THE USE OF CROP RESIDUES FOR ANIMAL FEED IN THE GAMBIA

by

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Ministry of Agriculture
Government of The Gambia
and
The Consortium for International Development
with
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THE USE OF CROP RESIDUES FOR ANIMAL FEED IN THE GAMBIA

Introduction

Inadequate nutrition is perhaps the single most important constraint to livestock productivity in the tropics. In The Gambia, the problem of inadequate feed supplies is exacerbated by several factors including the eight-month dry season, a decrease in natural and permanent grasslands, an increase in both the livestock and human population, the unavailability of improved pasture seed and the dearth of research on animal nutrition in the country. The traditional land tenure system, with land rights assigned by the village chief on an annual basis and communal grazing lands, provides little incentive to farmers to grow forage for their livestock. The Forage Agronomy Unit of the Mixed Farming Project was given the task of improving the feed supply for livestock in the country. The approach has been directed toward two areas: the search for adapted tropical legumes which could be used to improve native pastures and fallow lands or provide fodder banks and the study, through cattle feeding trials, of the various crop residues available for use as a dry season feed. This paper will focus on the latter area, describing the research conducted by the Unit from 1982-1985, the results of that research and recommendations both for future research and extension of the research results to the livestock owners.

Literature Review

The use of crop residues for livestock feed in The Gambia is not new. For many years farmers have been allowing livestock to graze the crop fields after harvest and have been saving some of their groundnut hay to be fed to draft animals and small ruminants. Crop residues are in fact used worldwide, in both developed and developing countries, for many purposes of which livestock feed is but one.

What is new for The Gambia are the feeding trials run from 1982-1985 with the specific intent of determining the nutritive value of crop residues in The Gambia and to initiate an animal nutrition program to test those residues with N'dama cattle. Feeding trials had been conducted sporadically in the early 1970s but data from these trials are elusive (see Dunsmore et al., 1976). These trials are a first small step toward developing a year round livestock feeding program for Gambian farmers and documenting the results for future research.

In a talk given by Peter Brumby, Director-General of ILCA (1985, Addis Ababa) figures were cited showing that over half of the livestock in Africa were managed under agropastoral systems. (see Table 1) Agropastoral systems combine sedentary cropping and the raising of livestock simultaneously. The majority of the farmers remain in one area while their animals migrate for some part of the year. In other words, the animals use communal land part of the year and cropland the rest of the year. A more complete breakdown of those figures follows.

Table 1. Livestock Systems and Distribution in Africa

	Livestock Units* (millions)	Percent of total
Ranching	8	6
Pure Pastoralism	29	20
Pure Mixed Farming	32	23
Agropastoral	74	51

*Livestock Unit = 250 Kg. liveweight

Source: ILCA unpublished data

The 1985 FAO Country Tables list land use patterns worldwide. A few selected African countries are presented in Table 2.

Table 2. Land use in Africa (ha. x 10 3) for 1982.

	Arable and permanent crops	Irrigated Crops	Forests	Other land including desert	Total
Gambia	160	33	204	603	1000
Senegal	5227	180	5318	8475	19200
Niger	3650	36	2780	120,204	126,670
Kenya	2388	50	2470	52,017	56,925
Botswana	1360	3	962	56,212	58,537

The importance of crop residues as compared to natural grazing clearly depends on the ecosystem involved and the pressure for land from the human population. Desertification in the Sahelian

countries and a population growth rate throughout much of Africa of over 3.5% are two factors which influence the availability of land, both for crop production and livestock use. In The Gambia, the amount of land put into arable crops increases every year as the human population increases. Livestock can no longer rely solely on native pasture and bushlands for their feed supply. Although livestock owners are beginning to show an interest in improved pastures, it will undoubtedly be a long time before they become an important component in Gambian farming systems. Hence, the continued interest in finding alternative sources of feed.

An understanding of the animal feeding system is needed in the framework of the farmer's total farming system of which livestock production is only one aspect. A small farmer's livestock production goals are usually survival of the animals during the dry season rather than maximum animal performance. In addition, generally little cash expenditure is made on the animal production enterprise (Kiflewahid et al., 1983). Technical solutions must be appropriate for these systems and alternatives should be evaluated by measuring the costs and benefits incurred. Many crop residues and by-products are thought of as "free" because there is no apparent market price for them or because the farmer's labor costs for collecting them are not considered. It is not in the scope of this review to go into the factors needed to determine the cost of feed in the animal-production system but merely to point out that there is always a cost which cannot be ignored when technical solutions are sought.

It is a generally accepted maxim that a minimum of 7% crude protein in the diet is required for maintenance of ruminant livestock, i.e., at zero liveweight gain. Yet several interesting studies have indicated that Bos indicus breeds (including N'dama) have the ability to survive at even protein levels. The suggestion is that because B. indicus breeds have developed under conditions of poor nutrition they have been naturally selected

for low fasting metabolism and good survival abilities. This is linked, however, with relatively low growth rates under better conditions (Butterworth, 1985). The tropical breeds of cattle seem to be "buffered" against fluctuations in feed supply. A review by Butterworth and Brand (1981) on the protein requirements of tropical cattle indicates that levels of protein required by tropical cattle may be less than that of cattle in temperate areas.

The same review suggests that energy is not so efficiently used for growth as for maintenance and that this is associated with lower intake of nutrients as well as a lower fasting metabolism. Ledger and Sayers (1977) maintained a group of B. indicus and B. indicus x B. taurus steers at constant weights of 185, 275 or 450 Kg. for 24 weeks by adjusting their daily ration. As time progressed, less ration was required to maintain liveweight; indicating an increasing efficiency of feed utilization as time, at the same weight, increased. The most interesting data from the study showed that the B. indicus steers were 46% more efficient than the cross-bred steers. This is extremely important for cattle in the tropics which may spend most of their time in states of maintenance or near-maintenance. Another factor affecting nutrient requirements is compensatory growth which has been associated with the increased efficiency that exists under conditions of subnormal nutrition.

In the United States, crop residues are considered to be high energy feeds because they are high in cellulose or the lignocellulose complex (lignin, cellulose, and hemicellulose). The high fiber is considered essential in cattle feeding to keep the animals on feed, prevent ruminal parakaratosis and reduce liver abscesses in high concentrate cattle rations (Owschwald, 1978). However, in the tropics where both protein and energy levels in the animals diets are low, crop residues may be considered both a

protein and an energy source. Indeed, all sources of protein are used for energy when glucose availability limits metabolism.

Where there is no limitation to grazing lands, the use of crop residues for supplemental feed becomes less important. In very populated areas with little or no access to grazing by animals, crop residues may be the only feed available. The Gambia lies somewhere between these two situations. Whether or not feeding of crop residues becomes economically attractive depends upon the farmers' goals with respect to slaughter cattle and the decreasing availability of land. For the time being, if the farmers' goals are accepted to be survival of their cattle with minimal cash input, then research on the technical aspects of crop residue feeding in The Gambia should continue in order to assist farmers in meeting these goals.

Description of Feeding Trials

All of the feeding trials were conducted at the Farmyard, Yundum using animals from the research herd of the Department of Animal Health and Production. Animals were placed 2-5 per pen on a random basis, fed once a day, supplemented with mineral salt and .5 Kg. groundnut dust/head/day, provided with water and weighed regularly. The amount of feed on offer was weighed daily as was the feed left from the previous day in order to determine actual

average daily intake (see Figure 1 and 2). Specifics of each experiment will be discussed separately. From 1982-1983 Don Hedrick, Fred George, Musa Bojang, Mamadi Jawo and Kutubo Sanyang ran the experiments; in 1984 and 1985 Sandra Russo and Kutubo Sanyang were responsible for the trials.

Trial 82-1 (January - February 1982): Eight two-year old heifers were assigned randomly to one of four feeds: unchopped gamba grass hay, unchopped maize stover, traditional groundnut hay or good quality groundnut hay. The difference in quality of the two groundnut hays was achieved by using a new method of harvesting which involved baling the groundnut plants the same day as lifting and after the pods were combed off in the field.

Trial 82-2. (June 1982.): One-year old weaners were used to compare traditional groundnut hay and rice straw over a two week period.

Trial 82-3. (December 1982 - February 1983): Eight four-year old bulls were divided into two groups at random. Group A received groundnut hay ad libitum as did Group B which also received ground maize grain. The trial, which ran for nine weeks, was initiated by the Maize Agronomy Unit under the direction of Don Kidman for the purpose of demonstrating the use of maize as a feed grain for fattening beef animals.

Trial 83-1. (February - March 1983): Fifteen two-year old heifers were fed one of four rations: maize stover, sorghum stover, groundnut hay, or rice straw without any protein supplement (e.g., groundnut dust).

Figure 1. Daily weighing of feed, Yundum

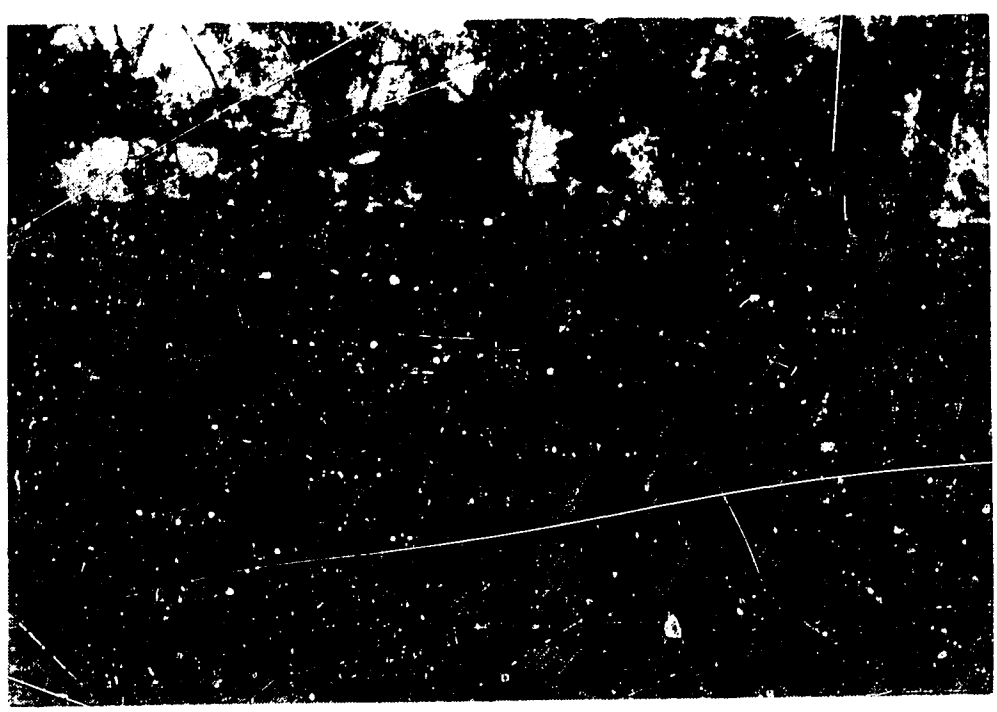


Figure 2. Weighing heifers, Yundum

Trial 83-2. (March - April 1983): Sixteen yearling heifers were selected for the feeding trial. They were all fed sorghum silage for a week and then were fed one of four rations: sorghum silage, maize silage (without ears), chopped gamba grass hay or groundnut hay for four weeks. The silage was made in a trench using a forage chopper run off a tractor PTO.

Trial 84-1. (March - April 1984.): Twenty two-year old heifers, in four groups of five each, were fed either groundnut hay, chopped maize stover, chopped sorghum or chopped gamba grass hay for six weeks after a two-week preconditioning period on gamba grass.

Trial 84-2. (April - May 1984.): The same heifers used in Trial 84-1 were continued in another trial using chopped sorghum stover plus groundnut hay (two replications, 10 animals) or chopped gamba grass plus groundnut hay (two replications, 10 animals) on a 1:1 ratio, i.e., 50% of each feed per treatment.

Trial 85-1. (January - March 1985.): An attempt was made to use as many of the heifers that had been used in 1984 for the 1985 trials. Thirteen of the twenty heifers selected had been used the previous year; all heifers were three-year olds. A larger group than 20 was selected initially and they were wormed and bled. Two animals were eliminated based on low blood counts and two for intractability. A pre-conditioning period on gamba grass hay was followed by an eight-week trial of four rations: chopped maize stover plus groundnut hay or Stylosanthes hay and chopped sorghum stover plus groundnut or Stylosanthes hay.

Trial 85-2. (March - April 1985.): For the second feeding trial, the heifers were fed one of two rations for four weeks: groundnut hay plus chopped gamba grass or groundnut hay plus chopped sorghum stover on a 1:1 ratio.

Trial 85-3. (April - May 1985.): The heifers were then fed for a week on gamba grass hay before starting the last trial. This trial consisted of feeding 5 Kg. of groundnut cake per head per day plus either chopped gamba grass hay or chopped sorghum stover full feed for four weeks. There were two replications of each ration in the trial. The sorghum used in all of the 1985 trials was a sweet sorghum variety.

In the 1984 and 1985 trials both feed and orts (the refused feed) were weighed daily in order to keep the amount of feed on offer at 20-30% above intake to ensure ad libitum feeding. In 1985, feed and ort samples were collected daily for forage analysis.

Results and Discussion

Five feeding trials were conducted in 1982 and 1983. These were preliminary investigation aimed primarily at establishing parameters and modifying methodology. Results of these trials are reported by Hedrick and Bojang (1983) and Kidman and Owens (1985).

Trial 82-1 was the first trial of the series. Observation of traditional groundnut harvesting methods and the resultant hay led researchers to attempt production of a better quality hay. The better quality hay was produced by cutting off the vines

before lifting the groundnuts. The vines were windrowed for about five days before being stored for the feeding trial. These two types of groundnut hay, unchopped gamba grass and unchopped maize stover were the feeds used. Intake was highest for the high quality groundnut hay, followed by traditional quality groundnut hay. The differences in intake, however, were not significant between the hays nor was the weight gain significantly different. Intake was lowest for gamba grass but weight losses were greatest on maize stover. Table 3 indicates these values on a per animal basis.

Table 3. Intake and Gain/Loss for Trial 82-1.

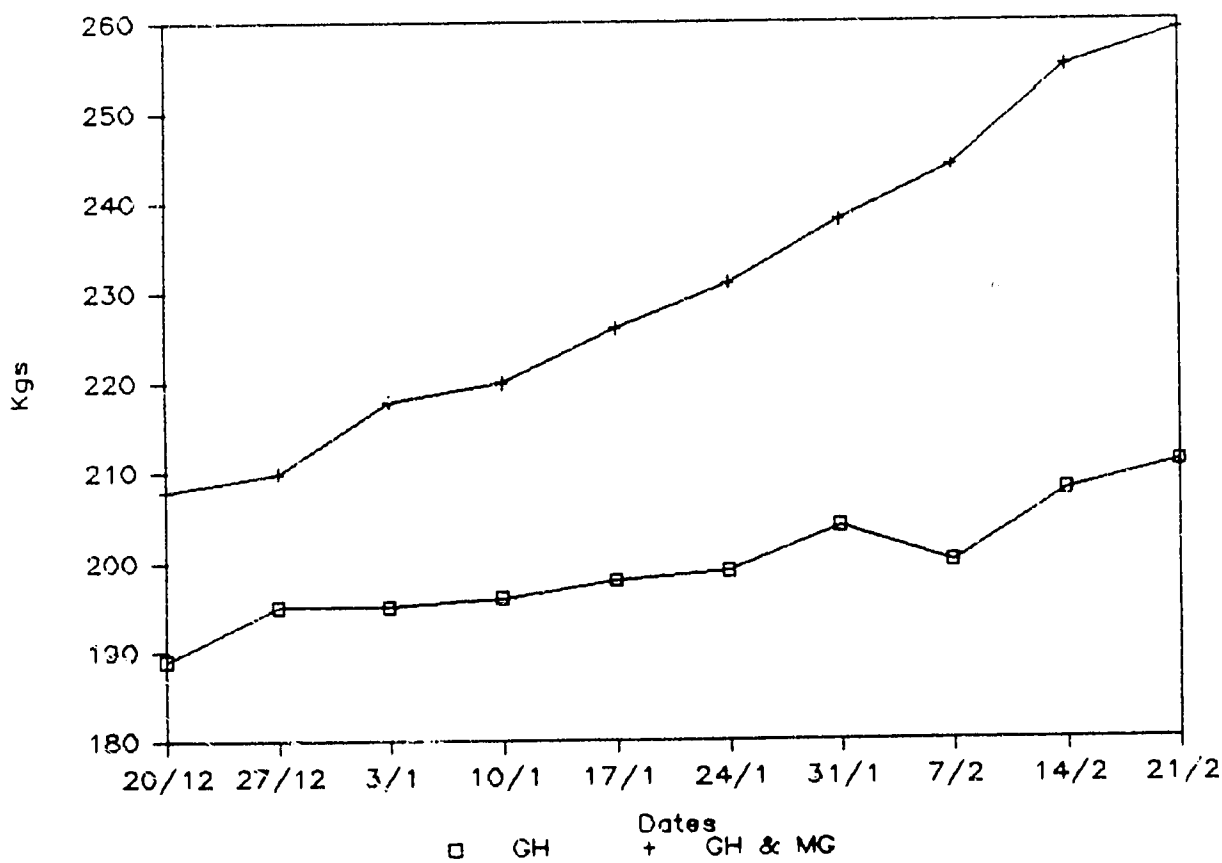
Forage	Average Daily Intake (Kg)	Average Gain or Loss During Trial (Kg)
Maize stover	4.4	-6.3
Gamba grass hay	3.5	-2.5
Traditional groundnut hay	5.3	11.3
Good quality groundnut hay	6.0	12.5

Trial 82-2 was a very brief trial designed to study rice straw as a feed compared with traditional groundnut hay. The results showed that one-year old weaners were able to maintain their weight for a brief period. Based on these results, rice straw was included in a trial the next season.

Initially the Maize Agronomy Unit had planned to raise maize for livestock feed but it proved so popular for human consumption that its promotion as livestock feed was abandoned. Neverthe-

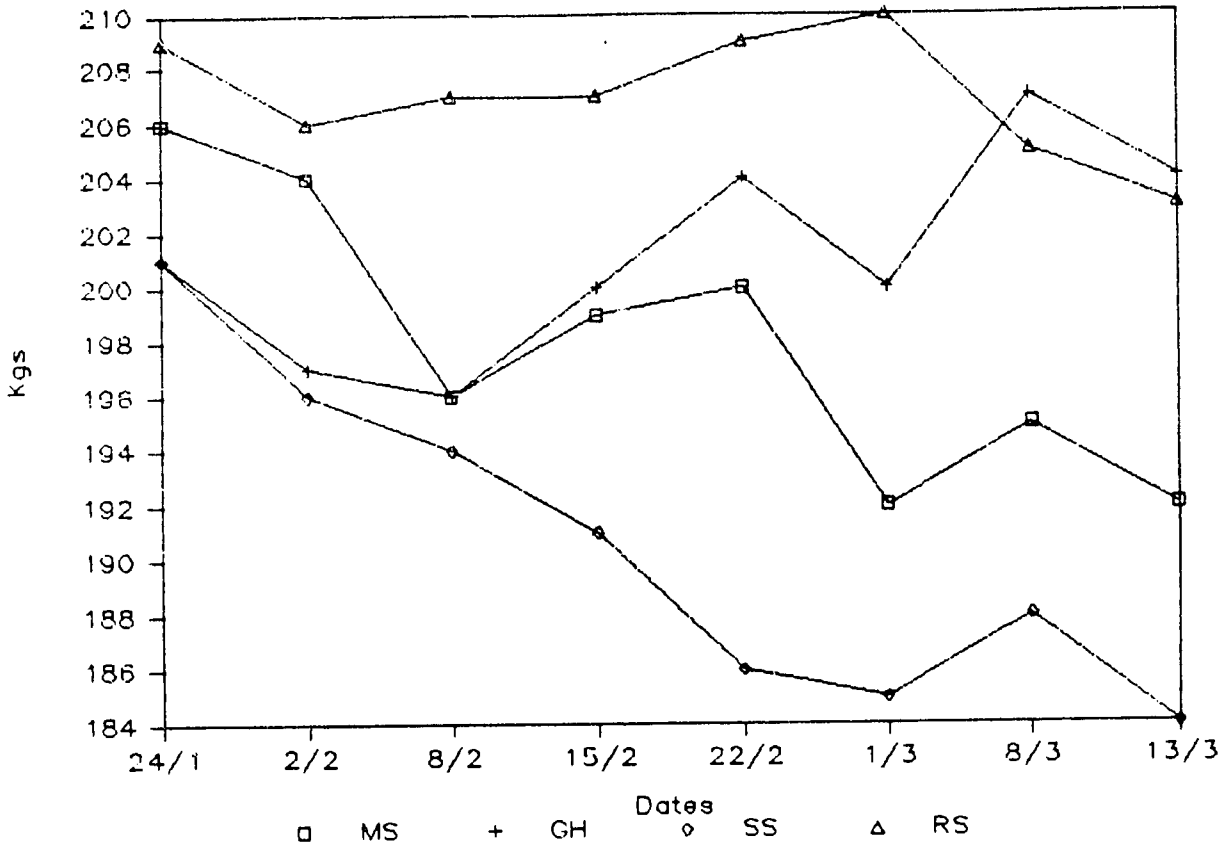
less, the maize agronomist desired to test the efficacy of maize grain for fattening N'dama bulls so Trial 82-3 was run, using groundnut hay and maize grain. The group fed groundnut hay alone finished the 63 day trial with an average per animal weight gain of 22.5 Kg, the group fed groundnut hay and maize grain finished with an average weight gain per animal of 51.25 Kg (see Figure 3). The animals were allowed free access to the feed. Those on groundnut hay only consumed an average of 5.03 Kg/day while the other group consumed 3.5 Kg groundnut hay and 2.90 Kg maize grain per day. These figures are 2.4 and 2.5% of their body weights which is just about the maximum an animal can eat. An economic analysis of the trial showed that farmers would experience a net loss if they added maize to the groundnut hay ration at the prices prevailing at the time of D390/ton for maize and D100/ton for the groundnut hay. In 1986, maize prices may go beyond D800/ton due to consumer demand.

Figure 3. Trial 82-3



GH: Groundnut hay
GH & MG: Groundnut hay and maize grain

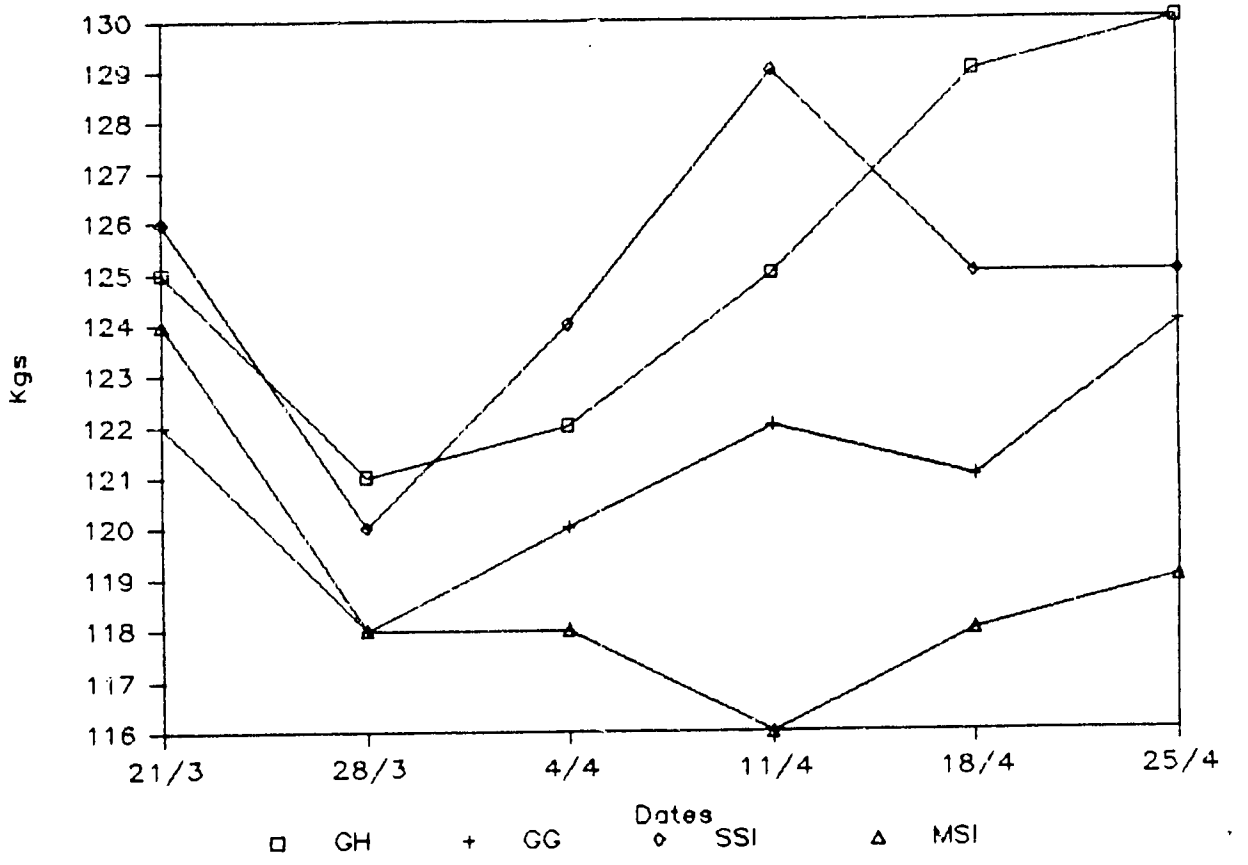
Figure 4. Trial 83-1



MS: maize stover
GH: groundnut hay
SS: sorghum stover
RS: rice straw

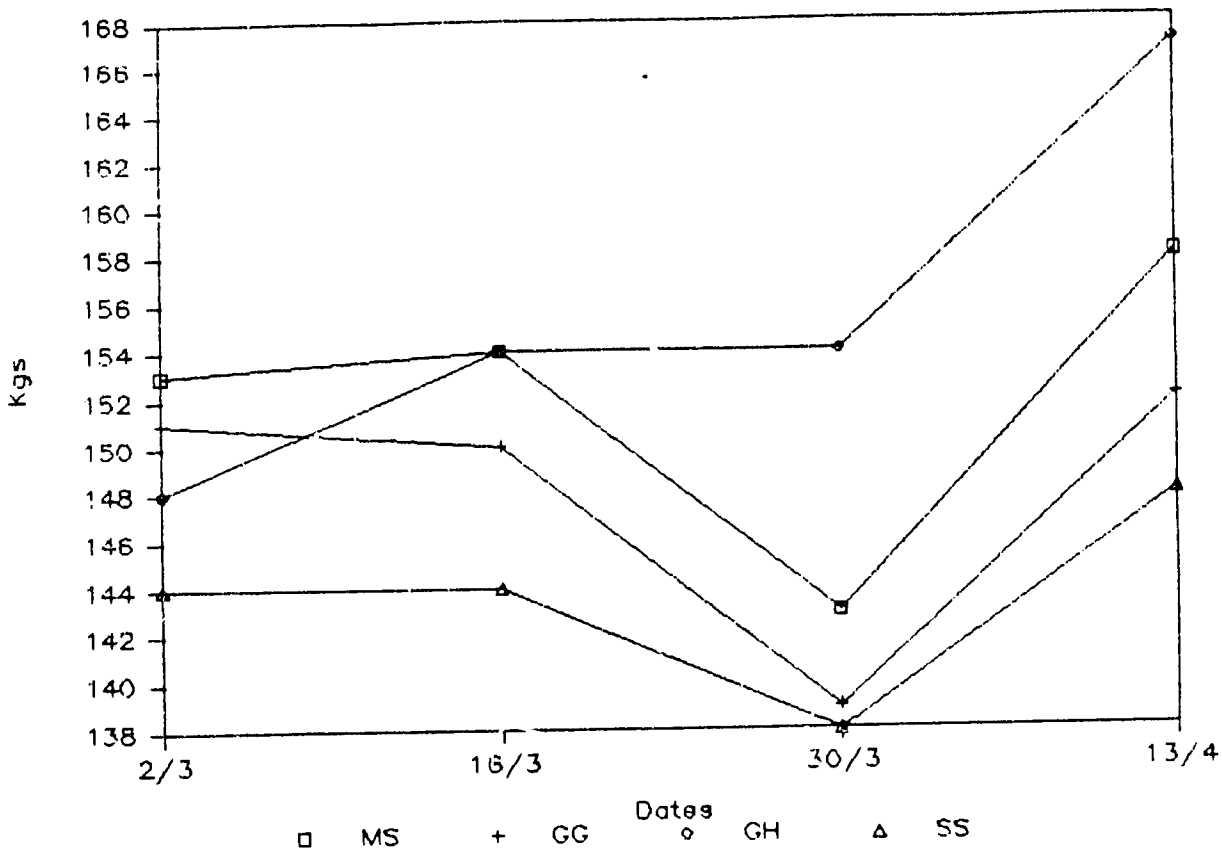
In 1983 improvements were made to the pens and feeding troughs to facilitate dispensing feed and recovering residues. Trial 83-1 with two-year old heifers used groundnut hay, maize stover, sorghum stover and rice straw. Weight gains or losses per animal on these feeds were 6.7 Kg., -11.2 Kg, -12.5 Kg and -3.75 Kg respectively for the 38-day trial (see Figure 4). The animals consumed almost all of the groundnut hay and rice straw; intakes of these two feeds were almost 30% higher than intake of the stovers. Despite moderate weight losses the animals were reported to be vigorous and healthy at the end of the trial.

Figure 5. Trial 83-2



Yearling heifers were used for Trial 83-2 and were fed groundnut hay, gamba grass hay, maize silage or sorghum silage. All feeds maintained the yearlings weight during the trials but only groundnut hay and gamba grass produced positive gains (see Figure 5). The animals seemed to take a long time adjusting to the feeds, only showing gains toward the end of the trial.

Figure 6. Trial 84-1



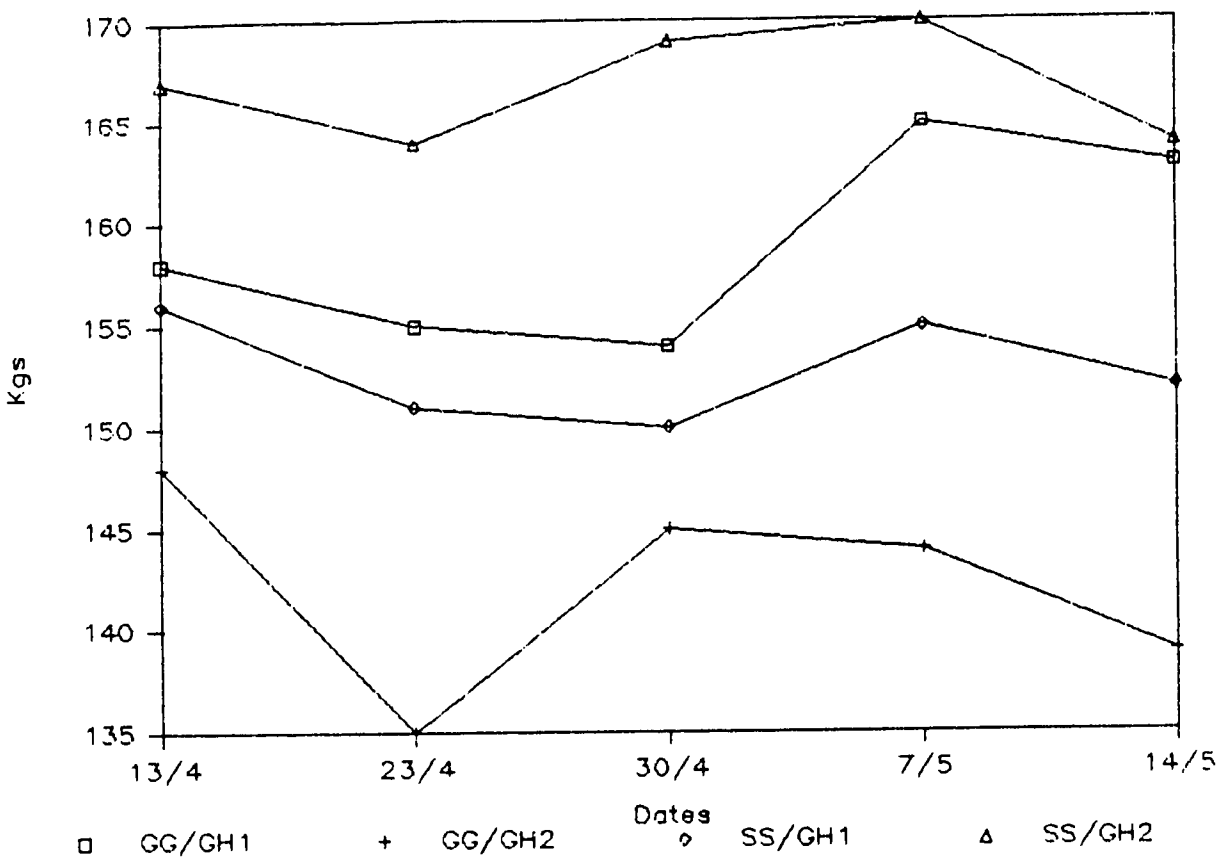
MS: maize stover
GG: gamba grass hay
GH: groundnut hay
SS: sorghum stover

There is little doubt that an excellent quality silage product can be made from sorghum or maize in The Gambia but the production of the silage requires inputs not available to the majority of farmers, viz., a power-driven forage chopper and heavy plastic to line the trench. Good silage can only be made from good quality feed, in this case, the entire maize or sorghum plant including grain. Such grain is best put to human use. Many studies have shown that silage can be made on a small scale, for example, manually chopped fodder packed in oil drums and sealed with mud, but this requires a great deal of intensive, organized labor and the quantity produced is adequate for only small ruminants or perhaps a dairy cow. Therefore, despite the

interesting results of this silage feeding experiment, further studies have been postponed indefinitely.

Trial 84-1, with 20 two-year old heifers (5 per treatment), used maize stover, sorghum stover, gamba grass hay and groundnut hay. The first three feeds were chopped with a manually operated chopper to increase intake. In this trial all animals gained weight (see Figure 6) with the expected maximum weight gain occurring with groundnut hay (+ 19 Kg). Average daily intakes were much higher (4.98 Kg) for groundnut hay as compared with the other feeds, maize stover being the lowest at 2.31 Kg.

Figure 7 Trial 84-2

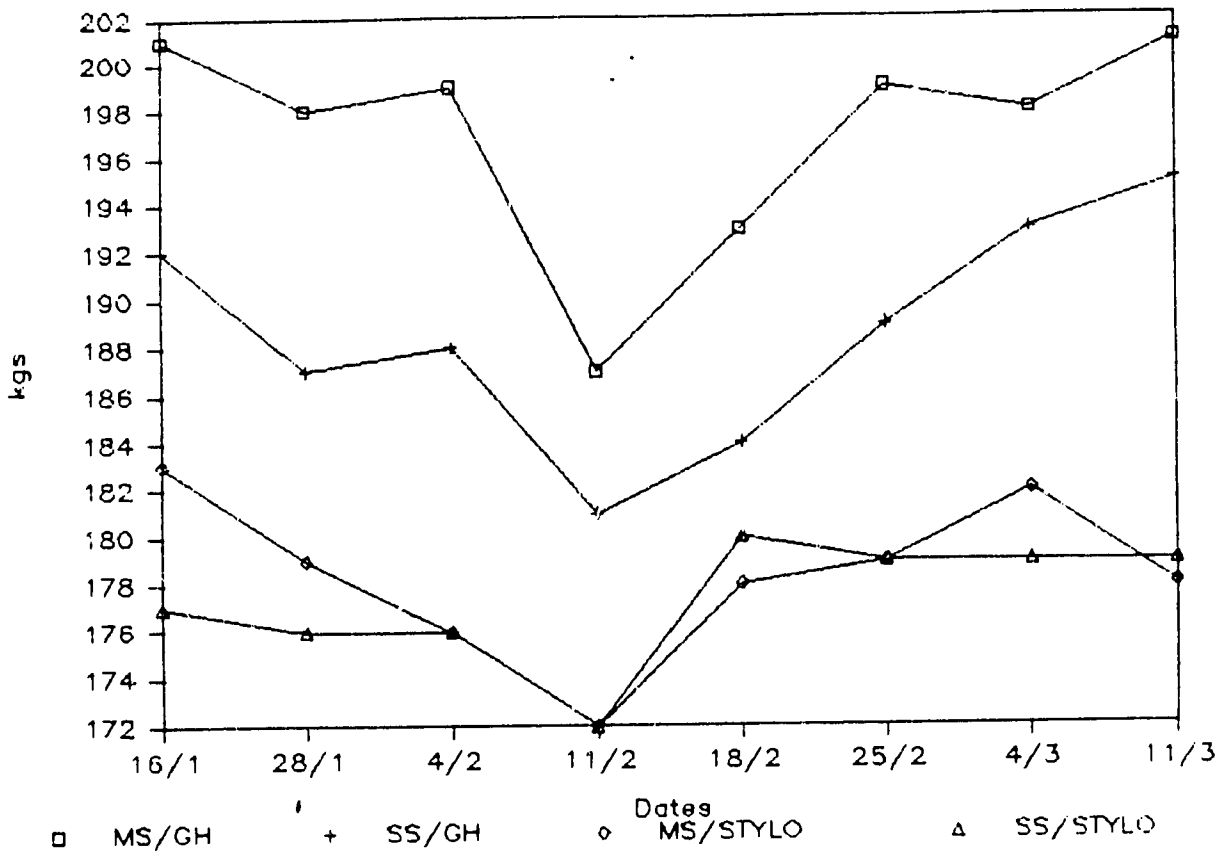


GH/GH1 and GG/GH2: gamba grass and groundnut hays. Reps 1 and 2

SS/GH1 and SS/GH2: sorghum stover and groundnut hay, Reps 1 and 2

The same heifers were used for Trial 84-2 in which they were fed one of two rations replicated twice: either groundnut hay and gamba grass or groundnut hay and sorghum stover. In this trial, all of the animals showed weight losses the last week of the trial and only one replicate of the groundnut hay-gamba grass ration produced an overall weight gain of 5 Kgs for the course of the trial (see Figure 7). Intakes were fairly uniform throughout the test period. From the beginning of trial 84-1 to the end of Trial 84-2, 16 out of 20 animals gained or maintained their weight, 3 animals lost 5 Kg or less and one animal lost 17 Kg.

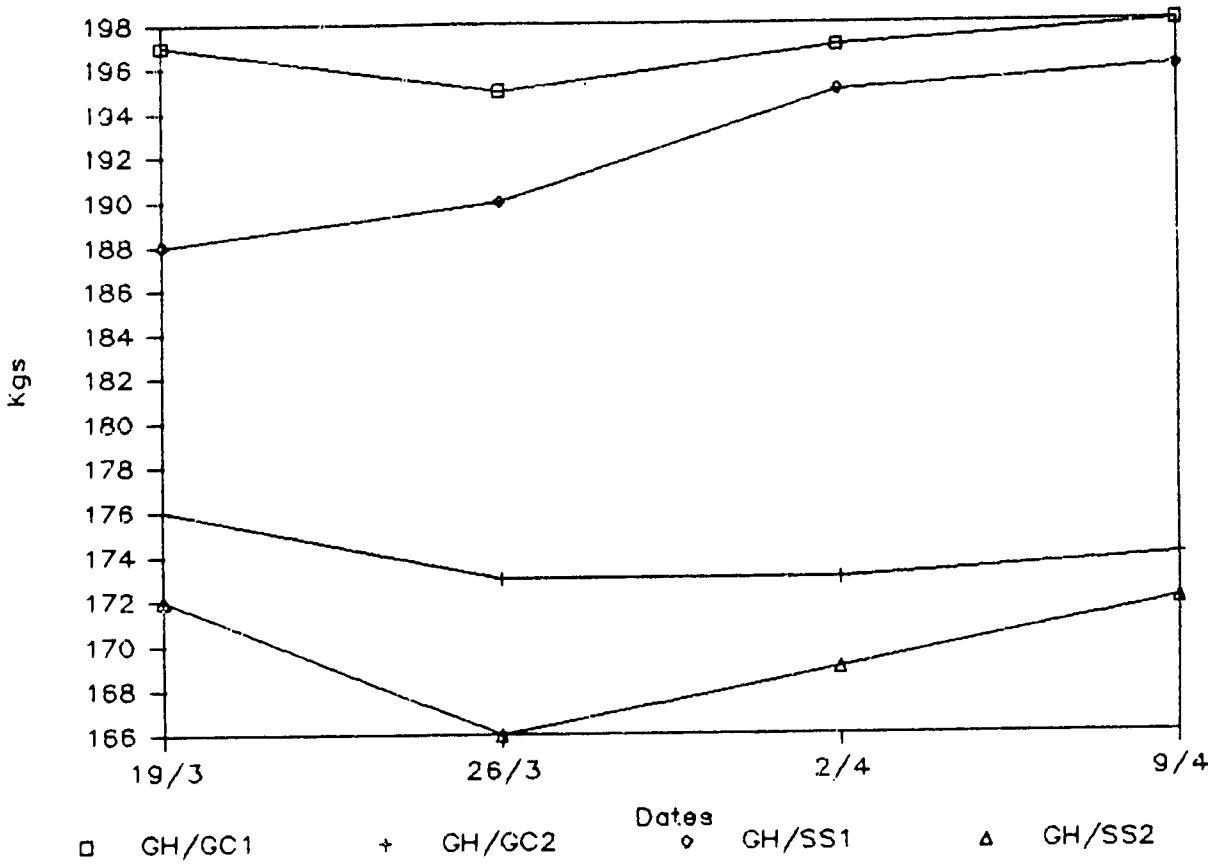
Figure 8. Trial 85-1



MS/GH: maize stover and groundnut hay
SS/GH: sorghum stover and groundnut hay
MS/STYLO: maize stover and Stylosanthes hay
SS/STYLO: sorghum stover and Stylosanthes hay

Due to management problems at the Farmyard, in 1985 all feed was stored at the field site and all feed and refusal weighings were done there. Trial 85-1 combined stovers and legume hays on a 1:1 basis. The feeds were maize stover or sorghum stover and groundnut hay or Stylosanthes hay. Twenty three-year old heifers were used. Average daily intake was equal for all feeds. Sorghum stover and either of the legume hays gave the best gains while animals on maize stover and legume hay only maintained or even lost weight (see Figure 8).

Figure 9. Trial 85-2

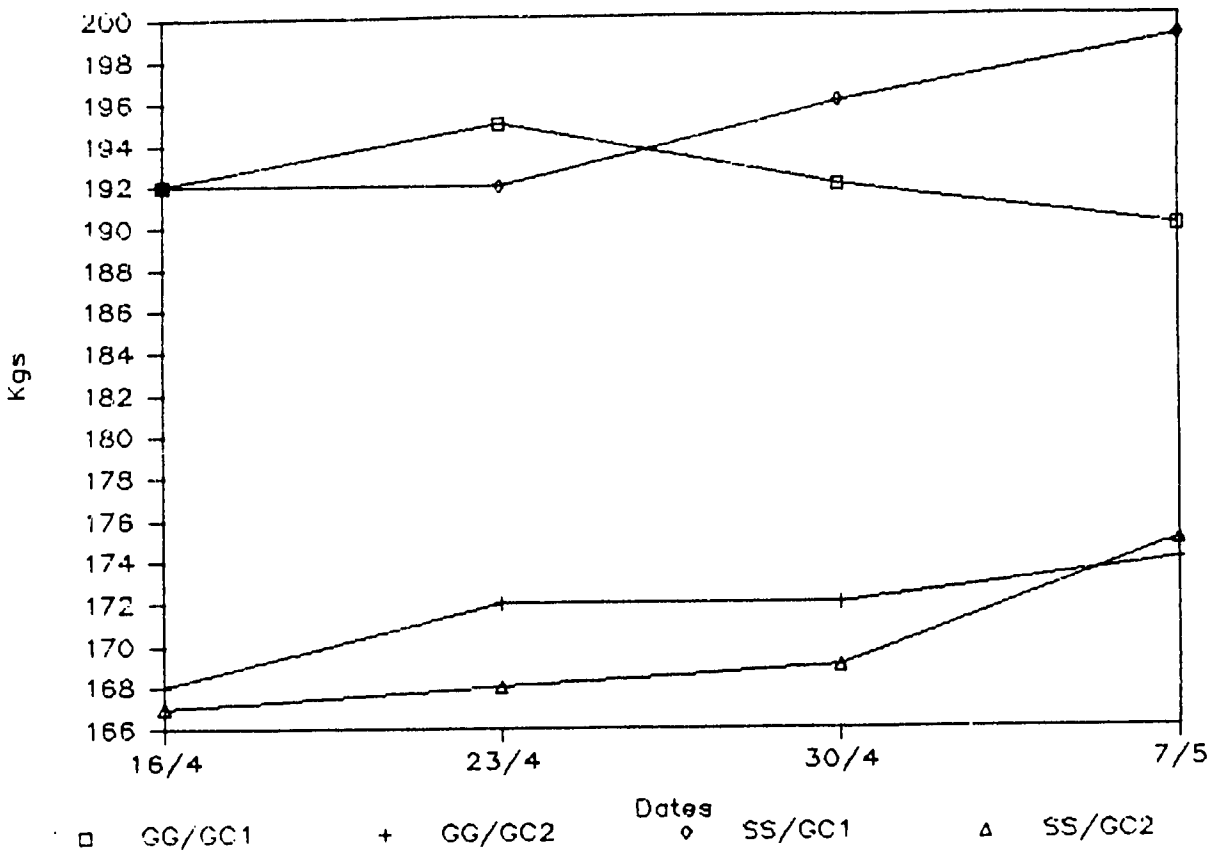


GH/GG1 and GH/GG2: groundnut hay and gamba grass, Reps 1 and 2.

GH/SS1 and GH/SS2: groundnut hay and sorghum stover, Reps 1 and 2.

In Trial 85-2, Trial 84-2 was repeated (see above, Figure 7) in order to replicate the experiment over time. Intake of the ration of sorghum stover and groundnut hay was higher than of the gamba grass-groundnut hay ration. Weight gains and losses were minimal (see Figure 9).

Figure 10. Trial 85-3



GG/GC1 and GG/GC2: gamba grass and groundnut cake, Reps 1 and 2.

SS/GC1 and SS/GC2: sorghum stover and groundnut cake, Reps 1 and 2.

In The Gambia there are several agroindustrial by-products available in certain areas. These are groundnut cake and groundnut dust (Banjul), citrus pulp (Yundum), rice bran (Kaur) and cotton seeds (Basse). The purpose of Trial 85-3 was to determine the feeding value of groundnut cake. Two treatments, replicated twice, were used: gamba grass or sorghum stover fed ad libitum with 5 Kg/head of groundnut cake. In 3 of the 4 treatments, animals gained weight (see Figure 10). The entire group gained an average of 238g/day. From January through May, heifers in these trials lost an average of 3.75 Kg. Some lost as much as 20 Kg while others gained up to 10 Kgs.

On all of the crop residues, with the exception of maize grain and groundnut cake which are high in both energy and protein, animal weights were usually maintained with the likelihood of actual gains occurring increasing with the amount of groundnut hay in the ration. This is to be expected because groundnut hay is a feed both high in protein and energy. A limited number of the feeds used in these trials have been analyzed for their nutritive value. Facilities for forage analyses are limited in The Gambia both by out-moded equipment and lack of reagents. The inability to determine the quality of feedstuffs makes it difficult, at times, to interpret results of the feeding trials. Analyses have been done of a few selected feedstuffs (see Tables 4, 5, and 6). All of the crop residues used, except groundnut hay, are quite low in crude protein content. Mixing the various residues with groundnut hay appears to be an excellent way to increase the crude protein content of the ration (see Table 4). Groundnut cake is very high in protein but is only available in the Banjul area. Groundnut dust, interestingly enough, is no better than groundnut hay as a protein source.

Table 4. Analyses of Crop Residues Used in Trials 83-1 and 33-2

Feedstuff	Crude Protein	Crude Fiber	Ash
Groundnut hay	11.9	24.4	6.3
Rice straw-Jan. 83	4.4	28.2	20.8
Gamba grass hay	4.0	36.5	4.5
Maize stover	3.1	37.1	4.5
Sorghum stover	1.7	33.9	6.2
Maize silage	3.5	32.0	6.0
Sorghum silage	4.4	27.8	6.6
Rice straw-April 83	2.8	32.5	n.a.

n.a. - not available

Analyses done at DAHP lab., Abuko

The neutral detergent fiber analyses (NDF, ADF, cellulose and lignin, Table 6) indicate that gamba grass hay, sorghum stover and Stylosanthes hay are fairly low quality feeds because they are high in poorly digestible fiber. This is coupled with low protein values for these feeds. The two legume hays are very high in lignin which is also usually associated with poor digestibility.

It should be stressed that the figures presented here are one time estimates of the feed quality of the crop residues. Data on fertilization of the crop, harvest and storage methods and date of sampling are essentially not available yet all of these factors have a significant effect on feed quality. Nevertheless, it is possible to visualize what would be required of the locally available feedstuffs to produce a reasonably balanced ration for livestock.

Table 5. Crude Protein Analyses of Feed and Orts for Trial 85-1

Feedstuff	MS/GH	SS/GH	MS/SH	SS/SH-
Feed	13.4	11.9	10.6	10.4
Orts	11.0	10.3	10.6	11.1

MS/GH - Maize stover and groundnut hay
SS/GH - Sorghum stover and groundnut hay
MS/SH - Maize stover and Stylosanthes hay
SS/SH - Sorghum stover and Stylosanthes hay

Table 6. Analyses of Crop Residues Used in Trials 85-1, 85-2, 85-3

Feed-stuff	DM	Ash	Pro-tein	Ether Extract	NDF	ADF	Cellu-lose	Lignin*
G.G.	95.5	4.4	1.8	n.a.	78.7	45.7	39.2	6.5
G.H.	94.8	8.5	11.6	n.a.	47.5	36.7	26.3	10.4
M.S.	97.5	41.4	2.9	n.a.	49.2	29.7	22.8	6.9
S.S.	96.2	10.6	3.1	n.a.	71.7	45.2	35.4	9.8
S.H.	95.9	10.2	4.2	n.a.	73.6	57.3	40.5	16.8
G.C.	95.3	4.3	52.2	5.6	20.4	13.4	10.5	2.9
G.D.	95.8	16.9	11.5	4.3	55.8	44.6	29.5	15.1

G.G. - Gamba grass
G.H. - Groundnut hay
M.S. - Maize stover
S.S. - Sorghum stover
S.H. - Stylo hay
G.C. - Groundnut cake
G.D. - Groundnut dust

n.a. - not available
Analyses done at University of Sweden, Uppsala

Crop residues and stovers are generally regarded in developed economies as low quality feedstuffs, usually requiring supplementation if animal weights and condition are to be maintained. Two points need to be considered. The first is that free-ranging ruminants normally have a choice of diet and when presented with stover will initially select the most palatable portions of the total plant, usually the leaves. An interesting study by Powell (1985) showed there were significant differences between the nutritive value of plant parts of sorghum, millet, maize and groundnuts. In maize plants the stalks were the most digestible part of the plant, being lower in lignin, NDF and ADF. Sorghum

and millet leaves were the most digestible portions of those plants while all parts of groundnuts, as expected, were highly digestible. Cereal crop residues would be of highest value just at harvest when the plants are still green and leafy, a factor which should be remembered in farmer training and extension visits.

Yet a second point is perhaps more important at this stage of stover feeding in The Gambia (and probably in other parts of Africa). Almost any crop residue has value as a dry season feed if only in that it prevents the drastic weight loss that usually occurs at that time of year. Even a low quality feed is used efficiently when an animal is under nutritional stress. In 1985 when the rains were four weeks late only those very few animals participating in the village feeding trials had something to eat. While research on crop residue feeding strategies continues, the first step of convincing farmers of the value of crop residues was made as a result of the late rains.

One crop residue in The Gambia that has always been utilized, to a greater or lesser extent, is groundnut hay. There are several ways to produce the hay, giving a product that ranges from bright green leafy material to dry stems and roots. According to Powell (1985) even the stems and roots of groundnuts are of higher feed value than residues of other crops. Trial 82-1 showed no significant differences in weight gain or intake between traditionally made groundnut hay and improved, good quality groundnut hay. In whatever form, this residue is an excellent feedstuff. In the past, it was kept primarily for draft animals and small ruminants or sold to Senegalese traders. Recently, however, farmers are saving as much as possible for their own livestock use. While hay may never be equal in monetary value to the nuts themselves, it is interesting to note that in the past three years a lorry load of hay has gone from D30 to D150 and that

groundnut hay is almost as difficult to obtain as fuel wood in urban areas.

Recommendations

Forage agronomy worldwide moves between two disciplines, crop agronomy and animal production. In The Gambia, the Forage Agronomy Unit works with both the Ministry of Agriculture and the Department of Animal Health and Production. This working relationship needs to continue in order to facilitate research and extension efforts.

Further research must be conducted on crop residues for all classes and types of livestock: young, old, draft, cattle, sheep, goats. In future work, multi-year research plans should be developed, including control groups, in order to determine the long-term effects of feeding crop residues on such factors as age at first conception, milk production, offspring per lifetime and slaughter weight. Economic studies should be included to determine the real cost of crop residues at the farm level. Would a farmer, for example, ultimately make more money by selling crop residues to other farmers than by feeding them to livestock. The excellent quality of groundnut hay was shown from these feeding trials. When used in combination with other crop residues it improves weight gains considerably. Extension agents should encourage farmers to take the extra effort to save their groundnut hay for dry season feed and to use it in combination with the stovers they have saved. The village-level feeding trials started by the project are of interest to farmers and a good way to test and demonstrate results from the research trials. It is not expected that all crop residues will be fed to Gambian livestock nor that all livestock will eat crop residues. What needs to be determined is the quality of the residues, the best time to feed them and which animals will benefit most from the feeding.

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