "wheel lick", put in worn out vehicle tyres cut and used as troughs(molasses with urea mixed in a ration of 10:1 by weight). It was found that as the grazing quality deteriorated, supplementation in this form was not enough. We have had far greater success with a solid lick containing 8% urea and 23% molasses together with other energy, protein and mineral sources, achieving maintenance plus through winter. Daily intake is 500 g per livestock unit at a cost of approximately 12 tambala (1 US dollar equals 2.23 Malawi Kwatcha; 1 Malawi Kwacha equals 100 tambala).

As mentioned, molasses has been used in our rations at up to 58%. The inclusion rate varies greatly with the type of roughage used, depending on its ability to absorb molasses. For example, rice husks will absorb little if any, cottonseed husks (not delinted) will absorb more, whereas baggase absorbs a greater amount. Other ingredients in a ration may also have a bearing on the quantity of molasses used; wheat offals or maize bran can carry a greater amount of molasses than cottonseed cake. Because of the availability and convenience of molasses (our feedmixer being adjacent to the sugar mill) and of course the cost, we try to maintain as high a level as possible in all our feeds without affecting the efficiency of the ration.

BAGASSE

Another by-product of sugar; used in our rations as a roughage. Very useful as a carrier for molasses. Inclusion rates vary as to fibre requirement. The success of our rations, we believe, is due to the coarse bagasse used as opposed to the separated and dried fine bagasse and pith used in other similar operations

Separating and drying allows the bagasse to re-absorb a greater amount of molasses and gives longer storage life. Unfortunately we do not have the facilities to do this. We use the bagasse as is, straight from the sugar mill. This sometimes contains a lot of moisture, depending on how soon we use it, which greatly reduces storage life to as little as 3 or 4 days. Mixed in the correct proportions, molasses and dried bagasse can totally replace maize in fattening rations and can replace a percentage of maize in pig and sheep rations, (protein correction would be necessary), thereby conserving a valuable human feed.

Bagasse is also used a fuel in the sugar mill and is therefore not always available, especially during the sugar off-crop period, December to April, when alternate roughages have to be used.

COTTONSEED HUSKS

A useful form of roughage which can totally replace bagasse in our feeds, higher in protein and T.D.N. (total digestable nutrients) but without the property of absorbing as much molasses.

RICE HUSKS

A roughage which does not absorb molasses and is not used to replace more than 50% of the bagasse - higher in protein but considerably lower in T.D.N.

WHOLE COTTONSEED

As mentioned earlier, the availability of this product was one of the reasons our feedlot was sited at Ngabu. Together with molasses, bagasse, urea, salt and Vitamin A, a complete feed was formulated capable of producing weight gains of one kilogram plus per day. This simple mixture, supplying approximately 12.5% crude protein and 69% T.D.N., has been the basis of all subsequent rations.

COTTONSEED CAKE

When whole cottonseed was no longer available to us, other sources of energy and protein were investigated. The first of these, cottonseed cake, remains an essential ingredient in our rations. Being higher in protein we were able to reduce the urea content, maintaining the level of protein. T.D.N. was more difficult to maintain, the cake being 10% lower than cottonseed and this dropped the T.D.N. to 57%. With the inclusion of wheat offals we were able to produce a successful feed.

WHEAT OFFALS

A by-product of wheat milling, fairly high in protein and T.D.N. Suits our high molasses feeds as it is a useful carrier for the molasses when bagasse is replaced by cotton or rice husks.

HOMINY CHOP (Maize germ and bran meal)

A by-product of maize milling which has been used in our fattening rations and is a major ingredient in our dairy and pig feeds. Also a useful carrier for molasses. Combinations of the above ingredients formulated as complete fattening rations of the following standards have been used successfully over the past 8 years.

C.P.	11.5%	-	13%
T.D.N.	67%	-	70%
Fibre	9%	-	12%
Calcium	0.7%	-	0.9%
Phosphorus	0.3%	-	0.4%
Fat	3%	-	5%

Rations of these standards on the type of cattle we are feeding, local steers aged 18 months to 3 years, give a liveweight gain of approximately 1 kg per day and a conversion ratio of an estimated 10:1. The average feeding period is 95 days.

Dressing out percentage from liveweight before transporting to Blantyre, is 52%. Average grades achieved over the past 7 months are 89% Choice, 10% Prime and 1% Standard.

Sidelines of the main feedlot operation are a beef breeding herd of 250 cows, dairy and pigs on a small scale and sheep breeding and fattening under intensive and extensive conditions. Production and maintenance feeds for all these operations are produced by the feedmill. Dairy feed is also produced for sale to small-holder farmers.

In conclusion I will say that the success of this feedlot operation is mainy due to the availability of suitable feedstuffs, mostly by-products, from which an efficient feed can be formulated.

APPENDIX 1

Standards used for ration formulation - (as is)

	CP	TDN	FIBRE	CALC.	PHOS	FAT
Molasses	3.5	75.0	-	1.00	0.10	-
Bagasse	1.0	36.0	49.0	0.90	0.24	0.4
Cottonseed husks	4.0	43.0	48.0	0.14	0.07	0.9
Rice husks	3.0	13.0	44.0	0.10	0.08	-
Whole cottonseed	18.5	83.7	16.9	0.14	0.70	22.9
Cottonseed cake	40.0	73.3	13.0	0.20	1.16	6.2
Wheat offals [1]	16.5	76.6	4.5	0.13	1.20	7.5
Hominy chop [2]	8.5	74.6	6.7	0.08	.34	7.6

1 Wheat offals = bran and middlings.

2 Hominy chop = maize bran and germ meal.

EFFECTS OF UREA, MOLASSES, MOLASSES-UREA, NOUG CAKE AND LEGUME HAY ON THE INTAKE AND DIGESTIBILITY OF TEFF STRAW BY HIGHLAND SHEEP

By

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ABSTRACT

A 37-day digestion trial was conducted to evaluate feed intake and utilization by male castrated Ethiopian highland sheep (initial weight, 17.9 ± 0.80 kg). Sheep were randomized across twelve treatments (3/treatment) on the basis of fasted body weights. The treatments were: teff (**Eragrostis tef**) straw **ad libitum** (basal), basal + 3 g urea, basal + 88 g molasses or 86 g molasses-urea (2.5% urea). The latter two were also given with 6.5 and 13 g noug (**Guizotia abyssinica**) cake or 65 and 130 g **Trifolium steudneri** hay.

Addition of urea to teff straw increased N digestibility significantly, and increased teff straw intake, dry matter (DM) and neutral-detergent fiber (NDF) digestibilities by 3.7, 8.3 and 7.3%, respectively over teff straw alone. Supplementation of teff straw with molasses alone (about 15% of diet DM) depressed teff straw intake, DM, N and NDF digestibilities, and depressed N retention below the levels attained with teff straw + urea, teff straw + molasses-urea (fed also at 15% of diet DM) and with teff straw alone. The depressing effects of molasses were reversed by including urea at 2.5% (2.2 g) of the mixture. Response of sheep to N (urea) supplementation was greater than to energy (molasses) supplementation, indicating the N deficiency in cereal crop residues is a greater cause of poor animal performance than energy deficiency. In addition to showing that molasses-urea was a better supplement than molasses, the data indicated that the effects of urea as a non-protein N supplement on increasing the intake of low quality roughages, nutrient digestibility and N retention were enhanced (often significantly) by giving urea with molasses instead of dissolving it in water and sprinkling onto the straw. Hence, molasses-urea was also a better supplement than urea alone.

The effect of feeding noug cake or Trifolium hay with molasses or molasses-urea on the measured parameters were significantly greater than those of feeding molasses or molasses-urea alone. Additional responses to the higher levels of noug cake and Trifolium hay were not significantly greater than the lower levels. The lower levels of noug cake and Trifolium hay would therefore be more appropriate for peasant farmers using molasses or molasses-urea to supplement cereal crop residues. Although noug cake in Ethiopia is a cheaper source of N than Trifolium hay (0.37 vs 0.95 cents/kg N), the latter is more

appropriate and available to small-scale farmers.

INTRODUCTION

When N content of the diet is less than 1.2%, rumen function may be impaired, feed intake reduced and animal growth markedly reduced (Conrad and Hibbs 1968). The N content of most cereal crop residues is usually less than 1.0% (Mosi and Butterworth 1985). Nitrogen deficiency is therefore the most important limiting factor in these feeds (Preston and Leng 1984). In addition to this quantitative protein deficiency, a qualitative deficiency; the limitation of the amino acid precursors of the branched (isobutyric, isovaleric and 2-methylbutyric) and straight chained volatile fatty acids (VFAs) may exist. Since these VFAs are essential nutrients for the growth of the principal cellulolytic and some non-cellulolytic rumen bacteria (Russell and Sniffen 1983), their deficiency may contribute to poor animal performance from unsupplemented or inadequately supplemented cereal crop residues (Butterworth and Nuwanyakpa, unpublished data).

The metabolizable energy (ME) requirement for maintenance of a 20 kg sheep kept in a thermoneutral environment is 3.4 meagajoules (MJ)/day (ARC 1980). The ME consumed by sheep fed various cereal crop residues ranged from 2.8 to 4.1 MJ/day (Mosi and Butterworth 1985), making energy deficiency another important factor limiting animal production from cereal crop residues. The low N and energy contents indicate that unless adequately supplemented, cereal crop residues may provide no more than maintenance rations for sheep and cattle.

Some of the beneficial effects of N supplementation represented by increased digestion, higher intake of low quality roughages and body weight gain in young animals, may be achieved through N fertilization of forages or supplementation with protein or non-protein N (Ammerman _et al_ 1972). Whether the full benefits of urea supplements can be achieved with urea alone or whether preformed carbon skeletons such as molasses are required also, is still debatable (Hunter and Vercoe 1984).

The objectives of this experiment were to compare two methods of administering urea (sprinkled onto straw vs mixed with molasses), to study the effects of energy (molasses) vs N (urea) supplementation and to evaluate the effects of two levels of noug (**Guizotia abyssinica**) cake and **Trifolium (steudneri)** hay when fed with molasses or molasses-urea on feed intake and utilization by sheep given a basal diet of teff (**Eragrostis tef**) straw.

MATERIALS AND METHODS

Thirty-six castrated Ethiopian highland sheep (initial weight: 17.9 ± 0.80 kg) were drenched against liver fluke with Ranide (Rafoxanide) and dipped to control ectoparasites two weeks before the trial started. They were allocated to twelve treatments (three/treatment) at random within fasted bodyweight classes.

The treatments were:

1. Teff straw **ad libitum** + 10% of air-dry straw weight as water (intended to equalize possible effects of water addition in Treatment 2. Water was not sprinkled onto the straw fed in Treatments 3-12).

2. Teff straw + 3g urea (dissolved in 10% weight of straw as water. Elemental sulfur was added to achieve N:S ratio of 10:1 and the resulting mixture sprinkled onto and mixed in the straw).

3. Teff straw + 88 g molasses (Amounts for molasses and the other supplements listed below are on DM basis)*

4. Teff straw + 88 g molasses + 6.5 g noug cake.

5. Teff straw + 88 g molasses + 13 g noug cake.

6. Teff straw + 88 g molasses + 65 g Trifolium hay.

7. Teff straw + 88 g molasses + 130 g Trifolium hay.

8. Teff straw + 86 g molasses-urea (2.5% urea).

9. Teff straw + 86 g molasses-urea + 6.5 g noug cake.

10. Teff straw + 86 g molasses-urea + 13 g noug cake.

11. Teff straw + 86 g molasses-urea + 65 g Trifolium hay.

12. Teff straw + 86 g molasses-urea + 130 g Trifolium hay.

* The ad libitum amount of molasses or molasses-urea offered daily was fixed at 120 g/sheep. Noug cake was offered at 7 and 14 g, and TH at 75 and 130 g/sheep, respectively. The DM contents of molasses, molasses-urea, noug cake and Trifolium hay were 73.3, 71.7, 92.9 and 86.6%, respectively.

Sheep, tethered in metabolism cages, had free access to mineralized salt licks and drinking water. The trial consisted of a 10-day preliminary period followed by three 7-day collection periods, and a 3-day "rest" period between collection periods. During the "rest" periods, faecal and urine collectors were removed. Rumen fluid samples were taken with a stomach tube 1 hour before feeding on the third "rest" day, and acidified with concentrated sulphuric acid.

The mean intake of teff straw by each sheep established during the adaptation period was increased by 15%, and was offered throughout the trial to ensure **ad libitum** intake. Noug cake and Trifolium hay were given in the morning and were completely eaten before teff straw with molasses or molasses-urea was offered. Molasses and molasses-urea were poured onto and thoroughly mixed with each sheep's daily straw requirement. The ratios of teff straw and molasses or molasses-urea offered each sheep daily were therefore known. The ratios of teff straw and molasses or molasses-urea in the feed offered each sheep was assumed to be the same as those in the feed refused. For example, if 720 g of teff straw + molasses was offered, then the proportion of molasses was 16.7% (120 g/720 g x 100). If the feed (teff straw + molasses) refused was 150 g, then 25 g molasses (150 g x 0.167) was refused. Mixing molasses and molasses-urea with teff straw was necessitated by the refusal of some sheep to eat these supplements when they were fed separately.

During the measurement periods, samples of teff straw, molasses, molasses-urea, noug cake and Trifolium hay offered and teff straw or teff straw with urea, molasses or molasses-urea were taken and composited. Subsamples of the weekly composites were dried at 60°C for 24 hours and ground through a 1-mm screen for analyses. Aliquots were dried overnight at 100°C for DM determinations.

Faeces and urine were collected every 24 hours during each collection period. Urine was acidified with concentrated sulphuric acid and measured volumetrically. Aliquots of each sheep's urine and faecal outputs were refrigerated, bulked at the end of the period and subsampled. Faecal samples were processed as for feeds.

Feed, faecal and urine samples were analyzed for N, rumen fluid for ammonia (AOAC 1980), and feed and faecal samples for neutral-detergent fibre (NDF) (Goering and Van Soest 1970). Apparent digestion coefficients were calculated. All data were subjected to analysis of variance and differences among treatment means were determined (Snedecor and Cochran 1980).

RESULTS AND DISCUSSION

The N and NDF contents of feeds offered are shown in Table 1, while Table 2 shows the effects of supplementation of teff straw with urea. Adding urea at about 0.7% of the air-dry weight of teff straw offered increased straw intake, apparent DM and NDF digestibilities by 3.7, 8.3 and 7.3%, respectively, but these increases were not significant ($P<0.05$). Urea supplementation significantly increased N digestibility and rumen ammonia concentration. Since about 80% of rumen bacteria may use ammonia as their sole source of N for microbial synthesis (Bryant and Robinson 1962), the boost in rumen ammonia concentration resulting from the addition of urea could have contributed to increased feed intake and utilization. The rumen ammonia concentration in sheep on the basal diet was lower but that in urea-supplemented sheep was similar to the 5-8 mg% reported by Satter ans Slyter (1974). It was lower in all sheep in the study than the 15-20 mg% suggested for optimum utilization of fibrous feeds (Krebbs and Leng 1984). However, rumen ammonia concentration may be an unreliable indicator of the degree of urea utilization if other factors needed for rumen microbial growth are not supplied in adequate amounts (Hunter and Vercoe 1984).

Sheep given urea supplemented teff straw excreted 42% more urine volume, containing significantly ($P<0.05$) 51% more N than those fed teff straw alone (6.7 vs 10.1 g). Since urea represents about 70% of the total urinary N in ruminants (Livingstone et al 1962), urea-supplemented sheep had a slightly lower N retention than the unsupplemented ones.

Table 1. Nitrogen and Neutral detergent fibre contents (%DM) of feeds offered

Feed ingredients	Nitrogen	Neutral detergent fibre
1. Teff straw	0.6	79.6
2. Molasses	0.7	-
3. Molasses-urea	2.1	-
4. Urea	45.0	-
5. Noug cake	5.4	32.2
6. Trifolium hay	2.1	42.4

Table 2. Effects of supplementing teff straw with urea on feed intake, nutrient digestibility, rumen ammonia concentration and nitrogen retention

Parameters	Amount of urea (g/hd/day)		
	0	3	SE
1. Feed intake (g/DM/day)	341	354	23
2. Apparent digestibilities (%)			
a. Dry matter	43.0	46.7	2.9
b. Neutral-detergent fibre	51.7	55.6	2.0
c. Nitrogen	16.6^{b}	21.8^{a}	3.0
3. Urinary N excretion (g/day)	6.7^{b}	10.1^{a}	1.2
4. Nitrogen retention (g/day)	-0.6	-0.8	0.2
5. Rumen ammonia concentration (%)	2.4^{b}	6.6^{a}	2.0

a, b Means within rows with different superscrips are significantly different ($P<0.05$).

The effects of molasses or molasses-urea alone, or of molasses or molasses-urea with noug cake and Trifolium hay on feed intake, and DM, N and NDF digestibilities are shown in Table 3. Total feed intake increased significantly ($P<0.05$) as the level of noug cake nor Trifolium hay with molasses or molasses-urea increased. The 6.5 and 13 g noug cake and 65 and 130 g Trifolium hay supplements represented about 1.5, 3.0, 13.9 and 24.4% of the diet DM intake, respectively. Neither level of noug cake nor Trifolium hay suppressed the intake of teff straw. These results agree with those of Mosi and Butterworth (1985) when a forage legume hay comprised 19 and 22% of the diet DM. Preston and Leng (1984) suggested that supplements may have beneficial effects on the utilization of fibrous feeds if the level of supplementation does not exceed 20% of the diet DM. However, in a trial by Butterworth and Nuwanyakpa

Table 3. Effects of supplementing teff straw with molasses or molasses-urea and their interactions with levels of noug cake and Trifolium hay on feed intake and nutrient digestibility.

Parameters	Noug cake intake (g DM/hd/day)				Trifolium hay intake (g DM/hd/day)			
	0	6.5	13.0	SE	0	65	130	SE
1. Effects of molasses intake (63 g DM/hd/day):								
a. Feed intake (g DM/Day)								
1) Straw	326	331	347	23	326	320	322	23
2) Total Feed	393^{b}	400^{b}	423^{a}	12	393^{c}	446^{b}	515^{a}	12
b. Apparent digestibilities (%)								
1) Dry matter	40.8^{b}	46.9^{a}	48.2^{a}	3.7	40.8^{b}	53.5^{a}	56.9^{a}	3.7
2) Neutral-detergent fiber	37.3^{b}	43.9^{a}	47.4^{a}	3.9	37.3^{b}	55.8^{a}	56.5^{a}	3.9
3) Nitrogen	15.1^{b}	30.7^{a}	29.6^{a}	3.0	15.1^{c}	32.4^{b}	39.5^{a}	3.0
2. Effects of molasses-urea intake ([illegible]8 g DM/hd/day)								
a. Feed intake (g DM/day)								
1) Straw	354	380	364	23	354	355	359	23
2) Total feed	428^{b}	458^{a}	447^{a}	12	428^{c}	487^{b}	549^{b}	12
b. Apparent digestibilities (%)								
1) Dry matter	53.1	50.4	53.1	3.7	53.1^{b}	58.1^{a}	59.2^{a}	3.7
2) Neutral-detergent	53.1	52.3	52.3	3.9	53.1^{b}	57.4^{a}	57.5^{a}	3.9
3) Nitrogen	37.6^{c}	42.7^{b}	46.7^{a}	3.0	37.6^{c}	44.8^{c}	50.4^{a}	3.0

a, b, c For each of the molasses and molasses-urea effects, means within rows with different superscripts are significantly different ($P<0.05$)

(unpublished data), supplementing teff straw up to 42% of the diet DM with a legume hay significantly increased feed utilization.

Adding a small amount (6.5 g) of noug cake with molasses (0.7% N) significantly increased DM, NDF and N digestibilities over molasses alone. However, doubling the amount of noug cake did not significantly increase these parameters beyond the levels obtained with 6.5 g (Table 3). Similar results were obtained when molasses was fed with 65 and 130 g Trifolium hay (except for N digestibility). These data suggest that in a N deficient diet the effects of a N supplement may be greater at the lower levels of supplementation, with additional benefits decreasing as supplementation is increased (Butterworth and Mosi 1985). Therefore, the lower levels of noug cake and Trifolium hay are more appropriate for smallholders.

When noug cake was fed with molasses-urea, DM and NDF digestibilities were affected differently than observed for molasses. Except for N digestibility, neither level of noug cake improved feed utilization beyond the levels attained with molasses-urea alone. This suggests that the amount of N provided by noug cake was not high enough to significantly affect feed utilization more than molasses-urea, which was moderately (2.1%) high in N. As with molasses, the effects of feeding molasses-urea + 24.4% of the diet as Trifolium hay were statistically similar to those of molasses-urea + 13.9% Trifolium hay. The data therefore show that the lower levels of legume and noug cake supplementation were as effective, but more appropriate for small-scale farmers.

Dry matter intake and digestibilities of DM, N and NDF were lower in sheep given teff straw supplemented with molasses alone (Table 3), than in those given either teff straw + urea or teff straw alone (Table 2). Therefore, N deficiency may be a greater cause of poor performance in animals given cereal crop residues, than energy deficiency.

Nitrogen (urea) supplementation did not only result in better feed intake and utilization than energy (molasses) supplementation, but was also more economical. At prevailing market prices in Ethiopia (6 and 80 cents/kg for molasses and urea, respectively), about 0.24 and 0.53 cents were spent/sheep/day for single supplements of urea and molasses respectively. Urea is also easier to transport than molasses. Therefore, even if both urea and molasses were available, and could be handled and fed safely, supplementation with urea alone would be more beneficial for small-scale farmers than with molasses alone.

Nuwanyakpa <u>et al</u> (1986) fed molasses-urea (2.5% urea) **ad libitum** to Ethiopian highland sheep and observed that teff straw intake and fibre digestibility were negatively correlated with the intake of molasses-urea. The increase in feed utilization associated with molasses-urea (also 2.5% of urea) supplementation in the present study may have been because the amount of molasses-urea on offer was limited. Loosli and McDonald

(1969) stated that in order to improve the utilization of forages with molasses-urea as a supplement, intake of the supplement must be restricted by making the mixture "unpalatable" or by limiting the amount offered.

Feed intake and utilization were greater when teff straw was supplemented with molasses-urea than molasses. The inferiority of molasses to molasses-urea could be explained by the fact that when molasses is used, even at restricted levels, as the sole supplement to low quality roughages (Peralta and Hughes-Jones 1981), digestibility, rate of passage and voluntary feed intake may be reduced (Sutton 1979; Van Niekerk and Jacobs 1985). These effects may be caused by the proliferation in the rumen of the fast-growing sugar digesting micro-organisms depriving the slower-growing cellulolytic organisms of what little N is available in the rumen (Gilchrist and Schwartz 1972).

Molasses-urea (Table 3) significantly (P<0.05) improved DM and N digestibilities, and N retention than urea alone (Table 2) or molasses alone (Table 3), although the dietary proportions of molasses (14.8%) and molasses-urea (14.7%) were similar. At each level of noug cake or Trifolium hay, the effects of molasses-urea on teff straw and total feed intake, and nutrient digestibilities were significantly greater than those of molaases, suggesting that the small amount of urea significantly improved the value of molasses as a supplement, perhaps through making more N available for rumen bacterial growth and protein synthesis.

That molasses is a poorer supplement to low quality roughages than urea or molasses-urea is in agreement with the findings of Van Niekerk and Jacobs (1985). These workers reported that the intake of sugarcane tops and liveweight gains in cattle were significantly greater with protein (25% true protein and 75% urea) than energy (molasses) supplementation. The greatest performance in cattle was obtained when both supplements were fed together.

Sheep performance was better on teff straw + molasses-urea than teff straw and urea diets, suggesting that the energy and minerals in the molasses (McKiernan 1982) may not only be beneficial at the whole animal level, but also in enhancing the utilization of urea by rumen microbes. As such, administering urea as part of a molasses-urea mixture rather than dissolving it in water and sprinkling onto straw is recommended.

As shown in Table 4, N retention in sheep given molasses-urea alone was greater than in those given molasses alone. While N retention in sheep supplemented with molasses alone was significantly (P<0.05) lower than in those given molasses + 13 g noug cake, feeding the same amount of noug cake with molasses-urea did not affect N retention. This differential response between molasses and molasses-urea suggests that in the presence of urea, the small amounts of noug cake did not

Table 4. Effects of supplementing teff straw with molasses or molasses-urea and their interactions with levels of noug cake and *Trifolium* hay on urinary N excretion, N retention and rumen ammonia concentration.

Parameters	Noug cake intake (g DM/hd/day)				*Trifolium* hay intake (g DM/hd/day)			
	0	6.5	13.0	SE	0	65	130	SE
1. Effects of molasses intake (63 g DM/hd/day)								
a. Urinary N excretion (g/day)	5.9	6.0	7.0	1.2	5.9^{b}	7.6^{a}	8.7^{a}	1.2
b. Nitrogen retention (g/day)	-0.7^{b}	-0.1^{a}	0.0.^{a}	0.2	-0.7^{c}	0.1^{b}	0.7^{a}	0.2
c. Rumen ammonia concentration (%)	1.9	3.8	3.7	2.0	1.9^{b}	6.2^{a}	5.6^{a}	2.0
2. Effects of molasses-urea intake (68 g DM/hd/day)								
a. Urinary N excretion (g/day)	9.1^{b}	11.3^{a}	10.1^{ab}	1.2	9.1^{b}	11.6^{a}	12.2^{a}	1.2
b. Nitrogen retention (g/day)	0.4	0.3	0.5	0.2	0.4^{c}	0.7^{b}	1.4^{a}	0.2
c. Rumen ammonia concentration (%)	7.9	8.2	10.0	2.0	7.9	7.6	8.1	2.0

a, b, c For each of the molasses and molasses-urea effects, means within the rows with different superscrips are significantly different ($P<0.05$).

stimulate rumen microbial activity enough to contribute significantly to N retention. Feeding 65 g and 130 g Trifolium hay with molasses or molasses-urea significantly increased N retention over either supplement alone. Greater beneficial effects were obtained with Trifolium hay than with noug cake probably because more N was ingested from Trifolium hay than from noug cake. M.Y. Nuwanyakpa, M. Butterworth and L.J. Lambourne (unpublished data) fed lactating dairy cows a forage legume hay and noug cake at iso-nitrogenous levels, and found that two supplements to be statistically similar in their effects on hay intake, milk production and composition, and molar proportions of straight - and branched - chain rumen VFAs.

Changes in rumen ammonia concentration due to the inclusion of noug cake or Trifolium hay with molasses or molasses-urea were generally non-significant. This may have been due to the fact that the same amount of urea fed was low and that rumen fluid samples were taken 24 hours after noug cake and Trifolium hay had been consumed. With either molasses or molasses-urea, rumen ammonia concentration was higher in sheep fed Trifolium hay than in those given noug cake (more N was offered through Trifolium hay).

CONCLUSION

The major conclusions drawn from this trial were that:

1. Feed intake and utilization were slightly greater in sheep given teff straw + urea than in those fed teff straw alone, and significantly greater than in sheep on teff straw + molasses indicating that N deficiency in cereal crop residues may be a greater cause of poor animal performance than energy deficiency. At prevailing market prices in Ethiopia, N (urea) supplementation was also more economical than energy (molasses) supplementation.

2. Feed intake was, in general, significantly greater in sheep on teff straw supplemented with molasses-urea than in those supplemented with urea alone. Therefore, urea is more beneficially administered as part of molasses-urea mixture rather than being dissolved in water and sprinkled onto a cereal crop residue.

3. Whether given with molasses or molasses-urea, the lower levels of noug cake and Trifolium hay were as effective as molasses or molasses-urea but more affordable and hence recommended for small-holders.

4. Even when offered at a restricted level, molasses decreased the intake of teff straw and reduced the digestibilities of DM, NDF and N, and the retention of N below the levels observed in sheep given unsupplemented teff straw. Therefore molasses should probably not be used as the sole supplement to cereal crop residues.

5. At each level of noug cake or Trifolium hay, the effects of molasses-urea on teff straw and total feed intake,

and nutrient digestibilities were significantly greater than those of molasses, showing that a small amount of urea significantly improved the supplementary value of molasses.

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THE EFFECT OF DIFFERENT PROTEIN SUPPLEMENTS ON WEIGHT GAIN AND VOLUNTARY INTAKE OF MAIZE STOVER BY CATTLE

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ABSTRACT

Twelve (12) young Zebu bulls of Gudali breed, 276 kg average liveweight and 2½ years of age were randomly put into 4 groups of 3 animals under intensive feeding system to determine the effect of different protein supplements on growth, and intake of chopped, dried maize stover. A control group was fed stover and libitum only, and the other groups were fed daily 750 g cottonseed cake/head, 1 kg leucaena hay or 900 g of leucaena/cottonseed cake (66:34; w/w).

Significant differences were observed on average daily liveweight gains. Animals on leucaena and its mixture registered higher daily gains (236 g) and (325 g) respectively, followed by cottonseed cake (154 g); The control group lost weight (-8.0 g/d).

Contrary to the liveweight gains, animals fed on leucaena and its mixture had lower maize stover intakes, 3.35 kg DM/animal/day and 3.70 kg DM respectively, while those on cottonseed cake and the control group ingested respectively 4.72 kg DM and 4.16 kg DM maize stover.

It is concluded that during the critical period in the southern part of Cameroon, small-scale farmers can prevent loss in liveweight by utilizing simple available rations.

INTRODUCTION

In southern Cameroon small-scale farmers practise mixed farming. Animals, especially ruminants, lose 20 to 30 percent of their liveweight during the dry season due to low productivity of pasture (Hoste 1974). Therefore six years of studies on the utilization of rice bran and rice straw in ruminant feeding have been implemented at the animal research centre in Bambui. Satisfactory results with the incorporation of 100 percent rice bran (NDumbe 1979, 1980) and 60 to 80 percent chopped maize stover (NDumbe et al.; 1982, 1984) were obtained. But the use of concentrate supplements, or the chemical, physical and microbial treatments generally recommended (Nicholson 1981; Hartley 1981) to improve the low energy and protein in lignified straw (Leng et al. 1983) are not actually applicable to small scale farmers. There is a great need to prevent weight loss by using simple techniques and readily available rations.

A study was therefore undertaken to evaluate the effect of different protein supplements on the growth and feed intake of young bulls fed intensively on chopped dried maize stover.

MATERIALS AND METHODS

Animals

Twelve Gudali Zebu bulls, of average liveweight 276 kg and aged 2½ years were randomly assigned to 4 groups of 3 animals each. The animals were housed in a roofed, half walled shed with a concrete floor, treated for worms and ectoparasites, and injected with A, D, K, E polyvitamins.

Feed and Feeding

A two week adaption period of maize stover was followed by a 12 week experimental period during which maize stover was given ad libitum at the rate of 120% of the intake. The diets were composed of:

basal diet	-	ad libitum dried chopped maize stover.
diet 1	-	basal diet + 750 gm cottonseed cake/animal/day.
diet 2	-	basal diet + 1000 gm leucaena hay/animal/day
diet 3	-	basal diet + 900 gm/day of a mixture of leucaena hay and cottonseed cake in the ratio of 66:34 (w/w).

The supplement was given separately each morning before the basal diet of maize stover. Water and a mineral supplement 50:50 common salt/bone meal) were given separately ad libi-um. Chopped maize stover and refusals were weighed each morning. nimals were weighed fortnightly from the beginning of the adaptation period to the end of the experimental period.

The chemical composition of maize stover and leucaena was determined using the methods of Van Soest (1967) for cell wall materials and nitrogen was measured by a Kjeldahl procedure; these figures are shown in Table 1.

Table 1: Chemical composition of ration ingredients (%).

	Dry Matter	Crude Protein	Cellulose	Hemicellulose	NDF	ADF	Lignin	Ash
Maize Stover	92.05	4.05	29.20	19.50	42.60	62.10	12.50	9.50
Leucaena hay	89.05	25.53	8.60	12.76	22.22	34.99	12.76	14.56
Cottonseed cake	88.60	34.05	-	-	-	-	-	-

	basal diet	diet 1	diet 2	diet 3
Crude protein in daily supplements fed	0	255.37	255.30	255.84

Liveweight gains and feed intake were submitted to analysis of variance and Fisher's test was applied to determine significant differences among treatments.

RESULTS AND DISCUSSION

Intakes of maize stover and liveweights are given in table 2. Cottonseed cake slightly but non-significantly increased maize stover intake, but both leucaena and leucaena/cottonseed mixture reduced maize stover intake significantly (P<0.5).

Table 2. Effects of diets 1, 2 and 3 on dry matter intake of maize stover and on liveweight gains in cattle over an experimental period of 12 weeks.

Rations / Parameter	Basal Diet	Diet 1	Diet 2	Diet 3
No. of animals	3	3	3	3
Liveweight (kg)				
- initial	275	277	276	277
- final	274	290	295	305
LWG (g)/day	-8[a]	154[b]	236[c]	325[d]
Daily maize stover intake kg DM/animal	4.16[a]	4.72[a]	3.25[a]	3.70[b]

a, b Means in the same row not having common letters differ significantly (P<0.05).

Table 2 shows that the liveweight gains (LWG) of the supplemented groups differed significantly from each other, and all significantly exceeded that from the basal diet of maize stover, which produced weight loss (-8 g/animal/day). In terms of LWG, leucaena hay alone was more effective for animals than cottonseed cake alone. Animals supplemented with the mixture of leucaena hay and cottonseed cake registered the highest LWG, showing the mixed supplement to have been more beneficial for cattle growth than either supplement alone. In the three supplemented groups, the quantity of supplementary protein was the same, and thus LWG was significantly affected by the source of supplementary protein.

Morgan (1977) observed in sheep that finely ground cottonseed meal provided animals with by-pass protein resulting in increased total feed intake (Leng and Preston, 1983). The low voluntary intake of maize stover could be the result both of low crude protein content and low digestibility (Finn 1976), in turn probably related to its high lignin content (12%) which limits the fermentable energy available (Lindberg et al., 1984).

While both leucaena hay alone and its mixture with cotton-seed cake significantly decreased maize stover intake, the effect of leucaena alone was relatively more pronounced. This might have been due either to its lignin content (12% as in corn stover) or to the toxic effect of mimosine (Jones et al., 1983) which was not assessed, but in view of the gains observed, probably unimportant.

It is concluded that small-scale farmers could avoid animal wieght loss during the critical period of the year by using small quantities of higher quality supplements, and consequently reduce animal mortality and weakness due to malnutrition.

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CASSAVA BY-PRODUCTS IN RABBIT AND SHEEP DIETS

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ABSTRACT

Sundried cassava leaves were fed to rabbits, and peels to sheep, in an attempt to determine suitable rations that can prevent dry season animal weight losses. Rabbits fed 50, 62.5 and 75% levels of leaves in test diets ate 65.8, 73.5 and 71.8 g/d and gained 17.4, 19.4, 18.2 g/d respectively. There was no difference in growth traits between female and male rabbits.

Sheep fed 0, 35, and 70% of the diet as cassava peels (and respectively 70, 35 and 0% elephant grass), with cottonseed cake as the protein source, gained respectively 45, 107 and 227 g/d; these differences were significant ($P<.0.05$). These diets show promise as dry season feedstuffs.

INTRODUCTION

A survey of sheep and goat production systems in Cameroon showed that nutrition, especially in the dry season, and the tethering management practice, are the principal constraints to increased meat and milk production from these species. This study attempts to evaluate the use of cassava by-products as feedstuffs for animals in an attempt to avoid weight losses normally observed during this period (mid-November to mid-March).

Cameroon produces an estimated 620 thousand tonnes (t) of cassava (Manihot esculentum Crantz) annually, the by-products of which amount to 37.2 thousand t of leaves, 74.4 thousand t of peels and 528 thousand t of stems. Currently these by-products are used as manure, or fuel in the case of stems. Some leaves are used as human food. Cassava contains the cyanogenic glucosides linamarin [2(B - D - glucopyranosyloxy) isobutyronitrile] and lotaustralin [2(B - D - glucopyranosyloxy) 2 - methylbutyronitrile] which yield HCN on hydrolysis; apparently grass-eaters are somewhat adapted to dispose of this poison and its metabolic products (Oke 1973, Devendra 1977).

Sonaiya and Omole (1981) demonstrated that growing rabbits successfully utilized a ration containing 40% cassava peel meal. Eshiett, Omole and Ademosun (1981) fed five-week old rabbits on rations containing 0, 15, 30 or 40% cassava root meal and found liveweight performance and carcass quality to be similar on all rations. Adebowale (1981) fed sheep fermented cassava peels at levels of 0, 20, 40 or 60% in the diet over a 6 month period. The 40 and 60% cassava peel rations had lower digestibilities of dry matter, crude fibre and TDN, feed intake, body weight gain and feed efficiency, but had no effects on weights of liver and hides.

In this work the effects of including sun dried cassava leaves with the diet were examined in rabbits and sheep.

MATERIALS AND METHODS

Animals: 36 four-week old rabbits, (18 male, 18 female crossbred New Zealand x chinchilla x Californian) were allocated to three groups each of 6 males and 6 females, and fed diets containing 50, 62.5 or 75% cassava leaf (Table 1). Water and feed were given *ad libitum* with feeding being carried out twice a day. The feed and water were supplied in clay croques and the animals were allowed 12 hours of light. The temperature ranged from 23.2°C to 28.3°C. Ten hour fasted weights were obtained every week and the experiment lasted four weeks. In the second trial, nine rams of initial weight 24.3 kg were fattened on three test diets (Table 2) using a 3 x 3 latin square design over 3 months.

Table 1. Percentage composition of cassava leaf based diets for rabbits

	Rations		
Feed Items	I	II	III
Cassava leaf	50.0	62.5	75.0
Ground maize	45.5	33.0	20.5
Palm Oil	3.0	3.0	3.0
Minerals/vitamins etc	1.5	1.5	1.5
Calculated analysis			
Energy DE (Kcal/kg)	3454	3230	3008
Crude protein %	16.1	16.8	16.8
Crude fibre %	13	14	16
Calcium %	0.64	0.76	0.88
Phosphorus %	0.46	0.48	0.51

Table 2. Percentage composition of test diets containing graded levels of cassava peels for sheep

Cassava peels	0	35.5	71
Elephant grass	71	35.5	0
Cottonseed cake	20	20	20
Molasses	5	5	5
Bone meal	2.5	2.5	2.5
Salt	1.5	1.5	1.5
Calculated analysis			
Crude protein %	14.4	13.9	13.4
Crude fibre	23.8	16.5	9.2
Calcium %	1.2	1.1	1.1
Phosphorus %	0.6	0.6	0.7
D.E. (Kcal/kg)	2527.8	2573.2	2618.7
HCN (mg/kg)	0	72.2	144.4

Cassava leaf and peels

Cassava leaf including petioles and cassava peels were obtained from 15 month-old plants and were sundried on black polythene sheets for about 2 - 3 days. Old leaves, seeds and stems were picked out and the rest bagged in jute sacks and stored until ready to be fed. Leaves contained 74 mg HCN/kg leaf and peels contained 203.4 mg/HCN/kg determined by the agentometric method.

RESULTS AND DISCUSSION

Table 3 shows that sex differences and ration effects were not statistically significant as far as rabbits fed graded levels of cassava leaves were concerned. However, female rabbits tended to eat less feed (66.0 g/d vs 71.2 g/d) and grew slightly faster (18.8 g/d vs 18.0 g/d). Female rabbits are generally heavier than male rabbits. There was a tendency for higher feed intakes and higher weight gains with higher levels of cassava leaf in the diet. There were no differences between sexes or rations in efficiency of feed utilization, and no rabbits died nor were any cases of diarrhoea observed.

Table 3. Feed intake and weight gains of rabbits fed cassava leaf-based diets

Sex	Leaf level	Daily Dry Matter Intake (g/rabbit)	Daily weight gain (g/rabbit)	Feed/gain
Female	50	72.2	16.8	4.0
	62.5	68.2	18.7	4.1
	75.0	71.6	21.1	4.6
Male	50.0	57.8	17.9	6.4
	62.5	78.2	20.8	4.2
	75.0	63.2	15.2	3.8
S.E.M.		23.14	15.13	5.16
Sex means				
Female		66.0	18.8	4.2
Male		71.2	18.0	4.8
S.E.M.		18.04	12.62	6.83
Ration means				
	50	65.8	17.4	4.2
	62.5	73.5	19.4	4.1
	75.0	71.8	18.2	4.2
	S.E.M.	20.31	18.01	5.12

Harris *et al* (1981) fed several tropical forages to weanling rabbits and observed daily weight gains of 33 g/rabbit and a feed/gain of 3.38 for rabbits fed cassava leaf-based diets. These workers observed no mortalities nor diarrhoea cases with these diets, but diarrhoea did occur in rabbits fed low saponin alfalfa, winged bean and Stylosanthes guianensis.

The low weight gains observed in this trial may be due to the fact that the feed was not pelleted and was scattered. Harris, Cheeke and Patton (1983) showed that feeding non-pelleted diets resulted in much feed being scattered. Nevertheless, cassava leaf based diets for rabbits show promise, and will reduce competition for other protein sources such as oil seed cakes as well as supplying the fibre required for rabbit growth.

In the second trial (Table 4) the sheep fed diets with cassava peel grew significantly better ($P<0.05$) than those fed the elephant grass diet (227 g/d vs 45.2 g/d). The differences could be attributed to higher intakes of digestible dry matter. The cassava peels also contributed additional soluble carbohydrate (8%) as peels were removed from tubers in pencil sharpening format.

Table 4. Weight gains and feed intake of sheep fed graded levels of cassava peels

Characteristics	Level of peel		
	0%	35%	70%
Dry matter intake (kg/day/sheep)	0.87	1.36	1.06
Daily weight gain (g/sheep)	45.20^{a}	106.70^{b}	227.14^{c}
Dry matter digestibility (%)	50.91	79.02	88.13
Crude protein digestibility (%)	56.12	76.23	74.27

a, b and c. Within rows means not bearing the same superscript are significantly different ($P<0.05$).

Adebowale (1981) fed fermented cassava peel to sheep and observed depressed weight gains as the level of peel increased in the diet. It is possible that fermented cassava peels depressed rumen function, while in the present work, sundried cassava did not. The diets were palatable and no sheep died nor showed any adverse effects.

Cassava peels show great potential in sheep and goat production in Cameroon not only in preventing dry season weight losses but also in supporting growth. The technology of feedstuff preparation is simple, not labour intensive and easily applicable to farmer situations.

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PRELIMINARY OBSERVATIONS ON GRAIN SPROUTS TO SUPPLEMENT POOR QUALITY ROUGHAGE

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ABSTRACT

The nutritive value of poor quality by-products may be improved by supplementary sources of easily fermentable carbohydrates, crude protein, minerals and vitamin A-precursor.

The technique described here was found successful in providing most of these requirements at a relatively low price. Grains (one kg) were sown on double their weight of chopped rice straw and irrigated daily with 7 litres of tap water. Some urea and traces of foliar fertilizer were added to the water on the seventh day. One kg grains gave six times its weight of sprouts within two weeks. The sprouts and the rice straw bedding contained 11% crude protein and 55% TDN and was readily consumed by sheep.

INTRODUCTION

Before the recent droughts and human population explosion, feeding animals on pasture and cultivatable land for food crops did not present any problem. Economics demand maximum inclusion of agricultural and agro-industrial by-products in animal diets to save as much cereals and oil seeds for human consumption as possible.

Many successful approaches to improving the nutritive value of these by-products are now practised either through alkali treatments, feeding with leguminous forage or supplementation of the deficient nutrients by adding urea, molasses, vitamin A and some minerals. Such improved by-product based diets may satisfy the maintenance requirements of animals. Feeding for production or reproduction necessitates supplementing the by-product based diet with some nutritious concentrates to a level around 30% of the diet dry matter. The supplement in this case should be rich in protein, energy and vitamin A. It may, therefore, be expensive, especially under most small farmer conditions.

The present results describe the adaptation of the hydroponic technique to obtain an adequate supplement at a reasonable cost.

MATERIALS AND METHODS

The hydroponic technique

Rice straw was chopped and spread over a plastic sheet as a bedding for maize and barley seeds. Used fertilizer bags were spread close together to form the sheet. The grains were sown on the surface of the bedding, and left in the open air. Irrigation was applied frequently by spraying tap water until the seedlings reached a height of 30 cm. The final product, consisting of the bedding and sprouts, was offered to sheep as the sole diet.

The technique was tried in winter with barley and in summer with maize. Mould growth was prevented by adding 4% chlorax in the irrigating water; at the beginning and on the 7th day. The mould disinfectant was not detectable in the bedding four days after application. It did not apparently cause any harm to the animals.

Irrigation frequency, chop length and depth of bedding

The effect of the length of chopped rice straw was investigated, using three lengths (1, 3.5 and 7 cm), and three bedding depths (4, 8 and 12 cm) were also compared. The bedding was irrigated with 7, 14 or 21 litres per m^2 per day. Irrigation was carried out at three frequencies, once or twice per day and every other day. Foliar fertilizer was dissolved in the irrigating water at one or two parts per million.

The voluntary feed intkae (g/head/day) and dry matter digestibility of this products were estimated. An economical evaluation was also carried out.

RESULTS

There were no significant differences between any of the treatments in dry matter production of the sprouts, although increasing depth of the bedding showed a tendency to promote higher production (Table 1), possibly through greater water holding capacity and reduced evaporation. The results also indicated that a grain to bedding ratio by weight of 1:2 was preferable to ratios of 1:1 or 1:4 (Table 2). Perhaps higher grain density caused competition by the sprouts for nutrients in the bedding, while light density may have been inadequate for optimum photosynthetic activity. Athough frequency of irrigation and rate of foliar fertilizer application showed no significant effect on the DM yield from sprouts, water tended to be more effective when it was applied at three times the weight of the bedding.

Table 1. Dry matter gains in form of sprouts expressed as percent of the weight of originally added grain.

Bedding depth (cm)	Season (grain type)	
	Winter (barley)	Summer (maize)
4	514	389
8	641	575
12	675	680

Sheep consumed the product at the rate of 86 $g/kgW^{0.75}$/ /day, and the digestibility of DM approximated 57%. Total crude protein content in the shoots ranged between 20 and 25. Three to 10% of the dry matter of the bedding was contibuted by the root network of the sprouts.

Table 2. Effect of grain: bedding ratio (W/W) on the dry matter gain of sprouts per m^2 expressed as percent of the weight of the grain originally added

Grain bedding ratio *	Grain type	
	Barley	Maize
1:1	521	513
1:2	687	530
1:4	641	462

* The weight of grains was consistently one kg/m^2.

DISCUSSION

Tables 1 and 2 indicate that the weight of grains increased about 6 times in two weeks. This would mean that 4.25 tons of grain sown on 8.5 tons of chopped by-products (maize stover or cobs) and irrigated with 450 cubic meters of water, repeated over 20 cropping batches each of 15 days would result in the production of 150 tons of a nutritious feed containing 11% crude protein and 55% TDN. This technique reduces the need for extended land areas for producing animal feed and also cuts down the water demand for cropping 0.5 ha from 14-16 thousand m^3/year to only 9000 m^3.

If a diet of roughage and concentrate in the ratio of 1:1 is sought it is recommended that 20% maize or barley grains be added to chopped roughage and irrigated for some 14 days. The price of the roughage by-product material may be one sixth of the price of grain. The two week's old sprout is very rich in protein, low in fibre and is high in digestibility. It also contains high levels of carotene.

The sprouts can be fertilized by any nitrogenous fertilizer to improve their true protein content. They supply the by-product based diet with easily fermentable carbohydrates, vitamin A-precursor, true protein and improve its palatability and digestibility. The technology reduces the costs of feed production by reducing rent on land and irrigating water, while maximizing the benefits of photosynthetic activity through such an intensive cropping system.

THE ECONOMICS OF BY-PRODUCTS TRANSPORTATION

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ABSTRACT

Crop by-products are bulky and of low value, and high transportation costs can be incurred if they are not located in user sites. For many smallholder farmers raising livestock under a zero grazing system, high transport costs are unavoidable as long as the by-products are transported in loose form and economics of scale cannot be realized due to small volume requirement.

On cooperative basis, by-products can be baled to reduce losses and to increase the quantity of material transported. Such a measure will reduce the cost of transportation per unit weight of by-products. A further distribution efficiency can be gained if choice of routes minimizes distance or time taken to deliver the by-products.

This paper demonstrates the application of linear programming in organizing transportation of maize stover and bean straw from production zone to user sites in the Hai District. Three production zones and ten user sites have been identified. Estimates of by-products supply are based on hectarage and yield data for the District. Demand for the by-products is estimated using daily dry matter requirements per animal as a basis. Two scenarios are used, that is low level of feeding and high level of feeding. Costs of transporting the by-products are determined by considering components that are time dependent and those that are distance dependent.

Results obtained indicate that where several routes are available to reach the same destination, choice of routes to take will be that leading to minimization of costs. When the level of demand is increased by 22% transportation costs increase by 20% which is less than the increment in quantity shipped. The change in level of demand has in the process lead to additional activities coming into solution.

INTRODUCTION

The increasing costs of manufactured feeds, and the declining land area available for grazing and/or pasture production due to human population pressure have led to a growing interest in the utilization of crop by-products to feed livestock. Although crop by-products are available in large quantities, they do not in all cases occur at user sites. Their bulkiness and low value cause the costs accociated with transportation to be high. In addition, their removal from the fields and transportation may have to be done within a short time period to avoid spoilage by rain or to give way to field cultivation.

Smallholder dairy production in the Hai District is concentrated in the highland zone. The bulk of the crop by-products, mainly maize stover and bean straw, are obtained from the lowland zone. The average distance from the homestead in the highland zone to the farm plots on the lowland zone is 15 km (Urio and Mlay, unpublished data). By-products are transported in loose form using either human power or hired trucks. The loose form of transporting the by-products apart from leading to wastage, contributes to high cost per unit weight since volume limits the quantity that can be transported per trip. Baling would be one way to maximize the weight of by-products that can be transported per trip. Transport charges are fixed by contract and can be very variable. A survey conducted in the study area in March, 1986 showed that the average cost to transport a load of by-products over a distance of 7.5 km is Sh. 750. It is felt that costs associated with utilization of by-products can be reduced if the Cooperative movement undertakes on a commercial basis the function of baling and transportation of the by-products to user sites.

The objective of this paper is to demonstrate the application of mathematical programming techniques in planning the transportation of the by-products to user sites such that costs are minimized.

THE MODEL

In the Hai District, three zones have been identified as having the potential for large scale baling of maize stover and bean straw. These are Sadala-Weruweru, Sanya-West Kilimanjaro and Boma Ngo'mbe-Lawate. Ten user sites are considered in the problem and these are Mowo Njamu, Kirisha, Mae, Wanri, Siha, Kyuu, Nguni, Lukani, Machame and Lyamungo. The by-products are to be moved to central locations in the user sites, and these are selected to coincide with the location of the primary societies. Several of these central locations can be reached by more than one route. Since the cost of delivery is affected by distance travelled per unit of product delivered, any procedure which will result in driving a shorter distance or spending less time enroute while providing the same services can contribute to lower costs and improved marketing efficiency. Algebraically the transportation model can be presented as follows:

Minimize

$$C = \sum_{i=1}^{2} \sum_{j=1}^{10} T_{ij} X_{ij} + \sum_{i=1}^{2} \sum_{j=1}^{10} \gamma_{ij} V_{ij} \qquad (1)$$

Subject to

$$M_j \leq \sum_{j} X_{ij} \qquad (2)$$

$$U_j \leq \sum_{j} V_{ij} \qquad (3)$$

$Xi \geqslant 0 \qquad Vi \geqslant 0$ (4)

Where i = production site index

j = consumption site index

Xij = Metric tons of maize stover transported from production zone i to user zone j

Tij = Cost of transporting one metric ton of maize stover from production zone i to user zone j

Vij = Metric tons of bean straw transported from production zone i to user zone j

Yij = Cost of transporting one metric ton of bean straw from production zone i to user zone j

Mj = Demand for maize stover from user zone j

Uj = Demand for bean straw from user zone j

The production component has been deliberately eliminated from the model, and estimates of maize stover and bean straw that can be produced by each zone are obtained from hectarage and grain yield data presented in table 1.

Table 1. Maize and Bean Production in Hai

	Maize		Beans	
Year	Ha	Production Tons	Ha	Production Tons
1984/85	28530	57060	8010	3296
1985/86	29150	14575	8240	3190

Source: DADO's Office Hai District

The transportation cost per ton of by-products is estimated using the method proposed by Fedeler et al (1975). The costs are separated into costs allocated to distance and costs allocated to time as in equation 5.

$$TC = C_h + C_m \quad M \qquad (5)$$

where TC = total truck costs per trip

C_h = the cost per hour of truck use

H = hours required for the trip

C_m = the cost per km of truck use

M = the distance of the trip in km.

Costs allocated to time include purchase value of the truck overhead and the driver's wages. The costs allocated to distance include fuel, oil and maintenance costs.

User sites demands are based on estimates of dairy animals in the district (Table 2) under two alternative assumptions. In the first case, it is assumed, that the animals obtain 16% of their dry matter requirements from maize stover and bean straw.

In the second case it is assumed that this source supplies 22% of the dry matter requirements. In both cases, bean straw is set at 33% to reflect the limited supply. These assumptions generate two sets of demands as presented in table 3, hence permitting the observation of how costs change. A standard linear programming package is used to generate an optimum solution.

Table 2. Cattle Population in the Hai District

Division	Cattle Type	Number
Lyamungo	Local Zebu	8646
	Dairy	2902
	Beef	45
Machame	Local Zebu	2311
	Dairy	7555
	Beef	24
Masama	Local Zebu	26518
	Dairy	6292
	Beef	3
Siha	Local Zebu	21298
	Dairy	6283
	Beef	5930

Source: Ministry of Agriculture and Livestock Development 1985 Livestock Census.

Table 3. Estimated Demand of Bean Straw and Maize Stover by User Sites in Metric Tons

	Bean Straw		Maize Stover	
User Site	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Kirisha	32.7	98.2	58.2	174.6
Mae	98.2	294.6	174.6	523.8
Mowo Njamu	131	392.8	232.8	698.4
Wanri	163.7	491	291	873
Siha	65.5	196.4	116.4	349.2
Kyuu	161.8	484.5	287.1	861.2
Ng'uni	242.2	726.7	430.5	1291.8
Lukani	80.7	242.2	143.5	430.6
Machame	775.6	2326.7	1378.8	4136.4
Lyamungo	297.9	893.7	529.6	1588.8

Source: Own estimates.

TRANSPORTATION PROBLEM
OPTIMUM SOLUTION

OBJECTIVE = -1472542

CLASS	ACTIVITY	LEVEL	PRICE	TOTAL	SH. PRICE
1	SANKIR1	58.2	-429	-24968	
2	SANHOW1	233	-326	-75893	
3	SANMA1	175	-143	-24985	
4	SANSIH1	116	-326	-37946	
5	SANWAN1	0	-346		-75.3
6	BOMMA1	0	-244		-101
7	BOMWAN1	291	-271	-78716	
8	BOMKY1	287	-156	-44730	
9	BOMLUK1	144	-185	-26519	
10	BOMNG1	431	-224	-96604	
11	SADKY1	0	-198		-42.1
12	SADLUK1	0	-239		-53.9
13	SADNG1	0	-259		-34.2
14	SADMACH1	1346	-318	-428464	
15	SADLYM1	530	-206	-108886	
16	SANKIR2	32.7	-429	-14028	
17	SANMOW2	131	-326	-42706	
18	SANMA2	0	-143		-143
19	SANSIH2	65.5	-326	-21353	
20	SANWAN2	0	-346		-75.3
21	SANKY2	0	-517		-362
22	SANLK2	0	-558		-373
23	SANNG2	0	-590		-366
24	BOMMA2	0	-244		-244
25	BOMWAN2	164	-271	-44281	
26	BOMKY2	162	-156	-25208	
27	BOMLK2	80	-185	-14784	
28	BOMNG2	242	-224	-54350	
29	SADKY2	0	-199		-43.1
30	SADLK2	0	-239		-53.9
31	SADNG2	0	-259		-34.2
32	SADMACH2	776	-318	-246873	
33	SADLY2	298	-206	-61248	

CLASS	CONSTRAINT		LEVEL	SLACK	TOTAL	SH. PRICE
! 2	SANWEST 1	<	582	9689	10271	
! 3	BOMLAW 1	<	1152	5267	6419	
! 4	BOMSAD 1	<	1876	3260	5135	
! 5	SANWEST 2	<	229	2031	2260	
! 6	BOMLAW 2	<	648	1352	2000	
! 7	BOMSAD 2	<	0	400	400	
! 8	STRKIR	>	58.2	0	58.2	-429
! 9	STR4AE	>	175	0	175	-143
! 10	STRWWAN	>	291	0	291	-271
! 11	STRKYU	>	287	0	287	-156
! 12	STRLUK	>	144	0	144	-185
! 13	STRNG	>	431	0	431	-224
! 14	STRMACH	>	1379	0	1379	-318
! 15	STRLYM	>	530	0	530	-206
! 16	BEAKIR	>	32.7	0	32.7	-111
! 17	BEAMAE	>	131	-32.8	98.2	
! 18	BEAWAN	>	164	0	164	-271
! 19	BEAKYU	>	162	0	162	-156
! 20	BEALUK	>	80	0	80	-185
! 21	BEALY	>	298	0	298	-206
! 22	BEAMACH	>	776	0	776	-318
! 23	BEANGU	>	242	0	242	-224
! 24	STRMOW	>	233	0	233	-326
! 25	BEAMOW	>	131	0	131	-326
! 26	STRSIH	>	116	0	116	-326
! 27	BEASIH	>	65.5	0	65.5	-326

Table 4: Optimum Solution when the By-Products Provide 16 Percent of Dry Matter

TRANSPORTATION
OPTIMUM SOLUTION

OBJECTIVE = -4490276

CLASS	ACTIVITY	LEVEL	PRICE	TOTAL	SH. PRICE
1	SANKIR1	175	-429	-74903	
2	SANMOW1	698	-326	-227678	
3	SANMA1	524	-143	-74956	
4	SANSIH1	349	-326	-113839	
5	SANWAN1	0	-346		-75.3
6	BOMMA1	0	-244		-101
7	BOMWAN1	873	-271	-236147	
8	BOMKY1	861	-156	-134175	
9	BOMLUK1	431	-185	-79575	
10	BOMNG1	1292	-224	-289680	
11	SADKY1	0	-198		-153
12	SADLUK1	0	-239		-165
13	SADNG1	0	-259		-145
14	SADMACH1	3547	-318	-1128883	
15	SADLYM1	1589	-206	-326657	
16	SANKIR2	590	-429	-253024	
17	SANMOW2	393	-326	-128053	
18	SANMA2	0	-143		-143
19	SANSIH2	196	-326	-64026	
20	SANWAN2	0	-346		-41.1
21	SANKY2	0	-517		-327
22	SANLK2	0	-558		-339
23	SANNG2	0	-590		-331
24	BOMMA2	0	-244		-278
25	BOMWAN2	491	-271	-132816	
26	BOMKY2	589	-156	-91797	
27	BOMLK2	242	-185	-44768	
28	BOMNG2	678	-224	-152042	
29	SADKY2	0	-199		-8.90
30	SADLK2	0	-239		-19.7
31	SADNG2	49.2	-259	-12723	
32	SADMACH2	2327	-318	-740589	
33	SADLY2	894	-206	-183745	
			TOTAL	-4490276	

CLASS	CONSTRAINT		LEVEL	SLACK	TOTAL	SH. PRICE
2	SANWEST1	<	1746	8525	10271	
3	BOMLAW1	<	3457	2963	6419	
4	BOMSAD1	<	5135	0	5135	-111
5	SANWEST2	<	1179	1081	2260	
6	BOMLAW2	<	2000	0	2000	-34.2
7	BOMSAD2	<	0	400	400	
8	STRKIR	>	175	0	175	-429
9	STRMAE	>	524	0	524	-143
10	STRWWAN		873	0	873	-271
11	STRKYU	>	861	0	861	-156
12	STRLUK	>	431	0	431	-185
13	STRNG	>	1292	0	1292	-224
14	STRMACH	>	4136	0	4136	-429
15	STRLYM	>	1589	0	1589	-316
16	BEAKIR	>	590	-492	98.2	
17	BEAMAE	>	393	-98.2	295	
18	BEAWAN	>	491	0	491	-305
19	BEAKYU	>	589	0	589	-190
20	BEALUK	>	242	0	242	-219
21	BEALY	>	894	0	894	-206
22	BEAMACH	>	2327	0	2327	-318
23	BEANGU	>	727	0	727	-259
24	STRMOW	>	698	0	698	-326
25	BEAMOW	>	393	0	393	-326
26	STRSIH	>	349	0	349	-326
27	BEASIH	>	196	0	196	-326

Table 5: Optimum Solution when the By-Products Provide 22 Percent of Dry Matter from By-Products.

RESULTS AND DISCUSSION

The objective of the optimisation model is to select source and routes to deliver by-products to user sites to satisfy specific demands. In the case when maize stover and bean straw provide 16% of the required dry matter, the total cost of delivering the required quantities is Tz Sh 1,472,541. When the percentage contribution of dry matter from these two sources is raised to 22%, the total cost becomes TZ Sh 4,4 0,276 which is a 20.5% increase. The increase in dry matter c tribution from crop residues has caused activities which were exclu ed in the initial solution to enter the optimum solution. Details of the results are presented in tables 4 and 5.

In addition to providing the optimum solution and costs for transporting the required quantities to user sites, shadow prices for activities in solution and exhausted resources are provided (Tables 4, 5). The shadow prices show how the optimum solution would change if a unit of the activity not in solution was forced into solution or if a unit of an exhausted resource was made available. These prices allow a user to evaluate the solution to see whether a change is required.

Although not implemented in the present analysis, sensitivity analysis on unit transport costs could be performed. This would permit the evaluation of the stability of the optimum transportation plan when unit costs on some of the routes change. The tool is therefore quite useful in evaluating alternatives before resources are committed, and can assist in planning an efficient crop by-products marketing system.

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FORAGE RESEARCH IN SMALLHOLDER AND PASTORAL PRODUCTION SYSTEMS

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ABSTRACT

Progress in the incorporation of forage legumes into farming systems in sub-saharan Africa to alleviate livestock nutrition problems has been slow. This paper explains the reasons by showing how forages fit into smallholder and pastoral systems. It then speculates on the kinds of technical research that might accelerate their incorporation into current production systems.

INTRODUCTION

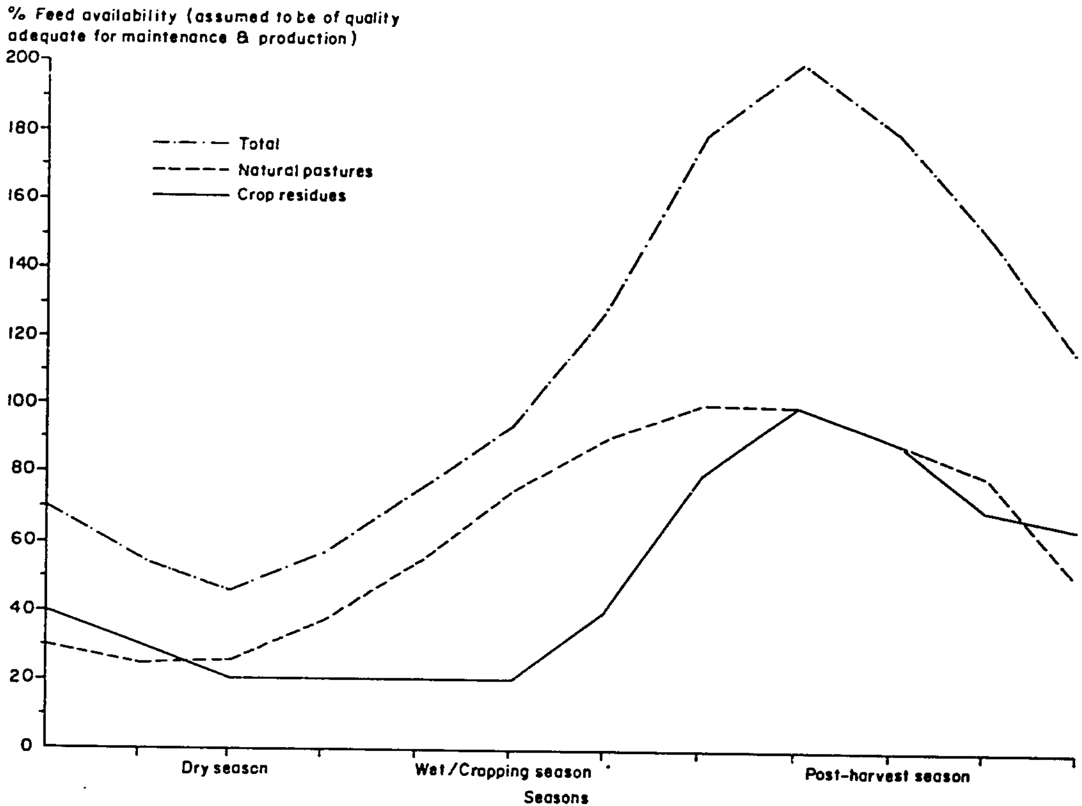
Among the constraints facing livestock development in Africa, inadequate feed supplies stands out as one of the most important. Seasonal variations in feed quantity and quality cause fluctuations in animal nutrition and productivity throughout the year. One recommended means of relieving the nutritional constraint is to incorporate forage legumes into animal diets. Such legumes can be grown in pure stands on farms, incorporated into natural pastures, intercropped or cultivated in fodder banks. Progress in such incorporation on the sub-continent has been slow. This paper seeks to explain why it has been slow by showing how forages fit into farming systems. The use of forage legumes in this paper is discussed in the contexts of seasonality of other feeds, particularly natural pastures and crop residues, the seasonality in animal movements, the competitiveness for land and labour of forage legumes with other feeds in smallholder as well as pastoral production systems in sub-saharan Africa. The paper argues that the principal constraints to the introduction of forage legumes into smallholder and pastoral systems is not their supply, that is, not the fact that they do not grow in sufficient quantities but that they are demanded only in special circumstances, ones which are not generally found in the sub-continent. This explanation then serves as the basis for some speculations about the kinds of technical research which might be carried out to accelerate the incorporation of such legume crops into the current animal production systems.

The paper also discusses forage legumes in the contexts of seasonality, competiveness and complementarity and shows how these attributes fit into the smallholder and pastoral systems. The reasons why forage legumes are not widely adopted on the sub-continent are discussed This is followed by a discussion of research implications and recommendations.

ROLE OF FORAGE LEGUMES IN LIVESTOCK SYSTEMS

Forages play varying roles in the different livestock production systems. In general, however, they are important as adjuncts to crop residues and natural pastures and may be used to fill the feed gaps during the periods of inadequate crop residue and

Figure 1. *Hypothetical profile of crop residue and pasture availability.*



natural pasture supply. Even in the presence of abundant crop residues, which are often free feed for ruminants, forage crops, especially legumes, are needed to improve the utilization of crop residues. Crop residues are potential energy sources while forage legumes provide protein. Forages also provide benefits to other crops. When used in rotation with other crops, they provide benefits such as soil fertility through their nitrogen-fixing ability and are also useful in breaking insect, weed or disease cycles which are likely to occur in their absence. In many situations, however, forages compete with other crops. In land-scarce smallholder systems, forages may compete with other crops for land, while in land-abundant pastoral systems, they may compete for the herder's labour.

SEASONALITY IN FEED SUPPLY

A common production problem faced by pastoralists, agro-pastoralists as well as smallholders is the seasonality in the quantity and quality of animal feeds; particularly natural pastures and crop residues. In the absence of irrigation, a hypothetical production profile of natural pastures and crop residues in the dry, wet and post-harvest seasons is shown in Figure 1. The vertical axis shows total availability of crop residues and natural pastures, assumed to be of quality adequate for maintenance and production. The horizontal axis depicts the production calendar.

Crop residues are only about 20% available, relative to their maximum, early in the cropping season, peak towards 100% at the end of the cropping season and then decline to about 60% in the post-harvest season. Natural pasture supply begins to rise sooner during the cropping season than crop residues. The supply rises from about 30% availability at the beginning of the cropping season, peaks towards 100% and declines to about 50% during the post-harvest season. This kind of pattern leads to proposition 1 about the supplementary role of forages which may be of relevance to forage research.

Proposition 1: Forages are most useful during periods of low quantity and quality of crop residues and natural pastures.

SEASONALITY OF ANIMAL MOVEMENTS

Seasonality in animal movements can be defined according to the degree of crop-livestock interactions depicted in Figure 2.

Fig. 2

Crop-Livestock Interactions Continuum

LOW INTERACTION	MODERATE INTERACTION	HIGH INTERACTION
Extensive nomadic movement; free grazing; limited use of crop residues.	Limited animal movements; more use of crop residues.	Animals kept on farm year round; crop residues form the main available roughage.

With low interations, there are extensive nomadic movements of animals characterized by free grazing of natural pastures. There is little cropping and crop residues are unavailable for feeding animals. With low to moderate interaction, there is more crop production and less animal movement. More crop residues are fed as herds are closer to sites of crop production. With high integration, animals are kept on the farm year round and consume crop residues as a major share of their diet. Herds are generally less mobile in such systems. This explanation leads to the proposition 2 about forage production vis-a-vis seasonal movement of animals:

Proposition 2: The less mobile a herd is, the more favourable are conditions for forage production and vice versa.

COMPETITION FOR LAND AND LABOUR

In the African context crop-livestock relations are positively related to population density. At very low population density, animals and crops will be managed by separate units and there will be little physical contact between the two; animals will graze open pastures. This situation introduces proposition 3.

Proposition 3: At low population densities, a new crop such as forage legumes will compete for the farmer's labour.

Under high population density, there will be very close interaction; animals will graze crop residues and will be managed and owned by cultivators, a system that generates proposition 4.

Proposition 4: At high population and cultivation densities, a new crop such as forage legumes competes for land.

COMPLEMENTARITY OF FORAGE LEGUMES

In addition to contributing to soil nitrogen and providing a break in cereal dominated rotations, forage legumes contribute significantly to livestock production in crop-livestock systems. Low quality crop residues need nitrogen supplementation, which could be provided by forage legumes, to become productive diets. In the Ethiopian highlands, for example, *Vicia faba* is not fed to livestock except in combination with cereal straw (Anderson 1985). It is also possible that forage legumes will increase both food crop production and quantity of crop residues available for livestock feed.

FORAGES IN SMALLHOLDER SYSTEMS

Wet Season Use

The use of forages during the cropping season for smallholders depends on animal mobility. Where animals are not mobile, forage production is an option if their benefits exceed the combined opportunity cost of such substitutes as leaf strippings, crop thinnings, pastures or cut hays. As noted above, where animals are highly mobile, then they are distant from forage production sites and would only benefit from such forage if conserved for the dry season. In terms of wet season use we propound proposition 5.

Proposition 5: Because of earlier pasture growth during the wet season, forages are not likely to have a comparative advantage at that time unless they are selected for rapid early growth and can support higher grazing pressure. However, if pasture land is limited, forages may be an option in the wet season. This proposition holds whatever the degree of mobility.

Post-Harvest Use

Under normal weather conditions, crop residues become available in high quantity soon after harvesting. Their utilization, in most cases, is not labour intensive since they can be grazed in situ and may be preferred to forages in the post-harvest season. They may contain high quality fractions for a short period after harvesting. In such a situation proposition 6 can be advanced.

Proposition 6: Crop residues will dominate forage use during the post-harvest season if they are of high enough quality to be fed alone.

Although the post-harvest period is short, it is probably the least relevant for forages. An exception is found in root crop systems where crop residues are less available.

Dry Season Use

This is the most relevant time for forages because of the general absence of crop residues (unless preserved earlier) and natural pastures. The critical constraint is soil moisture, but if forage can be cultivated on residual moisture it can fill the feed gap. The alternative is the use of conserved forages from the wet season for dry season use.

FORAGES IN PASTORAL AND SEMI-PASTORAL SYSTEMS

African pastoral systems are subsistence-oriented and based on seasonal milk production. The system is characterized by an acute conflict between milk intake for calves and milk offtake by humans. Because of low nutritional levels and lack of water, an animal's ability to produce milk under stress and to survive may be more important to pastoralists than high yields.

The introduction of forage crops into the pastoral system requires different considerations than in the smallholder system. First, potential competition between forages and crop residues is low or non-existent mainly because the system is not based on crop production. Second, labour use in pastoral systems is much less than in cropping systems. Third, local spatial risk in a pastoral environment is probabaly higher than in an annual cropping system. In the pastoral system there is a strong incentive for animal mobility to minimize risks. These considerations lead to the following propositions about the place of forage legumes in a pastoral system:

Proposition 7: The introduction of forage crops in a pastoral system implies less herd mobility, more total labour input per production unit, and higher short-term risks.

Proposition 8: Forage crops might be suitable for herds which are at least partially sedentary. If such herds are managed by women and children leaving the men to manage the mobile herd, labour demands for forages would be high relative to supply.

Proposition 9: Forages in pastoral systems would not face competition from crop residues and would not compete for land, but might compete with natural pastures in the wet season and for herding labour.

Loss of competition from crop residues means that, in contrast to smallholder systems, the post-harvest/early dry seasons are highest potential periods for forages. In view of the conflict between milk for calves and for humans, options for forages may be to supplement dams or calves. But it is better to grow forages for these purposes or to grow food crops for humans and leave milk for calves? Food crops face the same water constraint and the same labour constraint that forages face if there is extensive herd mobility. However, in terms of productivity in calories per labour input, food crops may be more efficient. It is to be understood that food crops and forages are only a solution to the milk conflict for that part of the herd that stays near the home site. For the mobile part, neither forages nor crops are an option and the mobility conflict remains.

SPECIALIZED FORAGE PRODUCTION

The above considerations apply to a smallholder or to a pastoralist producing forage crops for his own animals. What if he produces forage for sale? Demand constraints, in terms of competition from crop residues and pastures, still apply by season. Therefore what is necessary is an external market for forage and animal products. Such markets would usually be urban where there is year-round demand for milk and no seasonal competition from pastures and crop residues. On the supply side, the same arguments apply. Forage production will be done if it does not compete for land and if it is not too labour intensive; proposition 10.

Proposition 10: Forage production for sale will occur on common properties where land competition is low; the only costs to the producer will be collecting and transportation. It will also occur on private lands of low quality.

However, both sites are unfavourable production, irrespective of its labor intensity, but they provide saleable fodder at low cost. Production from marginal lands will fall when population density rises enough to make it necessary to cultivate or graze such lands.

Proposition 11: Specialized forage production will occur where urban demand is good, or where the specialized producer can assure food supplies via the market, or he is a small part of an extended family who has no responsibility for family food supply.

WHY FORAGES ARE NOT WIDELY ADOPTED

Forage crops are neither widely adopted for own use nor for specialized production; principally because of demand and supply constraints unique to forages and the production system. There are two conflicting forces militating against forage adoption in smallholder and pastoral or agro-pastoral systems. One is land abundance and site heterogeniety associated with it. Land abundance is unfavourable to forage use in extensive smallholder and in pastoral and agro-pastoral systems because such systems are based on herd mobility and on cropping with low labour input per hectare. Accordingly, forages compete with pastures and crop residues which can be grazed at low labour input (Propositions 2, 3 and 6). In pastoral systems, the structure of labour input is also unfavourable to intensive forage production (Propositions 7 and 8).

The second force is land scarcity, since forage production must then compete with food crop production for land (Proposition 4). In land-scarce smallholder systems with close integration of crops and animals, crop residues are the main animal feed. The availability of crop residues reduces the demand for forages. Lack of herd mobility and irrigation would be favourable to forage production.

Forage crops are not widely adopted as specialized products for sale mainly because of the structure of market demand. As mentioned earlier, specialized forage markets would usually be urban. Problems of transporting cut forage and the impossibility of transporting uncut forage limit use to production sites, for the producer's own animals. The specialized producer is also likely to face competition from the other feeds.

RESEARCH IMPLICATIONS AND RECOMMENDATIONS

The preceding sections highlight seasonality and other considerations in forage production and adoption in the smallholder and pastoral agro-pastoral systems. The challenge to forage researchers is to match this erratic pattern with continued feed requirements throughout the year.

In the <u>wet season</u>, forage demand is constrained by the existence of competitors such as grass, crop thinnings and leaf strippings. Forages must be selected to fit into relatively small or specialized niches to provide additional benefits. A selection strategy for the wet season would have to select for:

a) earliness; that is forages which can be sown with the first rains to provide major benefits before grasses, thinnings and leaf strippings become available.

b) tolerance for intercropping; if forages can be grown as intercrops, in whatever spatial arrangement, then they do not compete for land and compete less for labour than forages grown in pure stands. They may in addition suppress weeds and fix nutrients, both of which would benefit the other crop in the mixture, and

c) tolerance for marginal environments; select those which thrive on marginal lands or which can fit into fallow cycles. Each of these niches may be small and research for fitting into one might entail high experimental costs.

Assuming no severe crop failures, crop residues become available at low labour costs in the post-harvest season. If they are of high enough quality and type to be fed alone, forages become less important as animal feed in this season. A selection strategy for forages would include selection for harvest when crop residues are no longer available or when their quality falls off. These might be forages grown in relay systems, or those planted with residual moisture after the main harvest.

Forages are most relevant for dry-season use. A selection strategy would include:

a) selection for growth on residual moisture with deep rooting species. This would make forages available into the dry season without irrigation;

b) selection for conservation quality in forages grown in the wet season if the dry season is reliably dry;

c) selection for forages which can be grazed as opposed to cut and carry only;

d) selection for forages which do not interfere with land preparation for the next cropping season. The latter conflict may be particularly severe in bi-modal rainfall regimes, where the short rains are necessary to prepare land for the crop in the long rains. It should be noted that browse species meet most of these criteria.

RESEARCH EMPHASIS

Research emphasis should be in areas of high population density with low herd mobility. Research into intercropping, serial and relay cropping of cereals with legumes, and alley cropping might increase feed without diverting land from food crops. Forage research emphasis should also be on marginal lands unsuitable for food crop production or with residual moisture available after harvests. Forage research should be carefully evaluated in extensive smallholder areas, and in pastoral areas. The advantages of extensive grazing are such that it will be difficu't to adopt forages unless some very special conditions are met. In these areas, supplementation should be provided by purchased supplements since they do not pose a conservation problem, do not compete for labour, and do not inhibit mobility.

The updating of the existing feed data base to allow the construction of feed supply and demand profiles is essential for estimating feed gaps which might be filled by forages. Forage crops can then be screened for periods during which they are available and for their competitiveness and complementarity with other crops.

The use of irrigation trials should be viewed with scepticism. The reasoning here is that the constraint to forage use is not production, that is the capacity to grow them, but the demand for them by livestock owners in view of the alternatives available. Therefore, irrigation trials, while they provide useful information on growth characteristics, do not address the fundamental issue, which is fitting forages into existing systems. Even though irrigation gives a powerful impetus to forage production and use by providing high quality feed in the dry season, it is relatively rare in sub-saharan Africa and should not be tne main focus of a research programme.

The present forage valuation system may be underestimating the economic profitability of forage crops. An economic valuation of any crop comes down to a comparison between crop value and crop cost. Forage crops, being intermediate products, suffer from difficulties and inconsistencies in their valuation. There is generally no accepted yield unit, hence no consistent valuation method for forages. Forage yields are directly valued in tons per hectare, dry matter (DM), animal unit months (AUMs) of carrying capacity, beef, milk or wool produced per hectare, or as nutritional components such as total digestible nutrients (TDN) or crude protein (CP). Indirectly, many prefer to value forages by starting from the final product and inputting forage value backwards. Since different valuation methods result in various economic values, research emphasis could be directed towards a consistent valuation method for forage crops.

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FEEDING OF CROP RESIDUES TO MILKING COWS IN SMALL SCALE FARMS IN BOTSWANA

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INTRODUCTION

The need to increase milk production by the peri-urban small-scale farmers in Botswana is seen as a major objective by the Ministry of Agriculture during the current six-year National Development Plan; (NDP6-1985-91). Achievement of such objectives require investigating additional feed resources for livestock nutrition. Land suitable for arable farming is used mainly for cash and subsistence crops rather than for forage cropping.

To compensate for the increased need for milk on one hand and to examine the production potential of small farms, a research project was conducted and sponsored by the Animal Production Research Unit (APRU) of the Ministry of Agriculture, Botswana and the International Development Research Centre (IDRC) of Canada.

The objectives of this work were to:

1. Increase milk production by the animals owned by the small scale farmers.
2. Investigate the feeding and nutritive value of forages and by-products introduced to milking cows on-farm and on-station.
3. Technical and economic evaluation of new interventions, such as the introduction of dual-purpose crossbreds and fodder crops.

The project area included four villages situated between 15 - 20 km from Gaborone. The average rainfall was 316-414mm in 1985.

INGREDIENT ANALYSIS AND NUTRITIVE VALUE

At the end of the harvest season in June, 1985 all project farmers were encouraged to collect crop residues and legumes from their farms. Previous estimates of cereal crop residues for sorghum, millet and maize were 1.22, 1.15 and 1.16 ton of dry matter (DM) per hec are, respectively (Mosienyane 1983). In 1985 the average DM yield of lablab hay (Lablab purpureus) was 1.2 ton per hectare. Dry matter yield of cereal crop residues and lablab hay from farmer's fields ranged from 120 kg to 2,940 kg per farm (table 1). The wide variation in cereal stover yield was attributed to the low rainfall during 1985.

Table 1. Cereal stover yield and legume hay harvested by Project farmers in 1985.

Area	Maize, Sorghum and Millet kg/farm	Lablab kg/farm
Oodi	120 - 2,940 (3)	360 (1)
Bokaa	120 - 560 (4)	180-600 (2)
Kopong	160 - 360 (2)	80 (1)
Mmopane	120 - 620 (2)	120 (1)

During the 1984/85 harvest period samples of cereal and legume crop residue and lablab hay were randomly collected from all farmers for laboratory analysis and nutritive value estimation (table 2).

Table 2. Composition of stovers and fodder legumes collected by Project Farmers (1984-85).

Feed	Composition (%) of Dry Matter (1)					
	Organic Matter	Crude Protein	Crude Fibre	Ash	Ca	P
Maize stover	90.97	7.84	28.29	9.03	0.278	0.123
Sorghum stover	91.58	5.56	32.82	8.42	0.379	0.103
Millet stover	88.66	5.23	39.42	11.34	0.309	0.043
Lablab	88.59	16.14	22.68	11.41	1.688	0.131
Velvet bean	91.70	16.27	25.14	8.30	2.540	0.135
Cowpea stover	94.19	13.63	26.3	5.81	1.425	0.132
Sorghum bran(2)	97.32	11.48	3.15	2.68	0.381	0.310

(1) Means represent data from four replicate samples per farmer's field

(2) Sorghum bran (moroko) from Gababe Village Sorghum Millers

The *in vitro* digestion coefficients of the crop residues and fodder legumes harvested by farmers are given in table 3. Digestibility of dry matter (DMD) and organic matter (OMD) were lower for the cereal stovers (maize, sorghum and millet) than those of the fodder legume and cowpea stover. Digestibility of maize stover exceeded those of sorghum and millet stovers. The results show that higher digestibility coefficients were related to higher crude protein and lower crude fibre contents (tables 2 and 3).

It is clear that cereal crop residues need to be fed in association with supplements of higher crude protein and energy contents to meet the animals requirements for growth and milk production.

Table 3. In Vitro Dry and Organic Matter Digestibilities* of Stovers and Fodder Legumes collected by Dairy Project Farmers

Feed	Dry Matter Digestibility (%)	Organic Matter Digestibility (%)
Maize stover	59.1	53.2
Sorghum stover	48.6	40.0
Millet stover	40.1	28.9
Lablab	60.5	53.8
Velvet bean	55.2	49.0
Cowpea stover	66.4	58.8
Sorghum bran	56.9	48.3

* Each value is a mean of four replicate samples per farmer's field.

The rationale for introducing the legume fodders in the farming system was, therefore, to formulate diets that could satisfy nutritional requirements for pregnant and/or lactating dairy cows. As shown in table 3 the crude protein content of lablab (16.4%) and velvet bean (16.27%) were as high as that reported for lucerne hay (16.0% NRC 1976).

ON-FARM FEEDING TRIAL

In the rural production situation the opportunity to improve the quality of cereal stover based diets is either by providing a high quality legume fodder or by feeding moroko (a by-product of the local milling process of sorghum) or by a combination of both.

As part of the programme to evaluate alternative management interventions three winter feeding systems were carried out for the on-farm trials involving twelve farmers in the project. The objectives of the comparative feeding trial were to determine voluntary feed intake and performance of lactating cows fed sorghum stover supplemented with either lablab or moroko. Bonemeal salt (1:1) or Dicalcium phosphate/salt (1:2) were available to animals at free choice.

MATERIALS ANS METHODS

On-farm trials

Twelve farmers were divided into three groups to carry out a winter feeding trial of crossbred Simmental and Tswana cows in groups each of four head. The crossbred Simmental were provided by Government on an exchange basis with the Tswana cows from farmers. The treatments (feed systems) used by these three groups of farmers to feed their lactating cows were:

- 85% sorghum stover and 15% lablab (TRT A)
- 75% sorghum stover and 25% moroko (TRTB)
- 100% sorghum stover (TRTC)

All treatments had ad libitum phosphate lick.

RESULTS

The average chemical composition of the sorghum stover based diets as fed during the trial are shown in table 4. Crude protein in sorghum stover (5.5%) was lower than the 7.0% maintenance requirements. Supplementation with either lablab (15%) or moroko (25%) increased the crude protein in the diet to 7.40% and 7.01% respectively. Table 4 also shows that the crude protein contribution to the diet by lablab and moroko were 37.7% and 39.4% respectively, implying therefore that 15% lablab and 25% moroko are equivalent in their contributions as supplements.

Table 4. Components and chemical analysis of diets used in the on-farm trial.

Chemical analysis: (DM basis)	85% sorghum stover + 15% Lablab	75% sorghum stover + 25% Moroko	100% sorghum stover
Organic matter	91.10	93.00	91.60
Crude protein	7.40	7.01	5.56
Crude fibre	31.06	25.54	32.82
Ash	8.90	7.02	8.42
Estimated TDN	55.56	63.73	53.90
% contribution of crude protein content in the diet			
Sorghum stover	62.3	60.6	100
Lablab	37.7	-	-
Moroko	-	39.4	-

Mean daily dry matter (DM) intake (kg) and DM intake (kg) per 100 kg of body weight during the trial period for the three treatments are given in table 5. The higher intake of the moroko diet was attributed to the concentrated form of the bran which was fed first, before the sorghum stover. The DM intakes of the first and the third diets were close to the amount required to cover the requirement of suckling cows of 350 kg liveweight (NRC 1975).

Roughage consumption of 2 kg per 100 kg liveweight is considered satisfactory during the late stage of the lactation period (Crampton and Harris 1969). The average daily milk yield (kg) per herd and per cow during the milking period for the different treatments is given in table 6. Recorded daily milk yield does not include milk left for the calf. To initiate milk let down, calves were allowed 30 seconds to suckle before milking and put back to dams 1 hr after milking. The results showed that both Simmental crossbreds and Tswana cows on TRT B produced higher daily milk yields than cows on TRT A.

Table 5. Voluntary feed intake by lactating cows during the trial period.

	Diets		
	TRT A	TRT B	TRT C
Average Liveweight (kg)	356.3 (1)	356.5 (2)	322.6 (3)
DM Intake (kg/day)	8.27	10.21	8.96
DM Intake/100 kg LW (kg/day)	2.27	2.85	2.79
Crude Protein intake/100 kg LW (kg/day)	0.17	0.20	0.15

(1) Data from 16 cows of 4 farmers.

(2) Data from 13 cows of 4 farmers.

(3) Data from 9 cows of 3 farmers.

Table 6. Average milk yield (kg) of Simmental Crossbred (SX) and Tswana (TS) cows fed sorghum stover based diets.

	Diets				
	TRT A		TRT B		TRT C
Type of animals	SX	TS	SX	TS	TS
No. of cows	5	13	5	13	14
Period (days) of milk yield recording	118	92	123	91	41
Average milk yield:- kg/herd/day	13.5	22.1	20.5	27.3	21.0
Average milk yield kg/cow/day	2.7	1.7	4.1	2.1	1.5

All cows lost weight from September to January primarily due to parturition as well as the drought conditions (table 7). By January 1986 SX and TS cows on TRT A and TRT B had lost 17.8, 15.6, 24 and 21% of their initial liveweight, respectively. However, by March, 1986 the liveweight losses decreased to 6.6, 7.2, 10.7 and 10.1% of their initial liveweight respectively.

Table 7. Liveweight changes of Simmental Crossbred (SX) and Tswana (TS) cows on TRT A and TRT B diets.

Diet	Liveweight kg			
	Breed	Sept.	Jan.	Mar.
TRT A	SX (n = 6)	422	347	394
	TS (n = 9)	383	291	342
	Average	402	319	368
TRT B	SX (n = 6)	417	352	387
	TS (n = 14)	357	282	321
	Average	387	328	354

On-station feeding trial

A comparative on-station partial milking system had been going on at the Research Station since 1981 using both Tswana and crossbred Simmental cows. Results from investigations on the partial milking system conducted by APRU indicated the improved potential for milk production by the Simmental crossbred cows as compared to the Tswana cows (APRU 1983/84). Response to supplementation (Dairy meal) was evident during the period after deterioration of range grazing quality in March. Both types of cows produced higher milk yields in this period when their feed was supplemented. The results showed no advantage in supplementation of the feed during the normal grazing season (APRU 1984). There was no improvement in the performance of either cow or calf to supplementation and therefore, unless feed costs are very low, supplementation must be regarded as of marginal benefit during active pasture fodder growth.

Lactating cows trial

The trial was redesigned using Tswana, half-bred Simmental and three-quarter-bred Simmental cows to evaluate milk production and response of both cow and calf performance to alternative feed supplements. Within a breed type, cows were randomly allocated to treatments in calving sequence. Tswana cows (TS) received so supplement, half-bred Simmental were divided into two groups, with or without moroko supplement, while the three-quarter-bred Simmental (SSX) received either moroko or dairy concentrate. Calves from either treatment were divided into two groups, with and without moroko. The herd was milked twice daily with recorded milk being total milk less that suckled by calf.

RESULTS

Table 8 provides the lactation data according to breed and supplementation treatment. The drought conditions which prevailed in 1984/85 meant that throughout the grazing season (20 weeks of lactation) the cows had to be fed additional fodder in the form of either crop residues or medium quality hay. Due to poor quality of the fodder, milk yields became low and continued declining progressively.

Table 8. Milk yields and lactation length of Tswana/Tuli (TS) half-bred Simmental (SX) and three-quarter Simmental cows (SSX) on diets supplemented with moroko or balanced concentrate.

Breed Type (no.)	TS(18)*	SX(20)*		SSX(23)*	
Supplement	Nil	Nil	Moroko	Moroko	Conc.
Lactation yield (kg)	274.7	525.4	583.5	691.4	725.6
Yield range (kg)	98-475	410-741	255-928	452-970	605-1250
Lactation length (days)	208	245	269	278	291
Range (days)	108-298	209-295	216-309	190-332	271-329
Mean daily yield (kg/head)	1.32	2.14	2.17	2.49	2.49

* Number of cows per breed.

The effects of supplementation are summarised in Table 8. In the SX group there was only a small response to feeding moroko, mainly towards the end of lactation when the roughage diet was mainly maize/sorghum stover. The lactation yields were not significantly different (P>0.10) between animals fed moroko or no-moroko (Table 8). Mean lactation lengths between the two feed treatments were significant (P<0.10). There were 269 days for animals consuming moroko versus 245 days for those who were not supplemented.

There were no differences (P>0.10) in total lactation yield and lactation length in the SSX fed moroko versus those fed the dairy concentrate (Table 8). Comparisons between the breeds revealed higher lactation yield for SX and SSX compared to TS because of greater lactation persistence of the former. Milk yields in the SSX were 2.5 times those of the TS group.

The TS cows had a net post-calving gain of 1.6% while the unsupplemented and supplemented SX gained 5.1 and 6% respectively. There was no effect of the level of supplementation on the SSX who gained on average 6% of post-calving liveweight. The poor performance of the cows can be attributed to the drought conditions that prevailed during the trial.

Table 9 shows the performance of calves fed with or without moroko. The progery of the TS cows were bred from pure Tswana or Tuli whilst those of SX and SSX were bred by a Simmental bull. The results are expressed in terms of liveweight gain to 210 and 305 days corrected for sex and date of birth. Liveweight gains were generally poor, reflecting both the rate of milk extraction (twice per day) and the poor fodder situation. Liveweights at 210 days from weaning were 40% below the expected weights of ranch calves of these breeds under good grazing conditions. However, by 305 days, when the calves were weaned, liveweights were 25% lower than those from APRU ranches.

Table 9. Mean liveweight gains (kg) of calves reared by TS, SX and SXX breeds on-station.

		Birth to 210 days			Birth to 305 days		
		Calf treatment			Calf treatment		
Cow Breed	Cow Treatment	Nil Moroko	Plus Moroko	Mean	Nil Moroko	Plus Moroko	Mean
TS (17)*	Nil moroko	83.6	93.7	88.7	105	113	109.0
SX (16)*	Nil moroko	81.0	86.0	83.5	97.9	119	108.5
	Plus moroko	107.4	102.3	104.9	120.6	147	133.8
SSX(19)*	Plus moroko	77.4	83.4	80.4	97.3	117.8	107.6
	Dairy concentrate	86.3	100.0	93.2	109.0	130.3	123.7
Mean		87.1	93.0	90.1	105.9	127.0	116.5

* Number of cows per breed.

CONCLUSION

The potential for self-sufficiency in feeding dual purpose cattle based on crop residues was confirmed for milk production.

Cereal crop residues are available to all farmers and since they are low in crude protein content, there is a need to supplement them with high protein legumes (cowpeas) and fodder crops (lablab) or locally produced milling by-products (moroko). The feeding systems based on natural grazing (summer) and feeding of conserved crop residues (winter) are the most practical.

Further research is needed to investigate economic methods of allocating land for both feed for human consumption and livestock. Conservation methods for crop residues and other legumes should continue to assess the full benefits to be derived from these fibrous materials.

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A NOTE ON THE EFFECT OF SUPPLEMENTATION WITH NOUG CAKE (GUIZOTIA ABYSSINICA) ON THE MILK PRODUCTION OF CROSSBRED COWS

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ABSTRACT

In view of the importance of milk in the animal production systems of African smallholders, an experiment was conducted to evaluate the effects of feeding small quantities of noug cake (**Guizotia abyssinica**) to crossbred (Friesian x Zebu) cows at ILCA's Debre Berhan station in the Ethiopian highlands. Thirteen cows were randomly allocated to three treatments after stratification on the basis of stage of lactation; they were fed poor quality grass hay and molasses/urea blocks **ad libitum**, and experimental treatments consisted of a daily allowance of 0, 1 or 2 kg noug cake for 11 weeks.

The provision of noug increased milk yield by a mean of 35% or 1 l/d ($P<0.01$), with no difference in yield between the two noug treatments. Voluntary intake of hay plus block decreased linearly with increasing level of noug intake ($P<0.05$). It was concluded that the provision of small quantities of such oilseed cakes to lactating cows can be recommended as being economically very favourable.

INTRODUCTION

The great importance of milk in the animal production systems of African smallholders is widely recognized, and the benefit of increased milk yields gained by introducing exotic breeds, particularly the Friesian, for crossing with indigenous stock, has also been demonstrated (Schaar et al 1981). For example, a large study in Southern Ethiopia (Kiwuwa **et al** 1983) demonstrated that the mean milk production of local Bos **indicus** cattle (approx. 2.7 kg/day and 870 kg/lactation) was greatly increased in their Friesian crossbreds (approx. 6 kg/day, and 2000 kg/lactation), in conditions where concentrate feeding was practised.

While the feeding of concentrates is impractical in many areas, significant quantities of agro-industrial by-products frequently are available to supplement poor quality grass or crop residues that form the basis of many ruminant diets in Africa. In Ethiopia such a by-product is noug cake, a widely available high protein meal, the residue after extraction of oil from the seed of Guizotia abyssinica.

The Nutrition programme at ILCA is designed to emphasize the efficient utilization of readily available resources for optimal animal production, and this paper reports an experiment in which the influence of noug cake supplementation on the milk production of cows fed grass hay was measured.

MATERIALS AND METHODS

Cattle and Treatments

Thirteen mature lactating crossbred cows (Friesian x Zebu) were randomly allocated to 3 treatments after stratification on the basis of stage of lactation, with an effort to ensure that average stage of lactation within each treatment was the same. The animals were maintained in individual stalls at ILCA's Debre Berhan station in the Ethiopian highlands and experimental observations made from April 21 to July 7, 1986.

Poor quality grass hay and molasses/urea blocks were fed **ad libitum**, and the experimental treatments consisted of a daily allowance of 0, 1 or 2 kg noug cake, with 4 cows in each of the first two treatments and 5 in the third. Hay was offered at a rate sufficient to allow for a 20% refusal. The molasses blocks, which weighed between 6 and 10.5 kg, were weighed daily and replaced when the quantity remaining was less than 2 kg. The molasses blocks were made at ILCA, with a percentage composition as follows: molasses 42, urea 10, cement 15, triple superphosphate 3, NaCl 5 and wheat bran 25.

Measurements and Sampling

The cows were weighed weekly, milked twice daily and the total daily yields recorded. Samples were obtained at each milking, and those from individual animals bulked for weekly determinations of fat and protein contents by the Gerber and formalin titration methods respectively.

Daily samples of feed offered were taken and bulked weekly, and individual feed refusals were treated likewise. Determinations of dry matter (DM) were made to allow calculations of voluntary DM intake, and the samples were subsequently analysed for N by a Kjeldahl method; OM; NDF and ADF by the methods of Goering & Van Soest (1979); **in** vitro digestibility (IVD, Tilley & Terry 1963); P (colorimetry) and Ca, Na, K, Mg, Cu, Zn, Fe & Mn (atomic absorption spectrometry). Noug cake was analysed similarly, and also for ether extract. The IVD data were used to estimate daily intakes of metabolizable energy (ME, MJ).

Data Analysis

The daily estimated ME consumption (excluding noug) and daily milk production for each cow after week one were analysed, with the fixed effect of treatment and the regressor of first week's milk production per day per cow, by the least squares procedure of Harvey (1977), using a fixed model. As the cows entered the trial at different stages of lactation, it was necessary to include the first week's daily milk production of each individual as a covariate in the model, to remove the effect of differing level of initial milk yield.

Linear contrasts of least squares estimates were computed to determine the significance of differences between treatment groups.

RESULTS AND DISCUSSION

The compositions of the hay offered and refused are given in Table 1, from which it is clear that there was no evidence of selection since these did not differ. All of the noug cake offered was consumed. Body weights, and lactation stage at the outset, are shown in Table 2. There were no significant differences between groups in any of these parameters, and no significant changes in body weight occurred during the experiment.

Table 1. Mean (± SD) composition of Hay offered and refused, and Noug Cake (DMB)

	Hay Offered	Hay Refused	Noug Cake
OM (%)	91.2 ± 1.77	90.6 ± 0.77	89.8 ± 0.71
NDF (%)	73.5 ± 1.91	73.7 ± 0.87	46.7 ± 0.01
ADF (%)	40.6 ± 1.29	43.0 ± 2.66	30.6 ± 0.35
N (%)	0.80 ± 0.05	0.92 ± 0.12	6.89 ± 0.04
P (%)	0.08 ± 0.03	0.09 ± 0.02	1.28 ± 0.01
Ca (%)	0.41 ± 0.07	0.51 ± 0.07	0.70
Mg (%)	0.25 ± 0.04	0.25 ± 0.03	0.62
Na (%)	0.13 ± 0.05	0.16 ± 0.03	0.10
K (%)	0.93 ± 0.23	0.94 ± 0.16	1.16
Cu ppm	6.4 ± 1.4	5.1 ± 1.0	73
Zn ppm	31.4 ± 2.3	34.3 ± 2.0	90
Fe ppm	346 ± 85	425 ± 62	169
Ether Extract (%)	-	-	2.65 ± 0.13

Table 2. Mean (± SD) body weights and lactation status of groups given 0, 1 or 2 noug supplement/day

Supplement	Body wt (kg) Initial	Body wt (kg) Final	Day of Lactation at outset
0	430 ± 37	406 ± 39	91 ± 61
1	404 ± 42	405 ± 47	118 ± 86
2	404 ± 16	413 ± 32	114 ± 89

Average daily milk yields were 2.86, 3.87 and 3.96 l for the 0, 1 and 2 kg noug treatments respectively for the experimental period. The mean squares of the analysis of variance show that significant effects of treatment occurred, and that the effect of level of milk production during the first week was also significant (table 3). For this reason the statistical approach was adopted whereby individual milk yields were adjusted to a common origin, so as to remove the effects of initial differences in yield due to wide variation in the stage of lactation at the outset. The resultant figures are shown in Table 4; milk yields from the two supplemented treatments were very similar, and both significantly greater than that from the control group. Actual yields are plotted in Fig. 1, showing the marked improvement following the provision of 1 kg noug, and illustrating that no further benefit was gained from the second increment. There was no effect of treatment on the fat and protein concentrations in the milk; respective mean (± SD) percentages of fat for the 0, 1 and 2 noug treatments were 4.4 ± 0.33, 4.2 ± 0.59 and 4.1 ± 0.29, and of protein, 2.8 ± 0.36, 3.0 ± 0.46 and 3.0 ± 0.41.

Table 3. Mean squares from analysis of variance for effects on milk production and intake traits of cows supplemented with 0, 1 or 2 kg Noug Cake/day

Source	df	Milk yield per day	Estimated ME Intake (Hay + block) per day
Treatment	2	1.577**	22.830*
1st week Milk yield/day	1	11.124***	0.663
Remainder	9	0.214	7.521

The mean daily intakes of hay for the 0, 1 and 2 kg noug treatments were 11.09, 11.61 and 10.83 kg DM respectively, and intakes of molasses/urea block averaged 1470,570 and 900 g/d respectively. It was estimated that the hay contained 5.99, and the molasses blocks, 5.26 MJ ME/kg. These values were used as noted above to compute intakes of ME from hay plus block against which to compare the effects of noug supplementation.

Table 4. Least squares estimates for milk production and intake traits of cows supplemented with 0, 1 or 2 kg noug cake/day

	Number	Milk yield per day (kg)	Estimated ME Intake (hay-block) per day (MJ)
Overall	13	3.496	77.637
Treatment			
No noug	4	2.782	79.863
1 kg noug	4	3.904	77.720
2 kg noug	5	3.801	75.329
Milk yield/day (1st week)	-	0.954	-0.209

Figure 1. *Mean daily milk yield per week of cows supplemented with 0, 1 or 2 kg noug cake/day.*

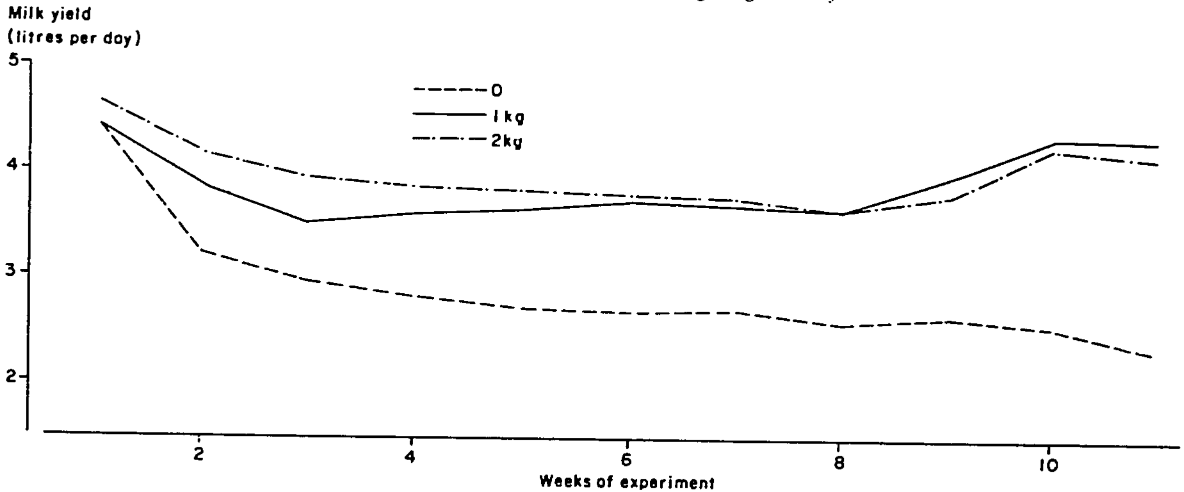

Table 3 shows the effect of treatment on daily estimated ME intake from hay plus block only, significant at the 10% level, whereby the intake of hay plus block decreased linearly with increasing intake of noug. The noug was estimated to contain about 10 MJ ME/kg, resulting in total estimated ME intakes for the three treatments of approximately 80, 88 and 95 MJ ME respectively, for the 0, 1 and 2 kg noug treatments. The increment of 7 MJ between the two noug treatments was not reflected in increased milk yield. There is some suggestion in the body weight data that extra tissue was being stored, since these groups respectively gained 1 and 9 kg over the experimental period, while the control group lost 24 kg (Table 2); none of these changes or differences was statistically significant, however.

In the Debre Berhan area, noug cake currently costs about 14 ¢/kg, and the market value of milk approximates 60 ¢/l. It is clear, therefore, that the extra litre of milk yielded daily bt the group supplemented with 1 kg noug, compared with the control animals, was obtained on a very economically beneficial basis, bearing in mind also the lower level of consumption of hay and molasses/urea block.

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PRODUCTIVITY OF DAIRY COWS UNDER SMALLHOLDER FARMS USING AGRO-BY-PRODUCTS AS A CONCENTRATE SOURCE

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INTRODUCTION

The programme of smallholder dairy farming was initiated in Malawi by the Food and Agriculture Organisation (FAO) through the agency of the United Nations Development Programme (UNDP), in the early 1970's. The main objectives are:

1. To provide fresh milk for the increasing population.
2. To reduce imports of milk by-products.
3. To provide an alternative source of income to farmers.

Each farmer established a pure stand of Leucaena leucocephala and a mixed stand of Napier grass. In drier areas Rhodes grass (Chloris gayana) was also planted, on a minimum of 0.8 ha per two-cow unit. Liberal amounts of a mixture of maize bran and dried leucaena leaves are fed on some farms while the majority of farms use only maize bran. All cows are confined to stalls as a means of conserving energy, for easy detection of heat and to avoid contact with local Malawi Zebu bulls.

BACKGROUND INFORMATION

The economy of Malawi depends on agriculture, in which about 90% of the population is involved. Main cash crops include tobacco, tea, groundnuts and rice. Average land holding size is 1.5 ha, and emphasis is therefore on increased production per hectare.

The Government policy on livestock is directed towards self sufficiency in all livestock products and to export any surpluses that arise. However, the country suffers from insufficiency of milk and milk products, sheep and goat meat. Both large and smallholders are integrated in the farming system programme. There are about 1,200 dairy farmers in Blantyre (in the South), Lilongwe (in the Centre) and Mzuza (in the North) who were given ½ Friesian crosses. Upgrading continues on the farms due to the breeding programme being implemented.

This paper describes dairy farming systems before and after 1984.

Dairy farming system before 1984

Records for each cow were kept from 1973 to 1984. Data collected from these records (over 10 years) was sent to the International

Livestock Centre for Africa (ILCA) where it was analysed with the following objectives:

1. Compare the important reproductive and productive traits.
2. Measure the infuence of environment (years, season, etc) on dairy production traits.
3. Assess the suitability of various crosses to the different agricultural areas; and
4. Determine trends in dairy production over the years.

RESULTS AND DISCUSSION

The results of data alalyses covering the years 1973-83 are shown in Table 1.

Table 1. Estimated least squares means* for age at first calving, calving interval and days open for smallholder dairy herds (1973-83).

Variable	No.	Age at first calving	No.	Calving intervals (days)	No.	Days open
Overall	165	38.4	577	485	591	213
AREA						
Blantyre South	19	38.1	54	461	54	168
Blantyre North	24	40.1	147	512	160	233
Chiradzulu	27	36.6	87	463	87	193
Thyolo North	50	38.5	165	498	165	229
Mulanje West	22	38.2	87	477	88	201
Zomba	23	38.8	37	501	37	238
BREED GROUP						
½ Friesian	110	36.7a	432	488	441	216
¾ Friesian	55	40.1b	145	482	150	211
YEAR OF BIRTH						
1970	18	37.6a	-	-	-	-
1971	24	37.2a	-	-	-	-
1972	20	41.8bd	-	-	-	-
1973	33	42.2bc	16	471	16	218
1974	20	39.5acd	32	434	32	171
1975	18	36.8a	53	544	53	277
1976	16	34.5a	72	488	72	216
1977	16	37.9acd	101	494	101	221
1978	-	-	118	473	119	203
1979	-	-	96	471	96	202
SEASON OF BIRTH						
Nov.-March	38	37.0	35	495	48	222
April-May	42	41.9	47	461	47	188
June-Aug.	43	37.3	50	473	52	206
Sept.-Oct.	42	37.5	49	499	50	228

* Age values followed by the same letter do not differ significantly ($P<0.05$). Values in other columns did not show a significant difference.

Table 2. Estimated least square means* for total lactation yield, lactation length, milk yield per lactation day and dry period.

Variable	No.	Lact. yield (kg)	Lact. length (days)	Milk yield day (kg)	No.	Dry period (days)
Overall	781	2188	392	5.7	544	107
AREA						
Blantyre South	59	2147ad	391a	5.4a	49	107
Blantyre North	189	1761a	417a	4.3b	144	113
Chiradzulu	114	2085de	376ab	5.7a	74	106
Thyolo North	225	2513b	390ab	6.6c	156	116
Mulanje West	126	1851ae	361bc	5.2a	87	117
Zomba	68	2772b	417a	7.1c	34	83
BREED GROUP						
½ Friesian	554	1953a	382	5.3a	403	116
¾ Friesian	227	2424b	401	6.2b	141	98
YEAR OF CALVING						
1973	-	-	-	-	7	44
1974	29	2061ad	437ade	5.0ae	28	81
1975	49	2510ab	443ae	5.8ace	49	107
1976	74	2463ae	414ade	6.0ac	71	107
1977	122	2523bef	440a	5.9adf	77	120
1978	160	2580cbe	402ef	6.8b	78	102
1979	149	2444ab	396ef	6.6bc	79	134
1980	106	2285abf	384cdf	6.3bcd	53	144
1981	45	1864d	373bdf	5.0ef	26	132
1982	36	1701d	352bdf	5.0ae	12	103
1983	11	1451d	289bc	4.8ad	-	-
MONTH OF CALVING						
January	74	2144a	402ab	5.5	46	84
February	78	2240a	409ab	5.6	56	89
March	50	2764b	454a	6.0	34	125
April	65	2352b	402ac	6.1	41	101
May	52	2113a	438ad	5.4	42	88
June	62	2167a	357bc	6.0	42	99
July	72	2176a	375bcd	6.0	48	119
August	67	1954a	374bcd	5.2	44	121
September	71	2061a	369bc	6.0	47	170
October	63	1982a	348bcd	5.7	51	114
November	73	2304a	394ac	5.9	58	89
December	54	2045a	381bcd	5.4	35	89

* Group values followed by the same letter do not differ significantly ($P<0.05$).

In the Blantyre North area, where rainfall was only about 700 mm, the age of heifers at their 1st calving was later than that in the other areas. Birth in years of higher rainfall resulted in earlier ages at 1st calving, and the 50% Friesian heifers delivered their first calf 3 months earlier than the 75% Friesian heifers.

Long open periods (and hence long calving intervals) may be ascribed to improper management and/or reproductive problems, but problems of management of artificial insemination (heat detection, time of insemination and attendance to calls etc.), are likely to be significant.

Agricultural area, breed group, year and month of calving, and area by breed interaction each had a significant effect on total lactation milk yield (Table 2). Total milk yield was highest in Zomba and Thyolo North where feed resources are more uniform throughout the year and where most farmers were new to livestock farming. In these areas farmers were prepared to accept innovations from extension agents more readily than their counterparts elsewhere who had previous experience in raising the Malawi Zebu, and who resisted the idea that crossbred cows should be managed differently. In addition, smallholder dairy operations were first started in Thyolo North and farmers in that area had gained more experience in handling crossbred cows than farmers elsewhere.

Crosses with 75% Friesian blood produced significantly more milk than the 50% crosses (2424 kg versus 1953 kg). Cows that calved in bad years, in terms of rainfall distribution, produced significantly low milk yields. Likewise cows that calved between November and April produced more milk than those that calved between May and October. These differences also closely followed the monthly rainfall distribution which determines the availability of feed.

The longer lactation length is attributed to the following factors:

1. Where farmers realised that cows that calved in a favourable month were capable of producing more milk there was a tendency to milk these cows longer. It can also be a reflection of the problems associated with management of artificial insemination.

2. Dry periods were associated with decreases in lactation lengths; this suggests that the shortening of the lactation length was a result of constraints (most likely feed availability) that forced cows to dry up while the foetuses they were carrying were still young.

Dairy farming system after 1984

From Tables 1 and 2 it is evident that productivity of cows in smallholder farms was low. The need was recognized to develop feed resources that would allow an increase in total animal productivity without increasing the size of land holdings. Smallholder dairy farming has been based on Napier grass, Rhodes grass, groundnut haulms and banana chops to provide roughage while maize and rice bran have been the main concentrates. The establishment of more agro-industries has given rise to the availability of by-products which can be utilized to compound dairy animal concentrates. The interest in the programme is to maximise daily yields per cow through the feeding of a balanced ration with agro-by-products as the main ingredients. The formulations of concentrates prepared by the feedlot company (Southern Malawi) and the Government farm (Central Malawi) are shown respectively in Tables 3 and 4.

Table 3. Composition of a dairy concentrate manufactured by the Feedlot Company (Southern Malawi)

Ingredients	Kg/100 kg of concentrate	kg CP	kg TDN (kg)
Urea	1.0	2.7	-
Cottonseed cake	25.0	10.0	18.2
Molasses	10.0	0.4	6.8
Maize bran	61.0	5.5	47.6
Monocalcium phosphate	2.0	-	-
Salt	1.0	-	-
	100.00	18.6	72.6

Table 4. Composition of a dairy concentrate made at the Government farm (Central Malawi)

Ingredient	Kg/100 kg of concentrate	kg CP
Maize	45.0	3.6
Groundnut cake	19.5	8.6
Cottonseed cake	12.0	4.2
Wheat middlings	20.0	3.0
Dicalcium mineral	2.5	-
Salt	1.0	-
	100	19.4

The concentrate mixtures shown in Tables 3 and 4 have been in use only relatively recently at the smallholder level. In the Southern area, Holstein/Friesian cows on the smallholder farms have been found to produce a mean 2,900 kg milk .n an average lactation of 170 days (mean 16.3 kg/d), while on the Goverment farm in Central Malawi, average figures of 4,880 kg during an average lactation of 259 days (mean 18.8 kg/d) have been recorded. Strict comparisons of these data is not possible because of differences in rations used, and the fact that machine milking was employed on the Government farm, but the figures give an indication of the levels of production that may be expected, and could encourage the acceptance of higher yielding breeds by smallholders particularly those who intend to go into dairy as a full time farming activity.

CONCLUSIONS

Many areas of Malawi are geographically unsuitable for producing and sustaining good stands of crops or forages. With the increase in the availability of agro-byproducts and the identification of private firms prepared to undertake milling a production of dairy concentrates from these materials, the potential of the smallholder dairy business in Malawi appears promising. Many Friesian x Malawi Zebu cows have proved capable of high milk yields, and crosses appear superior to the Friesian in this environment.

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THE OPTIMAL USE OF AGRO-INDUSTRIAL BY-PRODUCTS AND CROP RESIDUES IN NIGERIA

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ABSTRACT

Agro-industrial by-products and crop residues represent a vast animal feed resource, which is as yet largely unexploited. Considerable research has been, and is being, carried out on the potential of these by-products and crop residues but to date, very little effective practical application has been achieved. This paper concentrates on their use for ruminant nutrition, as due to their ability to digest low quality feeds and roughages, ruminants can utilise these products more effectively than monogastric livestock, and in doing so, they are not competing for human feed resources. If this optimal utilization can be achieved, then considerable increases in animal production will follow, helping to reduce the acknowledged animal protein deficit. This production will be achieved at a lower cost than before, resulting in improved net profits and most importantly. in foreign exchange savings.

CATTLE FATTENING IN NIGERIA

Cattle fattening has been an established practice in Nigeria for some time, but in the past, largely carried out by butchers and cattle traders, being the only category with the resources to buy both cattle and feed. This traditional fattening was largely inefficient, and consisted mainly of the purchase of low priced cattle in the dry season and merely keeping them alive until the wet season. During Nigeria's First Livestock Development Programme (FLDP), the Livestock Project Unit (LPU) developed and promoted the smallholder fattening of cattle. Essentially, this was achieved by the provision of supervised credit, enabling the smallholder to purchase 4 cattle, sufficient supplementary feed for a 120 day fattening period, also to purchase anthelmintics and to cover other miscellaneous charges.

The cattle used for this smallholder fattening scheme (SHFS), are the indigenous cattle of Northern Nigeria (white Fulani, Red Fulani and Sokoto Gudali) in the range of 300-350 kg live weight; although in Southern Nigeria the smaller Ndama cattle in the range of 200-250 kg liveweight were used. The Southern States of Nigeria are infested with tsetse fly, and thus most cattle fattening is carried out in Northern Nigeria which is comparatively tsetse free. The aim is to purchase healthy fairly mature bulls or oxen in poor to lean condition, the combination of improved animal health and improved feeding maximises the benefits of compensatory growth, thus obtaining the optimum liveweight gain. In addition to their supplementary feed, the cattle are provided with crop residues, or grass in the wet season. The target feeding standards are to achieve a daily intake of 56.40 M.J. of metabolisable energy (M.E.) and 540 gm crude protein, theoretically allowing a daily liveweight gain of 0.5 kg per head.

The actual supplementary feed rations vary according to the availability and cost of the ingredients. The 3 most common rations are shown in Table 1, and provide a daily allowance of 3 kg wheat offals or dried brewers grains and 1 kg molasses, and may use groundnut or cottonseed cake. The ration using dried brewers grains and molasses is considerably cheaper, but unfortunately its use is limited by the present low availability of dried brewers grains.

It has proved very difficult to obtain reliable information on the actual liveweight gains achieved; the cattle are weighed at purhcase, but only rarely has it been possible to achieve reliable sale weights. However, from the liveweight gains achieved by two groups of cattle in NE Nigeria (Table 2) it seems reasonable to assume that the target daily liveweight gain of 0.5 kg has been achieved. In view of the gains acheived in the first periods of fattening (Table 2) it seems possible that if the standard fattening period was reduced to 100 days, gains approximating 0.7 - 0.8 kg/d might be achieved, with the added advantage of rendering two fattening cycles per year feasible. Further close study of feed utilization and cattle gains is presently being conducted in Kaduna State.

AGRO-INDUSTRIAL BY-PRODUCTS PRESENTLY AVAILABLE

Wheat Offals

The present practice in Nigeria is to market one product, a combination of weatings and wheat bran containing approximately 10 MJ metabolisable energy and 150 crude protein per kg dry matter. Wheat offals are generally widely available and cost about N 140 per tonne; a considerable quantity is also exported, but this material constitutes a major ingredient of LPU's cattle fattening rations, particularly as dried brewers grains are not readily available in Northern Nigeria.

Cottonseed cake

In 1975, 125,000 tonnes of cottonseed were purchased for processing, whereas in 1983 only 11,946 tonnes of cottonseed were available, producing only 6,081 tonnes of cake. In 1978 the average price per tonne was N50, and is now N 300. The approximate energy and protein values are 11.0 MJ ME and 269 gm crude protein per kg dry matter. Its use in monogastric rations is restricted due to the presence of gossypol, but it is widely used and well accepted by cattle and sheep. It was first used in 1962/63 for supplementary feeding of cattle to reduce mortality and weight loss during the dry season (Anon 1962/63). Initially the quantities used were small but gradually increased, until during the Supplementary Feed Programme 1970-75, a total of 22,488 tonnes were used for dry season supplementation

Table 1. Examples of Nigerian Smallholder fattening rations* (Data from LDP: LPU)

Ingredients	Cost **(naira/t)	Dry Matter %	ME (MJ/kg DM)	Crude Protein (g/kg DM)	Quantity in Ration (kg)	DM in Ration (kg)	ME in Ration (MJ)	CP in Ration (g)	Cost per head (naira/d)	Quantity per head (kg/100d)	Cost per head (naira/100d)
1. Wheat Bran	170.00	90	9.16	150	3.00	2.70	24.73	405	.51	300	51.00
Groundnut Pellets	300.00	90	12.00	480	0.25	0.23	2.70	108	.075	25	7.50
***Molasses	100.00	75	12.70	41	1.00	0.75	9.53	31	.1	100	10.00
Sub Total					4.25	3.68	36.96	544	.685	425	68.50
Crop Residues/Grazing		90	6.29	22	3.58	3.22	20.23	71		358	
Total					7.83	6.90	57.19	615	.685	783	68.50
2. Wheat Bran	170.00	90	9.16	150	3.00	2.70	24.73	405	.51	300	51.00
Cottonseed cake	260.00	90	10.[illegible]7	269	0.50	0.45	4.80	121	.13	50	13.00
***Molasses	100.00	75	12.70	41	1.00	0.75	9.53	31	.1	100	10.00
Sub Total					4.50	3.90	39.06	557	.74	450	74.00
Crop Residues/Grazing		90	6.28	22	3.33	3.00	18.82	66		333	
Total					7.83	6.90	57.88	623	.74	783	74.00
3. Dried Brewers Grains	120.00	90.00	10.30	204.00	3.00	2.70	27.81	551	.36	300	36.00
***Molasses	100.00	75.00	12.70	41.00	1.00	0.75	9.53	31	.1	100	10.00
Sub Total					4.00	3.45	37.34	582	.46	400	46.00
Crop Residues/Grazing		90	6.28	22	3.83	3.45	21.65	76		393	
Total					7.83	6.90	58.98	567	.46	783	46.00

* Rations based on mature 275 kg cattle, DM intake of 6.9 kg/head/day, with ME requirement of 56.4 MJ/head/day, and CP requirement of 533g/head/day, to achieve 0.5 kg av. daily liveweight gain.

** All costs refer to Kaduna Zone only.

*** Does not include the cost of returnable plastic drum charged as infrastructure & equipment.

Table 2. Two examples (A + B) of cattle liveweight gains in smallholder fattening enterprises in north eastern Nigeria.

	A			B		
	Period 1	Period 2	Total	Period 1	Period 2	Total
No. of Cattle		53			61	
Total gain (kg)	3515	1550	5065	4156	2300	6456
Total cattle fattening days	4127	4053	8180	5135	5266	10419
Mean fattening period (days)	77.87	76.47	154.34	84.48	86.33	170.80
Mean liveweight gain (kg/d)	0.85	0.38	0.62	0.81	0.44	0.62

(Anon 1975). The main constraints to the present and future use of cottonseed cake are its declining production and escalating price.

Groundnut cake

In 1974, 450,000 tonnes of groundnuts were purchased for processing, whereas in 1983, less than 20,000 tonnes were purchased, a potential of less than 10,000 tonnes of groundnut cake. In 1978, the average price per tonne was N 220, but is now N 600. The approximate energy and protein values are 12 MJ of ME, and 486 gm of crude protein per kg dry matter. This also has been used for dry season supplementation since 1962/63, although in smaller quantities; during the 1970-75 supplementary feed programme only 4,568 tonnes were used (Anon 1975). It was also used as a protein ingredient in the cattle fattening rations during the First Livestock Development Programme. Unlike cottonseed cake, it can also be used for monogatric nutrition, and thus is widely used in compounded feeds for pigs and poultry. The main constraints to its use are availability and price; other factors influencing its use are high oil content and the aflatoxin level, which can become unacceptably high, if the groundnuts are of poor quality, or badly stored.

Palm Kernel Meal

In 1974, 293,000 tonnes of palm kernels were purchased for processing, and in 1983, 173,000 tonnes were purchased, of which 85,000 tonnes were exported, the remainder being processed, producing 47,300 tonnes of palm kernel cake/pellets. The approximate energy and protein values are 12 MJ of ME and 207 gm crude protein. Its use to date has been limited, due to its alleged unpalatability, and at present the bulk (75%) of this product is exported.

Molasses

There are two sugar cane processing factories in Nigeria, the Nigerian Sugar Company at Bacita, in Kwara State, and Savannah Sugar Company at Numan, in Gongola State. The Nigerian Sugar Company sells the bulk of its molasses for the distillation of alcohol, but estimates that there could be up to 3,000 tonnes available for animal feeding during 1984-1985; their present price is N 60 to N 65 per tonne. The Savannah Sugar Company is prepared to sell all its molasses for animal feeding; in previous years production varied from 7,000 to 10,000 tonnes. Although no molasses was produced during 1983-1984, the 1984-1985 production was estimated at 10,000 tonnes. Prior to October 1983, the price was N 15 per tonne, and is now N 45. The approximate energy and protein values of molasses are 12.7 MJ of ME amd 41 gm of crude protein per kg dry matter. It is a cheap source of energy, has the further benefit of being extremely palatable, and is frequently used to encourage the intake of other less palatable feeds. It can be fed to all livestock, but due to its laxative effect, inclusion rates should not exceed 10% for poultry, and 20% for pigs; this rate is also recommended for cattle and sheep, but under certain systems this can be exceeded (Preston & Willis 1970; Preston 1972). The main constraint to the use of molasses, apart from its laxative effect, is the high cost of transport, and handling problems in actually getting the molasses to the smallholder.

Dried Brewers Grains

At present, the annual production of dried brewers grains in Nigeria is just under 10,000 tonnes, the approximate energy and protein values are 10.3 MJ ME and 204 gm of crude protein per kg dry matter. The cost per tonne varies from N 45 to N 120. At present only 20% of the available brewers grains is being dried. Apart from availability, the main constraint to the use of dried brewers grains is transport; the majority of Nigeria's breweries are in the South, whereas the cattle are in the North. This can involve distances of up to 1400 km which greatly increases the cost to the farmer.

Rice Bran

Until recently, the bulk of Nigeria's rice was milled locally, and the quantities available have been small and scattered. The Nigerian Grains Board is now responsible for the majority of rice milling and by 1985 expected to have 6,000 tonnes of rice bran available for sale. The approximate energy and protein values of a recent sample were 10.8 MJ ME and 140 gm of crude protein per kg. High fibre content limits its use by mongatric animals, but it can be utilized by ruminants. The major constraint is the high oil content which limits its storage life; stabilising is required, further adding to costs.

Crop Residues

The major crop residues are maize, sorghum and rice straw; smaller quantities of millet straw are also available. These have traditionally been used by Nigeria's pastoralists, the cattle and sheep being allowed to graze on the crop residues, in return for the manurial value of their dung. However, sorghum straw in particular contains a far higher proportion of lignin than the temperate cereal straws, which reduces its nutritive value and also the actual dry matter intake by the cattle.

Small scale treatment of maize and sorghum straw with urea, an adaptation of the ammonification of rice straw using urea (Saadullah et al 1981) has been initiated in Kano (W.B. Ritchie unpublished data). The sorghum stover was placed in a polythene lined pit and 5% urea added (1 kg urea in 10 litres of water per 20 kg sorghum straw); when full the pit was sealed for 20 days. This treatment increased the crude protein content of the sorghum straw from 2.2% to 11.9%, increased its digestibility and estimated ME value, and the voluntary intake of the treated straw was greater than that of untreated straw.

The various by-products presently available have been compared on the basis of costs per unit ME and crude protein (Table 3). Palm Kernel meal and dried brewers grains are the cheapest sources of crude protein, and molasses, palm kernel meal, and dried brewers grains are the cheapest sources of ME. However, palm kernel meal is mainly exported, while the total annual production of dried brewers grains is less than 10,000 tonnes. Thus the by-product with the greatest potential is molasses, especially in close proximity to the Savannah Sugar Company where transport costs will be lower. There is also scope for an increased use of wheat offals, in that exports could be reduced, although the price is rapidly escalating. Millers now sell wheat offals for the same price as they pay for imported wheat. The traditional protein supplements, cotton-seed cake and groundnut cake also are rapidly becoming prohibitively expensive.

FUTURE POTENTIAL

Dried Brewers Grains

Present production is approximately 10,000 tonnes per annum, and a survey of breweries indicates that a further 28,600 tonnes could be produced by those breweries that indicated an interest in drying their spent grains. This quantity could provide sufficient feed, if fed at 3 kg per head for 100 days, to fatten an additional 95,333 head of cattle, with a potential live-weight gain of 6,673,333 kg, and a potential saleable meat production of 6,000 tonnes. If eventually the other breweries also dried their spent grains, the additional 12,000 tonnes would help to produce a further 2,500 tonnes of saleable meat. This appears to justify Government intervention, to ensure that this valuable by-product is made more available as a livestock feed (Adegbola 1976).

Palm Kernel Meal

This probably has a potential for increased use second to that of dried brewers grains. Reports from Latin America (Chico & Shultz 1976) indicate that palm kernel meal can be used for ruminants, and that up to 2-3 kg per head can be fed to cattle. It is almost certain that its reputation for unpalatability is unjustified and that its present and previous under-utilization has been due to the earlier availability and low cost of cottonseed cake and groundnut cake. Further research into its use in Nigeria is certainly warranted.

Molasses

There is considerable scope for an increased use of molasses, firstly as a liquid feed and secondly as an important constituent of a molasses/urea feed. A prototype mineralised molasses/urea feed has been produced, further improvements are required, and a decision will have to be made as to whether to produce a feed block, or pellets, or both. It is important to restrict the intake of urea to less than 100 g per head per

Table 3. Costs of by-products in Kaduna, per unit of metabolisable energy (ME) and of crude protein (CP).

	COST PER TONNE IN KADUNA	DRY MATTER PERCENTAGE	ME MJ/kg DM	CP (g/kg DM)	COST PER KG DRY MATTER	COST PER 10 MJ	COST PER 100 g CP
Palm Kernel Meal	140.00	90	12.20	207	0.16	0.13	0.08
Dried Brewers Grains	120.00	90	10.30	204	0.13	0.13	0.07
Wheat Bran	170.00	90	10.10	150	0.19	0.19	0.13
Cotton Seed Cake	330.00	90	11.00	269	0.39	0.33	0.14
Groundnut Pellets	630.00	90	12.00	486	0.70	0.58	0.14
Molasses (only)	100.00	75	12.70	41	0.13	0.10	0.33
Rice Bran (proposed)	90.00	90	10.80	140	0.10	0.09	0.07
Sorghum Crop Residue	0.00	89	6.28	22	0.00	0.00	0.00
Treated Sorghum Crop Residue	0.00	85	7.50	120	0.00	0.00	0.00
Dried Brewers Grains	80.00	90	10.30	204	0.09	0.09	0.04
Mineralised Molasses/urea feed*	250.00	80	7.76	220	0.31	0.40	0.14
Mineralised Molasses/urea feed**	150.00	80	4.50	225	0.19	0.42	0.08

* Using wheat bran

** Using ground maize cobs

day for cattle, and to less than 10 g per head per day for sheep. This is usually done by limiting intake by the degree of hardness of the block, but it could also be done by restricting the intake of pellets. It must be remembered that this molasses/urea feed is only suitable for ruminants and cannot be fed to monogastric animals. However, it could be safely fed to cattle and sheep as a partial substitute for cottonseed cake and groundnut cake, and at half the cost per 100 g crude protein (Table 3). If this feed can be successfully produced and marketed as a mineralised molasses/urea block or pellet, it would have a tremendous effect on Nigeria's cattle production and reproduction.

Rice Bran

An estimated 6,000 tonnes are available annually as a potential livestock feed, providing that it can be effectively stabilised. If then fed as a supplement, at 3 kg per head per day together with 1 kg of the mineralised molasses/urea feed, similar liveweight gains to those achieved on dried brewers grains and molasses might be achieved, i.e. 0.7 - 0.8 kg liveweight gain per head per day. Thus the 6,000 tonnes of rice bran would help to provide sufficient feed to fatten an additional 20,000 cattle, representing a potential incremental meat production of 1,260 tonnes of saleable meat.

Wheat Offals

In order to make more locally produced feed available for poultry and pig production, the flour millers should be encouraged to separate the wheat offals into "weating" and wheat bran. The weatings could then be used for pigs and poultry, and the wheat bran would still be available for cattle and sheep. In addition the millers should be encouraged to make these products available to Nigeria at a reasonable price, rather than to export them as they are doing at present.

Dried Brewers Yeast

Present production is approximately 400 tonnes per annum, and this could be increased to at least 2,500 tonnes if the potential production could be achieved. This would represent a saving of 2,000 tonnes in the annual imports of protein concentrates for poultry and pig feeding.

If as discussed above, more breweries were persuaded to dry their spent grains, only the prior separation of the yeast from the grains would be required.

Cottonseed cake and Groundnut cake

Both these products are over-priced at present largely because oil seed processing capacity vastly exceeds the availability of cottonseed and groundnuts for processing. If the Nigerian Cotton Board and the Nigerian Groundnut Board can take steps to ensure a higher production of cottonseed and groundnuts processing costs would be reduced, which might lead to a reduction in the selling price of cottonseed cake and groundnut cake.

Crop Residue

These are on the whole being utilised, but there is considerable scope for more effective utilisation. The treatment of crop residues by ammonification using urea, initiated by the Kano Agricultural and Rural Development Project, should be replicated in other project areas where the necessary extension supervision is available. There are at present 13 Agricultural Development Projects and 11 River Basin Rural Development Projects in Nigeria, the main aim of which is to increase crop production. If this crop residue can be successfully treated using urea, the resulting increases in digestibility, crude protein and metabolisable energy could well benefit animal production.

Dry Season Supplementation

Most of Nigeria's estimated 9.3 million cattle are located in the Northern States and experience a dry season at least of five to six months duration, during which the poor quality feed produces weight loss which is often severe. Reduced fertility and increased mortality are common, and these effects can be alleviated by dry season supplementation. There are approximately 8 million cattle in Northern Nigeria, at least 3 million of these are breeding cows, their present calving percentage approximates 45%, overall herd mortality about 7%, and calf mortality 20%. If dry season supplementation were made available to those breeding cows, it is quite possible that calving percentage could increase to 50% (a potential increase of 150,000 calves), herd mortality could be reduced to 5%, (a potential saving of 60,000 breeding cows) and calf mortality could be reduced from 20% to 10% (a potential saving of 150,000 calves). In addition to the above savings, it would also be reasonable to expect heavier weaning weights. Thus although more difficult to quantify, the benefits from dry season supplementation could be far greater and longer term than those from cattle fattening.

Due to the ever increasing cost of supplementary feed in recent years, the ILCA sub-humid team has introduced the fodder bank concept, a protected area of protein rich forage, usually of Stylosanthes spp., kept as a reserve for dry season grazing by selected animals. ILCA and LPU have successfully introduced this fodder bank method of supplementation to settled and semi-settled pastoralists in Kaduna State, and are now monitoring its introduction to other Northern States. One of the most acceptable methods of establishment is to undersow a cereal crop with Stylosanthes seed, since the farmer, having cleared the land, wishes to crop it before using it as a fodder bank. This has the additional advantage of increasing the integration of crops and livestock, and increases the value of the crop residue.

CONCLUSIONS

There is tremendous scope for an increased and more efficient utilisation of agro-industrial by-products and crop residues, which will result in a significant increase in animal production. Dried brewers grains alone could cater for an annual increase of over 8,000 tonnes of beef, which would help both to reduce Nigeria's animal protein deficit and reduce imports. Further increases would be made possible by an improved utilisation of palm kernel meal and rice bran, and also from an increase in the urea treatment of crop residues.

This paper has concentrated on the use of by-products and crop residues for small-scale ruminant fattening, but they can also be used for dry season supplementation, although the benefits of this are more difficult to quantify. If they were used also for intensive or feed-lot fattening, such production established in close proximity to the major feed sources would result in considerable reduction in feed costs. The by-products and methods of utilisation described in this paper are not specific to Nigeria, they are found and can be applied throughout the tropical world.

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STRATEGIES FOP RURAL DEVELOPMENT WITH EMPHASIS ON LIVESTOCK PRODUCTION, RESOURCE UTILIZATION AND FAO ASSISTANCE

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ABSTRACT

Different aspects of rural development are discussed. It is emphasized that the most important single factor is the correct identification of constraint. It is further emphasized that this can only be done by understanding of and involvement with the target group otherwise the wrong constraints are often identified. Problems of risk factors play a very important role in whether new technologies are accepted. Cost of new technologies must be recovered in a gauranteed sale of the excess produced. Improvement in resources are most readily accepted by producers of milk when resources are limiting production and when a high and predictable price of milk can be obtained. Appropriate methods of improving resource utilization is discussed but it is emphasized that such technologies should only be attempted when resource utilization or availability is identified as the first constraint.

INTRODUCTION

In almost all developing countries, particularly in Africa and Asia, there is a large rural population, sometimes up to 95% of the total. Common to most of the rural populations are very low incomes or subsistence-type farming, high birth rates and more often than not low literacy. Attention to their progress has often been neglected as governments have paid more attention to industrial development. Usually the rural populations have little or no political power and usually their voice is not heard, even in affairs dealing with their own development.

On the other hand problems of rural poverty and rural development are in many respects soluble and it is in the relief of rural rather than urban poverty that such agencies as the Food and Agriculture Organization can play a major role, because they have the technical expertise to assist in its amelioration.

Identification of target groups

It is relatively easy to identify target groups for development. They can be defined as communities below a certain income and subsistance communities producing little or no surplus and receiving few or no services.

Identification of constraints in target groups

Having identified the target groups for aid and development assistance, the next and by far the most difficult problem is that of identifying constraints, in particular of identifying which of the many constraints are the most important. It is in this process that most mistakes in development have been made.

In the identification there can be conflicting views. First of all, government officials may be biased somewhat by orientation towards increasing the supply which are limited in cities. The ex-patriate expert can be equally biased since his perception of constraints and indeed perception of normality is influenced by his background. The target group, having limited political power, is hardly ever consulted in the process of identifying the constraints.

From my limited experience in project identification work in rural communities, the target group rarely appears on the initial itinerary. Yet I have become firmly convinced that, in order to identify the correct constraints and the order of constraints, one must understand the target group, their social conditions, their perception of constraints and their perception of values, all of which are crucial to any success in development. While a specialist in animal breeding or feed resource utilization may feel tempted to identify constraints which come within his or her area of expertise, this temptation must be resisted at all costs. The sight of cows yielding 2 litres of milk/day should not necessarily lead to a recommended policy of crossbreeding and importation of exotic animals. Nor should the sight of poorly utilized resources necessarily lead to projects involving investments in methods of increasing resource utilization. Lack of concentrate in pelleted form should not lead to a recommendation for the erection of large feed mills.

While famine occurs in rural areas due to droughts, wars and other catastrophies, let us for the moment deal with rural communities in which it is desired to increase the production of food and, if possible, to produce an excess to supply food for the cities.

Consideration of risk

It is common to all subsistence farmers that investments involving perceived risk will not readily be made. There are good reasons for this; poor investments can have serious repercussions for subsistence farmers. Even long term reasonably safe investments are difficult; such as buying feeds for calves in which the investment may only be returned in 2 years time. Investments in fertilizer for crops, in anticipation of returns at harvest, are sometimes reluctantly made, particularly in drought prone regions. Sometimes the most serious constraint is simply risks and the solution simply the removal of risks.

Investment in feeds for dairy cows is on the whole more readily made if the milk can be sold at a high price, as the investment may be returned quickly in increased milk yield. A guaranteed price for products can greatly assist. Production of maize by communal farmers in Zimbabwe increased several fold when a fixed price was offered and the maize was collected.

Farmers in a part of Bangladesh did not invest in high yielding varieties of rice. This was not due to lack of knowledge but to a high risk of damage from flooding. High yielding varieties also need higher investment in fertilizer than the indigenous varieties.

Constraints due to lack of infrastucture and land rights tenure

However high in demand a product may be in cities it is often too difficult to reach the markets because roads are inadequate. A constraint in a rural area can sometimes be removed simply by making the area accessible at all times of the year. Poor grassland management and overgrazing on communal land cannot be overcome without some legislation on the land rights or agreement among farmers using the communal land. The right to crop land which maybe withdrawn, can make life uncertain for pastoralists and thus make investments difficult. Secure investments in banks, rather than in cattle or other animals, could lift many constraints to production in Africa.

The examples mentioned above are but few. However, they serve to illustrate the difficulties in identifying constraints adequately, without which an aid development programme is unlikely to succeed.

Improving resource utilization

Let us assume that animal feed resource quantity and quality have been identified as major constraints in a given community and that prices of products are correct relative to input and that marketing of the product is possible and sustainable in the foreseeable future. It is then necessary to identify the most relevant principle of improvement in nutrient supply and the most important technology.

Sometimes an appropriate technology has to be developed. The methods chosen obviously depend on the type of resources locally available. There is little point in importing molasses in order to feed urea via molasses blocks. There is little point in recommending feeding of urea or treating straw with urea unless the supply of urea is secure and sustainable. There is no point in chopping straw for treatment if straw is normally handled in bundles. There is no point in using urea if the cost is prohibative relative to potential benefit. Nor is there any point in recommending schemes for breed improvement if the present constraint to production is nutrition. On the other hand improved resources can often be exploited better by crossbred animals.

It is important to discuss the technologies in detail with the rural community for which it is intended. Sometimes simple things which can make or break a new method have been overlooked. Adaption of technologies must be done in collaboration with village farmers before a large venture into a community development programme is undertaken.

Useful technologies to increase resource utilization when this has been identified as a constraint to production

Urea supplementation

Lack of degradable N in many fibrous residues can be corrected by supplementation with urea or a mixture of urea and sulphur. In some areas where molasses is available and underutilized, urea can be incorporated into blocks made from molasses and fibrous residues (bran, poultry manure, etc) and cement. This makes urea available for supplementing poor rangeland as the blocks can be transported with the animals. Urea-molasses blocks can also be used to supplement fibrous residues grazed in situ.

A relatively safe method for adding N to fibrous residues is to spray them with a solution of urea at feeding time. Here the consentration of urea involved is only about 1% whereas much higher consentrations are used for the ammonia treatment of straw. Simple addition of urea can lead to considerably greater intakes and increased digestibility.

Urea/ammonia treatment

While simple additions of urea ensure increased digestion of the feed, use of urea as a source of ammonia increases the potential digestion further by making more cellulose and hemicellulose available for digestion. The use of urea as the method of ammonia treatment has advantages over the use of anhydrous ammonia for small farmers in rural communities, particularly in areas where the mean daily temperature is 10 to 15° celsus or above since high temperature ensures a rapid hydrolysis of urea. The exact method adopted will depend on the harvesting procedure and the form in which stover/straw is gathered (chopped, bundles etc). It will also depend on the site of treatment (pit, stack etc) and that which is locally most appropriate.

Use of anhydrous ammonia requires relatively large scale production and a developed infrastructure for economy and may be used on farm co-operatives; making its use much less wide-spread than that of urea. Other alkalis such as calcium hydroxide, caustic soda or other locally available sources can also be used. However it must be remembered that the increasing availability of cellulose also increases the need for N supplementation and this is usually taken care of when ammonia is used.

Introduction of leguminous forages into straw

Planting legumes before maize, millet or sorghum is ripe is another method of improving utilization of straws which can be produced in many parts of Africa. Legumes provide N supplement for the straw as well as a highly digestible forage.

Supplementation

Rates of fermentation of fibrous residues can often be improved by feeding small amounts of highly digestible nutrients such as citrus residues, sugar beet pulp, green grass, leguminous forages or leaves/pods of trees or poultry manure. Production of milk and meat by the host animal is often limited by the supply of protein which escapes degradation in the rumen and research into methods for decreasing the rumen degradability of locally available protien supplements is needed.

Attention to recycling

It is possible in some areas to increase output of human food by greater attention to recycling. Thus it may be possible to recycle manure through feeding, biogas or aquaculture before it is returned to the soil.

Attention to water availability

It is well known that many rough grazing areas are underutilized due to limited access to water. Thus resource availability can be improved either by increasing watering points or by using a selection of animals with greater ability to conserve water, which can graze over wider orbits around existing watering points.

Disease and pests

This is not the place to discuss aspects of disease, except to point out for completeness the resources in large areas of Africa are underutilized due to tse tse and tick infestations. Selection of animals tolerant to these pests and associated diseases can thus increase resource availability as, of course, can methods of controlling the pests themselves where practical and economical.

Separate feeding of the highest producing animals

Many small farmers in Africa, while keeping their animals in a kraal at night, make no attempt to feed milking or working animals differently from non-producing animals. A separate pen for milking animals, with preferential feeding, might help both to increase milk yield and to decrease calving interval.

Evaluation of technology introduced

It is sometimes difficult to predict the consequences of the introduction of a new technology such as improved resource distribution. FAO has increasingy encouraged the use of a system approach in which a survey of all aspects of the community's activities have been conducted. After introduction of the technology or new price system the resulting changes are monitored at regular intervals. This is for instance the case in the areas where integrated dairy development programmes have been introduced.

CONCLUSIONS

There are many pronciples for improving resource utilization. From the point of view of FAO it is important first of all to ensure that for example resource utilization is a major constraint, the removal of which could contribute to relieving rural poverty and increase surpluses for sale. Having ascertained that it is a major constraint, it is then important to identify the most appropriate method or methods for its removal and how best to adopt those most appropriate for the community. It is essential to consult the target group regarding all aspects since otherwise many projects can be wrongly conceived and doomed to failure, often creating more harm than good to the community it was designed to benefit.

THE EFFECT OF PROTEIN SOURCE ON THE PERFORMANCE OF BROILERS

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INTRODUCTION

Intensive poultry production in Malawi is increasing slowly, and major factors limiting growth of the poultry industry include shortages and high prices of balanced feed. At times such ingredients as groundnut cake and fish meal are not available in the country for compounding chicken feed, and meat and bone meal is not produced in sufficient quantities to replace fish meal in time of scarcity. There are no data on the effect of feeding local fish meal from Mangochi to chickens, and although groundnut cake has long been used in the country no research has been documented.

Studies have shown that groundnut meal of high protein value (54%) does not need di-methionine supplementation to improve the performance of layers (Davidson and Boyne 1962; Carpenter et al 1954). Reports on roasted soybean have shown this to be a suitable source of protein for layers (Arends et al. 1971). When roasted or extruded soybean meal or soybean meal plus raw soyabeans were fed to layers, all treatments gave similar egg production, but soybean meal with added fat gave the highest egg weight (Lalshaw and Clayton 1976). There is a need, though, to heat-treat soybeans to deactivate trypsin inhibitors (Rogler and Carrick 1964). Bray et al. (1971) found that heating soybeans to less than 120°C, resulted in pancreatic hypertropy in hens and that heating to 140°C increased the efficiency of utilization of the soybeans. Fish meal is one of the most used animal protein sources for poultry. In Malawi commercially used fish meat is imported and is the main animal protein source for monogastrics.

The objective of these experiments was to find locally available protein sources that could be used in broiler diets without adversely affecting performance.

MATERIALS AND METHODS

Experiment 1: 270 two-week old mixed sex broiler chicks (shaver starbro) were used in this experiment on deep litter with wood shavings. There were two replicates per treatment (diets) with 27 birds per replicate.

Five broiler starter and finisher diets were used (table 1). Diet 1 contained groundnut cake with meat and bone meal, diet 2 contained roasted soybean meal with meat and bone meal, diet 3 contained groundnut cake with local fish meal (Mangochi fish meal), diet 4 contained roasted soybean meal with local fish

Table 1. Composition of broiler diets in Trial One (%DM)

Ingredients	STARTER DIETS 1	2	3	4	5	FINISHER DIETS 1	2	3	4	5
Maize meal	59.47	54.11	61.40	51.73	Commercial	67.71	61.96	69.64	64.35	Commercial
Groundnut cake	31.98	-	30.05	-	broiler	23.74	-	21.81	-	broiler
Roasted soybean	-	37.34	-	39.72	starter	-	29.49	-	27.10	finisher
Meat and bone meal	7.00	7.00	-	-		7.00	7.00	-	-	
Fish meal	0.82	1.04	7.00	7.00		-	-	7.00	7.00	
Mono-calcium phosphate	0.82	1.04	1.34	1.53		0.90	1.05	1.41	1.56	
Ground lime-stone	0.23	-	0.70	0.37		0.22	-	0.69	0.47	
Salt	0.40	0.40	0.40	0.40		0.40	0.40	0.40	0.40	
Vitamin-mineral premix	0.15	0.15	0.15	0.15		0.15	0.15	0.15	0.15	
	100	100	100	100		100	100	100	100	

meal and diet 5 was a commercial broiler feed. Fish meal or meat and bone meal were included at 7% in all diets.

Experiment 2: 270 two-week old mixed sex broiler chicks (Shaver starbro) were used; also on deep litter. There were three replicates per treatment with 30 birds per replicate.

Three broiler starter and finisher diets were used in this experiment (Table 2). Diet 1 contained groundnut cake with 2.50% meat and bone meal and 5% local fish meal, diet 2 contained roasted soybean meal with 2.50% meat and bone meal and 5% local fish meal, and diet 3 contained roasted soybean meal with 10% cotton seed cake, 2.50% meat and bone meal and 5% local fish meal. The soybeans were roasted at 200°C for ten minutes and then ground. All the diets were drum mixed at the site of the experiments. Both trials were carried out in 5 weeks, 2 weeks for starter diets and 3 weeks for finisher diets. The birds were randomly assigned to diets. Weight and feed consumption data were collected weekly, and subjected to analysis of variance and Duncan's Multiple Range Test.

RESULTS

The results of experiment 1 (Table 3) indicate that birds fed on experimental diets 3 and 5 (both starter and finisher diets) gained significantly more than those fed on diets 2 and 4 which contained roasted soybean meal ($P<0.05$). Birds on starter diet 1 had statistically similar weight gains to those on starter diets 2 and 4, but finisher diet 1 did give significantly higher gain. The figures for feed conversion efficiency yielded the same picture as those for weight gain. There were no significant differences among diets in terms of feed consumption.

The results of experiment two are shown in table 4. Birds fed on starter and finisher diets 1 gained significantly more than those fed on diets 2 and 3 ($P<0.05$). There were no statistically significant differences in feed conversion efficiences in the three finisher diets. Feed conversion efficiency for birds on diet 1 was better than those on starter diets 2 and 3 ($P<0.05$), and again no differences between diets in feed consumption occurred.

DISCUSSION

The findings of these two experiments indicate that groundnut cake is superior to roasted soybean meal, the poorer performance from the latter probably being due to the processing of the soybeans to deactivate trypsin inhibitors. Although soybeans were roasted at 200°C for ten minutes, it is probable that the time was not enough to inactivate trypsin inhibitors so as to increase utilization efficiency.

No differences in feed consumption were observed in these experiments. However, Arends et al (1971) and Lalshaw (1974) recommended that diets containing roasted full fat soybean meal must be balanced for energy/amino acid ratio because birds on

Table 2. Composition of broiler diets in Trial 2 (% DM)

Ingredients	STARTER DIETS 1	2	3	FINISHER DIETS 1	2	3
Maize meal	60.34	52.17	52.68	68.44	62.42	63.79
Groundnut cake	29.56	-	-	22.03	-	-
Roasted soybeans	-	37.89	27.86	-	28.24	16.83
Cottonseed cake	-	-	10.00	-	-	10.00
Meat and bone meal	2.50	2.50	2.50	2.50	2.50	2.50
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00
Mono-calcium phosphate	0.87	0.83	1.05	0.87	0.70	0.71
Ground limestone	1.18	1.06	0.86	0.61	0.59	0.62
Salt	0.40	0.40	0.40	0.40	0.40	0.40
Vitamin-mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
	100	100	100	100	100	100

Table 3. The effect of protein source on performance of broilers in Trial one

DIET	LWT WEIGHT GAIN (g) STARTER (WK 2)	LWT WEIGHT GAIN (g) FINISHER (WK 5)	FEED CONSUMPTION (g/bird) STARTER DIET (2 WKS)	FEED CONSUMPTION (g/bird) FINISHER DIET (5 WKS)	FEED/LWT GAIN STARTER (WK 2)	FEED/LWT GAIN FINISHER (WK 5)
1	452[ab]	712[a]	1060	1863	2.67[ab]	2.71[b]
2	329[b]	522[b]	1096	1793	2.98[a]	3.41[a]
3	562[a]	705[a]	873	1878	2.34[b]	2.89[b]
4	335[b]	546[b]	929	1892	2.98[a]	3.74[a]
5	602[a]	695[a]	863	1965	2.27[b]	2.93[b]

[ab] - Means not followed by a common letter, within a column, are significantly different at $P<0.05$.

Table 4. The effect of protein source on the performance of broilers in Trial two

DIET	LWT WEIGHT GAIN (g) STARTER (WK 2)	LWT WEIGHT GAIN (g) FINISHER (WK 5)	FEED CONSUMPTION (g/bird) STARTER DIET (2 WKS)	FEED CONSUMPTION (g/bird) FINISHER DIET (5 WKS)	FEED/LWT GAIN STARTER (WK 2)	FEED/LWT GAIN FINISHER (WK 5)
1	474[a]	1293[a]	1029	2861	2.23[b]	2.34[a]
2	341[b]	1002[b]	1041	2702	3.08[a]	2.83[a]
3	370[b]	1042[b]	1065	2627	2.87[a]	2.59[a]

[ab] - Means, not followed by a common letter, within a column, are significantly different at $P<0.05$.

high energy full fat roasted soybean meal will consume less feed. Dewan and Gleaves (1969) similarly reported that heated full fat soybean meal significantly reduced feed intake by layers. In this study, however, energy determinations of the experimented diets were not made.

Finisher diets 1 and 2 in experiment one containing meat and bone meal did not have adverse effect on the performance of the birds over the experimental period of 5 weeks. However, Anderson and Warnick (1971) stated that bone meal is a poorer source of essential amino acids than fish meal. Isabo and Trifunovic (1963) reported that groundnut cake is low in lysine and methionine. They also reported that broiler pullets fed 7% fish meal in their diets together with either soybean meal or groundnut meal performed equally well. In this study birds on groundnut cake performed better than those on roasted soybean meal. It is possible that the meal and bone meal and fish meal could have improved the lysine and methionine contents sufficiently in these diets.

CONCLUSION

It is concluded that groundnut cake in combination with either meat and bone meal or local fish meal can be used in broiler feeds without adverse effects. Importation of fish meal may be necessary only to add to the local sources. The use of roasted soybean meal needs to be studied further before recommending it to the smallholder farmers. There is a need to establish optimal roasting time and temperature and inclusion rate for optimum performance by poultry.

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ESTABLISHMENT OF FODDER LEGUMES IN TWO COMMUNAL AREAS OF ZIMBABWE

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ABSTRACT

The Farming Systems Research Unit (FSRU), entrusted with the task of improving and testing livestock technologies for the Communal Farming Areas, has selected two representative areas to carry out its programme. Mangwende is of medium altitude, predominantly sandy soils with pH between 4 and 5, and rainfall between 700 and 900 mm per annum. Chivi has similar characteristics but rainfall is between 400 and 600 mm per annum and is thus classified as a low potential area. In both areas a mixed crop/livestock farming system is practiced. The major constraint to improving livestock management and productivity is the limited availability of feed particulary in the dry season due to the low productivity of the grazing areas and the low quality of the grain stovers.

Previous research on forage legumes in Zimbabwe has shown marked increases in the dry matter yield and crude protein percentage of herbage and improved body weight gains per hectare of up to 60% where fodder legumes have been established. These improvements have occurred in large scale commercial farming area but not in the communal areas because of general shortage of land, the role of animals in the system and little attention to these areas by researchers.

The FSRU is working on the establishment of fodder legumes-Fine Stem Stylo and Siratro on fallow land in the high potential area (Mangwende) and Leucaena leucocephala as a living fence around homesteads and gardens in the low potential area, Chivi. The first year's results of a four year trial show that the legumes can be established and protection against destruction by animals and by white ants and crickets (for Leucaena) is necessary in the first year of planting. There has been no response in yield to fertilizer application in both areas and Leucaena appears very sensitive to excess moisture.

(Abstract only; corrected manuscript not received before publication of workshop proceedings).

UTILIZATION OF CROP-BYPRODUCTS AND AGRO-INDUSTRIAL RESIDUES FOR RUMINANT FEEDING SYSTEMS IN ZANZIBAR*

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ABSTRACT

Two trials were conducted to investigate daily weight gains of yearling bulls fed rations containing various combinations of crop and agro-industrial by-products. In the first trial, the performance of yearling bulls fed urea-treated rice straw was compared with that of those fed untreated rice straw supplemented with leucaena. During the 22 days trial period, the group fed untreated rice straw with leuceana gained more liveweight than those fed treated rice straw alone.

In the second trial two groups of five yearling bulls each were fed on two combinations of banana whole plant and Napier grass, the first group with a ratio of 60:40, and the second, a 40:60 ratio of banana - Napier on dry basis respectively. Records of liveweight gains were taken during the 7 months trial period. During the initial period, each group showed a gain in weight with the group fed the 40:60 ratio performing better. However, later the animals lost weight due to outbreaks of worm infestation and Lumpy skin disease. Because of these disease outbreaks, it was not possible to obtain conclusive results. However, the trials demonstrated that the materials examined can be effectively utilized by ruminants.

* Abstract only; corrected manuscript not received for inclusion in published proceedings.

TECHNICAL RECOMMENDATIONS FROM THE WORKSHOP

Technical recommendations formulated during a final discussion period in which rapporteurs first presented major points from discrete sessions of the workshop, fell into two categories:

i) Standardization of Methodology

- Indiscriminate performance of large numbers of chemical analyses on feeds should be discouraged as being potentially wasteful. Since nitrogen is probably the most widely deficient nutrient, its concentration will be the most frequently performed analysis.

- Determination of apparent digestibility of N is meaningless, unless accompanied by fractionation of faecal N using detergent procedures, so that the proportion of truly indigestible feed N can be identified.

- N balance remains a useful determination if carried out with due care, but cognizance should be taken of the physiological state of the experimental animals used. Lactating or young growing animals are the most sensitive to nutritional stress, and attempts should be made to use such animals as far as possible in experiments designed to evaluate feeds in terms of production response criteria.

- Digestibilities of dry and organic matter remain useful measurements that should continue to be made, and emphasis was also placed on the value and applicability of the intraruminal nylon bag method for determining degradation of feeds. Further development of a standardized approach to all aspects of this technique is to be undertaken at ILCA.

ii) Research Priorities

Several areas were identified in which a need was felt for further applied research results. These included:

- The influence of suckling management (restricted suckling) on calf growth and survival, and reproductive and lactational performance of the cow.

- Urea supplementation vs urea treatment of crop residues on their utilization.

- Use of forage and browse legumes to improve crop production and residue utilization.

- Supplementation using molasses/urea based blocks of varying formulation depending on the local availability of appropriate ingredients.

- Survey data obtained during collaboration between crop and animal scientists in relation to regional availabilities of quantities of crop residues, variation in grain: stover ratios, and studies directed towards economic aspects of residue transport and alternative uses.

- Use of by products in non-ruminant rations.

Other matters raised included the identification of constraints to by-product utilization in smallholder communities, the responses of these communities to the introduction of interventions, and problems of technology transfer. All of the above items will be considered in developing the programme for the 1987 workshop; problems associated with smallholder production systems remain the recognised priority for ARNAB activities.

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