OVERCOMING CONSTRAINTS TO THE EFFICIENT UTILIZATION OF AGRICULTURAL BY-PRODUCTS AS ANIMAL FEED

PROCEEDINGS OF THE FOURTH ANNUAL WORKSHOP
HELD AT THE INSTITUTE OF ANIMAL RESEARCH,
MANKON STATION, BAMENDA, CAMEROUN
20–27 OCTOBER 1987

ARNAB is coordinated by ILCA with
the financial support of the International
Development Research Centre (IDRC), Canada

DECEMBER 1989

AFRICAN RESEARCH NETWORK FOR
AGRICULTURAL BY-PRODUCTS (ARNAB)
ILCA, P.O.BOX 5689, ADDIS ABABA, ETHIOPIA

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Edited by
A.N. Said and B.H. Dzowela

Editorial Sub-Committee
A.A. Adegbola, J.A. Kategile, D.A. Little,
M.A. Naga and S. Sibanda

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PREFACE

The theme of the Fourth Annual Workshop was on "Overcoming constraints to the efficient utilization of agricultural by-products as animal feed". It was held at the Institute of Animal Research, Mankon, Bamenda, Republic of Cameroun, 20–27 October 1987. The workshop was sponsored by the International Development Research Centre (IDRC), Canada, which is the co-funding agency for the African Research Network for Agricultural By-products (ARNAB). The logistical support was provided by the International Livestock Centre for Africa (ILCA). The Steering Committee would like to record their appreciation to IDRC and to ILCA for the financial and logistical support.

His Excellency Mr Abdoulaye Babale, Minister for Higher Education and Scientific Research of the Republic of Cameroun, was the Guest of Honour and opened the workshop. Dr Emmanuel D. Tebong, Director of the Institute of Animal Research, Cameroun, also officiated at the opening ceremony.

The ARNAB Steering Committee would like to record their appreciation to His Excellency Mr Abdoulaye Babale for finding time in his busy schedule to open the workshop and for his encouraging words and for his hospitality in hosting the workshop dinner. The Steering Committee would also like to express their appreciation to the workshop hosts, the Institute of Animal Research, Mankon, Bamenda. In particular we would like to express our gratitude to Dr Emmanuei D. Tebong, the Director and to Dr Ruby Fomunyam, Mankon Station Manageress, and to all the staff at the station who spent so much of their valuable time assisting the Secretariat in the various aspects of the workshop organization and also in playing host to the workshop participants.

Finally we would like to record our thanks and appreciation to the individual members of the Editorial Sub-Committee for the initial editing of those papers allocated to them. We would also like to thank Aster Amde, Azeb Bekele, Fantu Solomon and Tsedale Layeh for word processing some of the papers. We thank Shewangezew Lemma for putting in so many hours word-processing and formatting the final camera-ready copies.

Editors.

CONTENTS

STRATEGIES FOR FEEDING STRAW TO SMALL RUMINANTS: UPGRADING OR GENEROUS FEEDING TO ALLOW SELECTIVE FEEDING

E. Owen, R.A. Wahed[1], R. Alimon[2] and W. El-Naiem[3]
Department of Agriculture, University of Reading,
Earley Gate, P.O.Box 236, Reading RG6 2AT, UK

ABSTRACT

Population growth will accelerate crop - animal integration, creating a need for stall-feeding systems for goats and sheep based on crop residues, especially on small farms. Five experiments with goats and two with sheep showed that allowing small ruminants to 'stall-graze' long barley straw will increase intake because of selective feeding. Allowing goats to reject 50% of the straw offered, instead of the conventional ad libitum refusal-rate of 10 to 20%, increased straw dry-matter intake by 30 to 47%, and that of the estimated digestible straw by 41 to 78%. In one experiment, goats fed rejected straw (50% rate) after treatment with ammonia, consumed as much digestible straw as when the original straw was fed generously. Botanical fractionation of offered straw and rejected straw showed goats to select leaf rather than stem when the amount offered was large enough to allow selective feeding. Similar experiments with tropical straws are required.

INTRODUCTION

The case for crop residues, small ruminants and stall-feeding

The future importance of agricultural by-products as feeds for livestock, particularly fibrous by-products for ruminants, is acknowledged (Owen, 1985). Identifying ways of overcoming

[1] Permanent address:University of Mosul, Mosul, Iraq.
[2] Permanent address:University of Pertanian Malaysia, Serdang, Selangor, Malaysia.
[3] Permanent address:Gezira Board, Barakat, Sudan.

constraints to their greater utilisation as feed is therefore an appropriate theme for the present workshop.

Sundstol and Owen (1984) pointed to the inevitability of straw being produced as a by-product of growing cereals for man. With world population predicted to double by 2025, cereal production and hence straw production, will obviously increase. This will be particularly so in the developing tropics where population is likely to treble by 2025. The change will reduce the area available for pastoral farming and accelerate the integration of crop and animal (mainly ruminant) agriculture (Gartner, 1984).

During the past decade the importance of small ruminants (especially goats) to the agriculture of developing countries has at last been recognised (Devendra and Burns, 1983; World Bank and Winrock International, 1983; Timon and Hanrahan, 1986). Less publicised is the fact that the small ruminants are mainly associated with small farmers; and it is the small farmers who will increasingly need to practise crop - animal integration. A major constraint to the latter is damage to food crops caused by indiscriminate grazing, especially by goats. For these reasons, we believe that there is need to research and develop stall-feeding systems for small ruminants based on crop by-products.

Background to experiments undertaken - the grazing animal

Methods of upgrading straws as feed are well documented (Sundstol and Owen, 1984) and guidelines on researching the subject are published (Preston et al, 1985). There has been more emphasis on upgrading straws for cattle than sheep (Greenhalgh, 1984) but goats have received little attention (Owen, 1981; Owen and Kategile, 1984). The expense of upgrading techniques and the technical expertise required are frequently cited as being inappropriate for developing countries. Greenhalgh (1984) concluded that in many situations chemical upgrading will be superceded by breeding more nutritious straws, improved harvesting methods and judicious supplementation. The research to be reported suggests another approach, namely to improve animal productivity from crop residues by using the selective eating behaviour of goats and sheep.

The literature on feeding straws to sheep and goats involves experiments where intake and digestibility have been measured under ad libitum feeding. Ad libitum is defined as offering sufficient (usually in chopped form) to ensure that 15 to 20% is left (refused) at the end of the feeding period (Blaxter et al, 1961). This approach is standard and has the advantage (for the experimenter, but not the animal) of minimising selective feeding. We would argue that the latter is a disadvantage. The capacity of sheep (Gibb and Treacher, 1976) and goats (McCammon-Feldman et al, 1981) to graze and browse selectively is recognised. Indeed experiments (e.g. Gibb and Treacher, 1976) indicate that maximum intake by grazing sheep is achieved only if the herbage allowed (g organic matter per kg liveweight day, g OM/kg w.d) exceeds intake by 400%. We therefore hypothesised that conventional ad libitum feeding of straw, allowing excesses of only 15 to 20%, would restrict intake (by reducing the opportunity to select).

This hypothesis was tested in the experiments to be reported.

The experiments are also aimed at helping us develop strategies for stall-feeding straw to goats and sheep.

MATERIALS AND METHODS

Seven experiments conducted at Reading University during the past five years are presented. All involved measuring straw intake (as affected by various parameters) and aimed to assess the degree of selective feeding, by careful sampling and analysis of feed offered and refused. Except in Experiment 1 (no concentrate fed), all involved feeding a concentrate supplement (sugar beet pulp, 600 g/kg; soya bean meal, 180 g/kg; fish meal, 180 g/kg; minerals and vitamins, 40 g/kg) at 15 g DM/kg $W^{0.75}$. d. to satisfy nitrogen, mineral and vitamin requirements (Agricultural Research Council, 1980) for maintenance and modest growth in sheep. Numbers of animals used, type and mean weight are shown in Tables 1 to 7. All experiments involved housed (16 hours light, 8 hours dark) individually penned castrated animals bedded on sawdust and provided with water. In Experiment 6 goats were in metabolism cages and faeces was collected over 9 days following a preliminary period of 14 days. In all experiments preliminary periods were of 14 to 21 days and experimental periods (except Experiment 6) lasted 21 days (42 days in Experiment 4). Feeds were offered twice daily and straw refusals carefully collected daily. Representative samples (based on aliquots) of straw offered and refused were taken daily and subsequently analysed, after pooling (Wahed and Owen, 1986),for dry-matter, ash and nitrogen (AOAC, 1975), acid detergent fibre (Goering and Van Soest, 1970) and *in vitro* digestibility (Tilley and Terry, 1963).

RESULTS

Treatments applied in given experiments and results obtained are shown in Tables 1 - 7.

Experiment 1 (Table 1) was designed to examine whether any of the claimed superiority of goats over sheep, in regard to roughage intake and digestion, could be attributed to differences in food selected in a stall-feeding situation. The straw used was treated with aqueous ammonia using a stack method (Sundstol and Coxworth, 1984). The experiment showed goats to eat more than sheep, but there was no large difference between the quality of straw refused by the two species. What was clear, however, was that both species were feeding selectively. Refused straw was of lower nutritive value than that offered.

Table 1.

Experiment 1. Intake and selection of NH_3-treated barley straw by sheep and goats.

	Suffolk cross Mule wethers	Saanen castrate goats	SED
Number of animals	8	8	
Liveweight (kg)	57.9	50.7	9.0
Straw intake			
Offered[a] (g DM/d)	1299	1477	
Intake (g DM/d)	956	1117 152.4	
(g DM/kg W.d)	16.4	21.6	1.5

Chemical composition	Straw offered	SE		Straw refused	
Nitrogen (g/kg DM)	17	0.5	11.6	12.2	0.6
Acid-detergent fibre (ADF) (g/kg DM)	567	5.7	612	600	6.4
In vitro digestibility (DOMD)[b] (g OM/kg DM)	607	6.0	544	566	

[a] To allow a refusal rate of 20 to 25% of amount offered.

[b] Tilley and Terry (1963).

Source: Wahed and Owen (1986a).

Experiment 2 (Table 2) was the first trial to test the hypothesis outlined earlier. Allowing goats to refuse 50% of the straw offered clearly led to greater DM intake (by 31%) than allowing the more conventional 20% refusal rate. Refusal quality indicated goats allowed the higher refusal rate were selecting more nutritious straw. Thus the estimated intake of straw digestible OM (based on in vitro digestibility) was markedly higher (by 40%). The goats used (18 / treatment) represented a wide range of liveweight (15 to 65 kg). Small goats tended to be more selective than large ones.

In Experiment 3 (Table 3) increasing the refusal rate allowance increased intake of both long and chopped straw. The trend (non-significant) was for greater intake of long straw. Straw length interacted significantly with refusal-rate for refusal digestibility, indicating easier selective feeding with long rather than chopped straw. All subsequent experiments were therefore carried out with long straw.

Experiment 4 (Table 4) simulated the 'grazing approach' (e.g. Gibb and Treacher, 1976) in that the amount of straw offered was based on goat weight so as to achieve a target rate of refusal. The results, however, corroborated those of Experiments 2 and 3. They also showed, as expected, that intake response increased with increasing allowance rate. This was particularly so for the estimated digestible OM intake. Experiment 5 (Table 5) with sheep showed similar results.

Table 2.

Experiment 2. Effect of allowing two rates of refusal on intake and selection of barley straw by goats.

	Straw refusal allowance 20%	50%	SED
Number of goats [1]	18	18	
Straw intake [2] (g DM/kg W.d)	14.4	18.9	0.70
Straw intake (g DM/kg $W^{0.75}$. d)	33.1	43.7	1.60
Straw refused (% of offered)	20.5	48.3	
Estimated intake of straw digestible OM [3] (g/kg W.d)	5.9	8.3	

Chemical composition of straw	Straw offered Mean	SE	Straw refused		
Nitrogen (g/kg DM)	5.1	0.02	4.5	4.6	0.13
ADF (g/kg DM)	552	7.0	612	596	4.8
In vitro DOMD [4] (g OM/kg DM)	412	4.8	320	347	7.7

1. Mean liveweight (W) 32.6 kg.
2. Concentrate supplement also fed at 15 g DM/kg $W^{0.75}$. d
3. Calculated from *in vitro* digestibility of straw offered and refused.
4. Tilley and Terry (1963).

Source: Wahed and Owen (1986b).

Table 3.

Experiment 3. Effect of chopping the straw on the response of goats to increasing refusal-rate allowance.

Treatments[1]	Refusal-rate main effect 20%	50%	Straw length main effect Long	Chopped[2]	SED Main effect	Refusal rate x straw length interaction
Number of goats[3]	16	16	16	16		
Straw intake (g DM/kg W.d)	13.1	18.0	16.5	14.7	1.71	NS
Straw refused (% of offered)	19.4	49.1	39.3	40.8		
Composition of refused straw						
Nitrogen (g/kg DM)	4.9	5.0	4.7	5.2	0.22	NS
ADF (g/kg DM)	583	582	608	557	5.64	NS
In vitro DOMD[4] (g OM/kg DM)	343	371	326	388	1.20	$P<0.05$[5]

1. Design: 2 x 2 factorial, 8 replicates.
2. Using a precision-chop stationary forage harvester.
3. Mean liveweight (W), 30.5 kg.
4. Tilley and Terry (1963).
5. Difference between long and chopped greater with 20% refusal-rate.

Source: Wahed (1987).

Table 4 .

Experiment 4. Effect of amount offered on intake and selection of barley straw by goats.

	Straw offered (g DM/kg W.d) 18	54	90	SED
Number of goats	12	12	12	
Initial (day 1) liveweight (kg)	30.2	30.6	30.4	0.56
Final (day 42) liveweight (kg)	30.1	33.1	34.0	0.71
Straw intake [1] (g DM/kg W.d)	15.5	22.8	26.2	0.74
Straw intake (g DM/kg $W^{0.75}$ .d)	36.0	54.2	62.3	1.73
Straw refused (% of offered)	12.5	56.6	70.3	
Estimated intake of straw digestible OM[2] (g/kg W.d)	7.2	12.8	14.5	

Chemical composition of straw	Straw offered Mean	SE	Straw refused 18	54	90	SED
Nitrogen (g/kg DM)	7.4	0.12	5.5	5.7	6.1	0.11
ADF (g/kg DM)	528	2.0	565	583	574	6.9
In vitro DOMD [3] (g OM/kg DM)	443	4.5	354	370	403	14.5

1. Concentrate supplement also fed at 15 g DM/kg $W^{0.75}$ .d
2. Calculated from *in vitro* digestibility of straw offered and refused.
3. Tilley and Terry (1963).

Source: Wahed and Owen (1986b).

Table 5.

Experiment 5. Effect of amount offered on intake and selection of barley straw by sheep.

			Straw offered (g DM/kg W.d)			
			18	54	90	SED
Number of wethers[1]			10	10	10	
Straw intake (g DM/kg W.d)[2]			14.1	19.0	22.2	0.81
Estimated digestibility of straw consumed[3] (g OM/kg DM)			467	562	572	
Straw refused (% of offered)			20.8	64.7	75.1	
Chemical composition of straw	Straw offered		Straw refused			
	Mean	SE				
Nitrogen (g/kg DM)	6.4	0.2	4.5	5.1	5.5	0.12
ADF (g/kg DM)	542	7.9	610	581	564	8.4
In vitro DOMD[4] (g OM/kg DM)	432	0.8	294	361	374	7.2

1. Mean liveweight (W) 52.8 kg.
2. Concentrate supplement also fed at 15 g DM/kg $W^{0.75}$ .d
3. Calculated from *in vitro* digestibility of straw offered and refused.
4. Tilley and Terry (1963).

Source: Naate (1986).

Experiment 6 (Table 6) investigated the feasibility of refeeding 'stall-grazed straw', as such, or after treatment with ammonia (stack method-Sundstol and Coxworth, 1984). Intake of untreated ' stall-grazed straw' (straw-previously-refused) was significantly less than that of the original straw, but after treatment, the intake of digestible OM (measured *in vivo*) was the same as the original, untreated straw.

Experiment 7 (Table 7) was only recently completed and aimed to assess whether intake and selection response to increasing refusal allowance would be affected by whether or not the straw was treated with sodium hydroxide (dip method according to Sundstol et al, 1981). The preliminary results are somewhat surprising, indicating no apparent increase in straw DM intake due to increasing the refusal-allowance rate. There was a response to NaOH treatment. In this experiment samples of straw offered and refused were botanically fractionated (Ramazin et al, 1986). Interestingly, the results (Table 7) indicate that with generous feeding (allowing high refusals) intake of leaf plus sheath increased and stem decreased. As expected with barley straw (Ramazin et al, 1986), Table 8 shows leaf plus sheath to be of higher nutritive value than stem.

DISCUSSION

The results obtained clearly support the hypothesis stated. Goats and sheep will consume more barley straw if they are permitted to reject 50% of that offered, rather than the conventional 10 to 20%. Furthermore, the improvement in consumption of digestible straw is even greater because generous feeding allows animals to select the more digestible fractions (leaf rather than stem).

There is need to corroborate the findings with direct measurements (*in vivo*) of digestible straw intake and also animal productivity measurement. The experiments reported

(Tables 1 - 8) are tedious to execute and offer much scope for arriving at erroneous conclusions. For example, incomplete collection of straw refusals would exaggerate treatment response, as unrecorded refusal would be deemed eaten. Grazing research techniques (e.g. Mayes et al, 1986) might have application for measuring quantity and quality of straw consumed.

The extent to which selective feeding of straw occurs with higher levels of concentrate supplementation, or when feeding other forages, needs investigating. Similarly the effect of straw allowance on consumption and selection of straws other than barley needs researching. The works of Capper et al (1986), Tuah et al (1986), Ramazin et al (1986) and Doyle et al (1986) stress the magnitude of differences between straws of a given type in terms of feeding value. Difference in leaf:stem ratios probably accounts for much of this. There are likely to be other factors e.g. content of soluble phenolics (Reed, 1986) contributing to nutritive value differences in some crop residues and other tropical forages. Interactions between straw allowance rate and straw type, as affecting intake and selectivity, are therefore likely. Zemmelink (1986) has clearly shown this to be so for tropical forages.

Table 6.

Experiment 6. Digestible-straw intake by goats fed straw or straw-previously-refused, with or without ammonia treatment.

	Straw[1]		Straw-previously-refused by goats[2]		SED
	Untreated	NH_3 treated	Untreated	NH_3 - treated	
Number of goats[3]	6	6	6	6	
Straw intake					
g DM/kg W.d	22.8	24.5	15.8	19.4	1.98
g DM/kg $W^{0.75}$.d	53.9	58.9	37.5	47.3	4.71
g digestible OM[4]/kg W.d	9.7	12.6	6.6	9.7	0.90
g digestible OM/kg $W^{0.75}$.d	22.9	30.4	15.6	23.7	2.11

1. Barley straw fed in Experiments 2 and 4; fed to allow 50% rate of refusal; straw chopped.
   Concentrate supplement also fed, at 15 g DM/kg $W^{0.75}$ .d
2. Straw from 50% refusal rates in Experiments 2 and 4; straw chopped. Concentrate supplement also fed at 15 g DM/kg $W^{0.75}$ .d
3. Mean liveweight (W) 36.0 kg.
4. In vivo digestibility measured; concentrate OMD assumed to be 80%.

Source: Wahed and Owen (1987).

Table 7.

Experiment 7. Effect of refusal rate and NaOH-treatment of barley straw on intake and selection by goats.

	Untreated straw		NaOH - straw	
Straw refusal allowance (% of offered)	20	50	20	50
Number of goats[1]	9	9	9	9
Straw offered[2]				
Amount (g DM/d)	805	1398	1031	1807
Leaf plus leaf sheath (g/kg straw DM)	449	449	451	451
Stem (g/kg straw DM)	477	477	502	502
Straw (g/kg straw DM)				
Amount (g DM/d)	166	758	197	933
Leaf plus leaf sheath (g/kg straw DM)	307	359	355	405
Stem (g/kg straw DM)	661	613	612	559
Straw consumed				
Total (g DM/kg W.d)	16.5	16.7	19.8	20.0
Leaf plus leaf sheath (g DM/kg W.d)	6.6	10.6	7.1	11.2
Stem (g DM/kg W.d)	7.1	5.3	9.4	8.8

1. Saanen castrates, mean liveweight (W) 41.4 kg
2. Concentrate supplement also fe, at 18 g DM/kg $W^{0.75}$ .d

Source: Owen et al, Reading University, Reading, UK, unpublished data.

Table 8.

Experiment 8. Composition of straw offered.

	Untreated straw		NaOH - straw	
	Leaf + leaf sheath	Stem	Leaf + leaf sheath	Stem
Ash (g/kg DM)	28.0	22.0	72.0	44.8
NA (g/kg DM)	1.7	1.2	21.1	14.5
ADF (g/kg DM)	521	668	501	610
DOMD *in vitro*[1] (g OM/kg DM)	515	262	664	367

1. Tilley and Terry (1963).
Source: Owen et al, Reading University, Reading, UK, unpublished data.

A feeding strategy allowing goats and sheep to reject 50% of the straw offered is clearly wasteful (Table 9) and can only be justified if the rejected straw can be used too. Experiment 6 (Table 6) demonstrated that rejected straw can be refed to achieve high levels of digestible straw intake provided it is treated with ammonia. Feeding untreated straw to allow 50% refusals and refeeding these after ammonia treatment would result in little wastage and would also achieve high intakes of digestible straw (Table 9). The economics of such a strategy need investigating as labour costs would be high. A simpler approach would be to graze the straw in the field. Ungrazed straw would then be collected and refed after upgrading.

Table 9. Strategies for feeding barley straw to goats.

	Feed to allow 20% refusal (conventional *ad lib* feeding)	Feed to allow 50% refusal (generous feeding)	Feed to allow 50% refusal, then reffeed refusal after NH_3 treatment and allow 20% refusal	Treat with NH_3 and feed to allow 20% refusal
Initial quantity of straw (kg DM)	1000	1000	1000	1000
Unused (refused) straw; available for bedding or other purposes (kg DM)	200	500	100	200
Total straw fed (kg DM)	800	500	900	800
Total digestible straw fed (kg OM)	350[a]	244[b]	444[c]	430[d]
Daily intake of digestible straw (g OM/kg W.d)	6.2	9.5	9.5	9.5[e]

a. Assuming digestibility of consumed straw to be 438 g OM/kg DM.
b. Assuming digestibility of consumed straw to be 488 g OM/kg DM.
c. Assuming digestibility of treated refusals to be 500 g OM/kg DM.
d. Assuming digestibility of treated straw consumed to be 538 g OM/kg DM.
e. Assuming NH_3 treatment increases DM intake by 25%.

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SMALLHOLDER LIVESTOCK PRODUCTION: CONSTRAINTS ON THE ADOPTION OF IMPROVED TECHNOLOGIES

E.N. Tambi
Institute of Animal Research, Bambui
P.O. Box 80, Bamenda, Cameroon

ABSTRACT

This study made use of information collected from a formal survey of sheep and goat farmers in the North West Province of Cameroon to test the hypothesis that the ability of a farmer to adopt a particular technology with which to increase production depends on the resources of the farmer, his/her socio-economic characteristics and expectations as well as factors outside his/her own control.

The framework of analysis was based on a multistage economic model of the adoption process relating to agricultural innovations. A general profit function was estimated by the method of maximum likelihood to derive coefficients and probabilities of explanatory variables likely to influence farmer attitudes towards increased sheep and goat production.

Estimated coefficients showed that current herd size, available pasture land, housing and fencing facilities, current income from sales, and market price for sheep and goats had significant effects on the ability to increase sheep and goat production through adopted technology. The variables - family and hired labour, age, and expected future returns from sheep and goat - did not significantly affect the decision to increase sheep and goat production. From the interviews, over 80 percent of farmers were willing to increase sheep and goat production if constraints on production and marketing were lifted. This suggested that a substantial number of farmers were being prevented by a number of factors from expanding production. Against this background of constraints, a strategy for developing the sheep and goat sectors in the North West Province should aim at not only minimising constraints against increased productivity, but also exploiting the biological,

economic, management and institutional possibilities available for sheep and goat production.

INTRODUCTION

Small ruminant production in general, and sheep and goat production in particular, has in recent years gained increasing popularity in most of the developing countries. Apart from the social and economic functions small ruminants play in developing societies, they also provide most of the meat supply for human consumption. Increased demand for goat meat for example provides potential economic advantages to farmers of small ruminants over large ruminants (Cross, 1974; McDowell and Bove, 1977). Adu and Ngere (1979) and Brinkman and Adu (1977) have estimated that sheep and goats contribute 11 and 20 percent of the meat supply in Nigeria respectively, while Bayer (1986) estimated they supply 35 percent.

The most serious constraint, however, on small ruminant production in Africa in general and Cameroon in particular is the small size of the average farm. It is estimated that there are approximately 20,000 and 57,000 sheep and goat farmers in the North West Province of Cameroon (18.3 and 13.1 percent of the national total) with sheep and goat population representing 10.9 and 12.6 percent of the national herd size respectively. The average herd size per farm is 8.8 sheep and 7.8 goats with births making up 61.7 and 56.6 percent of the increase in herd size and mortality accounting for 39.5 and 36.5 percent of the reduction in herd size respectively (Cameroon Agricultural Census, 1984). Since the herd size is small, one way of increasing it is by means of intensification; that is, increasing output in a way that is economically worthwhile to the farmer.

The key to intensification and increase in output of sheep and goat production is the application of improved production and marketing technologies. These include significant increases in the use of purchased cereal/protein feeds (concentrates) including crop by-products (Fomunyam and Meffeja, 1985) and conserved grasses (Tait, 1973), improvement of existing vegetation by upgrading soil fertility, improvement of seeding (Newbold, 1974), investments in improved stock breeds and the application of processing and marketing techniques. These measures of intensification are difficult to come by because of low income levels, inadequate resources and managerial skills as well as general socio-economic characteristics which, together, constitute production and marketing constraints in sheep and goat production. The testing of innovations and monitoring of sheep and goats on smallholder farms outside the station therefore requires an understanding of existing constraints relating to available resources, management practices, ownership patterns as well as marketing conditions.

This study made use of a formal survey with a pre-designed questionnaire to collect information on these parameters from a sample of 60 sheep and goat farmers in the North West Province of Cameroon. This was being done as a follow-up of a diagnostic survey of sheep and goat farmers carried out as part of the IRZ-IDRC on-farm research project. Given the several production and marketing constraints identified in that survey, it was observed that most sheep and goat farmers were reducing the number of animals they keep and were shifting towards crop production which seemed to offer a better alternative to subsistence life.

Based on these findings, it was hypothesised that the ability of a farmer to adopt a particular technology with which to increase productivity depends on the resources he/she has available, his/her socio-economic characteristics as well as those factors outside the farmers' own control. To the extent that these constitute constraints to the farmer, they will affect his ability to adopt the technology and therefore his ability to expand his farm size. The object of this paper therefore is to correctly identify those factors which influence the farmers' decision to increase production through improved technology.

MODEL

A farmers' attitude towards sheep and goat production is influenced by his resources, his socio-economic characteristics and expectations, and also the attributes of the present and alternative job opportunities available. The model used in analysing these factors is based on previous research concerning factors influencing the adoption of agricultural innovations (Kennedy, 1977) generally, and on explanatory variables identified from research specific to constraints on sheep and goat production and marketing in Africa (Lebbie and Mastapha, 1985; Tambi and Fomunyam, 1985).

The procedure used to measure farmer response to increased sheep and goat production was to utilise binary as well as non-binary variables to quantify factors likely to influence the positive/negative attitudes of farmers towards sheep and goat production. The economic framework rests on a multistage model of the adoption process relating to agricultural innovation (Leuthold, 1966; Kennedy, 1977; Hill and Kau, 1973; McFadden, 1976 and Opare, 1977). In the model, the farmer is confronted with a choice (to expand his/her sheep and goat operation or not to do so) to which he/she reacts positively or negatively depending upon his/her resources, expectations and socio-economic characteristics. The task is to quantify factors (Table 1) which influence this decision.

The probit procedure (Hill and Kau, 1973 and Turner et al, 1983) which specifies a binary dependent variable as a function of a number of quantitative explanatory variables (Kmenta, 1971 and Gujarati, 1978) was chosen for use here because of its ability to generate bounded probability estimates for each individual farmer. The model can be specified as :

$$Y_i = a + b \sum_{i=1}^{n} X_i + E_i \qquad (1)$$

where the X_is represent vectors of n(n=9) explanatory variables of the i^{th} farmer, and Y_i is a binary variable such that

Y_i = 1 if the i^{th} farmer wants to expand production = 0 otherwise.

In the model, the X_is are assumed to be stochastic and independent of the zero mean random variable E_i. Since Y_i can only assume two different values, 0 and 1, the following expected probability can be obtained:

$$E(Y_i) = 1Xf_i(1) + 0Xf_i(0) = f_i(1) \qquad (2)$$

where $f_i(1)$ is the probability that a farmer with a set of resources and economic characteristics (X_i) would expand his operation. From (1) and (2),

$$E(Y_i) = a + \sum_{1=1}^{n} X_i \qquad (3)$$

meaning that the probability $f_i(1)$ would be different for farmers with different levels of resources and economic characteristics. Thus, the expected probability $E(Y_i)$ which can be interpreted to mean the proportion of all farmers with resources and economic characteristics (X_i) likely to expand operation would be given by:

$$0 \leq a + b \sum_{i=1}^{n} X_i \leq 1$$

The larger the proportion the greater the decision to expand operation and vice versa.

Following Turner et al (1983) the general probit form for the i^{th} farmer is :

INT = f(HDS, PLD, HOU, LAB, FNC, PRI, GIN, AGE, EXP)

where the independent variables are defined as in Table 1 and INT is a hypothetical index signifying the farmers' intention to expand his sheep and goat farm or not to do so. The maximum likelihood technique (Kmenta, 1971; Gujarati, 1978) was used to estimate coefficients and to test hypotheses about factors relevant in shaping farmers' attitudes towards expanding sheep and goat production.

Table 1. Variables hypothesised to influence farmer attitudes towards increased sheep and goat production in the North West Province, Cameroon.

Variable name	Description	Measurement	Mean	Expected impact
HDS	Herd size (no. of animals available on farm)	Actual number of animals reported	16.05	-
PLD	Land area containing pastures for grazing	No. of hectares of pasture land reported	8.00	+
HOU	Housing facility for sheep and goats	1 - housing available 0 - no housing available	0.85	+
LAB	Labour resources (no. of hired and family labour)	Actual number of persons working on farm at least half time	2.25	+
FNC	Fencing facility for confining sheep and goats.	1 - Fencing available 0 - no fencing available	0.85	+
FRI	Current market price for sheep and goats	Actual market price observed per live adult animal (CFA)*	11.975	+ -
GIN	Gross income from sheep and goat sales	Actual gross income reported from sales of sheep and goat (CFA)	44.800	+
AGE	Age of farmer	Actual age of farmer reported	46.45	-
EXP	Farmer's expectation of future farm income	1 - rising 0 - falling	0.55	+

* 1US$ = 315.5 CFA

RESULTS

Estimated coefficients obtained from the likelihood function specifying explanatory variables likely to influence farmers' attitudes towards increased sheep and goat production in the North West Province of Cameroon are given in Table 2. Current herd size (HDS) was hypothesised to be inversely related to the decision to expand production because the probability of a positive response increased for farmers with smaller herd sizes and vice versa. At $P<0.10$ the results in Table 2 supported this hypothesis. Sample data obtained on farmer response bear this out since farmers with fewer animals showed a greater desire to increase herd size to fulfil household cash needs while farmers with larger herd sizes were not only constrained by land and pasture shortages (particularly in the dry season), but also by problems of marketing.

Available pasture land (PLD) was an important positive factor influencing farmers' attitudes towards increased sheep and goat production. The results supported the hypothesis that farmers who have grazing land were more apt to increase herd size than those with little or no pasture land.

Two other factors that seemed to influence farmers' attitudes were facilities available for housing (HOU) and fencing (FNC) sheep and goats. These variables exerted, as hypothesised, a positive influence on attitudes. Existing housing and fencing facilities provide positive environments for improved management of small ruminants. Most farmers interviewed in this survey provided housing (68 percent) and fencing (54 percent) for their sheep and goats. This agrees with the findings of Agyemang et al (1985) who reported 82 percent of farmers housing sheep in the Ethiopian highlands.

Table 2. Coefficient estimates, student t's and probability levels of farmers exhibiting positive attitudes towards increased sheep and goat production in the North West Province, Cameroon.

Explanatory variables	Estimated coefficients (standard errors)	Student t's	Probability of farmer exhibiting a positive response
HDS	0.30		
	(0.021)	1.428	0.210
PLD	0.015		
	(0.009)	1.667	0.204
HOU	0.876		
	(0.663)	1.320	0.196
LAB	-0.170		
	(0.234)	-0.727	0.130
FNC	0.210		
	(0.125)	1.680	0.220
FRI	0.731		
	(0.347)	2.107	0.310
GIN	0.073		
	(0.038)	1.932	0.240
AGE	0.37		
	(0.030)	1.224	0.141
EXP	-0.386		
	(0.566)	-0.682	0.072
Constant	1.179		
degrees of freedom	8		

Available family and hired labour (LAB) was hypothesised to be positively related to increased production. Households with a larger work force are more apt to increase production as this makes the task for tethering, herding, feeding etc easier. The results did not support this hypothesis. The variable had the wrong sign and was not significant (P>0.05). This is not surprising, however, given that family labour, which makes up the largest chunk of the labour force in subsistence agriculture often is shared among different alternative farm activities (see for example Jones, 1983). Assuming from neo-classical theory that household members do not have conflicting interests over the allocation of labour time for farm work, the contrary was observed for sheep and goat farmers in the North West Province. As became apparent through interviews with men and women and observations, there was frequent and sometimes pronounced conflicts between men and women over the division of labour for crop and livestock production. In the North West Province sheep and goats are tended mostly by men while women are concerned more with crop production (Tambi and Fomunyam, 1985). Although children assist on the farm, this often is restricted to vacation periods (June to September). It is probable therefore, that the combined effects of the division of labour together with this variable's correlation with other variables in the equation might have biased the results.

AGE was hypothesised to be inversely related to the probability of a positive response because older persons tend to be less vigorous on the farm than younger ones. The results obtained here did not verify this because AGE was not significantly (P>0.05) affecting the decision to expand production. From the interviews, older men seemed to have preferred having larger herd sizes. The results reported here did not agree with the findings of Glazner and Sporleder (1979) who showed AGE to be significantly affecting producer attitudes towards a computerised feeder cattle marketing nor did they agree with those of Turner et al (1983) on the effect of AGE on producer attitudes towards multicommodity electronic marketing.

The variables gross income (GIN) and the expected income potential (EXP) from sheep and goat production (proxies for initial capital and future returns) were hypothesised to directly influence farmers' attitudes. That is the more income a farmer has and the more optimistic he/she is about future returns, the more likely will he/she have a positive attitude towards increased production. Only GIN was statistically significant ($P<0.05$) indicating that the proxy for initial capital has a mejor effect on the decision to increase production. By implication, any commercially oriented approach to sheep and goat production will require substantial initial cash inputs to purchase more animals, for better housing, improved pastures and the necessary infrastructure (Lebbie and Mastapha, 1985). The average gross income of 44,800 CFA* reported per farmer is too low to meet these costs. The variable EXP was not only insignificant ($P>0.05$) but had the wrong sign; an indication that higher anticipated returns do not necessarily influence farmers to invest to increase production particularly if the investments are associated with higher levels of risks (Tambi, 1985). Of the farmers interviewed, only 36 percent indicated that they would increase production if future income from sheep and goat production proved good.

Current market price (PRI) was another variable tested and found statistically significant at $P<0.05$. It was expected a priori that the levels of current market prices would exert either a positive or a negative force on the decision to increase herd size depending on whether they are relatively higher or lower than the previous year's price.

The likelihood estimates shown in Table 2 give an indication of farmers' response to constraints (explanatory variables) affecting his/her decision to expand production through improved technologies. The estimates were used to derive the probability of a farmer reacting positively towards the expansion of production. To obtain this probability the mean values of the explanatory variables in the equation were used to arrive at the value to the dependent variable, which in turn was used to derive the probability of a positive reaction towards increased sheep and goat production. These probabilities are shown in Table 2.

DISCUSSION

The random sample of sheep and goat farmers in the North West Province, Cameroon revealed that over 80 percent of those interviewed were willing to expand production if constraints on production and marketing were lifted. This suggested that a substantial number of farmers were being prevented by several factors from expanding production. The average herd size of 11 for example, provided limited scope for a commercially oriented approach to sheep and goat production in the North West Province. A market-oriented approach, if it is to be of practical value, must take account not only of the biological (nutrition and health) possibilities, but also, of a variety of economic and management constraints. Economic constraints have a major effect on the extent to which some of the biological factors can be employed. It is, for example, technically possible to improve the nutrition and health of animals by concentrate supplementation and other management factors, but the relationships between input costs and product prices serve to limit their use. Dry season supplementation of sheep and goat diets for example, offers an effective means of increasing output during periods of scarce pastures but the high concentrate and labour costs incurred render it uneconomic.

Land and pasture improvement for sheep and goat production is an expensive operation particularly in regions where there is dominance of native pastures (Newbold, 1974; Eadie and Maxwell, 1975). Studies by Maxwell et al (1976) have shown clearly that beyond a certain point investments in land improvement for development of improved systems of production can lead to severe disadvantages to the enterprise concerned. This is more so when labour and capital costs are high as a proportion of total cost. In the sheep and goat production system of the North West Province capital for the purchase of additional stock is lacking and skilled labour for management is a scarce commodity so that improved systems must seek to provide a framework within which capital and labour can be more efficiently used.

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* 1 US$ = 315.5 CFA

Against this background, a strategy for developing the sheep and goat sector in the North West Province, if it is to be successful, should aim at fully exploiting the animal, human and land resources by removing or minimising the current and future constraints against improved productivity. There is a need to move away from traditional methods by intensifying production through the adoption of simple techniques of improved feeding, more efficient health regime, and improved marketing services and facilities. Although more research into the economic viability of feeding concentrates, use of improved pastures, controlled breeding, health maintenance and marketing is needed to provide a stronger base for any development programme, it is important that before the programme is drawn, the economic consequences of investments in intensive sheep and goat production be known.

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CONSIDERATIONS IN THE DESIGN OF ON-FARM LIVESTOCK EXPERIMENTS AND EVALUATION OF RESULTS

G.I. Mlay and N.A. Urio
Departments of Rural Economy and Animal Science and Production, Sokoine University of Agriculture, P.O.Box 3004, Morogoro, Tanzania

ABSTRACT

The paper identifies major extraneous factors which can have a significant effect on the variation of response variables in on-farm livestock research. The implications of such factors on the design of experiments and evaluation of results are discussed. Important statistical considerations are presented and their importance in guiding experimental designs demonstrated. The paper uses a case study based on a feeding trial of dairy cattle under small farms to illustrate the design, management and evaluation problems resulting from the extraneous factors. A case is put forward to support the use of farmer-evaluation and economic analysis as additional approaches to statistical methods in evaluating research results.

INTRODUCTION

On-farm research can be considered as an intermediate step between station level research and development. Interest in on-farm research has arisen out of difficulties encountered in the large-scale extension of technical innovations developed under controlled research environment. The rate of adoption of such technologies has been particularly disappointing in the case of small farmers (Jouve and Mercoiret, 1987).

The movement of a research process from a controlled laboratory environment to farm conditions entails additional considerations in experimental design and the evaluation of research results. Not only does the process introduce more extraneous factors whose control may be difficult, but an additional dimension, the farmer, has to be considered.

Arbodela (1987) identifies the researcher, technology, the farmer and farmer's values as important components in on-farm research. While the researcher makes his recommendations based on an objective evaluation of the results arising from the methodology used in the research, the farmer makes a decision about the recommendation on the basis of an overall assessment of the research in the light of his values (Arbodela op. cit.).

Devendra (1987) identifies the following shortcomings based on experiences from Asian countries: "that methodologies presently used are haphazard, lack sophistication and control and are unimaginative; the nature of the work does not allow for statistical analyses of the results; and ad-hoc innovations are often imposed in the hope of demonstrating causes and effects, usually in quantitative terms". These shortcomings are a reflection of the special problems encountered at farm level which make a direct transfer of on-station research approaches difficult or very costly to implement.

This paper highlights the problems of experimental design of dairy cattle feeding trials and proposes alternative evaluation criteria where formal designs cannot be implemented.

EXTRANEOUS FACTORS TO BE CONSIDERED IN ON-FARM LIVESTOCK EXPERIMENTS

Inferences made about population parameter variables measured in experiments can be seriously affected depending on how extraneous factors are handled in a design. If a researcher completely ignores extraneous factors, then the variation that cannot be accounted for by treatments will be lumped together as error. Since the error mean square is involved in computing test statistics, this may lead to wrong inferences. In addition when significant extraneous factors are ignored, the usual assumption of homoscedastic error term is no longer valid and hence variance estimates and test statistics computed from such data will be biased. Therefore the usual practice is to attempt to stratify the experimental units on the basis of non-experimental factors which are thought to show significant variation across the experimental units. These are subsequently separated from the error sum of squares components in the analysis.

In on-farm livestock research, where weight gain or milk yield are the key response variables to be measured, the extraneous factors which the researcher will have to contend with may include: location (when the area being covered shows large climatic variation), breed, time, age, stage of lactation, lactation number and differences in the level of management across farmers.

The larger the number of extraneous factors to be handled in an experiment, the more complex the design becomes and the requirements in terms of resources also increase. In addition, interpretation of results become difficult particularly when interactions of higher orders are involved.

STATISTICAL CONSIDERATIONS

In order to apply statistical methods in data analysis and to make statistical inferences from the results, the design of experiments must satisfy the following conditions (Anderson and Mclean, 1974):

- The inference space must be defined. These are the limits within which the results will apply. The definition of an inference space will determine a relevant sample size to use.

- The experimental units must be randomly selected. Random selection is necessary to protect against bias in the experiment which could be the result of some unknown factor having had prior influence on the experimental units in some systematic fashion. When the experimental units turn out not to be homogeneous then stratification based on some inherent characteristic(s) will be necessary.

- Assignment of treatments to experimental units likewise must be random.

With the assistance of a statistician, a mathematical model evolving as a result of the problem to be studied, factor levels to be used in the experiment and the conditions listed above needs to be written down. The mathematical model will give rise to the ANOVA table which at this stage will consist of degrees of freedom, and expected mean squares for each of the specific factors selected. The expected mean squares will provide information on the various factors which will have tests available. The researcher can review the ANOVA table and if some of the assumptions and conclusions implied by the table are not realistic or practical, the design will have to be changed.

- Extreme care in data collection is essential. Other factors given, the success of a scientific investigation depends upon the validity of all data obtained.

In the light of the farm conditions under which livestock trials have to be conducted, it is clear that either some of the conditions listed above will be violated or high costs will have to be incurred in terms of both financial and human resources in an attempt to satisfy the stated conditions.

EXPERIENCES WITH DAIRY FEEDING SYSTEMS PROJECT: HAI DISTRICT - TANZANIA

Smallholder farmers in Hai District keep an average of 4 heads of cattle per household. These are mainly cross breeds (Zebu crossed with exotic dairy cattle) and a few pure breeds, mainly Jersey cattle. In a diagnostic survey conducted in 1984, one of the factors identified as constraining smallholder dairy production was the availability of adequate feeds in terms of quantity and quality. After some assessment of feeds situation in the district, it was decided to test the impact of introducing bean haulms/chaff and molasses-urea mixture in basal rations on milk yield under smallholder farmer conditions.

The problems that arose with regard to the design of experiments were (a) several levels of a factor could not be implemented within a household; (b) the dairy cattle being kept varied in breeds/crosses and age, and were at different stages of lactation. Often the farmers were unable to provide an accurate history of their cattle; (c) the basic management, including housing and feeding varied across households; (d) the fact that the project site is 500 km from the home base meant that the day-to-day management of experiments and keeping of records was to be left under the control of farmers. That the success of the experiments depended on the willingness and the ability of the farmers to manage the trials meant that purposive selection of farmers and hence the cattle (experimental units) was unavoidable.

Ideally the experiments would need to satisfy the statistical considerations mentioned earlier and the blocking for the above extraneous factors would be necessary. If these were satisfied, a linear model of the following form would be specified:

$$Yijklmno = A + B_i + C\,(_i)\,j + D_k + E_l + F_m + G_n + H_o + (\text{Interactions}) + Eijklmno$$

Where = Yijklmno is milk yield of the jth cow of the k^{th} breed, in 1^{th} lactation, managed by the m^{th} farmer in n^{th} location, fed i^{th} ration on the o^{th} day.

A is the overall mean
Bi is the effect of the i^{th} ration on milk yield
C(i) j is the effect of the j^{th} cow on the i^{th} ration
D_k is the effect of the k^{th} breed
E_l is the effect of the 1^{th} lactation
F_m is the effect of management by m^{th} farmer
G_n is the effect of n^{th} location
H_o is the effect of the o^{th} day
Eijklmno is the error term

The model as presented is still too basic. Considerations by an animal scientist on important interactions are essential, and thereafter, practicality of implementing the experiment will need to be considered. Where restrictions are necessary, these will have to be introduced in the model as restriction errors since these have an important implication on the resulting ANOVA table and the tests which will be subsequently available.

The actual feeding experiments conducted did not satisfy the criteria mentioned, and therefore subjecting the data to statistical analysis and drawing inferences from that basis is not warranted. The design adopted reflected practical considerations in the project site and resources at the disposal of the researchers. In addition, researchers were satisfied that the trade-off between design quality and developmental effects of the research was worthwhile in the initial stages of the work.

MATERIALS AND METHODS

Participating farmers were purposely chosen from three villages: 10 from Ng'uni, 5 from Mowo-Njamu and 5 from Wandri. Discussion was held with the farmers on the objectives of the experiments and the tasks they were expected to perform. Information was sought on the history of the cattle they kept. For practical reasons, the farmers were to continue with their usual feeding routines, only that supplementation with molasses-urea mixture sprinkled on bean haulms was introduced. Molasses-urea mixture and bean haulms were provided at cost. Daily feeding of the latter two feeds was at the rate of 2 kg and 8 kg per animal respectively. Farmers were asked to record, on a daily basis, milk yield, types of basal feeds being used and types and quantities of other concentrates fed. The experiment was continued for a period of 6 months.

Analysis and evaluation of results

The design used suffered from the following weaknesses:

(a) The effects on milk yield of other diets whose feeding varied within and across households were not controlled or accounted for the design.

(b) The design lacked control treatment.

(c) Only one level of the factor was considered.

As a result of the above weaknesses, it was not possible to assess the treatment effects on milk yield through statistical methods.

A subsample of the data collected is used here to illustrate the importance of controlling or accounting for extraneous factors when designing on-farm trials. The results were based on one-way analysis of variance by cow, farmer, breed, village (location) and ration. The results are presented in Tables 1 to 5. It is shown that with the exception of location (village), all other factors have significant effects on the variation of daily milk yield at 0.01 probability level.

Table 1. Average daily milk yield by cow.

Cow no.	Mean yield (litres)	Standard deviation	No. of records
1	5.6	0.8	35
2	2.2	0.5	35
3	4.0	0.6	30
4	10.3	1.3	30
5	11.4	1.4	28
6	7.2	0.8	21
7	8.9	1.5	21
8	3.1	0.5	23
9	7.2	1.0	35
10	10.2	1.5	33
11	5.2	1.0	18
12	7.8	0.8	20
13	7.5	1.3	27

Table 2. Average daily milk yield per cow by 9 farmers.

Farmer	Mean yield (litres)	Standard deviation	Samples size
1	3.9	1.8	70
2	8.5	3.5	88
3	8.1	1.5	42
4	3.1	0.5	23
5	5.2	1.0	18
6	7.8	0.8	20
7	7.5	1.3	27
8	7.2	1.0	35
9	10.2	1.5	33

Table 3. Daily average milk per cow by breed.

Breed	Mean yield (litres)	Standard deviation	Sample size
Jersey	8.6	3.2	153
Friesian	7.3	1.0	168
Crosses	5.4	2.2	35

Table 4. Average daily milk yield per cow in two villages.

Village	Mean yield (litres)	Standard deviation	Sample size
Ng'uni	7.0	3.2	291
Mowo-Njamu	6.9	1.5	65

Table 5. Average daily milk yield per cow by ration.

Ration	Mean yield (litres)	Standard deviation	Sample size
Only molasses-urea	5.7	2.1	33
Cottonseed cake plus molasses-urea	7.4	3.2	248
Wheat pollard plus molasses-urea	6.0	2.1	75

PROPOSALS FOR EVALUATING RESULTS WHEN STATISTICAL METHODS ARE INVALID OR INADEQUATE

From experience in the Dairy Feeding Systems Research Project, it is proposed that farmer-evaluation of the research, and economic evaluation of benefits and potentials for development should always be either in conjunction with statistical methods, or on their own when statistical methods are invalid.

Farmer-evaluation is important particularly when it is considered that recommendations from on-farm research are expected to be a basis for development of technologies for adoption. As pointed out earlier, farmer-evaluation takes into account other dimensions which are not handled by statistical methods. A survey carried out at the end of the experiment which covered both participating and non-participating farmers, showed that the research was addressing an important problem and that there had been a positive impact on milk yield performance. The results of the survey are summarised in Tables 6 to 10.

An economic analysis of on-farm research can take several forms. The simplest analysis is that restricted on costs and returns. In order to examine input-output relationships and resource use efficiency of research trials a production function approach can be used. In the cases where a farmer is involved in several enterprises (crops and livestock) budgeting and linear programming techniques can be used to arrive at optimum combination of enterprises and employment of various resources. Mdoe (1986) using a multiperiod linear programming model was able to demonstrate the effects of alternative dairy production technologies on optimum enterprise combinations and farm incomes in Hai District.

Table 6. Impact of the research project on dairy management.

Management practices	Number of farmers			
	Ng'uni	Mowo-Njamu	Wandri	Total
No change in management	1	0	0	1
Record keeping	8	3	2	13
Use of molasses	7	5	4	16
Measuring milk production	3	2	2	7
Chopping of maize stover	1	0	1	2
Increase use of crop residues	1	0	0	1
Pasture management	0	1	0	1

Table 7. Dairy cattle performance.

	Percentage of farmers		
	Ng'uni	Mowo-Njamu	Wandri
Performance remained the same	0	20	0
Performance improved	100	80	100
Performance declined	0	0	0

Table 8. Ng'uni vallage: milk yield before and during the project period (litres).

Farmer number	Yield before project	Yield during project	Change in yield
1	6.5	8.0	1.5
2	4.0	5.0	1.0
3	4.5	5.0	0.5
4	4.0	5.5	1.5
5	6.0	7.0	1.0
6	4.0	4.5	0.5
7	3.0	4.0	1.0
8	5.0	6.0	1.0
9	4.0	5.0	1.0
Total	41.0	50.0	9.0
Mean	4.5	5.5	1.0
S.D.	1.10	1.3	0.4

Table 9. Mowo-Njamu: Milk yield before and during project period (litres).

Farmer number	Yield before the project	Yield during the project	Change in yield
1	6.0	7.0	1.0
2	7.0	8.0	1.0
3	5.0	6.5	1.5
4	3.0	4.0	1.0
5	3.0	4.0	1.0
Total	24	29.5	5.5
Mean	4.8	5.9	1.1
S.D.	1.8	1.8	0.2

Table 10. Wandri village milk yield before and during the project period (in litres).

Farmer number	Yield before the project	Yield during the project	Change in yield
1	7.0	8.5	1.5
2	5.0	6.0	1.0
3	5.5	6.5	1.0
4	3.5	4.5	1.0
Total	21.0	25.5	4.5
Mean	5.3	6.4	1.1
S.D.	1.4	1.7	0.3

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THE ECONOMICS OF PEASANT CATTLE FEEDING IN MALI

H. Baur[1], K. Sissoko[2] and S. Debrah
ILCA, BP. 60, Bamako, Mali

[1] Universitat Hohenheim, 7000 Stuttgart 70, West Germany
[2] Projet Sectoriel de l'Elevage de Mali, ILCA, BP. 60, Bamako, Mali

ABSTRACT

On-farm cattle feeding activities of selected peasant farmers in the semi-arid zone of Mali were followed in the dry seasons of 1984, 1985 and 1986 under the "Embouche paysanne" project, financed jointly by the Government of Mali and the USAID. The abattoir-destined cattle were sample-fed for 80 to 90 days during the dry season and were sold in May when prices were high. Coarse fodder and cottonseed cake were the main feed inputs, and producers benefited from loans provided especially for the project.

The animals gained on average between 0.58 and 0.81 kg/day during the feeding period. Gross returns of approximately 25320 CFA* and 35319 CFA on average were realised in 1984/85 and 1985/86 respectively by the sample taken as a whole. Disaggregating the gross returns into its price and weight components, higher sale prices in May during the 3-year campaign contributed on average about 55% while weight gains and the interactions between weight gains and price changes accounted for 37% and 8% respectively. However, after deducting purchase and production costs, average profit per animal including the value of unsold animals was substantially reduced, affecting the ability of participants to repay loans. In 1985 for example, about 27% of the sample made no profit or lost money in the cattle-feeding programme.

Since the fattening programme depended largely on cottonseed cake of limited long-term availability, feed trials were undertaken to determine the economic viability of the

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* 1 US$ = 315.5 CFA

project using reduced amounts or partly replacing cottonseed cake with other farmer-produced supplements. Although cattle fed reduced amounts of cottonseed cake gained less weight than those on larger quantities, profitability was increased.

INTRODUCTION

The general absence of good quality feed during the long dry season is a major constraint faced by livestock producers particularly in the arid and semi-arid areas of West Africa. Research efforts to match seasonal fluctuations in feed supplies with constant requirements include the promotion of packages which combine various feed resources such as forage legumes, fodder trees, cottonseed cake and agro-industrial by-products to supplement grazing and to provide adequate feed supplies throughout the year.

In mixed farming systems where crop production and animal husbandry are closely integrated, the availability of cottonseed cake, especially during and after harvest, provide cheap sources of feed for livestock. In Mali, the use of cottonseed cake as livestock feed has long been encouraged in the semi-arid and subhumid zones. In 1975, the ECIBEV (Etablissement de Credit et d'Investissement Betail-Viande) was established with financial assistance from USAID (United States Agency for International Development) to provide credit to peasant farmers to undertake on-farm cattle feeding in the dry season.

"Embouche Paysanne", the smallholder cattle-feeding project in the semi-arid zone of Mali started with 48 peasants involving 107 animals in 1975 and had grown to 1105 peasants and some 3600 animals by the end of 1986. Under the programme, peasants obtained credit for the purchase of mature feeder cattle and supplementary assistance in the form of concentrates and veterinary care from ECIBEV. Animals were then fed on-farm on cottonseed cake and agro-industrial by-products for about three months in the dry season and sold in May when prices normally reached their peak. This paper presents the economic aspects of the feeding project based on observations from 1984 to 1986 within a sample, on average, of 31 farmers.

The study area

The cattle feeding activities were monitored in the Banamba zone of Mali, located west of the Niger river and about 150 km north of Bamako. The zone lies within isohytes of 600 and 800 mm of annual rainfall but has received less than 600 mm in recent years. Between 1975 and 1985 for example, it received an average of about 579 mm, with 1983/84 being particularly dry. In general, the zone experiences a short rainy season between June and September during which about 85% of the total annual rainfall is received. This is followed by a long dry period from October to May. The zone is characterised by mixed crop-livestock production systems. The principal crops grown are millet, sorghum, cowpeas and groundnuts. The average household keeps cattle, sheep and goats, as well as donkeys and some poultry. Producers in the study area have access to three major weekly markets which serve as the main centres of trade for agricultural and livestock products.

The sample

A general criterion for credit and participation in the feeding programme is the ownership of work oxen and/or agricultural equipment. This fulfils the function of a guarantee of credit worthiness, and in the case of work oxen, an indication that the farmer has had previous livestock management experience.

Approximately between 29 and 33 participating farmers and a total of about 125 feeder cattle were observed from 1984 to 1986. Roughly 50% of the farmers fed four or more animals over the study period. In terms of land ownership, the sample owned on average 9.8 ha of crop land per household. They also possessed livestock holdings of 11.5 cattle (including at least 1 ox), 9 sheep and 16 goats, on average, per household. A participating household comprised, on average, 16 members of which approximately 10 were active members of the family labour force.

The animals involved in the fattening programme were generally Peul and Maure Zebu bulls and steers, 7 years of age or older, of which the majority were castrates. In 1986 for example, 58% of the animals were Peuls and 39% Maures. Eighty-one percent were castrates, 11% entire males and 8% females. The principal components of the daily ration consisted of millet and sorghum stalks (17%), bush hay (35%), and cottonseed cake supplements (40-60%). These components together constituted between 84% and 97% of total daily feed intakes.

The cattle entering the fattening programme were given routine vaccinations for rinderpest and contagious bovine pleuropneumonia, anthelminthic treatments and prophylactic treatments against trypanosomiasis. A mortality rate of less than 3% was observed during the fattening period.

Purchase of feeder cattle

The procurement of feeder cattle was made possible by a fixed credit in the amount of 45000 CFA per animal. In the Banamba area, the farmers had to supplement the credit from their own resources as average prices usually exceeded the amount of credit. Prior to purchase, the farmers made several trips to livestock markets in the area to ascertain price levels and the general conditions of the animals. Although cattle were not explicitly sold by weight in the local markets, the study showed a strong relationship between actual liveweights of the animals being sold and their total sale prices. Cattle buyers thus bought by estimated liveweights for a reasonably constant price per kilogram. Estimated purchase prices for Maure Zebus averaged 161 CFA and 230 CFA/kg in 1985 and 1986 respectively. Corresponding figures for the Peul Zebus in 1985 and 1986 were 171 and 219 CFA/kg respectively. The average weights of all cattle entering the programme were 339 kg in 1985 and 304 kg in 1986.

Sale of fed cattle

The average weights of finished animals were 370 kg and 356 kg in 1985 and 1986 respectively. They were normally sold by the farmers themselves at home or in nearby local markets. The main buyers were cattle dealers who generally bought for terminal markets in the capital, Bamako, and other urban markets such as Kati. Informal purchase contract arrangements were usually made between buyers and the farmers prior to the end of the the feeding period. Animals sold this way were sold on credit of about 30 days duration. The Maure Zebus were sold at estimated unit values of 208 CFA and 288 CFA/kg in 1985 and 1986 respectively while the Peuls were sold at 228 and 302 CFA/kg respectively. Table 1 summarises the purchase and sale weights and prices for the two types of cattle in 1985 and 1986.

Table 1. Purchase and sales summary of Maure and Peul Zebus in the feeding programme.

Cattle type	Maure		Peul	
Year	1985	1986	1985	1986
Average purchase weight (kg)	356	308	329	302
Average purchase price (CFA)	57316	70840	56259	66138
Average purchase price per kg (CFA)	161	230	171	219
Average sale weight (kg)	400	360	345	351
Average sale price (CFA)	83200	103680	78660	106002
Average sale price per kg (CFA)	208	288	228	302

ECONOMIC ANALYSIS

The economic analysis of the smallholder cattle feeding programme reported here involves the examination of overall profitability, the determinants of profitability and possible measures for improving the economic performance of participating farmers.

Financial and economic viability

The gross financial margin, defined as the difference between the final sale price of a fed animal and its initial purchase price, was 25320 CFA per animal in 1985 and 35319 CFA in 1986. Because this margin excludes feeding costs as well as other cash and opportunity costs of labour and farmer-produced feed during the feeding period, it represents an overestimate of profitability. However, by subtracting direct cash costs for feeding and labour from the gross financial margin, profitability was expressed in terms of the net financial margin per animal. These were 3391 CFA and 4748 CFA in 1985 and 1986 respectively. The net financial margins were then expressed as percentages of total financial costs and multiplied by the fraction of the year animal was fattened to obtain annual financial rates of return of 63% in 1985 and 68% in 1986. Taking further account of the opportunity costs of family labour and of farmer-produced feed, the resulting economic rates of return to fattening were 0% and 21% on average in 1985 and 1986 respectively. Although on average farmers appeared to get high returns to fattening, as much as 27% of the sample for example in 1985 made no profit or actually lost money in cattle feeding. Table 2 shows the distribution of financial and economic returns within the sample population in 1985 and 1986. In 1985, about 61% of the sample made net financial returns of over 10000 CFA per animal, compared with 29% in 1986. Similarly in 1985, 86% of the sample made economic returns of less than 10000 CFA per animal compared with 50% in 1986.

Disaggregation of the gross margin

In order to examine the relative contributions of weight gains and of price changes to the gross margin during the course of the fattening, period the gross financial margin was disaggregated as follows: Let C = cost of purchasing cattle, R = revenue from selling cattle, P = price per kg of liveweight, W = liveweight in kg, and d = change in P or W over the fattening period. For the subscripts, let i = initial period representing the beginning of fattening and f = final period or the end of fattening. Then,

$$C = P_i * W_i \quad (1)$$

$$R = P_f * W_f \quad (2)$$

$$M = R - C \quad (3)$$

By definition,

$$P_f = P_i + d(P) \quad (4)$$

and

$$W_f = W_i + d(W) \quad (5)$$

Substituting equations 4 and 5 for R in 2 and expanding, we have

$$M = d(P) * W_i + d(W) * P_i + d(P) * d(W) \quad (6)$$

Dividing equation 6 by M and multiplying by 100% gives

$$100\% = \{\%(d(P)*W_i) + \%(d(W)*P_i) + \%(d(P)*d(W))\}/M \quad (7)$$

The first term on the right-hand side defines the price component of the gross margin and is the change in price multiplied by the original weight, the weight component is the second term and is equal to the change in weight multiplied by the original price, and the interaction component is the change in price multiplied by the change in weight. All the components are expressed as percentages of the gross financial margin. In 1985, the weight gain for the sample as a whole accounted for 27% of the gross margin while price changes and the interactions accounted for 67% and 6% respectively. Corresponding figures in 1986 were 45%, 46% and 9% respectively.

Perspectives for improving performance

In the last two years of the feeding campaign, the price component averaged 55% of the gross margin as compared with 37% for weight gains. This suggests that price changes over the feeding period played a relatively important role in the determination of profitability. A regression analysis of the determinants of unit sale prices indicated that liveweight, number of days fed, duration of credit and seller type (i.e. whether seller is ECIBEV-sanctioned seller or not), significantly explained variations in unit sale prices at the 5% level. These factors together accounted for 52% of the total variation. Liveweight and number of days fattened had negative coefficients suggesting that the fatter animals were allowed to get and the longer the feeding period, the lower the unit prices received. The duration of credit and seller type had positive influences, indicating that ECIBEV-sanctioned buyers received higher unit prices, and those who gave longer periods of credit obtained higher prices.

Table 2. Distribution of financial and economic benefits within the sample.

	Net financial benefit				Economic benefit			
	1984/85		1985/86		1984/85		1985/86	
CFA/animal	n	%	n	%	n	%	n	%
0 < = 0	8	26	13	46	12	57	4	22
1 - 10000	4	13	7	25	6	29	5	28
10001 - 20000	18	58	6	22	3	14	5	28
> 20000	1	3	2	7	0	0	4	22

Source: Baur and Sissoko (1986).

Apart from the purchase of feeder cattle which represented about 70% of total production cost, feeding was the most expensive item ranging from about 22% to 29%. One way farmers might increase profitability is by reducing feeding cost per animal by perhaps reducing the amount of cottonseed cake in the ration since it represented 41% and 53% of total feed costs in 1985 and 1986 respectively. A number of feeding trials were conducted in 1986 in order to determine the economic viability of the programme using reduced amounts of cottonseed cake or partly replacing it with farmer-produced cottonseed cake. It involved 6 rations conducted over 36 animals for 77 days. The rations were:

1. Bush hay (*ad lib*) + 2 kg cottonseed cake (T1)
2. Bush hay (*ad lib*) + 4 kg cottonseed cake (T2)
3. Bush hay + 40% molasses + urea + 2 kg cottonseed cake (T3)
4. Bush hay + 40% molasses + urea + 4 kg cottonseed cake (T4)
5. Bush hay + 2 kg cowpea haulm + 2 kg cottonseed cake (T5)
6. Bush hay + 4 kg cowpea haulm + 4 kg cottonseed cake (T6)

The effects of these rations on average daily weight gains are shown in Table 3. In general, animals fed on 4 kg cottonseed cake gained more weight than those on 2 kg per day. The addition of molasses and urea to bush hay and cottonseed cake resulted in higher weight gains than the addition of cowpea haulms.

Table 3. The effects of diet on average daily gains.

	Weight gain (kg/day) when fed cottonseed cake	
Bush hay (*ad libitum*)	2 kg/day	4 kg/day
Bush hay (T1*, T2)	0.72	1.01
Bush hay + molasses/urea (T3, T4)	1.00	1.12
Bush hay + 2 kg cowpea haulm (T5, T6)	0.85	1.04

* T1 - T6 are rations.

An economic analysis was carried out on the rations using 1985 prices. The results are shown in Table 4. Rations T2 and T1 were the most profitable followed by T3, T4, T5 and T6 in that order. Rations T5 and T6 which replaced molasses and urea in T3 and T4 with farmer-produced cowpea haulms were less profitable, since the opportunity cost of cowpea haulms appear to be higher than the market prices of molasses and urea. A 50% increase in the cost of cottonseed cake was hypothesised and the profitability of the rations re-examined. Although the order of profitability did not change much, ration T1 with lower amounts of cottonseed cake became more profitable than T2.

Table 4. Profitability of alternative rations in the cattle feeding programme.

	Rations					
	T1	T2	T3	T4	T5	T6
Average initial wt (kg)	266	266	266	266	266	266
Average final wt (kg)	321	344	343	352	331	346
Average weight gain (kg)	55	78	77	86	65	80
Gross returns (CFA)	38055	45070	44746	47510	41105	45680
Total ration cost for 77 days (CFA)	12243	18172	21637	25564	20790	26026
Net returns (CFA)	25812	26898	23128	21946	20315	19654
Effect of a 50% increase in the cost of cottonseed cake: Net returns (CFA)	22411	20323	19727	15865	16666	12967

Source: Baur and Sissoko (1986).

CONCLUSION AND IMPLICATIONS

Smallholder beef fattening, especially in the dry season, is a way by which agropastoralists can intensify the traditional system and increase farm income. The majority of the sample farmers in the feeding project made money during the dry season to augment their farm income. The gross margin analysis shows that substantial portions of the margin is made up of gains due to price speculations. One implication of the importance of seasonal price fluctuations in the livestock market is that farmers can strategically raise their animals towards target markets such as dry season markets and religious festivals to take advantage of high prices.

The small negative but statistically significant relationships between unit sale prices and liveweight gains as well as length of feeding period, implies that since sales are made on weight estimates rather than actual weights, it may not be advantageous to get the animals too fat or keep them on feed for too long.

Finally, the results of the feeding trials appear to indicate that the profitability of a ration depends on the relative prices of the components and the final products. For example since the opportunity costs of cowpea haulms at the time of the trial were higher than the market prices of urea and molasses, rations that contained cowpea haulms, designed to replace the industrially produced urea and molasses were less profitable. In 1985 the price of cowpeas in the market was exceptionally high as a result of the particularly dry 1984/85 cropping season. In normal years one would expect the opportunity costs of feeding farmer-produced cowpea haulms to be lower than the price of industrially produced feeds and therefore quite profitable to smallholder cattle feeders.

The current feeding performance of cattle in the programme depends very much on the availability and affordability of cottonseed cake. Even if prices are currently within reach, the profitability of feeding cottonseed cake will eventually drive up its demand hence its cost to farmers. The effects of anticipated increases in its price (a hypothetical 50% increase), clearly indicates that rations with reduced quantities, even though they produce smaller daily weight gains, are more profitable to feeders. The implication is that if farmers could obtain cottonseed cake at lower prices and hence use greater quantities, they would be able to turn out heavier animals over shorter feeding periods. However, since the unit cost of a commercially produced feed on the farmer's field includes transportation costs, feeding animals close to feeds factories where transportation costs are minimal appears to be a good strategy for increasing profitability.

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Combinations of agro-industrial by-products for use in dairy diets formulated by on-farm use of a least cost ration system

J.M. Chesworth[1], D.F McKillop[1] and D.J. Spriggs[2]
[1]University of Zimbabwe, Department of Animal Science
P.O. Box 167, Mount Pleasant, Harare, Zimbabwe
[2]National Association of Dairy Farmers
P.O. Box 1241, Harare, Zimbabwe

ABSTRACT

The main limitations to the use of by-products in diets for farm animals are the uncertainty of the likely response in terms of animal production and their need for supplemenation with other materials to provide a diet adequate for the needs of production. These problems are found at all levels of animal production from subsistence systems to commercial farming. In industrialised countries and some developing ones agro-industrial by-products are commonly incorporated into commercially compounded feeds on a basis of decisions made using computing methods. A computer package has been written to offer these same facilities at a relatively low-cost to the individual or group of farmers. The system has application in situations in which there exists some element of choice in the feeding of animals. There are three components to the system for calculating diets in this way.

This paper describes the development and application of one such system as a decision-making tool in the optimisation of utilisation of feeds, including agro-industrial by-products, on dairy farms in Zimbabwe. Copies of the computer package are available to organisations in developing countries for the cost of the media.

INTRODUCTION

Application of feeding systems in small-scale agriculture

At the previous meeting of the African Research Network for Agricultural by-products held in Egypt, strong criticism was voiced of the application to small-scale farming operations of feeding standards, developed in industrialised countries (Preston, 1986). This criticism was based upon the fact that in some subsistence-type farming environments it has been shown that animal performance obtained after the feeding of combinations of poor quality materials was not accurately predicted from published laboratory assessments of these feeds.

If it is accepted that at very low levels of production it is inappropriate to use feeding systems but that it is entirely correct when dealing with animals on large-scale commercial enterprises then there must be a point of cross-over between the two. Most of the difficulties with the application of feeding standards stem from the fact that many of the forages and by-products that are used in subsistence agriculture are of relatively poor quality and that book values for their probable nitrate composition give a poor prediction of their usefulness. The reason for this is to be found in the so-called associative effects of feeds. These are often ignored in the formulation of rations in large-scale farming as, with high quality diets, they bring very limited changes. As the number of ingredients in a diet is reduced the chances of large interactive effects increase.

Given a very large number of dietary components there is a much greater chance that the range of materials will combine to i) support optimum rumen fermentation and ii) supply materials to the rumen hall and to the hind gut in approximately the right proportions. One of the objectives of feeding systems such as the combined ME and new protein systems of the ARC (1980, 1984) has been to give results which will provide good rumen fermentation leading to the uptake of appropriate materials from the gut. That it is not possible to transfer such rationing systems to many small-holder situations is due to the fact that the small number of materials of very unbalanced composition which are available do not combine satisfactorily to provide optimum rumen fermentation.

The dairy industry in Zimbabwe

Zimbabwe has a very well developed commercial dairy industry which is characterised by a relatively small number (approximately 540) of large-scale producers. The technology used on many of these farms is comparable to that found in industrialised countries; in addition cows are of European breeds and are usually fed on combinations of home-grown roughages together with factory-compounded concentrate feeds. Since Independence there has been a move towards the development of a small-scale dairy sector. The objectives here are twofold: (i) to provide a higher level of nutrition for the human population in these areas and (ii) to create some cash income for small-scale farmers. As a consequence of the large-scale commercial industry the country already possesses a sophisticated distribution and marketing network serving a largely urban market. Much of the infrastructure in terms of bulk-handling facilities is already in place and in a number of areas points have been established for the collection of milk from small-scale producers.

The fact that the infrastructure exists for the farmers to get their produce to the market also means that they are able to buy foodstuffs from external suppliers and do not have to rely solely upon farm-produced materials. The largest schemes of this nature form part of planned resettlement schemes where the farmers would have access to land, water and amenities such as schooling. Many farming decisions are not available to the farmer; he is only allowed to crop a part of his land, the remainder must be used for animal production. As a part of the whole package, they are growing Napier grass, *Pennisetum purpureum* (approximately 2.23 ha per producer), and have a smaller area for cropping. Under Zimbabwean conditions Napier grass may be expected to yield between 4 and 10 tonnes of dry matter per hectare per year (Addison, 1952). Under most conditions this dry matter has a relatively low crude protein level. Cropping will undoubtedly produce residues which may also be incorporated into the animal production systems. Again these materials may be expected to be of low digestibility and low protein content. In addition to the home-produced feeds they are purchasing compounded feeds from stock-feed companies and thus are in the same market as their large-scale colleagues. Farmers on the resettlement schemes have costs to meet in producing their milk and in transporting it to the collection points and for this reason they have to work on similar, but smaller, budgetary considerations.

One of the factors which has underlined government policy towards the dairy industry over the past few years has been a notable squeezing of the margins between the permitted prices of compounded feeds and the producer price for milk. The same prices are paid to all producers irrespective of size of enterprise so the difficulties are common to all sizes of farms. These changes in financial structure have resulted, in the commercial sector, in a much greater interest in the home-mixing of feeds and the incorporation into them of cheaper materials, many of them agro-industrial by-products. The aim is to balance what materials the farmer has with the minimum amount of purchased food. On the small-scale resettlement schemes the aim is just the same. These organised small-scale schemes do have one advantage over the more scattered communities which are typical of subsistence farmers: they are concentrated in one place and can use this opportunity to purchase larger quantities of feed or feed ingredients.

Availability of agro-industrial by-products in Zimbabwe

A large number of the ingredients available to the feed formulator are in fact agro-industrial by-products as these are generally cheaper than products which are available to the human food market. Within Zimbabwe many of the milling by-products are not accessible in raw form to the farmer as they are used by the feedstuffs divisions of the milling companies which produce them. A list of some of the by-products currently available in Zimbabwe is presented as Table 1.

Availability of computing facilities

Computers are now increasingly available to farmers and extension workers for a whole variety of tasks. The cost of a machine of sufficient sophistication for the formulation of livestock diets has fallen dramatically in recent years. In the early years of the decade one would have cost about the same as an expensive limousine, now when freely available they are about the same price as a basic motor cycle.

In addition to the computer hardware the following components are needed:

1. a system for calculating the likely requirements of farm animals,

2. a knowledge of the nutritional properties of each material which is likely to be fed expressed in the same terms as those in which animal requirements have been described, and

3. some way of choosing, from the information on feeds, the most advantageous mixture needed to satisfy the needs of animals.

Animal requirements

In designing a rationing system for farm animals the first consideration has to be the method used for the expression of animal requirements. There are a number of competing methods which have been developed in different countries of the world. In setting up the original computer program one consideration was to look for a system which would generate easily the values for the requirements of each nutrient. It was for this reason that we chose the British ARC method (ARC, 1980, 1984).

There are some disadvantages to the British scheme, the first one being the need to establish the quality of the diet before calculating the animal's needs and thus before the diet can be formulated. The technique has therefore to be an iterative one starting from a 'good guess' based on a knowledge of the materials likely to be available. The second is in the use of the protein rationing system. The theoretical basis of the ARC protein system (ARC, 1984) is not in serious question, it provides a useful conceptual framework which explains many of the apparent anomalies in previous schemes. Where it breaks down is in its need for an estimate of the likely fate in the rumen of any one protein source. Basically, the degradation of proteins will depend on the fermentative environment of the rumen and on the rate at which materials pass through. These will in turn depend upon the particular combination of feeds which enter the rumen, in other words it is necessary to know the result of the dietary formulation before starting to devise it.

Table 1. Agro-industrial by-products available directly to farmers in Zimbabwe.

Grain products	Straws and stovers
Maize superdust	Maize stover
Cracked maize	Sorghum stover
Sorghum bran (red and white)	Wheat straw
(Note: wheat products are not generally available to the farmer directly)	Barley straw
	Navy been straw
	Soyabean straw
	Cotton stalks
Animal by-products	
Feather meal	
Poultry manure	
Meat and bone meal	
Blood meal	
Fish waste	
Oilseed and associated products	Human food and beverage by-products
Cottonseed meal (extracted)	Bakery waste
Cottonseed (whole)	Peanut skins
Cotton hulls	Brewers grains
Sunflower meal	Navy (baked) bean waste
Sunflower hulls	Fruit pulp
Soyabean meal	Grape residues
Groundnut hulls	

In evolving a practical scheme that could be used some ways around these had to be found. In relation to the dietary quality, a first approximation of a metabolisability (q) of 0.5 is taken. This represents an overall ME in the dry-matter of a little less than 10 and is probably fairly representative of the overall diets that may be offered to dairy animals in tropical environments. At the end of the formulation procedure the metabolisability of the diet is estimated by the program and if this value differs widely from the starting estimate the operator is warned to start the whole procedure again using the new value.

Estimates of protein requirements made using the British system depend upon two completely separate sets of figures. The first is an estimate of the likely needs of the animal for amino acids. These figures can be well predicted from physiological data. The second set of information concerns the ability of the feed to provide amino acids. Here the precision of estimates must be much lower. The main problem is that many of the by-products which we might like to use have not yet been investigated.

When the ARC protein system was first published it was suggested that feeds should be divided up into four groups depending upon their likely degradabilities, each being assigned an assumed value. We have continued this procedure by ascribing new materials to the most similar group. To give some sort of latitude to the formulation in terms of protein quality we calculate independently the protein (UDP) and the rumen degradable protein (RDP) and sum them to produce the overall crude protein (CP) figure. A quite arbitrary 'safety margin' of 10% is added to the overall crude protein figure. In setting up the requirements for linear programming all three, UDP, RDP and CP are made 'greater-than' constraints. This means that an oversupply of protein is given but that this can be made up of either RDP or UDP.

There are two constraints which are set by the program package which are not derived from the ARC (1980, 1984) recommendations. These are for the minimum value of fibre in the diet and for the maximum value of fat. Neither of these is likely to be a significant problem for the small-scale producer. Given his inputs of poor quality crop residues or of very fibrous grass then he is unlikely to be short of fibre. Similarly it is unlikely that he will have access to high fat materials such as unextracted soyabeans.

It was decided not to formulate in terms of trace elements; it is notoriously difficult to predict reliably the trace element composition of feeds particularly when buying feed ingredients from distant, and possibly unknown, sources. As a policy we recommend the incorporation of the recommended amount of a proprietory mineral mixture in what has been referred to as the "shot-gun" approach. This has the added advantage of reducing the number of constraints that may be applied and thus speeds solution of the linear programming matrix. The constraints applied to formulation are shown in Table 2.

Table 2. Constraints used in dietary formulation.

Component	Unit
Metabolizable energy	MJ/kg dry matter
Crude protein	g/kg dry matter*
Rumen-degradable protein	" " "
Undegradable protein	" " "
Calcium	" " "
Phosphorous	" " "
Magnesium	" " "
Fibre	" " "
Fat+	" " "

*Set to be 10% higher than the sum of rumen-degradable and undegradable proteins.

+Set as a maximum value.

Information of feed composition

To perform the calculation, figures are needed for the composition of each of the individual ingredients that may be considered for inclusion in the diet. In a large commercial organisation there may be several hundred ingredients that are available to the compounder. It is not possible for the company to analyse every batch of material as it enters the factory and indeed this may be a waste of time in terms of the known variability of sample composition between different parts of the same bulk delivery of a feed. Not only this, the feed manufacturer may not physically have some of the ingredients on his premises at the time at which the initial formulation is undertaken. Buying of a needed ingredient may actually follow the decision to incorporate it. The feed manufacturer thus makes his decisions on the incorporation of ingredients on a basis of information which he has gleaned from a wide variety of sources and which experience has shown him to be relatively reliable. As an example of the consistency of data relating to feed composition it is worthwhile looking at the detailed studies of the Rowett Research Institute's Feed Evaluation Unit (FEU, 1980). For example, 16 samples of maize from all over the world had ME values with a mean of 13.7 MJ/kg dry weight and coefficient of variation of only 6.6%; the average crude protein was 104.5 g/kg dry weight with a coefficient of variation of 5.0%. It is unlikely that changing the maize from the best one to the worst would have had any great effect on the cost of diets which incorporated them, nor upon the resulting animal production.

In setting up the linear programming system for use on farms a major difficulty has been in ascribing likely nutrient composition to many of the materials which have been found to be available in relatively small amounts. The collection of data has used a large number of sources and not all of these are consistent in the ways in which they calculate or even express their information. In a small country it is not possible to have analytical data on every single type of material, much less every batch that is released onto the farming market. Many of the materials which do become available are common to a number of countries and it ought to be possible to agree on one or two 'compromise' figures that describe the properties of each type of feed. Such effort would be more economically expended at an international level and as such would tend to reduce the problems associated with the various schemes of analysis employed in different countries.

The use of analytical figures which may not precisely reflect the nutrient value of the material under consideration is open to question. If, however, we look for instance at the metabolisable energy of a poor quality feed and consider it for incorporation into a diet, does it matter significantly if we assume its ME to be 8.5 rather than 7.5 MJ/Kg, the errors that we shall experience in arriving at first estimate of intake may be much greater than this. It must be emphasised that this is a management tool and only provides a likely first estimate that the farmer will have to modify in the light of experience.

Linking of the animal requirements and feed composition

The programs have been written to run on two different machines. The first release (Release 1.0) of the package was written for the small farm which might have access to a 'BBC Model B' computer manufactured in Britain by the Acorn Computers Limited (Cambridge, England).

With the rapid increase in the number of computers available in the agricultural sector in Zimbabwe it became obvious that the main type of machine that was and would continue to be available was the IBM personal computer (IBM/PC) and its derivatives and copies. With this in mind a second version of the program was written. The flexibility of the system was reduced by fixing the number of constraints to 9 and by limiting it to cattle diets. With the larger amounts of memory available on the IBM/PC machines it became possible to increase to a maximum of 30 the number of ingredients considered each time a diet is formulated.

Operation of the package

Animal requirements

The package consists of three elements. The first section calculates, according to the ARC (1980, 1984) recommendations, the likely daily nutrient requirements of cattle under different production systems for ME, crude protein, rumen-degradable protein, undegradable protein, calcium, phosphorous and magnesium. The user is then prompted to enter values which he considers appropriate for the maximum amount of fat and the minimum amount of fibre in the ration (there are default values of 50 and 150 g/kg dry matter respectively). The program also calculates a maximum value for the dry-matter intake of the animals using relationships that are described elsewhere in this paper. These relationships are ones which have been developed for the most part using cattle of European breeds and maintained under good nutritional conditions. The estimates may not be appropriate for all conditions so provision is made for the estimates to be reduced in the light of experience with local conditions. Once the nutritional conditions have been set, the display shows the likely nutrient densities (in MJ/Kg or g/kg dry-matter as appropriate). If any of these figures are apparently out of line with practical diets the figure is 'starred' and the user asked to consider collecting the dietary requirements again with more realistic production targets. As an example, it is unlikely that diets with an ME content of more than about 13.5 MJ/kg could be formulated under practical condition. Once the operator is satisfied with the ration in terms of its composition the details are sorted as a data file until required for the third segment of the package.

Feed information

The second element of the package is a data handling system for the feedstuffs which works similarly to a standard spreadsheet. This program can create and maintain a file in which details are kept of all the ingredients which are likely to be encountered in the country in question. The maximum number of ingredients that may be so maintained at the moment is 98 but there is no reason why this number should not be increased if users find the current limit too restrictive. The filing system works rather like a commercial menu-driven spreadsheet. In addition to the nutritional data on any material the price per kg of fresh weight must be entered. The individual user in his own country will have to build up this file for his own circumstances. There is on the diskette as released a trial version of the data file but this is included only for demonstration purposes and no guarantee is given as to the accuracy or applicability of the data.

Not all of the ingredients which are stored in the main matrix file will be available to the user at any one time. For this reason when making practical diets the user chooses a subset of ingredients that he already has or to which he might have access. The maximum number that can be chosen for consideration on entry into the diet is 30. On a farm, a co-operative or in a small feed manufacturing company it is unlikely that this figure will need to be exceeded.

Restrictions on inclusion

At this stage the user may choose to set limits on the inclusion of materials into the ration. For instance, in the case of a roughage of low quality it is often prudent to set a maximum amount to the proportion of the overall diet that this can represent due to the fact that it is likely that the animal will have a very restricted voluntary intake of this meterial. On the other hand, if the farmer has a very large stock of some material, it may be that he has to include at least some of it in his diets to ensure that it does not go to waste. The inclusion of this ingredient will have to be limited in the opposite direction, in other words the user sets a minimum amount that must be incorporated in the diet. It has to be admitted that limits of this nature can often prove to be obstacles to the successful formulation of diets and the tool must be used with great care. One other way of promoting the inclusion of an ingredient into a diet is to reduce its price to a ridiculous value and see if the least cost formulation includes or excludes it. If the ingredient is excluded even at a very low price it may be that the prudent farmer will consider throwing it away as its use is likely to cost rather than save money.

Dry-matter intakes of roughages

It is a fairly clear limitation to the use of roughages of low digestibility that it is difficult to assess the likely intake of such materials by ruminants. Intakes of some of the poorer materials may be as low as 0.5% of body mass whereas intakes as high as 1.8% of body mass have been achieved by animals given improved roughages supplemented with sources of high quality concentrates. Obviously in designing diets for livestock the likely intake has to be a major consideration.

In assessing dry-matter intakes of dairy animals we have used models that have been developed and used with great success in industrialised countries. A selection of such regressions is presented in Table 3.

Table 3. Equations used for prediction of total dry-matter intake of cows.

A. TDMI[1] $= 0.10MY + 0.015LW$

B. TDMI[2] $= 0.2MY + 0.22LW$

C. TDMI[3] $= 0.076 + 0.404CDM + 0.013LW - 0.129WL + 4.120\log WL + 0.14MY$

D. TDMI $= 3.476 + 0.404CDM + 0.013LW - 0.129WL + 4.120\log WL + 0.14MY$

E. TDMI[4] $= 27.8 + 106.5q \times LW^{0.75}/1000$

F. TDMI[5] $= 116.8 - 46.6x \times LW^{0.75}/1000$

Where TDMI is total daily dry-matter intake, CDM is concentrate dry-matter intake/day, MY is daily milk yield in kg/day, WL is week of lactation, LW is animal liveweight in kg, q = diets of 0.5, 0.6 and 0.7 kg/d of DMI.

Notes :

1,2. For cows on low and medium quality diets equations A and B are used, the latter for high yielding cows (defined as a daily milk yield of over 15 kg/day)

3. For lactation cows receiving high quality diets (defined as those with an overall metabolisability of 0.65 and above) equation D is used, the quantity of concentrates being calculated on a sliding scale assuming a metabolisability of 0.55 for the roughage component and 0.7 for the concentrates.

4,5. The program selects equations E and F for non-lactating cows receiving coarse and fine roughages respectively.

For the origins of equations A-D see Caird and Holmes (1986). Equations E and F are from ARC (1980).

Preliminary results obtained recently in Zimbabwe in a large scale trial in which a variety of treated roughages were fed to growing heifers on dairy farms are shown in Table 4. In each of these trials the animals were fed a high quality concentrate mixture of maize, cottonseed and soyabean meals and minerals at the rate of approximately 1% of live body mass. It can be seen from these figures that dry-matter intakes ranged from about 1.4 to 1.8% of live body mass. Most of these materials were of fairly high quality prior to chemical treatment and thus effects of treatment are not as great as might be expected. On the basis of these figures and those to be found in the literature we have made the assumption that roughage comes in 4 categories: poor, mediocre, good or excellent. The likely intakes of these materials as dry-matter have been set at 0.8, 1.0, 1.4 and 1.8% of live body mass. When setting the restrictions upon the inclusion of materials in the rations the appropriate figure is entered as a maximum value for the chosen roughage. This is likely to be subject to enormous errors but it has to be remembered that the whole purpose of the package is not to provide a precise prophesy of the amount of each dietary constituent to be consumed, it is a management tool to assist in decision making.

Linear program

The third segment of the program consists of the linear programming itself. The program calls for the name of the file on which details of the ingredients have been stored and the file on which the diet is specified. The user can then look at the matrix of data which is to be used to formulate his diet. It is also possible for data to be edited at this stage, for instance the user can change the specification of the feed to see what effect this has on the composition of the diet or even on its feasibility. After the user has finalised his choice of values the program continues to calculate the least cost ration. The results are expressed in terms of dry-matter and fresh matter.

Experience in the use of the programs

The suite of programs was originally written with the small farm in mind. It has been tested over a period of two years on a group of small- to medium-sized dairy farms in the Chequtu-Kadoma area of Zimbabwe through the co-operation of the National Association of Dairy Farming in Zimbabwe. Much of this area has a mean annual rainfall of approximately 650-800 mm and some is in natural region III. Some of the farms have limited areas of irrigation but many are involved in dry-land farming. It was found that most of the dairy farmers in the area were purchasing their feeds from one of four very large commercial compounders. The initial part of the study involved taking the manufacturers' published specification of feeds and formulating similar products. The saving to the farmer of home-mixing of feeds as against the cost of purchasing a ready made product varied from 15 to 45% depending on the feed. In general, savings were greatest with those feeds which had lower nutrient densities.

Table 4. Intakes of treated roughages by heifers (Holstein and Friesian breeds) on dairy farms in Zimbabwe.

Site	Roughage source	Treatment	Intake*
Ruwa	Maize stover	Chopped	1.6
"	" "	Chopped, urea added at feeding	1.6
"	" "	Urea incubeted	1.8
"	" "	NaOH (4%)	1.8
Nyamandhlovu**	" "	Chopped	1.8
"	" "	Chopped, urea added at feeding	1.8
"	" "	Urea incubated	1.8
"	" "	NaOH (4%)	1.8
Norton	Wheat straw	None	1.3
"	" "	Urea added at feeding	1.4
"	" "	Urea incubated	1.4
"	" "	NaOH (4%)	1.5
Chegutu	Veld hay	Chopped	1.6
"	" "	Chopped, urea added at feeding	1.5
"	" "	Urea incubated	1.8
"	" "	NaOH (4%)	1.8

* Dry-matter intakes are expressed as percentage of livemass, mean values for pen of ten animals per treatment (figures rounded to one decimal point). Preliminary results of Chesworth, Smith and Spriggs.

** The stover used in this trial was from green maize production and was exceedingly 'sweet'.

The next stage was to use the programs as a tool in the determination of the overall policy of the farm. Farmers were encouraged to list the quantities of materials that they expected to have available on their farms. These materials, principally low digestibility products such as veld grasses and crop residues such as maize stover and soyabean hay, were then forced into formulation both passively by setting their prices down to exceptionally low levels (typically the direct material costs of harvesting them) and by setting their levels as constraints in the formulation. Overall diets formulated in this way included roughage materials which were not normally mixed and included in a complete diet. Animals were allowed access *ad libitum* to the roughage and the higher quality materials were fed as a mixed meal in line with the normal feeding policy on that farm. For this reason the formulation program has the facility to give the composition of the required diet after the subtraction of one (release 1.0) or more (release 2.0) ingredients. The use of the program led to much more complete utilization of the materials available on the farm.

Future developments

Linear programming as it is used in most of the feed industry is a method which has only one clear-cut objective: it chooses the unique combination of ingredient materials which are the cheapest way of satisfying a series of fixed criteria. The feed industry does not have any duty to look further than that. The objectives of the farmer may be much more complex than those of the manufacturer. He has a number of criteria which are poorly defined and about which he has to make decisions. The decisions are made on the basis of imperfect data and are not all equal in their importance to him. As a simple example of this, compare the meeting of criteria for metabolisable energy with those for calcium. To increase the ME of a feed from 9 to 13 MJ/kg dry-matter would result in a major expense. The latter diet would probably cost several times the former. On the other hand an increase in calcium incorporation from 9 to 13 g/kg dry-matter would probably, on its own, add little to the cost of a ration. It is one of the weaknesses of linear programming that it will work just as hard to meet each of these criteria. Decisions in the real world of farming are not as clear-cut as those in the manufacturing industries and really need appropriate techniques to reflect this. There is a development of classical linear programming methods which is called linear goal programming. In this, the overall criteria are similar to those set up in linear programs but in goal programming the problem is expressed as a series of desirable objectives which can be set in order of priority. For instance the most important priority might be that a diet is produced with an ME value of 11 MJ/kg and with crude protein level which differs little from 160 g/kg. This is in fact the most important part of the specification of the diet; for the given level of production the animal needs its food and whatever price is necessary must be paid. Reducing the price of the diet then is of less importance. The third objective therefore becomes to set the overall price of the diet as near as possible to the cost of the cheapest ingredient. This is much closer to the decision-making process which is adopted empirically by farmers.

There are differences in the way in which two systems arrive at feasible solutions; the older method uses the technique of adding and subtracting 'slack' values of zero cost to allow for the over- or under-supply of nutrients. In goal programming a series of deviations from the goals or objectives (the right hand side of classical LP) are set. The solution uses an iterative procedure to reduce the overall deviation from the desired values in order of priority.

Experiences with the preliminary versions of goal programming have not shown any great deviations from the solutions that would be reached using more conventional linear programs. Advantages are likely to be more apparent when the group of ingredients which is available to the procedure is deficient in one or more of one of the minor components of the diet.

CONCLUSION

Linear programming has proved itself to be a useful tool in the formulation of diets in situations where some choice is available in respect of the ingredients that may be incorporated into diets for productive livestock. The technology is available and the facilities are becoming more common even in developing countries. In order to be able to use the system there will be an increasing need for the compilation of feed information, not only on the feeds themselves but also on their properties after modification.

Future developments will include the adoption of more appropriate optimisation methods that more closely parallel the empirical thinking needed to make rational decisions in animal production.

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OVERCOMING THE CONSTRAINTS OF NITROGEN AVAILABILITY TO IMPROVE CROP RESIDUE UTILISATION BY RUMINANTS IN BURKINA FASO

Kassu Yilala
Semi-Arid Food Grain Research and Development
Co-ordination Office, OAU/STRC
B.P. 1783, Ouagadougou
Burkina Faso

ABSTRACT

The improvement in the efficiency with which ruminant animals transform crop residues into meat, milk and draught power will have important implications in the integration of animals in the strongly cereal crop-oriented production system of the Soudanian zone of Burkina Faso. There is a mismatching of supply of nutrients and the physiological states of animals in the production system. The abundant cellulosic energy could not be utilised effectively mainly due to the constraint of nitrogen (N) availability. The choice of source of N, non-protein or protein-N, is crucial to the development of a feeding system that is sound biologically and economically.

The biological aspects of utilisation of crop residues with the aid of N supplements at ruminal and tissue levels are discussed to justify the choice of source of N that could fit into the objective conditions of the production system. The production system could be responsive to changes if the intervention is compatible with the long term productivity of cereal crop production through improved soil fertility and structure.

Amongst the sources of N emphasis was put on the use of forage or dual-purpose legumes for they could serve as the key link between animal and crop production systems, the latter through increased soil N and organic matter (OM) status. The patterns of *in vitro* degradation of OM and N of the forage legumes and sorghum and millet stovers were assessed and briefly discussed. It was shown that the forage legumes in addition to correcting the deficiency of rumen degradable nitrogen (RDN), if supplemented to cereal stovers, can also contribute a substantial amount of rumen-degradable organic matter (RDOM). However, due to the rapid degradation of N the available RDOM may not be able to match to the former. Suggestions are given to increase the supply of protein to the small intestine.

INTRODUCTION

Mixed crop-animal production occurs virtually throughout the farming sectors of Burkina Faso. In the Soudanian zone cereal crop sorghum and millet, production is the foundation of agriculture and animal production the vital economic unit of the system.

Declining crop yield/unit area accompanied by progressively increasing requirement for food is forcing farmers to cultivate more land at the expense of grazing pasture and browses. The other aspect of this process is the increase in the production of cereal crop residues. There is already a heavy reliance on the use of the by-products as feed during the long dry season, manifested by the large number of ruminants concentrated in the zone, while moving from the Sahel to the Guinean zones, immediately after harvest of cereals.

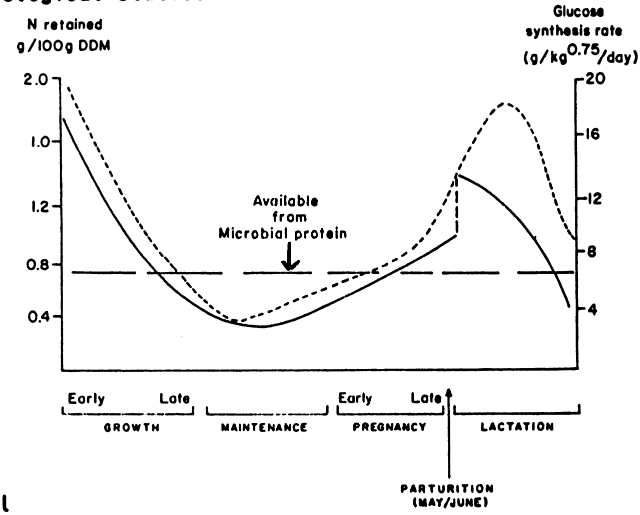
It is well documented that the utilisation of the energy components of such materials by ruminant animals is highly dependent on the efficiency of the fermentative activity of the microbes in the rumen. For optimum or maximum fermentation on a given diet a certain level of ammonia (NH_3) concentration in the rumen is required. Otherwise feed intake may be reduced if NH_3 concentration is limiting the rate of fermentation (Mehrez et al, 1977). Animals fed on such materials as their sole diet show low dry-matter intakes and decline in liveweight. There is ample evidence that with the inclusion of a source of nitrogen, NPN or protein-N, positive responses in intake and liveweight gain can be realised. In the Soudanian zone of

Burkina Faso, as in other semi-arid regions, nitrogen is the most limiting nutrient for ruminant animal production. Therefore, the incorporation of this nutrient in a feeding system based on low-nitrogen fibrous diet is of paramount importance. The attempt in supplementing with nitrogen should be to maximise the utilisation of the residues through the fermentative activities in the rumen and to realise as large responses as possible at the tissue level of the host animal at a given physiological state.

MISMATCHING OF SUPPLY OF NUTRIENTS AND PHYSIOLOGICAL STATES OF ANIMALS IN THE SOUDANIAN ZONE OF BURKINA FASO

Improvement in animal productivity requires improved nutrition throughout the year with a guarantee for adequate supply, quantitatively and qualitatively, in the latter part of pregnancy, lactation and early growth periods. Orskov (1970) and Kempton et al (1977) have demonstrated animal needs of amino acids and glucose according to physiological states (Figure 1). Such concepts could serve as guidelines to the budgetting of available nutrients according to nutritional needs of the animal. The demand for amino acids and energy (in the form of glucose) are high during growth, late pregnancy and lactation. In Burkina Faso the main calving, lambing or kidding seasons are just before or during the rains (May/June), but some births also take place in October/November just after the rains, when cereal residues become abundant. The high demand for nutrients during the last stage of pregnancy in the former case, or during lactation in the latter, cannot be met adequately from the natural pasture and cereal residues; the nutritional status of the animels, lactation parformance and growth of the young are reduced, and are reflected by high rates of pre-and post-weaning mortality of calves and lambs in the semi-arid regions, depanding on the month of the year (ILCA, 1982).

Figure 1. Potential retention of N in relation to digestible dry-matter intake (______) and glucose synthesis rate (-------)in various physiological states.*



* Physiological state	Major sources of nutrients
Growth	
- Preweaning	- Might benefit from improved pasture between July and September through dam's milk during early pre-weaning period.
- Postweaning	- Exposed to mature natural pasture and crop residues.
Maintenance	- If between October and June all animals are exposed to standing mature dry pasture and cereal residues.
Pregnancy	- Last 10 to 8 weeks before parturition exposed to extremely dry mature natural pasture and cereal residues. Period of severe deficit of nutrients.
Lactation	- First 90 - 120 days lactating animals exposed to improved grazing conditions to be followed by cereal residues.

Sources: Orskov (1970); Kempton et al, (1977).

The nutrient yield from the natural pasture increases between July and October, but the short rainy season accompanied by high evapotranspiration and high temperature results in rapid decline in the contents of nitrogen (Figure 2) and degradation of organic matter (OM) in the rumen (Table 1).

When available, farmers use groundnut and cowpea haulms, the latter grown in association with millet, to supplement cereal residues to selected animals. However, the quantities produced on the farm are not adequate to satisfy the requirements during periods of high nutrient demand.

Table 1. *In vitro* dry-matter digestibility (DMD) and *in-sacco* disappearance of DM of fallow natural pasture cut at different stages of growth, Soudanian zone, Burkina Faso.

Date of cutting	*In vitro* DMD (%)	Disappearance of DM in the rumen Incubation (h) 0	48
21-08-85	63.4	26.7	71.4
11-09-85	61.4	22.7	65.5
20-02-85	59.1	19.6	55.6
23-10-85	57.1	15.7	58.7
14-11-85	54.1	13.7	57.9
LSD (P=0.05)	2.3	3.3	4.1

Source: Yilala (1986b).

BASIC PRINCIPLES FOR THE CHOICE OF SOURCE OF NITROGEN TO UTILISE CEREAL BY-PRODUCTS

The feeding system that needs to be established under a particular condition should be based on the universal biological laws of nutrient utilisation by ruminants and also fit into the economic realities of the production system. Some aspects of the basic biological principles involved in the digestion in the rumen and utilisation by the host animal of cereal residues supplemented with NPN or protein-N, and the implications of these principles on the choice of sources of nitrogen to fit into the objective conditions of the production system in Burkina Faso will be discussed briefly.

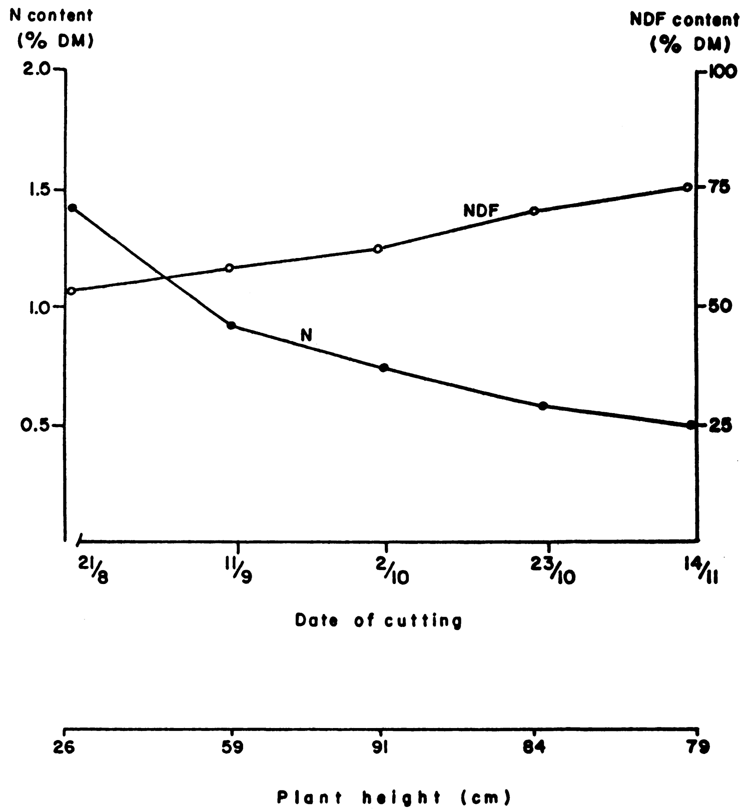
1. Biological

1.1 Effects of source of nitrogen on microbial digestion and voluntary intake

Several studies have shown improvements in the intake of low-nitrogen fibrous diets due to urea supplementation (Egan, 1965; Egan and Moir, 1965; Kempton and Leng, 1979; Sriskandrajah et al, 1982), attributed to increased rate of digestion of cellulose in the rumen (Egan, 1965; Egan and Moir, 1965), probably resulting in increased rate of passage of feed, thereby possibly alleviating a physical limitation to intake (Blaxter et al, 1961).

The degradation of urea is known to be too rapid (Johnson, 1976), indicating that the efficiency of utilisation could be low when used with cellulosic diets, which yield energy too slowly for the efficient capture of NH_3 by rumen micro-organisms (Meggison et al, 1979). To realise a more effective utilisation of urea its N may need to be released slowly (Orskov, 1982). The synchronisation of rate of degradation of N and carbohydrate components in the rumen is important for the synthesis of microbial protein (Meggison et al, 1979; Satter and Roffler, 1981). Microbial protein synthesised in the rumen is the major source of N to the host animal accounting for 60-85% of the total amino acids entering the small intestine (Orskov, 1982). The pattern of degradation, therefore, influences the choice of N source for efficient utilisation of cereal residues. A rapid degradation of N not matched to the release of OM from the carbohydrate could lead to a high absorption of NH_3 from the rumen (Meggison et al, 1979). The availability of suitable carbon skeletons and ATP from plant material is a requirement for the NH_3 released from dietary urea to be used for microbial protein synthesis (Czerkawski, 1986).

Figure 2. Pattern of change in the proportion of N and NDF in the DM of natural pasture on fallow land cut at different intervals from August 21 to November 14, 1985 (Soudanian zone, Burkina Faso).



Source. Yilala (1986b).

The NH_3 not captured in the rumen is absorbed and converted into urea, partly to be transferred to the rumen and influence the digestion rate of cellulose or be lost in the urine depending on the concentration of NH_3 in the rumen (Kennedy and Milligan, 1978). The synthesis of urea in the liver requires expenditure of energy, each mole of urea requiring 4 moles of ATP (Martin and Blaxter, 1965).

Compared with urea, protein-N sources could provide better conditions for the digestion of cereal residues by the microbes in the rumen, for the following reasons:

a. Although NH_3 is the major source of N for microbial growth, some species are able to utilise or require the presence of peptides and/or amino acids for growth (Cotta and Russel, 1982; Czerkawski, 1986; Harrison and McAllan, 1980; Maeng and Baldwin, 1976; Pisulewski et al, 1981).

b. Due to the variation in degradability, many protein-N sources release NH_3 at slower rate than urea-N, more closely coinciding with release of energy from the cellulosic component and thus enhancing microbial production (Miller, 1982). This in turn will also stimulate increased rate of cellulose digestion and voluntary intake.

c. Protein-N can also serve as a good source of sulphur which usually is lacking in low-protein roughage diets (Miller, 1982). The supplementation of roughage diets with sulphur showed increases in the digestion of cellulose (Gill et al, 1973; Gulati et al, 1985; Spaars et al, 1976) for it is an essential element for ruminal microbes (ARC, 1980; Spears et al, 1976).

1.2 Effects of source of nitrogen on the response at the tissue level

The animal is mainly dependent on volatile fatty acids (VFA) as its source of energy. However, glucose is the major energy component required for various metabolic processes in the tissue.

Because ruminants are unable to absorb sufficient glucose from the digestive tract to meet their needs (Lindsay, 1980), the availability of glycogenic materials such as propionic acid and amino acids is essential (Kempton et al, 1977). The fermentation of poor quality roughages such as cereal residues normally leads to the production of high proportion of acetic acid (Thomas and Rook, 1981) which is non glycogenic (Hovell and Greenhalgh, 1978). Thus cereal residues cannot supply adequate energy for the retention of N at the tissue level.

Under such conditions amino acids of microbial origin or catabolised from the tissues might through gluconeogenesis supply glucose for protein synthesis (MaCrae and Reeds, 1980), to utilise acetate for lipogenesis (Hovell and Greenhalgh, 1978), and for urea synthesis in the liver (Martin and Blaxter, 1965), indicating that the metabolism of absorbed amino acids contributes also to energy metabolism. The transformation of amino acids into glucose obviously reduces the efficiency with which the former are utilised for tissue synthesis (MaCrae and Reeds, 1980).

With no contribution from the urea to the energy pool the low N balance values for the urea-N, as compared to protein-N supplemented diets (Egan, 1965; Krzeminski, 1985) is not surprising. The large increase in liveweight gain (Saadullah et al, 1983; Kempton and Leng, 1979) or reduction in plasma urea and increase in N retention (Krzeminski, 1985) due to the inclusion of poorly degraded protein-N sources in straw diets containing urea supplements might, at least partially, be associated with the supply of glucose contributed by amino acids absorbed from the small intestine. Besides this, the improvements in N status of the animals were associated with increases in the intake of the fibrous diets (Egan, 1965; Kempton and Leng, 1979).

2 Objective conditions of production system

From the above it is clear that the form of N supplementation of cereal by-products should be considered if effective intervention is desired at small-scale farm level. Quite often it is urea-N, assumed to be easily available and cheap per unit of N, that is considered to improve the utilisation of cereal residues, either for direct supplementation or treatment of the by-product. Treating residues with urea has been observed to enrich the N content and result in positive effects on digestibility, intake (Dolberg et al, 1981) and liveweight changes better than the direct application prior to feeding (Orskov, 1981).

As a result of these and simplicity in the method of treatment it is believed to be applicable under small-scale farm conditions. However, under the prevailing conditions in Burkina Faso this does not appear to hold true, at least for the time being, for two main reasons:

a. Treatment with urea requires large quantity of water (1 litre of water/kg of straw; Dolberg et al, 1981); the principal constraint of the production system in the Soudanian zone.

b. NH_3 loss could be up to 60% when straw is treated with urea (Sundstol, 1981) and such losses cannot be justified under conditions of limited N supply.

Protein-N sources such as oilseed cakes and those of animal origin are produced in limited quantity and seem to be beyond the economic reach of the farmers. The self-reliance of the farmer in the source of N, therefore, is a prerequisite to improve the efficiency of utilisation of the cereal residues and productivity of animals.

Forage legumes have enormous potential under such conditions. Since N is also the most limiting nutrient in the soils of Burkina Faso, the production of forage, or dual-purpose legumes could be compatible with the long-term productivity of the production system comprising soil fertility through N_2 fixation. The increase in cereal grain yield could be accompanied with an increase in residue yield. Forage legumes could, therefore, serve as the key link for effective integration of animals into the strongly crop-oriented production system.

FORAGE OR DUAL-PURPOSE LEGUMES: RELIABLE SOURCE OF N

Intercropping of cereals with legumes such as cowpea is a common practice in the Soudanian zone of Burkina Faso. Groundnut is grown as a sole crop on small plots of land. The residues of these crops serve as sources of N to supplement the diets of selected animals. However, the quantity produced on the farm is low, compared to the DM of cereal residues, and cannot offset the deficiency of N (Table 2).

Studies with forage and dual-purpose legumes on fallow land showed the existence of great potential for the replacement of poor fallow pasture with legumes which could be conserved as hay for feeding as required. The legumes used were: *Dolichos lablab*, *Stylosanthes hamata*, *Macroptilium atropurpureum*, *Vigna unguiculata* (local and improved varieties) and *Phaseolus aureus*.

In general legumes are known to be less dependent on soil N for they obtain their N through biological fixation. As a result, the N content of all the legumes during the period of observation has always been above the critical level, for animal use, at all stages of growth compared to the natural pasture (Figure 3b). The critical level of N below which voluntary intake of DM is depressed is 1.12% (Whiteman, 1980). As expected there was a decline in the contents of N and increase in the contents of the cell wall components (Figure 3a). Differences were also noted in the solubility of DM due to species differences and stage of growth (Table 3).

Table 2. Estimated yields of dry matter (DM), metabolisable energy (ME) and rumen-degradable nitrogen (RDN) of cereal residues, legume haulms and legume hays.

	Cereal residue		Legume haulms			Legume hay	
			Cowpea		Groundnut		
	Sorghum	Millet	Sole	Intercrop		Cowpea	D. lablab
DM yield (kg/ha)[1]	4209	3125	373	101	1497	3010	3010
ME yield (kg/ha)[2]	31568	16875	2611	707	11527	26187	34595
RDN yield (kg/ha)[3]	20	10	4.4	1.0	16.9	115	148
RDN required to match ME yield (kg/ha)	40	21	3.3	0.9	14.4	33	43
RDN balance (kg/ha)[4]	-20	-11	1.1	0.1	2.5	82	105

1. Values are averages for different villages in the Soudanian zone, Burkina Faso.

2. Calculated using the *in vitro* digestible organic matter values.

3. Refers to the 24 h *in vitro* disappearance.

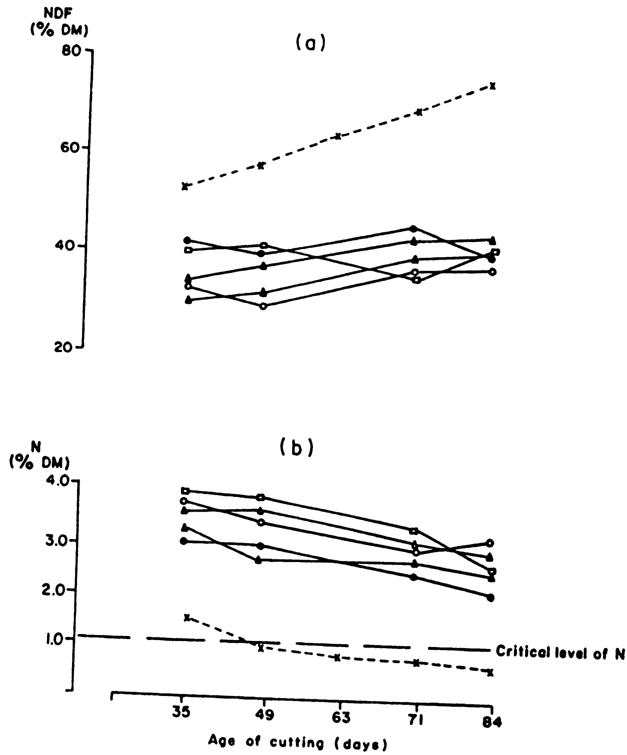
4. Assuming complete synchronization of release of energy and nitrogen in the rumen.

Table 3. Disappearance of dry matter (%) of forage legumes, grown on fallow land, from nylon bags in the rumen of cattle for incubation period of 0 and 48 h.

Species	Age of cutting (days)							
	35		49		77		84	
	Incubation (h)		Incubation (h)		Incubation (h)		Incubation (h)	
	0	48	0	48	0	48	0	48
D. lablab (cv Highworth)	52.9	84.9	55.9	89.6	40.3	80.1	40.0	83.0
V. unguiculata (cv KN-1)	46.5	88.8	41.6	79.9	43.1	80.8	41.1	85.7
P. aureus	45.1	82.9	46.2	86.3	40.1	86.0	42.5	85.9
S. hamata	-	-	36.4	81.1	34.8	75.9	32.5	75.4
M. atropurpureum	37.3	72.3	36.4	64.5	34.2	62.2	32.3	58.8

Source: Yilala (1986a).

Figure 3. Patterns of change in nitrogen (N) and neutral-detergent fibre (NDF) contents of forage legumes compared to fallow land natural pasture as growth advances : □ = D. Lablab, 0 = V. unguiculata (cv KN.1), △ = S hamata, ▲ = M. atropurpurium, ● = P. aureus, x = natural pasture



Considering the pattern of change with time in DM yield, N, NDF and lignin contents, digestibility and solubility of DM, the age of cutting that will fit into the conditions of the production system for conservation as hay was identified. Under the conditions of the Soudanian zone harvesting between 75 and 80 days of growth is suggested for all the species tested. This coincides with the period at which the labour requirement for cereal crop production is lowest, thus allowing the conservation of forage legumes at the preferred stage of growth.

1 In vitro degradability characteristics of forage legumes cut at 75 days of growth

The presence of N in the diet does not always guarantee the availability to the target microbes in the rumen. As noted earlier it is influenced by the pattern of degradability of the protein. The amount of protein that reaches the small intestine, besides degradability, is also influenced by the outflow rate from the rumen (Orskov and Robinson, 1981).

The pattern of N and OM *in vitro* disappearance in this study might indicate the characteristics of the legumes in their degradation in the rumen. Such information might allow effective screening of legumes to identify those whose N might be released in synchronisation with the release of OM from the cereal residues in the rumen (Table 4).

The results, however, need to be treated as indicative of the pattern of degradation and not to be equated with *in vivo* conditions. In addition to correcting the deficiency of rumen-degraded nitrogen (RDN) to utilise the rumen-degraded organic matter (RDOM) of the cereal crop residues, the forage legumes could also contribute a substantial amount of OM digested in the rumen. However, the N components of these legumes were rapidly degraded with a disappearance of not less than 80% within 6 hours of incubation.

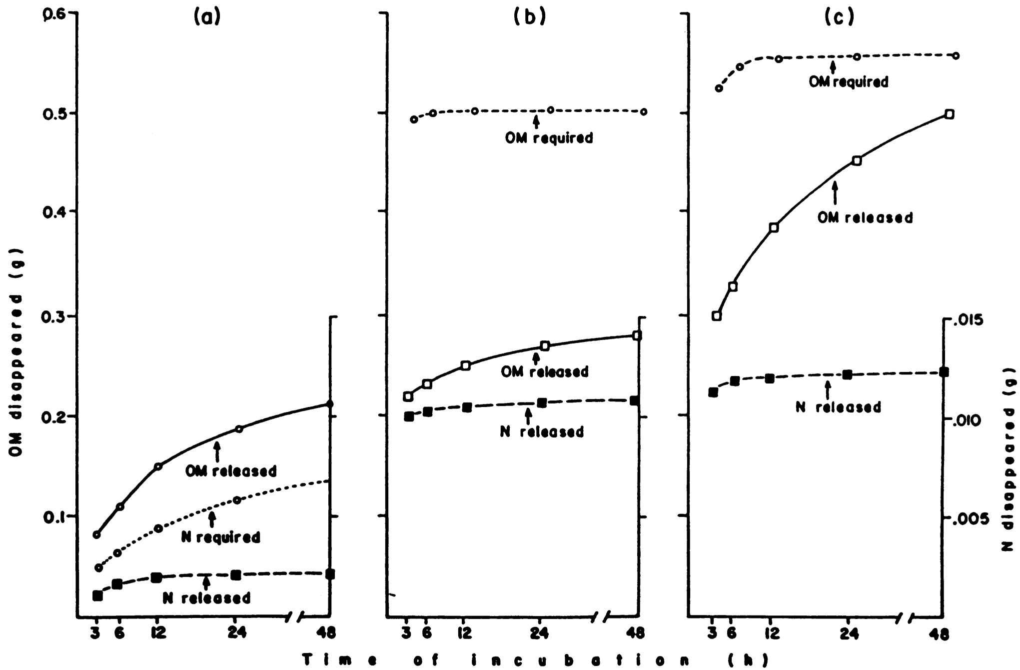
ARC (1980) estimated the ratio of RDN: RDOM required in the rumen to be 1:33.3. Based on this the OM and N releases of cowpea and millet stover were assessed for illustration purposes (Figure 4). In Figure 4 (a) it is noted that the OM released from the millet stover may not be utilised completely because of the inadequacy of N contained in it. Figure 4 (b) might illustrate a situation where cowpea N, is degraded rapidly and may not get adequate amount of OM released to match it, and the excess N could be lost in the urine. It is possible that the combination of the OM from cowpea and millet stover too may not provide adequate OM to match the N degraded (Figure 4(c)).

In places where conditions permit, forage proteins of high degradability could be treated with chemicals such as formaldehyde to increase their passage to the small intestine to be absorbed as amino acids. Whereas, in places where such possibilities do not exist, for example in Burkina Faso, other alternatives that could fit into the system need to be sought.

2 Suggestions to improve the utilisation of forage protein-N

There are reports (Kempton and Leng, 1979; Macrae and Ulyatt, 1980; Orskov and Robinson, 1981) which indicate protein deposition in animals to be positively related to the amount of amino acids absorbed from the small intestine. Such responses are higher in those animals fed rations with lower rather than higher concentration of degradable N (Cummins et al, 1980; Yilala and Bryant, 1985).

Figure 4: Illustration of release of OM and N in: (a) millet stover (N limiting for OM released), (b) Cowpea (OM limiting for N released), and (c) millet stover + cowpea (OM limiting for N released mainly in earlier hours of incubation).



In order to improve the supply of protein to the small intestine when forage legumes are to be included in crop residue basal diets the following suggestions may help:

a. Increase the level of readily fermentable carbohydrate to capture the degraded N for microbial synthesis to be absorbed as amino acids of microbial origin. Probably growing the legumes in association with grass species with known water soluble carbohydrates and adopted to the climatic conditions of the semi- arid region might help. Chopping the straw might increase the overall digestible organic matter in the rumen.

b. Combine the particular forage legume with other protein-N sources of less degradability so that the absorption of amino acids from the dietary source could be increased at the small intestine. Since protein-N of animal origin and oilseed cakes are scarce, legume forages and browses containing tannins could be introduced. Legumes containing a certain level of condensed tannins are known to increase the quantity of amino acids absorbed in the small intestine (Barry and Manley, 1983; Waghorn et al, 1987), although condensed tannins can also depress digestion in the rumen of the carbohydrate components (Barry and Manley, 1983).

In conclusion, the objective realities in the Soudanian zone of Burkina Faso favour the creation of conditions that will allow the effective integration of ruminant animals into the crop production system through recycling of resources. Forage legumes possess enormous potential as sources of N and could serve as the key link in the integration of crop and animal production systems

(Table 5). So far farmers have not given due importance to the incorporation of forage crops in the system. Possibilities that could increase the production of forage proteins do exist:

a. Replacement of poor fallow pasture with forage legume/cereal rotation.

b. Intercropping cereals with forage or dual-purpose legumes.

c. Production of browses along contour bunds or alley cropped with cereals.

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STRATEGIES TO OVERCOME CONSTRAINTS IN EFFICIENT UTILIZATION OF AGRICULTURAL BY-PRODUCTS AS ANIMAL FEED

L.P. Nkhonjera
Department of Animal Health and Industry, Malawi

ABSTRACT

The constraints in the efficient utilisation of agricultural by-products have been poor quality of the by-products, financial limitations for the procurement of chemicals and reagents and inadequate qualified manpower to carry on analytical work. Associated with this are inadequate laboratories and other facilities, lack of documented work on previous research work on the nutritive value of these feed resources making it impossible to derive suitable feed combinations for the various nutrient requirements. In general a strategy to promote the utilisation of by-products has been lacking and consequently affecting the development of the livestock industry. Intensive livestock production systems are currently implemented on a stratified model on a small scale. However simple formulated rations on a small scale have been used in beef cattle fattening and daily cattle feeding. The resulting daily liveweight gain of 1 kg and milk yields of up to 16 litres respectively have been encouraging. Lambs fattened on groundnut haulms and maize bran have shown daily weight gain of 112 g.

INTRODUCTION

The policy of the Government of Malawi is to be self-sufficient in food and sell the surplus. In the field of livestock efforts are concentrated on developing and intensifying rural animal production to provide adequate animal products with the objectives to improve the diet of the population and raise the rural income.

Malawi is a land-locked country with a total land area of 119,140 sq.km. Twenty percent of this land is under water. Of the remainder, 25 percent is steep land with slopes of 12.5 percent and above.

At present there is very little unused land that can be opened up for cultivation. Whatever little there is, it is generally confined to parts of the less densely populated Northern region. The livestock population is 1,010,659 cattle, 165,482 sheep and 789,300 goats. The ratio of man to cattle is 7:1 indicating the likely future shortages of meat if cattle remain to be its main source. Some attention is given to improving the productivity of the small stock. Goats and sheep are being improved under a crossbreeding programme and evaluations made of their performance. The suitable breeding stock will in turn be sold to smallholder farmers. A future programme to be promoted along with sheep farming would be fattening of lambs on agricultural by-products as the feed base. A lamb-fattening trial on the same feed base is being carried out to evaluate the performance. The overall objective is to promote a strategy whereby breeding is undertaken in rural grazing areas whereas stock would be finished on agricultural by-products in arable farming areas.

This paper describes the contributing factors to the inefficient utilisation of by-products that the country has experienced and ways of overcoming them.

As already mentioned, the agricultural policy has emphasised on increased crop production. This has led to an increase in crop residues and other by-products on smallholder farms and estates, in milling companies, breweries and other processing organisations. These by-products are likely to assist in increasing the carrying capacity of the land.

CONSTRAINTS

The grazing lands in Malawi are at or near their sustainable carrying capacity. There is therefore an increasing need to provide supplementary feed to sustain and improve animal protein production. Crop and agro-industrial by-products thus have a significant contribution to make as a cheap and renewable source of animal feed.

The following constraints are reckoned the most important limitations to utilise agricultural by-products with maximum efficiency. Table 1 shows the quantities of agricultural by-products Malawi produces.

Table 1. Basic statistics on the production of crop residues and crop by-products (tonnes).

Crop	Area planted (ha)	Kernel production	Crop residue production	Bran/ cakes
Maize	1,144,850	1,355,200	2,710,400	433,664
Rice	20,807	34,265	34,265	3,426
Wheat	1,126	787	787	197
Groundnuts	135,966	62,240	62,240	31,140

Source: Munthali and Dzowela (1987).

Nutritive values of these feed resources can be improved by chemical treatments as it is done elsewhere. This approach has certain limitations and implications:

1. Well-equipped laboratories are required to analyse untreated and treated feed resources.

2. The result of feeding treated feeds would be animal products at unaffordable prices. This would further result in a reduction in protein intake.

3. There is an acute shortage of qualified staff to measure and categorise the nutritive value of all crops and agricultural by-products. In addition chemicals and reagents to be used are also expensive.

4. Besides the research work done in the early 1960s on nutritive value of maize bran, maize stover and groundnut haulms, there is no documented information on these values or their combinations to provide the level of or nutrients required by the respective classes of livestock. The consequence of this is that livestock have been inadequately fed and hence delayed to reach slaughter weights.

5. Availability of these by-products is limited to areas favoured with a climate suited to crop production. In most cases these areas may not necessarily be blessed with livestock resources or good market infrastructures.

6. There is in general lack of a clearly defined overall strategy in the utilisation of agricultural by-products. As a result emphasis on diversification has lacked and that livestock programmes have not been well integrated in crop farming.

STRATEGIES TO IMPROVE THE EFFICIENCY IN UTILISATION OF AGRICULTURAL BY-PRODUCTS

The by-products of maize stover, maize bran, rice bran, wheat middlings, cottonseed cake and molasses are becoming more abundant to be used as ingredients in cheap livestock rations. The following measures are being taken in order to promote the utilisation of these by-products:

1. Emphasis is on stratification of livestock production and integration into the cropping systems so as to minimise competition for resources, and to promote stable mixed farming as well as to optimise production of scarce animal protein.

2. Use of agricultural by-products in animal feeding is optimised to overcome periods of feed shortage and at the same time to ensure a constant supply of livestock products throughout the year.

3. The setting up of livestock feed mixing companies close to arable cropping areas is encouraged.

4. The long existing companies have compounded rations from ingredients which are products of milling and oil companies and abattoirs while importing vitamineral premixes. The supply of these ingredients is not constant. At the same time imported ingredients are expensive. The larger proportion of the livestock industry is rural-based. The economics of marketing do not however encourage the use of these expensive commercial feeds. In some parts of the country which are close to sugar companies and cotton-growing areas, rations are being compounded for use by smallholder farmers. Table 2 shows an example of a ration compounded near the source of ingredients.

Table 2. Composition of the smallholder dairy ration.

Ingredient	Kg/100 kg of concentrate	CP%	Kg TDN %
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	-	-
	100.0	18.6	73.6

Source: Cattle Feedlot Company, Malawi, 1986.

The main concentrate in dairy feeding for a long time has been maize bran with crude protein percentages ranging from 8-10.7. The ration in Table 2 provides crude protein of 18.6. Average daily milk yields of 7 kg when feeding dairy cows on maize bran have increased to 16 kg when cows of high milk yielding breed are fed on the ration.

5. The farmers have been organised into groups to ease feed transport problems associated with distance. An individual would find it impossible and expensive to hire a vehicle to collect feeds. It has become possible on a co-operative basis.

EXAMPLES OF PROGRAMMES TO DEMONSTRATE IMPROVED UTILISATION OF BY-PRODUCTS

Under range conditions the average daily liveweight gain of 0.23 kg has been recorded (Department of Animal Health and Industry, Malawi, unpublished). When fed on agricultural products of maize stover (3.2% CP) and groundnut haulms (11.2% CP) recorded daily weight gain averaged 0.5 kg (Agyemang and Nkhonjera, 1984). The daily weight gain of 1 kg which is commonly recorded at the Cattle Feedlot Company demonstrates that a possibility still exists to improve the efficiency of utilisation of agricultural by-products under smallholder programmes. The ration composed of molasses, bagasse, cottonseed cake, rice husks, cottonseed husks, wheat offals and hominy cop is a rich one. This ration could also be available for use by smallholder feeder farmers.

Dairy farming and cattle fattening have been implemented for sometime now, though at a small scale. However, as the country's demand for lamb and mutton has not been satisfied, sheep and goat farming is being promoted along with lamb fattening in areas not covered by any of the above systems. Use is made of by-products that have been lying idle in the past.

This approach would obviously encourage the expansion of intensive livestock production systems in areas with abundant supply of by-products. The performance of lambs of various breeds is shown in Table 3.

Table 3. The results of a lamb-fattening trial under smallholder conditions.

No. of animals in breed group	Issue wt (x) (kg)	Final wt (kg)	DWG both to start of (g/d)	DWG trial (g/d)	HWD (kg)	CDW (kg)	Kill-ing 1/2
Local (18)	17.5	28.8	62	105	11.9	11.7	41.1
Dolpe x Local (4)	15.0	29.5	58.0	149	10.7	10.4	36.4
Dorper (6) SD	14.9	26.9	73	111	11.2	11.1	41.4
All breeds (28)	16.7	28.5	64	112	11.6	11.4	40.5

DWG = daily weight gain.
HDW = hot pressed weight.
CDW = cold dressed weight.

Source: Sill and Munyenyembe (1986).

On a fattening period of 107 days the animals gained on average 112 g. The killing-out percentage was 41% on average. All animals were graded choice and some prime (the top most grades). An expansion of such programmes makes it easier to utilise the by-products where they are not in use.

The Government in collaboration with the Food and Agriculture Organization (FAO) has currently conceived a project to improve the utilisation of crop and agro-industrial by-products in animal feeding. Some of the activities to be carried out are:-

1. Conducting a comprehensive and qualitative survey of feed value present and potential crop and agro-industrial by-products suitable for animal feeding.
2. Assessing the capacity and identifying the needs of the Department of Animal Health and Industry to enable it to meet its requirements for the utilisation of animal by-products.

3. Sending staff overseas for training on the processes involved in the utilisation of by-products.
4. Formulating by-product utilisation strategies using standard feed analysis tables and local laboratory analysis including on-farm testing.

CONCLUSION

The availability of agricultural by-products is justified by the level of agricultural development in the country. This provides the greatest opportunity for the development of a livestock programme that would use these by-products as livestock feed. The Department and related institutions are concentrating their attention on defining the most economic and acceptable ways of utilising these by-products because the future of the livestock industry is likely to depend on them.

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TOWARDS EFFICIENT UTILIZATION OF POULTRY WASTE BY RUMINANTS

E. K. Odhuba
Animal Production Research Centre, Muguga; Kenya Agricultural Research Institute, P.O.Box 21, Kikuyu, Kenya

ABSTRACT

Feeding experiments were conducted to evaluate the utilization of poultry waste-based diets by cattle. Sunflower seed cake could be replaced completely by broiler litter to constitute 30% of finishing rations for steers without affecting average daily gain or carcass merit. Cross-bred heifers which were supplemented with a fermented 60:40 poultry layer waste/ground sorghum grain were able to attain a breeding weight of around 260 kg by 18 months of age. In both experiments, dry-matter intake and digestibility coefficients of poultry waste-based diets were comparable to commercial-type rations. Ensiling sorghum forage (Sorghum vulgare) with layer waste making up 40% of the ensiled material improved crude protein (CP) from 6.5% in untreated silage to 12.2% in the treated silage. Steers that were supplemented with treated silage gained 0.87 kg/day and this was raised to approximately 1 kg/day when 1 kg of ground grain per day was fed in addition to treated silage. A ration compounded with 30% of the concentrate mixture as poultry waste could support about 10 litres of milk per day. Inclusion of the waste did not affect butter fat content of the milk. It would appear that CP values of around 12% in concentrate mixtures may be adequate for low producing dairy cattle.

INTRODUCTION

Poultry waste, also referred to as poultry litter or poultry manure, has been used as a fertilizer mainly to supply nitrogen to the soil. Chemical analysis shows that crude protein (CP) in poultry waste varies between 14 and 30% on dry-matter (DM) basis (Bhattacharya and Taylor, 1975; Smith et al, 1979). The nitrogen can be utilized up to ten times more efficiently when recycled through ruminants as a feed (Smith and Wheeler, 1979). Micro-organisms in the rumen have the unique ability of utilising uric acid and other forms of non-protein nitrogen (NPN) contained in the waste to make their own body protein which is subsequently digested in the lower gut for use by the host animal. The rumen microbes also degrade cellulosic materials used as bedding contained in the waste. The latter also contains high levels of calcium and phosphorus and can also be an important source of energy, yielding about 9.1 MJ per kg, which compares favourably with lucerne hay (Bhattacharya and Fontenot, 1966). The waste often includes varying proportions of high quality spilled chicken feed which may contribute significantly to its feeding value. However, its real feeding value is attributable to the provision of NPN rather than energy.

PROBLEMS ASSOCIATED WITH THE USE OF POULTRY WASTE AS A FEED

In feeding poultry waste, it is important to note that depending on the type and standard of management of the birds, the material may be a potential source of harmful agents including pathogenic bacteria (e.g. Salmonella), moulds and yeasts (Alexander et al, 1968). Also there may be problems associated with nutrient loss mainly through volatilisation of ammonia (Caswell et al, 1975). Besides, some forms of poultry waste e.g. caged-layer waste (CLW) have a particularly offensive odour and are rather messy to handle. Lastly, the high ash content especially in CLW tends to reduce the energy value of the waste.

PROCESSING AND FEEDING OF POULTRY WASTE

In attempting to obtain a stable and safe material, some form of processing is desirable. For instance, Fianu et al (1984a) treated CLW by air-drying, ovenheating and autoclaving but none of these methods was satisfactory for the simultaneous control of obnoxious odour, pathogens and nitrogen loss. Besides, the expenses incurred would be prohibitive to a large section of the farming community. It is imperative, therefore, that only the waste from healthy and properly managed birds, preferably on concrete floors, should be used, the idea being to start with material with a low bacterial count.

The waste should be thoroughly raked, removing any caked material and left to dry _in situ_ for at least three days. The material is subsequently milled through an 8-10 mm sieve to facilitate mixing with other feed ingredients. Poultry layer waste from deep litter houses does not, usually, require any milling. Further processing, if necessary, may be achieved by composting or deep stacking (Fontenot and Jurubescu, 1980) or better still and rather more cheaply, by ensiling (Harmon et al, 1975). Ensiling subjects poultry waste to a chemical process known as fermentation, in which soluble sugars are hydrolysed enzymatically by aerobic micro-organisms into acetic and lactic acids. Any pathogenic bacteria present in the waste are killed as a result of high temperatures and accumulation of these acids. In addition, these acids have a deodorising effect on the waste which acquires a pleasant aroma, thereby enhancing palatability and voluntary dry-matter intake by the animal. Johnson et al (1967) quoted work that showed NPN was more efficiently utilised by ruminants when added to plant material at ensiling time rather than when added to silage at feeding time. This was attributed to the improved nutrient composition of the silage arising from the sparing effect that NPN has on the degradation of protein in the forage. Ensiling, therefore, provides a technique for using NPN in amounts greater than can be used effectively by direct feeding. Besides, the method helps to preserve nutrients which can be used as and when required in addition to improving storage characteristics. Good silages have been made with up to 45% of the total DM contributed from poultry waste (Harmon et al, 1975). Baugarski et al (1980) obtained quality maize silage in the laboratory using up to 55% DM as broiler litter.

The amounts of poultry waste that can be fed would depend on plane of nutrition, production intensity and protein content of the waste. In general, the waste can supply 30-90% of the total protein requirements for ruminants (Shah and Muller, 1983). However, such rations must be fortified with readily fermentable carbohydrate to supply the energy required by the rumen micro-organisms to be able to handle the NPN more efficiently. An optimal inclusion level of 10% of the waste DM with molasses was suggested by Harmon et al (1972). Addition of molasses would also improve palatability and hence voluntary intake.

FEEDING OF POULTRY WASTE-BASED RATIONS-THE KENYAN EXPERIENCE

1. Utilisation of broiler litter in finishing rations for steers

Objective-To feed finishing steers with broiler litter-based diets so as to improve carcass grade and also promote liveweight gain in a semi-intensive production system.

Materials and Methods - Four groups of steers each weighing from 240-315 kg liveweight (Boran and Boran x Hereford crossbred) were grazed a predominantly Rhodes grass (*Chloris gayana*) pasture during daylight hours and supplemented during the night with finishing rations at the rate of 2 kg ground sorghum grain (*Sorghum vulgare*) and 1 kg mixture of broiler litter, sunflower seed cake (SSC), molasses, grass hay and mineral mix in the rations indicated in Table 1. These rations were compounded to give average daily gain (ADG) of around 0.8 kg. The fifth group was a negative control and was supplemented with Rhodes grass hay *ad libitum*.

Table 1. Composition of supplementary rations for finishing steers.

Ingredient	Ration kg (dry-matter basis)				
	Hay	2	3	4	5
Sunflower seed cake	0	1.0	0.6	0.3	0
Broiler litter	0	0	0.36	0.63	0.9
Sugarcane molasses	0	0	0.04	0.07	0.1
Sorghum meal	0	2.0	2.0	2.0	2.0
Ground grass hay	0	1.0	1.0	1.0	1.0
Unground grass hay	*Ad lib*	0	0	0	0
Mineral Mix *,g	150	150	150	150	150

* Obtained from Pfizer Laboratories, Nairobi.

Digestibility coefficients of the five supplemental rations were determined using another set of three steers per diet in conventional metabolism stalls. Animals were slaughtered after a feeding period of 110 days and carcass grades were assessed by the Kenya Meat Commission (KMC) graders. Percentage fat in the carcasses was determined by the 10th rib method as described by Ledger et al (1973).

Results - Tables 2 and 3 summarise the results of DM intake and digestibility, ADG and percent fat, respectively. Inclusion of broiler litter in finishing concentrate rations did not affect intake or digestibility which was consistent with the results reported by Kayongo and Irungu (1986) using sheep. Liveweight gains of supplemented animals were similar regardless of whether broiler litter or SSC was the source of nitrogen. Steers which were fed on a diet in which broiler litter replaced all the SSC gained, on average, 0.6 kg/day, slightly below the expected 0.8 kg/day, probably due to the severe dry conditions during the experimental period. For the same reason, carcass fat content fell short of the optimal levels of 22-26% (Ledger et al, 1973). However, all carcasses of animals supplemented with SSC or broiler litter-based rations were High Grade and well-fleshed with even fat cover. Details of this trial have ben reported by Odhuba et al (1986a).

Table 2. Mean DM intake and digestibility of rations fed to steers.

Parameter	Rations					
	Hay	2	3	4	5	LSD
DM intake, kg/day	4.3[a]	7.7[b]	7.8[b]	7.2[b]	7.8[b]	1.6
DM digestibility, percent	51.2					
DM digestibility : hay + concentrate	-	55.3	53.3	52.8	53.3	-
DM digestibility : concentrates alone	-	62.3[a]	56.9[b]	55.5[b]	57.3[b]	4.7

Numbers in a row with different superscripts differ significantly ($P < 0.05$).
LSD = Least significant difference.

Table 3. Weight changes and percent fat in the carcasses of finishing steers fed broiler litter-based rations.

Parameter	Rations					
	Hay	2	3	4	5	LSD
Initial mean weight, kg	339.8	348.0	346.5	344.0	347.5	
Final mean weight, kg	372.5	416.8	426.5	414.8	413.3	
Average daily gain, g	297[a]	625[b]	727[b]	644[b]	598[b]	243
Mean fat percent	12.8	17.3	17.4	17.1	18.1	

Numbers in a row with different superscripts differ significantly ($P < 0.05$).
LSD = Least significant difference.

2. Use of fermented caged-layer waste in rations for bulling heifers

Objective - To determine the extent to which caged-layer waste (CLW) fermented with grain can replace conventional concentrate diets based on sunflower seed cake (SSC) for growing heifers so as to attain a target breeding weight of 260 kg.

Materials and Methods - CLW was fermented with ground sorghum grain (Sorghum vulgare) in three percentage compositions on a DM basis as follows :

Mixture A - 40% CLW and 60% grain
Mixture B - 60% CLW and 40% grain
Mixture C - 80% CLW and 20% grain

Sugarcane molasses was added to mixtures A, B and C to replace 10% of CLW dry-matter. Water was added to make up 40% of total mixture (Caswell et al, 1974). The mixtures were allowed to ferment in drums for at least 30 days before feeding to three groups of animals each consisting of four Boran/East African Shorthorn Zebu (EASZ) x Hereford crossbred heifers averaging 230 kg. A fourth group received a commercial - type ration compounded with 68.4% ground sorghum grain and 31.6% SSC. The fifth group was a negative control and received 1 kg DM of Chloris gayana hay.

All the five groups were grazed together. Groups 1 - 4 were supplemented with the four diets, in the evenings, at the rate of 2.5 kg/animal/day plus a basal ration of 1 kg/day of grass hay for 84 days. Intake and digestibility of each ration were determined using three steers in metabolism stalls.

Results - The fermented mixture containing 60% CLW and 40% grain had a DM digestibility of 61.6% and gave ADG value of 431 g (Tables 4 & 5). These figures compared favourably with a digestibility of 62.3% (Table 2) and ADG of 494 g using a commercial-type diet based on SSC and grain. Dry-matter intake of the mixture containing 80% CLW was reduced significantly ($P<0.05$) resulting in a low ADG ($P<0.01$). Details of this trial are given by Odhuba et al (1986b).

Table 4. Mean DM intake and digestibility of caged-layer waste fermented with sorghum grain fed to steers.

Parameter	Rations				
	Hay	A	B	C	S.E.D.
DM intake, kg/day	6.0^a	8.8^b	8.7^b	8.0^c	0.3
DM digestibility, percent	55.0				
DM digestibility - hay + concentrate	-	56.9	57.0	55.4	2.3
DM digestibility-concentrate alone	-	61.3	61.6	56.9	4.2

Numbers in a row with different superscripts differ significantly ($P < 0.05$).
S.E.D. = Standard error of difference between any two means.

Table 5. Liveweight (kg) and daily gain of growing beef heifers fed rations containing fermented caged-layer waste and grain.

	Rations					
Parameter	Hay	Commercial	A	B	C	S.E.D
Initial mean weight	229.3	234.3	232.3	231.3	230.0	-
Final mean weight	229.0	275.8	265.0	267.5	242.3	-
Average daily gain, g	-3.6[a]	494.0[b]	386.9[b]	431.0[b]	146.4[c]	48.6

Numbers in row with different superscripts differ significantly ($P < 0.05$).

3. Use of layers-deep litter ensiled with sorghum forage for growing steers

Objective - To improve quality and characterise response of feeding sorghum forage ensiled with layers-deep litter.

Materials and Methods - Layers-deep litter was ensiled with sorghum forage (Variety 1291) to contribute 40% of total DM of the mixture. Sugarcane molasses was added to make up 3% of the mixture. Fermentation was allowed to continue for three months. Twenty five Friesian/Ayrshire x Boran/EASZ yearling steers were divided into five groups balanced for breed and initial weight. The animals were grazed on low quality dry season Chloris gayana pasture and were supplemented in the evenings with the following diets:

1. Chopped Chloris gayana hay ad libitum (negative control)
2. Untreated sorghum silage alone

3. Untreated sorghum silage + 1.0 kg DM cottonseed cake (CSC) and 1.0 kg maize meal (feedlot system, positive control)
4. Treated sorghum silage alone
5. Treated sorghum silage + 1.0 kg DM of maize meal

The total daily DM intake of treated and untreated silage, with or without concentrate, and including grazing, for steers weighing from 200 kg to 250 kg ranged from 5.1 kg to 7.6 kg. Grazing was estimated to provide approximately 2 kg DM/day. The trial lasted for 70 days.

Results - Crude protein improved from 6.5% in untreated silage to 12.2% in the treated silage. Animals that were fed treated silage plus 1.0 kg maize meal gained 0.98 kg/day which was not statistically different from ADG of 1.10 kg for the steers on a commercial-type feedlot diet (Table 6).

Table 6. Liveweight and average gain (kg) of growing steers supplemented with sorghum forage ensiled with layers deep litter.

	Rations					
Parameter	1	2	3	4	5	S.E.D
Initial mean weight	231.4	224.0	226.4	243.6	231.4	
Final mean weight	262.0	283.2	301.8	304.2	299.8	
Average daily gain	0.44^{a}	0.85^{b}	1.10^{c}	0.87^{b}	0.98^{bc}	0.09

^{abc}Means followed by different superscripts are significantly different (P<0.05).
S.E.D. = Standard error of difference between two means.

It would appear that untreated silage was near adequate in meeting the nutrient requirements of the animals, hence the marginal response to additional nitrogen and energy in the treated silage (Fig. 1). However, there was a noticeable trend towards improved growth rate when energy was added to treated silage. It would be of interest to evaluate these diets with more productive and demanding type of cattle such as lactating cows.

4. Broiler litter in dairy rations

Materials and Methods - The composition of the rations fed to milking cows is summarised in Table 7. The animals comprised Friesian and Ayrshire cows, pure or crossbred. Three animals were allocated to each of the three supplemental diets in a 3 x 3 latin square design. There were four replications in all. Each animal received 1 kg DM of the compounded concentrates (diets R0, R50 or R100) per 2 kg milk produced. Therefore DM intake of the concentrates ranged from 5-6 kg per cow per day. The quantities of feed provided (Table 7) were estimated according to Anon (1975) to provide 12 MJ of metabolisable energy per kg DM intake, being the amount of energy required by a 450 kg dairy cow producing 15 kg of milk/day. The trial lasted 9 weeks.

Figure 1. The pattern of liveweight gain of steers fed sorghum forage ensiled with poultry litter.

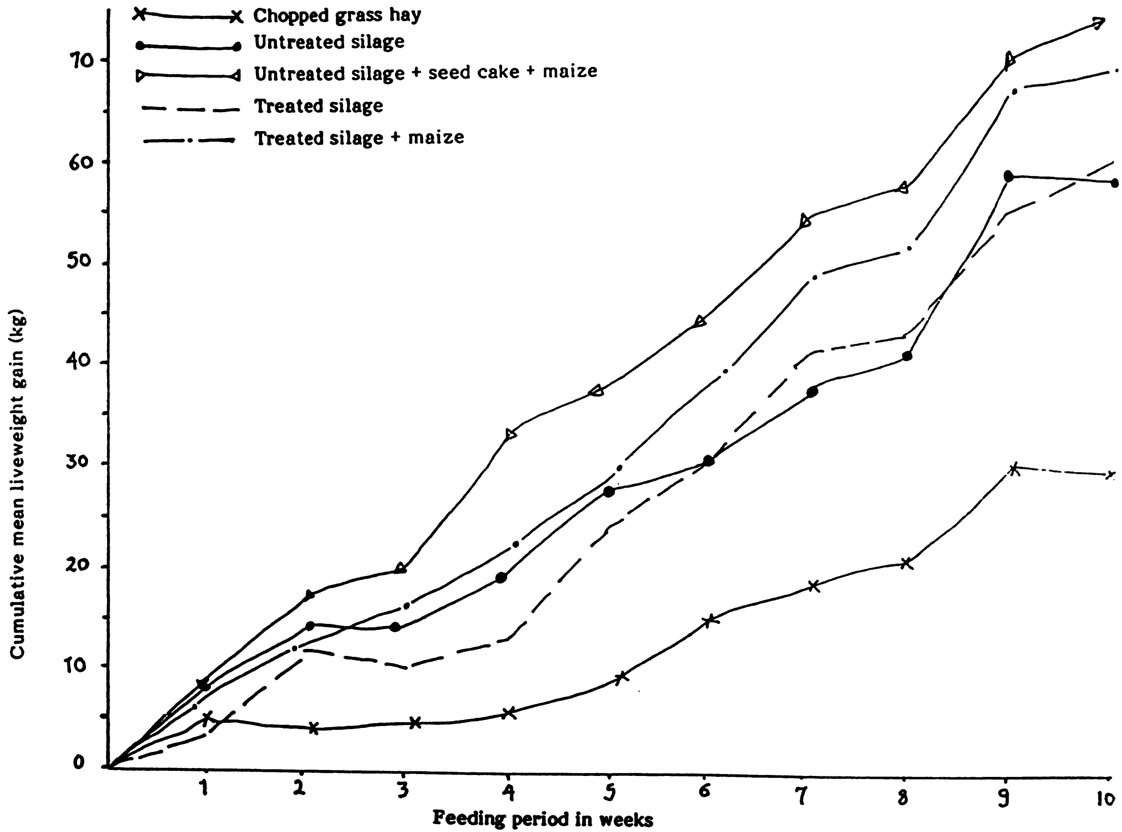

Table 7. Composition (%DM) of broiler litter-based dairy rations.

Ingredients	Diets*			
	R0	R50	R100	
	18.1	15.6	12.3	%Crude protein
Maize meal	42.00	42.00	42.00	
Barley	15.00	15.00	15.00	
Wheat bran	9.00	9.00	9.00	
Sunflower seed cake	4.50	2.25	-	
Rapeseed	9.20	4.60	-	
Cottonseed cake	8.20	4.10	-	
Sweet lupins	10.10	5.05	-	
Broiler litter	-	14.40	28.80	
Molasses	-	1.60	3.20	
Minerals	2.00	2.00	2.00	
Total %	100	100	100	

* R0 - Commercial protein concentrates only.
R50 - ration compounded to replace 50% of commercial protein source.
R100- ration compounded to replace 100% of commercial protein sources.

Results - The ration in which broiler litter completely replaced the conventional protein sources was able to support 10.2 kg of milk/day compared to 11.6 kg/day from cows fed diets compounded from commercial protein sources (Table 8). Although this difference was significant ($P<0.05$), the cost of feeding commercial protein supplements would tip the balance in favour of the poultry-based diet. DM intake and milk butterfat were not affected by feeding broiler litter. Similar results have been reported by Kayongo and Irungu (1986) at Naivasha using lactating Friesian heifers.

Table 8. Performance of cows fed concentrates containing different levels of broiler litter.

	Diets			
Item	R0	R50	R100	P
Milk yield, kg/day	11.6[a]	10.7[b]	10.2[b]	*
Milk butterfat, percent	4.0[a]	3.7[a]	3.9[a]	NS

ab Means on the same row followed by different superscripts are significantly different at the level shown.

* Significant at $P < 0.05$.

CONCLUSIONS

1. Dry season supplementation with energy and protein sources was beneficial to beef cattle grazing predominantly Rhodes grass planted pasture.

2. Poultry waste used in compounding rations for cattle should be dried <u>in situ</u> or ensiled to render it safe for use by the animals.

3. Sunflower seed cake can be replaced completely by broiler litter to constitute 30% of finishing rations for steers on a semi-intensive system as long as the animals are supplied with some grain and molasses.

4. Crossbred heifers could be fed for a period of three months prior to mating on a fermented 60:40 poultry layer waste/ground grain ration to attain a breeding weight of around 260 kg by 18 months of age.

5. Ensiling sorghum forage with poultry waste improved crude protein content of the silage almost twofold. Ensiling should be done with poultry waste and molasses making up 40 and 3 percent of total dry-matter of the mixture, respectively. Such silages should be fed with a grain supplement for optimal production.

6. Rations constituted with 30% of the concentrate mixture DM as poultry waste can support about 10 kg of milk/day. Such rations must be fortified with energy sources. It would appear that CP levels of 12% in concentrate mixtures may, in fact, be adequate for low to mediocre producing dairy cattle.

7. The ubiquitous distribution of poultry farms in Kenya, both small-scale and large enterprises, make poultry waste a readily available source for compounding relatively cheap cattle feeds of high quality.

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TEPHROSIA SPP AND COTTONSEED (*GOSSYPIUM* SPP) CAKE SUPPLEMENTATION OF RICE AND MAIZE STALKS FED TO SHEEP AND GOATS IN THE DRY SEASON

R.T. Fomunyam and S.E. Mbomi
Institute of Animal Research
Mankon, Bamenda
Cameroon

ABSTRACT

Tephrosia spp., a legume grown locally in Cameroon, and cottonseed cake, a by-product obtained from processing of cotton were used to supplement maize and rice stalk diets fed to sheep and goats in the dry season. There were 6 diets fed to 12 Dwarf forest sheep and 12 West African Dwarf goats. A 2x6 factorial design was used for the analysis. This supplementation increased the efficiency of utilization of the crop residues by the ruminants. There was a higher intake, weight gain and low mortalities for sheep than goats. There were high mortalities for goats but those which survived had intake above maintenance level. Diets supplemented with 50% *Tephrosia* and 50% cottonseed cake had the best results in terms of intake, weight gain and percent mortalities.

Apparent digestibility values for crude protein was quite high and similar for all the diets. Therefore *Tephrosia* can equally be utilized like cottonseed cake for protein supplementation in adult sheep as no mortalities were observed.

Apparent dry-matter digestibility values were high for the control checks indicating better palatability and therefore high intake. More work should be done on this study to find out the appropriate levels and the combinations needed for protein supplementation using the above supplements so as to improve on the intake of agricultural by-products and to encourage the use of *Tephrosia* which can also be used for fuel and maintaining soil fertility.

INTRODUCTION

A major constraint facing livestock development in Cameroon is the lack of adequate supplies of feedstuffs at economic prices. Feeds represent the greatest proportional cost in livestock production and its availability is affected by seasonal variation in feed quantity and quality which causes fluctuations in animal nutrition and productivity throughout the year.

There is competition between livestock and humans for the available protein feedstuffs.

Increasing land pressure and the resultant restriction of livestock to marginal lands has resulted in the need to supplement the animals that graze these lands. This problem is further aggravated by the rampant deforestation that is going on to divert lands to food crop production.

To increase animal production, recent stress has been on the utilization of agricultural by-products in animal feeding. Despite the availability of these by-products in great quantities and their potentials as substantial feed sources, they are lowly utilised due to their low protein levels which makes them less palatable. This can however be overcome by supplementing the diets with locally produced cheap protein sources.

This paper considers the feeding of _Tephrosia_ species, a cheap locally produced legume and cottonseed cake, a by-product from processing of cotton to overcome the constraint to the efficient utilization of rice and maize stalks fed to sheep and goats in the dry season when feed is in short supply.

Tephrosia species can also be used in alley cropping to improve soil fertility, prevent soil erosion and conserve moisture thereby increasing the yield of crops. At the end of the cropping season, _Tephrosia_ leaves can be used for protein supplementation and the stalks for firewood. Propagation of

Tephrosia species is by seeds which are abundant, therefore planting can easily be done by local farmers. Very little literature is known to the authors about the feeding of *Tephrosia* to small ruminants, although it is known to contain Rotenone, an insecticide and fish poison (National Academy of Science, 1979). In Cameroon, it is a big relish to cattle feeding; thus the study of its potentials as a protein supplement to small ruminant nutrition was necessary.

MATERIALS AND METHODS

In the first trial 12 Dwarf forest and 12 West African Dwarf goats (average age 6 months) with an initial weight of 9.4 kg - 10.2 kg were fed six diets namely :

1) 70% maize stover + 18% *Tephrosia* + 10% molasses + 2% bone meal

2) 70% maize stover + 18% cottonseed cake + 10% molasses + 2% bone meal

3) 70% rice straw + 18% *Tephrosia* + 10% molasses + 2% bone meal

4) 70% rice straw + 18% cottonseed cake + 10% molasses + 2% bone meal

5) 70% maize stover + 9% cottonseed cake + 9% *Tephrosia* + 10% Molasses + 2% bone meal

6) 70% rice straw + 9% cottonseed cake + 9% *Tephrosia* + 10% molasses + 2% bone meal.

Maize and rice stalks were harvested 3 months post-harvest and hand-chopped into 3 cm pieces and stored in jute bags. *Tephrosia* species was also harvested and dried on black polythene sheets and also stored in jute bags. Molasses was added to maize stalks or rice straw and fed separately while protein supplement was fed twice at 8 am and 2 pm each day. All animals had free access to water and salt licks.

The design was a 6x2 factorial consisting of 6 diets and two species of animals. The following parameters were determined, weight gain, feed intake, and percent mortalities. The study was conducted for 5 months. Data collected was subjected to statistical analysis (Steel and Torrie, 1980).

In the second trial, 24 adult Dwarf forest sheep (average age 2 years) with a weight range of 16 kg - 35 kg were used to test the apparent digestibility of maize stover and rice straw diets supplemented with Tephrosia species and cottonseed cake. The plan of feeding was 10 days of adaptability and seven days of total collections. The animals were fed the following diets:

1) 70% maize stover + 28% Tephrosia + 2% bone meal

2) 70% maize stover + 28% cottonseed cake + 2% bone meal

3) 70% rice straw + 28% Tephrosia + 2% bone meal

4) 70% rice straw + 28% cottonseed cake + 2% bone meal

5) 70% Pennisetum purpureum + 28% Tephrosia + bone meal

6) 70% Pennisetum purpureum + 28% cottonseed cake + 2% bone meal

7) 70% Tripsacum laxum + 28% Tephrosia + 2% bone meal

8) 70% Tripsacum laxum + 28% cottonseed cake + 2% bone meal

These animals also had access to water and salt licks.

Table 1 shows the chemical composition of feedstuffs used in these trials. Tripsacum laxum and Pennisetum purpureum were included as control checks.

Table 1. Percent chemical composition of feedstuffs used in test diets.

Feed items	Characteristics				
	Dry matter	Crude protein	Crude fibre	Ash	Ether extract
Maize stover	91.1	5.3	33.1	7.1	2.1
Rice straw	94.9	1.6	61.8	17.5	1.6
Tephrosia	91.3	15.4	25.6	5.4	2.6
Cottonseed cake	94.5	45.5	5.9	7.1	6.7
Elephant grass (*Pennisetum purpureum*)	96.0	5.3			3.2
Guatemala grass (*Tripsacum laxum*)	95.8	7.6			3.9

RESULTS

Table 2 shows that there was no significant (P<0.05) difference intake g/DM/day between animal species and between diets. However, values for goats averaged 404.3 g and for sheep 465 g. All animals fed rice straw and *Tephrosia* died between the second month and third month of the experiment while goats feeding maize stover and *Tephrosia* died during the second month of the experiment.

Table 2. Feed intake, weight gain and percent mortalities of sheep and goats fed rice and maize stalk/cottonseed cake and *Tephrosia* species.

Parameters	Breeds	Maize stover + Tephrosia	Maize stover + Cottonseed cake	Rice straw + Tephrosia	Rice straw + Cottonseed cake	Maize stover + Tephrosia + Cottonseed cake	Rice straw + Tephrosia + Cottonseed cake	± SEM
Feed intake g DM/animal	Sheep	379	498	286	570	528	529	
	Goat	216	507	112	570	501	520	1.34
Daily weight gain g/animal	Sheep	47	43	14.3	40	43	47	
	Goat	7.1	33	7.1	31	30	35	1.95
% mortality	Sheep	0	0	100	0	0	0	
	Goat	100	50	100	0	50	0	

Weight gain values varied between 33-35 g/day for goats and 40-47 g/day for sheep suggesting the levels fed were probably only adequate for maintenance.

Table 3 shows values for apparent digestibility. Values for crude protein were quite similar while those for dry-matter varied.

DISCUSSION

Feed intake for sheep and goats were in the range 3 - 3.7% of body weight indicating that the diets were palatable. Intake of dry-matter for goat meat should not exceed 3% of liveweight for any extended period of time (Devendra, 1980). However, the low weight gains showed poor efficiency of utilization which may be due to the use of stale maize stover ten months after it was harvested.

Table 3. Apparent digestibility (%) of the test diets fed to sheep.

Parameters	Maize stover + Cottonseed cake	Maize stover + *Tephrosia purpurea*	Rice straw + Cottonseed cake	Rice straw + *Tephrosia purpurea*	*Tripsacum laxum* + *Tephrosia purpurea*	*Tripsacum laxum* + Cottonseed cake	*Pennisetum purpureum* + Cottonseed cake	*Pennisetum purpureum* + *Tephrosia purpurea*
Dry matter (%)	51	54	60	59	85	85	84	80
Crude protein (%)	74.1	67.0	63.3	56.3	63.8	59.8	72.3	72.5

Percent mortality showed that all goats fed maize stover and *Tephrosia* and all sheep and goats fed rice straw and *Tephrosia* died. The cause was not known. However, *Tephrosia* contains an insecticide Rotenone (National Academy of Science, 1979) which is a fish poison. This must have been toxic to the young growing animals which cannot tolerate the level present in their diets.

However, there were no mortalities when *Tephrosia* was fed to adult animals in the digestibility trials. Diets of maize stover or rice straw, supplemented with equal amounts of *Tephrosia* and cottonseed cake were the best diets with high intake, high weight gain and low mortalities.

For the apparent digestibility we found out that the crude protein utilization was quite high and similar for all the diets. There was a high dry-matter digestibility for *Pennisetum purpureum* and *Tripsacum laxum* than for maize and rice stalks. This might be due to better palatability and therefore high intake. Cottonseed cake did as well to supplement the by-products as *Tephrosia*. However, more mortalities were observed with young growing animals feeding *Tephrosia*.

Postmortem examination of dead animals showed that they died of either gastro-enteritis, pneumonia or starvation.

CONCLUSION

From the results, it appears that young growing sheep and goats can tolerate *Tephrosia* as a protein supplement only to a certain level which has to be studied by doing more work. However, adult sheep can tolerate *Tephrosia* as a protein supplement as no mortalities were observed. The most appropriate protein supplementation was a combination of 50% *Tephrosia* + 50% cottonseed cake together with the agricultural by-product (rice or maize stalks). This was able to maintain the animals with few mortalities. More work should be done on *Tephrosia* species as it has a lot of potential for both livestock and in the crop farming systems.

Tephrosia species and cottonseed cake can equally be used for protein supplementation as both have high and similar crude protein digestibility values. The major limitations to the use of rice and maize stalks in this study was low intake due to the diets not being palatable. This constraint can, however, be overcome by supplementing these diets as was done in this study using *Tephrosia* and cottonseed cake.

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THE POTENTIAL OF CROP RESIDUES, PARTICULARLY WHEAT STRAW, AS LIVESTOCK FEED IN ETHIOPIA

Lulseged Gebrehiwot and Jamal Mohammed
Institute of Agricultural Research
P.O.Box 2003, Addis Ababa, Ethiopia

ABSTRACT

Crop and livestock production are important activities in the smallholder mixed farming systems in Ethiopia. Feed resources for livestock are natural herbage and crop residues. Cereal straws of teff (Eragrostis tef), barley, wheat and pulse crop residues are very important particularly during the dry season. Currently crop residues are used as is with no treatment to improve intake and digestibility. The quality and quantity of residues produced is also very low in relation to the total area of cropped land.

Results of experiments clearly indicate that the yield and quality of crop residues could be tremendously improved through agronomic practices and varietal selection. Undersowing of wheat with forage crops did not reduce grain yield but resulted in reasonable production of straw and undersown forages which could improve intake and digestibility of the residue. In the wheat improvement programme, significant variations were found among the varieties with respect to grain yield, straw yield and quality. There seems to be a wide range of possibilities to improve the production and utilisation of wheat straws, and crop residues in general. Breeders and agronomists need to consider the residue aspect as part of the overall crop improvement programme.

INTRODUCTION

Ethiopia is an agricultural country with a diverse climate varying from cool tropical highlands to arid lowlands. Though low in productivity it has the highest number of livestock in sub-Saharan Africa. Among other factors, feed shortage, both in quantity and quality, is a major constraint for the development of the livestock industry in Ethiopia.

At present two broad categories of livestock production systems are recognised in the country. In the pastoral areas, which are characterised by low and erratic rainfall, livestock are mainly kept for milk and to some extent for meat. They provide the sole means of subsistence for the nomadic pastoralists. It is estimated that some 25% of the total Ethiopian livestock population is found in this region. These animals depend entirely on the natural vegetation to satisfy their nutritional requirements.

The highlands of Ethiopia have more favourable climate; both for crop and livestock production. Over 70% of the human as well as the livestock population reside in this region. Small holder mixed farming is the dominant mode of production in the Ethiopian highlands. Major food crops grown are teff (Eragrostis tef), barley, wheat and pulses; and in the warmer regions maize and sorghum. The most important contribution of livestock to agricultural production in the Ethiopian highlands is the use of oxen for cultivation. Crops and livestock are closely integrated throughout the highlands in a complex of competitive and complementary ways (Gryseels and Anderson, 1983).

Livestock in the highland peasant farming system get their feed from natural herbage and crop residues. Cereal straws of teff, barley, wheat and pulse crop residues are stacked after threshing and fed to selected group of animals during the dry season. Livestock also have access to crop stubbles and weedy fallows. It is estimated that crop residues and aftermath grazing contribute 10% of the annual feed demand (FAO, 1981).

Crop residues have long been important as a maintenance feed for ruminants. However, when used alone, they are of very low feeding value with poor metabolisable energy, negligible available protein, and seriously deficient in mineral and vitamins (Staniforth, 1979). On the other hand, crop residues vary greatly in chemical composition and digestibility depending on varietal differences (Reed et al, 1986) and agronomic practices (Staniforth, 1979). Their feeding value and intake can also be greatly improved through treatments and supplementation with protein and energy-rich feeds (Butterworth et al, 1986, Olayiwole et al, 1986).

Developing countries like Ethiopia need to seriously consider improving the quantity and quality of crop residues produced by the smallholders. Varietal effects on the quantity and nutritive value of cereal and pulse crop residues have not received enough attention. Understandably because the major efforts have been on increasing food production only. These programmes should consider the residues as part of the overall improvement programmes.

This paper attempts to review the extent and use of crop residues in Ethiopia; mainly in the highlands. It places special emphasis on wheat with respect to varietal differences and agronomic practices to enhance the utilisation of the straws.

Extent of crop production and available residue

Estimates of the Ethiopian Central Statistics Office show that during the period of 1975 to 1978, on the average, annually about 5 million hectares of land were put under cereals and pulses. Mean grain yield for the same period was 970 kg and 810 kg/ha for creals and pulses respectively. However, during the period 1979 to 1982, the total area cultivated for cereals and pulses increased to 5.6 million hectares (Central Statistical Office, 1984). Respective grain yields also increased to 1240 kg 1140 kg/ha (Table 1).

As the area of crop production is increased, the size of grazing areas dwindles, exacerbating the problem of feed shortage. In this situation one could only cope with the problem by improving the quantity and quality of crop residues produced. FAO estimates indicate that in 1979/80, Ethiopia as a whole produced about 6.3 million tonnes of cereal straws, stovers and pulse residues (FAO, 1981). The figure seems to be low when compared with the total acreage under production. However, there are still wide options to improve total production.

Table 1. Estimated area and yield of major crops in Ethiopia.

Major Crops	1975/76 to 78/79 (4 years mean)		1979/80 to 82/83 (4 years mean)	
	hectares	kg/ha	hectares	kg/ha
Teff	1,368,500	750	1,401,600	920
Barley	722,800	980	864,800	1220
Wheat	522,300	960	605,400	1140
Maize	791,200	1360	769,600	1700
Sorghum	753,500	1000	1,013,800	1490
Faba bean	277,900	1020	340,600	1490
Field peas	121,900	650	176,300	950
Haricot beans	33,300	780	26,900	910
Cereals total	4,420,300	970	4,848,300	1240
Pulses total	643,000	810	795,300	1140

Source: Central Statistical Office (1975 to 1983).

Variability of crop residues in yield and quality

The quantity and quality of residues produced by various crops vary greatly depending on crop species. Wheat and barley usually give high straw yields but of inferior quality. Among the cereals teff straw is relatively the best and is comparable to a good natural pasture hay. Pulses residues, though low in yield, are of high quality (Table 2). The quality and yield of the various crop residues shown in Table 2 could vary depending on agronomic practices and environmental conditions. However, the figures give good indications of the relative importance of the various crop residues.

Table 2. Yield and chemical composition of various crop residues on dry-matter basis.

Residue type	Yield kg/ha	Percent				
		DM	EE	Ash	CP	NDF
Barley straw	10,000	92.6	2.3	8.4	4.7	71.5
Teff straw	5000	92.6	1.9	8.4	5.2	72.6
Wheat straw	9000	93.1	1.2	9.0	3.9	79.8
Faba bean residue	3800	91.7	0.8	10.4	7.2	74.3
Field peas residue	5000	91.9	1.2	6.1	6.7	73.6
Natural pasture hay	4100	92.2	1.5	9.5	6.6	73.8

DM = dry matter; CP = crude protein;
EE = ether extract; NDF = neutral-detergent fiber.

The performance of animals on residue diets is also known to vary depending on crop species. Table 3 shows the weight gains of steers fed for 116 days a ration composed of 50% residue, 20% molasses, 25% noug cake (<u>Guizotia</u> <u>abyssinica</u>), 4% bone meal and 1% salt (IAR, 1976). As shown in Table 3 wheat straw was the poorest roughage and teff straw the best. Dry-matter intake and daily weight gain were lowest for wheat straw, 5.0 kg and 352 gm/head respectively.

Table 3. Weight gains of steers fed crop residue based diets* at Holetta (1974/75) for 116 days.

Parameters considered	Roughage source			
	Teff straw	Wheat straw	Oats hay	Native hay
Initial weight (kg)	186	185	182	184.3
Final weight (kg)	258.8	225.9	231.9	239.6
Daily gain (g)	628	352	430	477
Daily feed intake (kg)	6.9	5	5.5	5.9
Feed/kg liveweight gain (kg)	11	14.2	12.8	12.4

* Rations consisted of 50% crop residue, 20% molasses, 25% noug cake, 4% bone meal and 1% salt.
Source : IAR (1976).

Possibilities for improving the yield, quality and utilisation of wheat straw

a) Agronomic practices

The grain yield of cereals and pulses is highly influenced by various agronomic practices. Since high grain yield is usually a function of active vegetative growth, agronomic practices which aim at increasing grain yields, do result in higher yields of residue.

A fertiliser trial was carried out on irrigated wheat in the Awash Valley, a fertile alluvial soil. Though the various rates of nitrogen fertilisation had very little effect on grain production (Table 4), straw yield and quality were significantly improved. Applying 46 kg N/ha improved leaf-to-stem ratio, and % N in the leaves and stems by 20, 47 and 21% respectively over the control. With more N application there was more influence on leaf-to-stem ratio and N composition of the plant. In Ethiopia, farmers who harvest good grain crops usually have more residues to feed their cattle during the dry season. Nowadays farmers are encouraged to use fertilisers, especially in areas where rainfall is more reliable. This practice will hopefully result in more crop residues and grain yields.

b) Undersowing of forage crops to wheat

Studies by the Institute of Agricultural Research in Ethiopia show that forage crops could be successfully established under cereals. The effect of the undersown forage crops on the grain yield of the cereals varied depending on crop species and the level of weed management. When maize was undersown after second weeding (about six weeks after planting) the grain yield was not affected at all. But in the case of wheat, where the forage crops were sown at the same time with the wheat the grain yield was reduced by about 20% (Lulseged et al, 1987).

Table 4. Effect of N fertilization on grain yield and on quantity and quality of wheat straw in the Awash Valley.

Fertilizer rate	Mean for 1985 and 1986				
	Grain yield	Straw yield	Leaf/stem ratio	%N leaves	%N stems
N kg/ha	.......kg/ha.......				
0	3500	7900	0.83	0.38	0.17
46	3800	8600	1.00	0.46	0.25
69	3800	9100	1.02	0.57	0.30
92	4200	9200	1.07	0.63	0.34
115	4300	10400	1.16	0.65	0.34
LSD (0.05)	NS	1.0 t/ha			

The practice of undersowing cereals with forages has particular relevance in the highlands of Ethiopia where fallowing of cropped-land is common and feed shortage is a serious problem. Table 5 shows results of an experiment at Holetta where wheat was undersown with various forage crops. The difference in grain yield of the wheat for the various treatments was non-significant. The yield on the control plot (sole crop of wheat) should probably have been higher than the undersown plots. But because of excessive lodging the yield was even lower than the other treatments.

Table 5. The performance of wheat and undersown forage crops at Holetta (1982/83).

Undersown forage species	Wheat grain yield	Wheat straw yield (air dry)	Forage yield (dry matter)
	kg/ha	.........kg/ha........	
Control (wheat only)	2040	7900	
Phalaris tuberosa cv Sirocco	2630	9800	3100
Lolium perenne cv Kangaroo Valley	3410	11400	3500
Lolium perenne cv Mt. Alma	2330	8200	7000
Lolium perenne cv Barspectra	2760	7600	4000
Festuca arundinacea	3100	11500	1300
Setaria sphacelata cv Narok	2560	9000	1900
CV%	17.8	19.8	15
LSD (0.05)	NS	NS	800 kg/ha

The most interesting part of this experiment was that on the average 9400 kg/ha of wheat straw and 3400 kg/ha of improved forages could be harvested from the same piece of land. Similar experiments in Ginchi area (Vertisol, 2200 m elevation) also showed various grasses and legumes could be successfully established under wheat (Table 6) (IAR, 1982).

ILCA's investigations on farmers' fields at Holetta indicated that undersowing native clovers namely *Trifolium tembense* and *T. rueppellianum* with 30 kg P/ha significantly improved both wheat grain and straw yields. The increase over the control (wheat alone) was 22 and 29% for grain and straw yields respectively (Abate and Jutzi, 1985). Undoubtedly the quality of the straw would be improved tremendously due to the presence of the forage species, particularly the legumes. Various investigators have reported that the digestibility and intake of crop residues alone are very low and weight gains of animals are minimal (O'Donovan, 1979; Reed et al, 1986). However, when supplemented with improved forages, particulary legumes, intake, digestibility and weight gains improved. Hence, wherever the environmental and farming system conditions permit, undersowing should be encouraged.

Table 6. Forage crops undersown to wheat, Ginchi, 1980/81.

Treatment	Wheat yield (kg/ha)	Forage establishment Score 0-5	Forage yield (kg/ha)
Sole crop (control)	2930	-	-
Alfalfa	2850	2	700
Barrel medic	3090	4	3200
Snail medic	2840	3	2100
<u>Phalaris</u>	3060	2	200
<u>Llolium</u>	1960	5	2600
Tall fescue	2900	2	700
<u>Setaria</u>	2790	2	400
CV	19%	0 = poor	
LSD (0.05)	NS	5 = Excellent	

c) The need to select for better grain and straw yielding varieties

Classically, the objective of any crop improvement programme is to raise the level of grain yields, with no consideration to straw yield and quality. Under small peasant holding, however, both the grains and straws are important. In Ethiopia over 90% of the agricultural produce comes from the peasant sector. Therefore in order to improve overall farm productivity and income of the smallholders, development of crop varieties with improved grain as well as straw yields is of paramount importance.

In the wheat improvement programme for irrigated lowlands, the selected varieties have been examined for grain yield as well as straw yield and quality. Fourteen varieties have been tested for three years in the Awash Valley. Of these, eight gave grain yields of over 4000 kg/ha. Some of the high-yielding varieties had low straw yields. Considering both grain and straw yields the varieties PAI 4, Dashen, Gara and Chenab 70 were the best with straw yields of 6300 to 7500 kg/ha (Table 7). Though there were other varieties with straw yields of nearly 8000 kg/ha, their grain yield was very low. The varieties also showed great variability with respect to leaf-to-stem ratio and % N in the leaves. Considering all these factors together, Chenab 70 and Dashen seem to be the best in terms of both grain and straw yield and quality.

CONCLUSION

In the Ethiopian highlands crop and livestock production are complementary. Since most of the livestock in the highlands are mainly kept for draught, the cultivation of more land results in more crop residues to feed the work oxen and selected group of animals. However, currently the quantity and quality of residues produced are very low.

Therefore inorder to compensate for the grazing land, which has been converted into crop land, agronomic practices and crop improvement programmes need to consider the improvement of both grain and straw yields and quality. Since there are strong crop improvement programmes of the major cereals and pulses in Ethiopia, there is a great chance of achieving success. The utilisation of crop residues also needs to be enhanced through the use of forage legumes and protein/energy-rich industrial by-products.

Table 7. Grain yield, straw yield and quality of wheat varieties tested in the Awash Valley (1985 to 1987).

	Grain yield (3 yrs mean)	Straw yield (2 yrs mean)	Leaf-to-stem ratio	%N leaves	%N stems
	.......kg/ha.....				
MLKS 11	4300	5700	0.83	0.68	0.29
PAI 4	4200	6300	0.78	0.56	0.22
Dashen	4000	6900	1.08	0.79	0.32
Blue Jay 'S'	4200	5400	0.79	0.54	0.25
CM 5287 -N-2M	3600	5300	0.61	0.74	0.33
CM 30136-3Y-1Y	3500	5300	0.78	0.68	-
Gara	4200	7500	0.91	0.57	0.32
Quimori	3800	6100	0.65	0.65	0.24
Chenab 70	4400	7200	0.77	0.83	0.28
Galld-4R-Resel (B)	4200	5900	0.85	0.64	0.30
Monco x WW x LEE	4100	5600	0.96	0.66	0.29
Gall-YR-Resel (B)	3700	7800	0.95	0.61	0.24
Enkoy	3700	7800	0.68	0.58	0.35
Ani 'S' Cm 26346	3600	5800	0.50	0.59	0.24
CV%	15	20			
LSD (0.05)	0.7	1.5			

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DOLICHOS LABLAB (<u>LABLAB</u> <u>PURPUREUS</u>) IN BY-PRODUCT-BASED DIETS FOR LACTATING COWS IN BOTSWANA

B. Kiflewahid and B. Mosimanyana
Animal Production Research Unit
P. Bag 0033, Gaborone, Botswana

ABSTRACT

Dairy cattle feeding was based on crop stovers supplemented with Dolichos lablab (*Lablab purpureus*) and post-harvest residues herein after referred to as lablab. Lablab was introduced to 30 small-scale dairy farms. Average lablab dry-matter yield from 30 farms farmers (ton/ha) for 0 and 100 kg/ha single superphosphate (10.5%P) fertilizer rate were 1.23 and 1.44, respectively, but not different (P>.05). Average dry-matter yield (ton/ha) at 0, 100 and 250 kg/ha rate, on-station, were 1.41, 1.56 and 1.70, respectively, but not different (P>.05). Phosphorus fertilization did not show significant (P>.05) effect in dry-matter yield due to low seasonal rainfall and distribution patterns in the project areas (262 to 414 mm rainfall). Total quantities of lablab hay, sorghum/millet stover and sorghum chaff/husks harvested by 30 farmers was 34.1, 56.4 and 7.2 tons dry-matter, respectively.

Sorghum and millet stover dry-matter yield (ton/ha), on-farm, ranged from 0.66 to 1.74 and 0.78 to 1.00, respectively. On-station dry-matter yield (ton/ha) ranged from 1.87 to 3.46 for different sorghum stover varieties. Dry-matter yield (ton/ha) for millet, maize and cowpea stovers were 2.42, 3.04, and 1.19, respectively.

The dry-matter and nutrient contribution of leaves, stems and twines and roots to whole lablab, Tswana cowpea and ER-7 cowpea were assessed. Dry-matter contribution by leaves to whole Tswana cowpeas (57.8%) were higher than lablab (47.0%) and ER-7 cowpeas (57.8%) were higher than lablab (47.0%) and ER-7 cowpeas (48.0%). Overall the total dry-matter and nutrient contribution of leaves to whole plants was higher than stems and twines in all three crops.

Average daily milk yield/cow/day (excluding milk left for calf) for Simmental-Tswana crossbred and Tswana cows fed sorghum stover based diets supplemented with either 15% lablab (diet A) or 25% sorghum bran (Diet B) were 2.2 and 3.4; 1.4 and 1.6 kg/day, respectively. The results showed significant differences ($P<.05$) between breeds but not within breeds fed the different diets. Average lactation length (days) and milk yield/cow/lactation (kg) for Simmental-Tswana and Tswana cows were: 273 and 223; 760 and 338, respectively. Average birth weight for Simmental-Tswana calves (34 kg) were greater than for Tswana calves (28 kg).

INTRODUCTION

The major objective of the Small Scale Dairy Production Project was to increase milk and milk products for both subsistence and commercial use in the traditional communal farms of the Gaborone region. The project covers six localities involving 30 farmers who participate fully in dairy production research.

In order to achieve optimal production objectives, a technical and management package incorporating the approaches and strategies related to baseline survey, animal feeding, management inputs, breeding and health, fodder production and utilization, milk marketing and extension linkages were developed (APRU, 1985).

The major constraint identified was lack of adequate feed (quantity and quality) to sustain milk production particularly during the dry season. The research emphasis has been to integrate fodder crops into the farming system and establish a practical feeding programme based on planted fodder and crop residues.

This paper focuses on the nutritional characteristics and use of lablab (*Lablab purpureus*) in crop by-product-based diets for lactating Simmental-Tswana crossbred and Tswana cows in small-scale dairy farms in Botswana.

METHODOLOGY

Feed production and conservation

The project introduced lablab to 30 participating farmers. Each farmer was provided with 20 kg of lablab seed and 100 kg of single superphosphate fertilizer (10.5% P) to plant one hectare of land. The fertilizer was applied to half of each hectare allocated for planting lablab. The seed was planted either in rows using planters or by the traditional method of broadcasting.

Three hectares of lablab was also planted at Sebele Agricultural Research Station. Superphosphate was applied at the rate of 0, 100, 250 kg/ha on each of the three 1 ha plots. Half of each plot was row planted while traditional broadcasting was used on the other half. An additional 27 ha of land were planted for bulk production and to examine the optimal stage of harvest and appropriate methods for harvesting, drying and storage.

Lablab and crop stover yields were measured using 2 metre radius circular subplots from three random locations in each farmer's plots and at Sebele Station. After measuring yield the plants were harvested, sun-dried and stored for dry season feeding. After the harvesting period the total quantities of lablab, crop stovers and post-harvest residues stored by each farmer were estimated. Dry-matter yields were also measured for several sorghum varieties, millet and maize screened on-station.

Nutritive value

Three replicate samples of fresh whole plants, leaves, stems and roots were obtained from lablab, Tswana and ER-7 cowpea plots to determine the dry-matter and nutrient contribution of each plant part. Three replicate samples of sorghum stover, millet stover, sorghum chaff, sorghum husks and sorghum bran were also submitted for laboratory analysis.

The fresh whole plants and plant parts were air-dried ($60^{o}C$) prior to grinding in a Wiley Mill (1 mm screen). The dried and ground samples were saved in airtight bottles and analysed (in duplicate) for organic matter, crude protein, crude fibre, ash, Ca and P according to methods approved by AOAC (1975) and *in vitro* dry and organic matter digestibility according to Tilley and Terry (1963) procedures.

Feeding trial

A dry season feeding trial was carried out to determine the voluntary feed intake (VFI) and performance of Simmental-Crossbred and Tswana lactating cows fed sorghum stover supplemented with either 15% lablab (Diet A) 25% sorghum bran (Moroko) (Diet B) or 100% sorghum stover (Diet C).

Treatments A, B and C contained 7.40%, 7.01% and 5.56% crude protein; 55.56%, 63.73% and 53.90% estimated TDN, respectively. In Treatment A lablab was mixed with the stover by hand at the time of feeding; in Treatment B the sorghum bran was fed separately in split used-oil drums. The animals were also supplemented with *ad libitum* bonemeal-salt (1:1 w/w ratio) and vitamins A, D, E. The Treatments A and B were randomly allocated to six each of twelve farmers. Voluntary feed intake (VFI) was determined in all treatment groups by measuring the daily weight of all feed offered and weight-back over a period of seven days and for a maximum of four lactating cows per farm. Statistical analysis using the t-test (Snedecor and Cochran, 1967) was conducted on the performance data obtained from the lactating cows that completed the trial.

Dairy cattle performance

Daily milk yields were recorded by each farmer on record forms provided by the project. Each farmer was provided with two calibrated 10-litre plastic milk buckets for recording milk yield. Milk records were collected and summarised by project staff at the end of each month. All lactating in-calf and non-pregnant cows were weighed, prior to watering in the morning, during the first week (between days 1 to 5) of each month.

Calf performance

The identity of the calf and its breed, sex, dam number, initial birth weight and birth date were recorded. Initial birth weight were measured using a heavy-duty spring balance. Subsequent monthly weights were measured using an electronic mobile cattle scale with the rest of the herd.

RESULTS AND DISCUSSION

Feed production and conservation

The average dry-matter yield (ton/ha) of lablab hay by farmers and at the Sebele Research Station is shown in Table 1. Average dry-matter yield for 0 and 100 kg/ha single superphosphate fertilizer application were not significantly different (P>.05) at 1.23 (range 1.00-1.60) and 1.44 (range 1.09-1.94) ton/ha, respectively. The dry-matter yield at Sebele Station for 0, 100 and 250 kg/ha single superphosphate application were 1.41, 1.56 and 1.70 ton/ha, respectively, but were also not significantly different (P>.05). The results also showed no significant differences (P>.05) in dry-matter yield between farmers' fields and Sebele Station. Phosphorus fertilizer application resulted in no change in plant constituents.

Random soil samples taken for soil nutrient analysis from farmers' fields and Sebele Station were generally acidic in all locations, with pH 4.50-4.90 at Sebele Station. There was a wide variation in soil content for farmers' fields (3.40-13.85 ppm) and at Sebele Station (4.91-15.82 ppm). Several findings have shown that phosphorous fertilization increases dry-matter yield, crude protein content by stimulating nodulation, and dry-matter digestibility of fodder legumes (Haque et al, 1986). The result from this fertilizer trial could not be conclusive due to the low seasonal rainfall experienced in the project area (262 to 414 mm range). The low yields and lack of response to superphosphate application could largely be attributed to this. Dry-matter yields of lablab did not appear to relate closely to variations in rainfall patterns in the project area. For example at Oodi (414 mm, 1.32 ton/ha DM) yields were lower than Kopong (262 mm, 1.60 ton/ha DM). These observations may also be attributed to planting time, rainfall distribution and differences in soil characteristics.

Table 1. Dry matter (ton/ha) of lablab hay (Lablab purpureus) from project farms[1] and Sebele Research Station as influenced by fertilizer application research rate[2].

Location and number of farmers	Fertilizer application rate (kg/ha)		
	0	100	250
Oodi (4)	1.32	1.37	-
Bokaa (8)	1.00	1.09	-
Kopong (2)	1.60	1.94	-
Mmopane (4)	1.08	1.20	-
Gabane (4)	1.12	1.64	-
Kumakwane (8)	1.24	1.42	-
Mean	1.23[a]	1.44[a]	
Sebele mean	1.41[a]	1.56[a]	1.70[a]

1. Data from three replicate yield measurements from each of 30 project farmers' plots.

2. Single superphosphate fertilizer (10.5%P).

Means in the same row and column with same superscript (a) are not significantly different (P>.05).

The average dry-matter yield of crop stovers on project farms and at Sebele Station is shown in Table 2. The yields of sorghum and millet stovers by farmers varied from 0.61 to 1.74 and 0.78 to 1.00 ton/ha of dry matter, respectively. Despite similar rainfall patterns sorghum and millet stover yields from the Sebele Station crop screening trial plots were higher than those from the farmers' fields.

Table 2. Dry-matter yield (ton/ha) of crop stovers harvested by project farmers[1] and Sebele Research Station[2].

Location and number of farmers		Type of feed				
		Sorghum stover	Millet stover	Maize stover	Cowpea (Tswana)	Cowpea (FR7)
Oodi	(3)	1.45	1.00	-	-	-
Bokaa	(3)	0.61	0.82	-	-	-
Mmopane	(2)	0.66	0.78	-	-	-
Gabane	(1)	1.35	-	-	-	-
Kumakwane	(2)	1.74	-	1.22	-	-
		3.44(a)	2.42(e)	3.04(f)	1.19	1.32
Sebele		1.87(b)	-	-	-	-
Station		3.46(c)	-	-	-	-
		3.46(d)	-	-	-	-

1. Data from three replicate yield measurements from each farmer's plot.
2. Sorghum, millet, maize and cowpea stover yields from Sebele agronomy and Botswana Agricultural College screening trials.
   (a) Segaolane. (d) Marupantsi.
   (b) Town. (e) Serere 6A.
   (c) 65 D. (f) Kalahari Early Pearl (KEP).

Maize stover yields of 3.04 ton/ha were achieved on-station but farmers' maize generally failed. The higher on-station yields are largely attributed to the effects of time of planting and use of fertilizer. Farmers harvested sorghum and millet stovers only.

Although farmers intercropped cowpeas with either sorghum or millets the yields were not measured. However, the dry-matter yields (ton/ha) for pure stands of Tswana cowpeas and as ER.7 cowpeas at Sebele station were 1.19 and 1.32, respectively.

At the end of the harvest season all farmers stored lablab hay, crop stovers and sorghum chaff/husks for dry season feeding. As shown in Table 3, there was a wide range in total quantities of feed conserved. Whereas all farmers harvested lablab from their 1-ha plots, harvesting of crop stovers primarily depended on the family labour available and the size of their planted field. Average quantities of lablab hay, sorghum/millet stover and sorghum chaff or husks harvested by farmers ranged from 1.04 to 1.65, 0.65 to 3.42 and 0.14 to 0.33 ton dry matter, respectively.

The total quantities of lablab hay, sorghum/millet stover and sorghum chaff/husks harvested by all the thirty participating farmers was 34.09, 56.44 and 7.17 tons dry matter, respectively. In addition a few farmers harvested small quantities of cowpea stover.

Table 3. Quantities of crop residue and lablab hay (ton DM) conserved by project farmers (1985-86).

Location and number of farmers	Lablab hay	Sorghum/millet stover	Sorghum chaff/ husks (Moko)
Oodi (4)	5.39	13.68	0.96
mean	1.35	3.42	0.24
Bokaa (8)	8.30	19.42	1.59
mean	1.04	2.43	0.20
Kopong (2)	3.29	4.23	0.29
mean	1.65	2.12	0.14
Mmopane (4)	4.55	2.60	0.99
mean	1.14	0.65	0.25
Gabane (4)	4.24	6.56	0.72
mean	1.06	1.64	0.18
Kumakwane (8)	8.32	9.92	2.62
mean	1.04	1.24	0.33
Total (30)	34.09	56.41	7.17
Overall mean	1.14	1.88	0.24

The major constraint observed during harvesting and conservation of lablab was the duration of time required to dry the stems. Lablab leaves dry and shatter within three days while it takes up to six weeks for the stems to dry completely. In view of this various methods of drying and storage using tripods, stocking on the ground and combining three rows into one row were tried at Sebele Station. Methods of drying had no effect on duration of drying time but the crop was baled more efficiently from stocks and tripods with minimum dry-matter loss due to leaf shattering, mouldiness or termite damage.

Nutritive value

Lablab and crop stover samples were submitted for laboratory nutritive value analysis (Table 4). There was a wide variation in dry-matter percent within the sorghum and millet stovers harvested by different farmers. The variation in dry-matter percent was attributed to the stage of maturity of the crops when harvested. Conversely there was much less variation in dry-matter percent of lablab harvested at the flowering stage.

Table 4. Percent dry matter of crop stovers and lablab conserved by project farmers (1985-86).

Location	Sorghum stover	Millet stover	Maize stover	Cowpea stover	Dolichos lablab
Oodi	40.4	39.1	-	-	21.6
Bokaa	32.4	33.3	-	-	22.3
Kopong	-	-	-	-	24.7
Mmopane	35.7	30.0	-	-	24.9
Gabane	35.3	-	-	24.8	27.5
Kumakwane	40.5	-	53.8	20.4	23.9

The average nutrient compositions and *in vitro* dry and organic matter digestibility of lablab, crop stovers and post-harvest residues are shown in Table 5. The mean crude protein and crude fibre percentage of lablab, cowpea stover, sorghum stover and millet stover were: 16.44 and 27.67; 15.67 and 21.08; 6.37 and 32.52; 5.75 and 35.94; respectively. On average the lablab and cowpea stover contained 2.5 times more crude protein than the sorghum and millet stovers. As shown in Table 5 the dry-matter and organic matter digestibilities of lablab and cowpea stover were higher than those of sorghum and millet stover. The higher digestibility coefficients are attributed to the higher crude protein and lower crude fibre content in lablab and cowpea stover than in the sorghum and millet stovers.

In view of these nutritional findings, diets for lactating and in calf dairy cows in the project areas were based on combinations of home grown lablab, cowpea, sorghum and millet stovers and post-harvest residues such as sorghum bran (Moko) and sorghum husks/chaff.

Table 5. Nutrient composition and in vitro dry-matter and organic matter digestibility of crop stovers and fodder legumes conserved by project farmers (1985-86).

Feed	Per cent composition of dry matter						DMD	DOM
	Organic matter	Crude protein	Crude fibre	Ash	Ca	P		
Lablab	90.8	16.4	27.7	9.2	0.3	0.2	59.9	57.1
Cowpea stover	89.1	15.7	21.1	10.9	0.2	0.2	74.1	70.1
Sorghum stover	91.6	6.4	32.5	8.4	0.4	0.1	54.9	49.8
Millet stover	89.5	5.8	35.9	10.5	0.4	0.1	52.2	45.1
Sorghum chaff	93.6	5.5	36.6	6.4	0.5	0.1	55.5	49.7
Sorghum husks	90.0	7.2	26.8	10.0	0.3	0.2	54.4	47.2
Sorghum bran	97.3	11.5	3.2	2.7	0.4	0.3	56.9	48.3

(1) Mean data from three replicate samples per farmer's field.

The fresh and dry-matter contribution of leaves, stems and twines and roots to whole lablab, Tswana cowpea and ER-7 cowpea plants is shown in Table 6. The percentage dry-matter contribution to whole plants by leaves of Tswana cowpeas (57.8%) were higher than lablab (47.0%) and ER-7 cowpeas (48.5%). Stems and twines for lablab (46.6%) and ER. 7 cowpeas (40.5%) were higher than Tswana cowpeas (31.1%). Overall, on both fresh and dry-matter basis the contribution of leaves to whole plant was higher than stems and twines in all three crops. Roots constituted a very small proportion of the total dry-matter in the plants studied.

Table 6. Fresh and dry-matter percent contribution by plant parts to whole lablab and cowpea residue[1].

	Dolichos Lablab		Cowpea (Tswana)		Cowpea (ER-7)	
Plant parts	Fresh	Dry	Fresh	Dry	Fresh	Dry
Leaves	53.3	47.0	62.9	57.8	57.4	48.0
Stems and twines	42.8	46.6	30.0	31.1	35.0	40.5
Roots	3.9	6.4	7.1	11.1	7.6	11.5
Whole plant	100.0	100.0	100.0	100.0	100.0	100.0

1. Mean data from three replicate samples of whole plants divided into plant parts.

The nutrient composition of fresh lablab, Tswana cowpeas and ER-7 cowpeas is shown in Table 7. There was a marked difference in crude protein and crude fibre percentages between leaves, stems and twines and roots in all plants. The crude protein and crude fibre percentage of fresh leaves of lablab, Tswana cowpeas and ER-7 cowpea were: 19.37 and 19.32; 21.24 and 13; 22.86 and 11.52, respectively. The average crude protein content of leaves was not greatly different. Stems and twines were generally lower in crude protein and higher in crude fibre than the leaves. However, as shown in Table 7, there was less difference in the crude protein content of leaves and stems/twines in the cowpea plants than in the lablab plants.

Table 7. Nutritient composition of lablab and cowpea residue whole plant and parts [1].

	Dry matter (%)	Composition of dry matter (%)					
		Organic matter	Crude protein	Crude Fibre	Ash	Ca	P
Lablab							
Leaves	21.6	87.8	19.4	19.3	12.2	0.7	0.1
Stems and twines	26.7	92.7	11.5	37.1	7.3	1.1	0.1
Roots	41.1	93.9	6.0	45.4	6.1	1.0	0.1
Whole	25.3	91.5	16.6	30.3	8.5	0.6	0.2
Cowpea (Tswana)							
Leaves	16.9	84.9	21.2	13.1	15.1	0.5	0.3
Stems and twines	19.1	90.3	21.0	18.5	9.7	0.3	0.3
Roots	28.8	93.0	12.7	18.5	7.0	0.2	0.2
Whole	21.2	85.4	21.3	16.8	14.6	0.3	0.2
Cowpea (ER7)							
Leaves	19.1	85.0	22.9	11.5	15.0	0.5	0.3
Stems and twines	26.5	92.5	19.4	21.3	7.5	0.2	0.3
Roots	34.7	94.7	11.1	23.5	5.3	0.3	0.2
Whole	25.4	88.5	19.2	18.3	11.5	0.4	0.3

1. Data from three replicate samples of whole plants from Sebele Research Station.

Summaries of the mean dry organic matter *in vitro* digestibility coefficients of fresh lablab, Tswana cowpea, ER-7 cowpea whole plant and plant parts are given in Table 8. Digestibilities of the dry matter and organic matter in lablab leaves were higher (67.85, 62.22) than in stems and twines (56.97, 50.78), but in the cowpeas the digestibilities of the stems and twines were higher than in the leaves. Between the plants the digestibilities of dry matter and organic matter were higher in Tswana and ER-7 cowpeas (73.57% and 73.85%) than in lablab (67.85%).

Table 8. In vitro dry-matter and organic matter digestibility (DMD and DOM) of lablab and cowpea residue whole plant and parts[1].

	DMD(%)	DOM(%)
Lablab		
Leaves	67.8	62.2
Stems and twines	57.0	50.8
Roots	46.9	43.8
Whole	60.8	55.1
Cowpea (Tswana)		
Leaves	73.6	71.5
Stems and twines	84.2	82.7
Roots	74.3	73.3
Whole	72.3	71.7
Cowpea (ER7)		
Leaves	73.8	73.1
Stems and twines	77.5	77.0
Roots	76.7	76.2
Whole	71.4	69.8

1. Means represent data from three replicate samples.

Feeding trial (dry season)

The average chemical composition and voluntary feed intake by farmers' lactating cows fed diets of 85% sorghum stover + 15% lablab (Treatment A), 75% sorghum stover + 25% sorghum bran (Treatment B) and 100% sorghum stover (Treatment C) were presented previously (Mosimanyana and Kiflewahid, 1987).

Chemical analysis of the lablab and sorghum bran-supplemented diets indicated that the crude protein percentages were 7.40 and 7.01, respectively and higher than the sorghum stover only diet which contained 5.56% crude protein. The crude protein content of sorghum stover was lower than the minimum 7.0% required for maintenance. In Treatments A and B the crude protein contribution to the diet by lablab and sorghum bran was 37.7% and 39.4%, respectively. In terms of the crude protein contribution to the sorghum stover-based diet 15% lablab was equivalent to 25% sorghum bran.

Mean daily dry-matter intake (DMI) during the trial period for the three treatments was lower for the lablab diet (8.27 kg DM/day) than for the Sorghum bran (10.21 kg DM/day) and the sorghum stover only (8.96 kg DM/day) diets.

Dairy cattle performance

The lactation data of the Simmental-Tswana crossbred and Tswana cows fed diets of sorghum stover supplemented with 15% lablab or 25% sorghum bran, are summarised in Table 9. Complete lactation data of the cows fed the sorghum stover only diet could not be obtained since farmers started to supplement their cows with either lablab or sorghum bran prior to the end of the lactation period.

The average lactation length of Simmental-Tswana crossbred and Tswana cows fed the 15% lablab and 25% sorghum bran diets were 270 and 240, 276 and 206 days, respectively. Lactations for Simmental-Tswana cows were longer ($P<0.5$) than for Tswana cows. There were no significant differences ($P>.05$) in lactation length within breeds fed different diets.

Average daily milk yield/cow for Simmental-Tswana crossbred and Tswana cows fed the 15% lablab and 25% sorghum bran diets were 2.2 and 3.4, 1.4 and 1.6 kg/day, respectively. Within breeds the milk yields were higher for cows fed the sorghum bran but not significantly ($P<0.05$). There were wide variations in daily milk yield within breeds and between treatments. These observations could be attributed to the variation in genetic potential of the individual Simmental-Tswana crossbreeds and Tswana cows owned by the different farmers (APRU, 1986; DPR, 1987).

Table 9. Milk yield[1] of Simmental-Tswana (SX)[2] and Tswana (TS) cows fed sorghum stover supplemented with lablab or sorghum bran[3] (1985-86).

	15% Dolichos Lablab 85% sorghum stover		25% sorghum bran 75% sorghum stover	
	SX	TS	SX	TS
Number of lactating cows	5	12	5	12
Average lactation length (days)	270[a]	240[b]	270[a]	206[b]
Total milk yield/herd (kg)	2941.3	4080.6	4655	4040.1
Average lactation yield/cow (kg)	588.3[a]	340[b]	931[a]	336.6[b]
Average milk yield/cow/day (kg)	2.2[a]	1.4[b]	3.4[a]	1.6[b]

1. Excluding milk left over for calf.
2. Milk recording period 1st lactation (Nov.'85-Sept.'86).
3. Plus ad lib bonemeal-salt (1:1 W/W ratio) and vitamin A,D,E.
Means in the same row with different superscripts (a,b) were significantly different ($P<0.05$).

The average milk yield/cow/lactation for Simmental-Tswana cows fed the 15% lablab and 25% sorghum bran diets were 583.3 kg and 931.0 kg, respectively. These values were not significantly different ($P>.05$) due to the large variation in milk yield within the Simmental crossbreeds. The milk yields of the Tswana cows for the two treatments (340 kg, 15% lablab diet and 336.7 kg for 25% sorghum diet) were also not significantly different ($P>0.05$).

At the end of the lactation period total milk produced by ten Simmental-Tswana and twenty four Tswana cows was 15,717.4 kg of which 7596.7 kg was from the ten crossbred cows and 8,120.7 kg from the 24 Tswana cows. On average under similar feeding and management systems each Simmental-Tswana crossbred cow produced 2.25 times more milk than Tswana cows. These observations are comparable to data obtained from similar trials on-station (APRU, 1986, DPR '86-87).

Average seasonal liveweight change patterns for both Simmental-Tswana crossbred and Tswana cows were similar. Despite dry season weight loss average initial liveweight for Simmental-Tswana (422 kg) and Tswana cows (379 kg) were not greatly different than weights for the same Simmental-Tswana (417 kg) and Tswana cows (365 kg) recorded after twelve months.

Calf performance

The average liveweight changes of all calves are summarised in Table 10. Birth weights of Simmental-Tswana calves (34 kg) were higher than Tswana calves (28 kg). Growth patterns of both breeds were similar. In terms of management all calves had access to their dams until the end of the lactation period and weaning coincided with the end of the lactation. On-station trial results have indicated that suckling prior to milking not only stimulates milk let-down but also prevents premature drying-off. Average liveweight at 12 months of age for Simmental-Tswana and Tswana calves were 147 kg and 124 kg, respectively. Unlike dry season weight losses experienced by adult cows the calves gained weight throughout the year.

Table 10. Monthly liveweight of Simmental-Tswana (SX) and Tswana (TS) calves (1985-86).

Breed	No.	Birth weight	Liveweight for age in months											
			1	2	3	4	5	6	7	8	9	10	11	12
SX	7	34	43	55	75	86	97	105	111	119	129	133	141	147
TS	25	28	35	43	49	60	72	82	92	102	110	115	119	124

CONCLUSION

The feeding system for in-calf and lactating Simmental-Tswana crossbred and Tswana cows is based on local feed resources. The dry season feeding strategy using high protein farmer-grown lablab hay (*Lablab purpureus*) in association with crop by-products and residues has been a significant intervention in small-scale dairy farms in Botswana. Despite low seasonal rainfall 30 dairy farmers participating in the project harvested and stored 34.1, 56.4 and 7.2 tons dry matter of lablab hay, sorghum/millet stover and sorghum chaff/husks, respectively.

The study demonstrated that there was no significant effect ($P>.05$) of single superphosphate (10.5%) application on dry-matter yield of lablab in both farmers' and on-station trials. However, wide variations in lablab and crop stover yields were observed within and between farms and project localities.

Chemical analysis results showed that on average lablab hay and cowpea stover contained 2.5 times more crude protein than sorghum and millet stovers. When lablab and cowpea whole plants were partitioned into leaves, stems and twines and roots; the dry-matter and nutrient contribution of leaves was higher than stems and twines.

A comparative (on-farm) feeding trial based on sorghum stover supplemented with either lablab or sorghum bran showed that under farmers' management conditions Simmental-Tswana crossbred cows produced 2.25 more milk per lactation than Tswana cows.

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CEREAL STRAWS IN THE FEEDING SYSTEM OF RUMINANTS IN SENEGAL

S. Fall, H. Guerin, C. Sall and ND. Mbaye
Departement de recherches sur les productions et la sante animales
Institut senegalais de recherches agricole (ISRA)
Laboratoire national de l'elevage et de recherches veterinaires
(LNERV), BP 205, Dakar-Hann, Senegal

ABSTRACT

Cereal straws represent an important source of energy. However they contain low concentrations of nitrogen, minerals & digestible energy which requires a good supplementation. Preference should be given to agro-industrial by-products available in the areas of cereal production. In the peanut basin and in the South, cereal straw can be supplemented by peanut cake, cottonseed, sorghum, millet & rice brans.

The rice agro-industrial by-products (rice polishing, rice bran) can be fed together to support high levels of production. This feeding package is suited to the northern and southern part of Senegal.

Treatment of straws with urea is the most promising alternative solution in order to enhance straw utilisation by ruminants. Urea which is an important source of non-protein nitrogen is available to farmers at low cost.

On-farm research should be geared towards comparing the economic feasibility of two alternative solutions: treatment and supplementation of cereal straw with urea.

INTRODUCTION

The drought which adversely affected the Sahelian countries of Africa during the past two years has now receded. However, the available biomass remains insufficient. Nutrition is still the major constraint to the improvement of livestock productivity in Senegal. The challenge for research workers, livestock technicians and farmers is to develop efficient feeding systems using the available feed resources in Senegal. Within the framework of crop-livestock interactions, low quality crop residues such as feed resources can play an important role in meeting the dry-matter and energy requirements of ruminants.

In 1986, 887,820 tons of maize, millet, sorghum and rice grain were harvested. The estimated straw output is 4,800,000 tons. This available quantity is expected to increase soon with the development of irrigation in Senegal river basin. The main areas of production are the groundnut basin, Senegal river basin, Tambacounda and Casamance.

Previous studies carried out in the Laboratoire national de l'elevage et de recherches veterinaires (LNERV) have investigated the problems of low concentration in digestible nutrients, bulkiness and low digestibility of cereal straws (Calvet et al, 1974).

Offered alone, cereal straws cannot meet the maintenance requirement of cattle, sheep or goat. They need to be supplemented with concentrates in order to support reasonable milk or meat production. Chemical treatment can also improve digestibility of low quality roughages.

Supplementation and alkali treatment of cereal straw have been carried out in LNERV and IEMVT. The objectives of this paper are to describe experimental procedures, discuss available results in order to set up the best way of integrating cereal straws in Senegal's ruminant feeding system.

EXPERIMENTAL PROCEDURES

Supplementation of rice straw

The main objectives of rice straw supplementation was to improve rumen environment and increase straw digestibility.

Rations were intended to allow either maintenance or low to medium levels of meat/milk production. Thus rice straw used was analysed and the chemical composition is given in Table 2. Composition of the complete rations and number of trials are specified in Table 1.

Table 1. Cereal straw supplementation.

Rations	Species	Number of trials	Level of concentrate (%)
Rice straw + cottonseed	Sheep	7	26
Rice straw + peanut cake	"	7	10
" "	Cattle	2	6.5
" "	"	8	10
" "	"	3	15
Rice straw + rice polishing	"	12	22
" "	Sheep	2	45
Rice straw + rice broken grain	"	6	28.5
Rice straw + molasses+urea	"	2	21.5
Rice straw + P*	Cattle	6	20

P* = mixture w/w of rice polishing and maize bran.

Alkali treatment of cereal straws

NaOH and urea treatments of cereal straw have been comparatively carried out. To avoid unjustifiable excessive loss of water and nutrients a semi-dry method (Jackson, 1979) was applied.

Different levels of urea (3.5 and 6 g/100 g of straw) and sodium hydroxide (3,4,5 and 6 g/100 g of straw) were tested. The effects of urea treatment in different species of cereal straw, millet, sorghum, maize and rice has been summarised in Table 3 and 6.

Table 2. Chemical value of agro-industrial by-products used as supplement.

Agro-industrial by-product / Fractions	Cotton-seed (g/kg DM)	Peanut cake N = 13 (g/kg DM)	Mixture w/w rice polishing + maize bran No = 1 (g/kg DM)	Rice polishing N = 14 (g/kg DM)	Rice broken grain N = 6 (g/kg DM)
Ash	41	52 ± 5	103	63 ± 3	153 ± 7
Protein	193	504 ± 50	135	119 ± 53	81 ± 0
Crude fiber	250	28 ± 9	78	65 ± 30	70 ± 1
Ether extract	184	7 ± 0	76	44 ± 32	16 ± 0
Nitrogen-free extract	256	408 ± 24	608	568 ± 242	683 ± 10
Calcium	1.5	1.2	1.1	0.8 ± 1.2	1.2
Phosphorus	5.1	6.2	9.5	10.7 ± 0,0	-

Evaluation of the nutritive value of rations

The nutritive value of supplemented rice straw, and alkali-treated cereal straws were evaluated by chemical analysis and *in vivo* digestibility trials. Chemical analysis involved organic matter, crude fiber, crude protein, NDF, ADF, lignin, silica and minerals. *In vivo* digestibilities were carried out with six cattle or sheep. This protocol was broken down into phases: 15 days of adjustment and 6 of measurement.

RESULTS AND DISCUSSIONS

1. Rice straw supplementation

1.1 Peanut cake

Peanut cake is available in the whole groundnut basin and in the south of Senegal. Rations based on rice straw supplemented with cake were well accepted by cattle and sheep (Table 3). However, high levels of peanut cake depressed digestibility of straw, and therefore the level of peanut cake should be restricted. Previous studies have also shown the depressive effect of peanut cake on organic-matter digestibility (OMD) of straw when fed at high levels. Data in Table 4 show a significant ($P<0.05$) depression of rice straw OMD at the level of 500 g peanut cake per day (10 per cent). It is also evident that rice straw OMD was not significantly improved by feeding at the rate of 250 g of peanut cake per day.

Table 3. Supplemented rice straw : Chemical value and digestibility of rations.

Rations / Analysis	Rice straw +rice polishing		Rice straw + peanut cake	Rice straw + rice polishing + maize	Rice straw + rice break	Urea-treated rice straw + urea	Urea-treated rice straw + molasses + urea
	Cattle	Sheep	Sheep	bran	Sheep	Sheep	Sheep
Organic matter*	849 ± 19 N = 14	-	793 N = 2	841 ± 2 N = 6	838 ± 5 N = 6	883 N = 1	818 N = 2
Crude protein*	63 ± 11 N = 14	- -	147 N = 2	52 ± 2 N = 6	47 ± 2 N = 6	141 N = 1	73 N = 2
Crude fiber*	260 ± 35 N = 14		258 N = 2	255 ± 6 N = 6	242 ± 8 N = 6	369 N = 1	344 N = 2
Ether extract*	31 ± 22 N = 14		17 N = 2	29 ± 2 N = 6	12 ± 0 N = 6	17 N = 1	10 N = 2
Nitrogen-free extract*	459 ± 16 N = 14		371 N = 2	505 ± 4 N = 6	583 ± 3 N = 6	356 N = 1	402 N = 2
N D F*	413 N = 2		499 N = 2				

Cont'd

Table 3. Supplemented rice straw : Chemical value and digestibility of rations.

Rations / Analysis	Rice straw +rice polishing		Rice straw + peanut cake	Rice straw + rice polishing + maize	Rice straw + rice break	Urea-treated rice straw + urea	Urea-treated rice straw + molasses + urea
	Cattle	Sheep	Sheep	bran	Sheep	Sheep	Sheep
A D F *	229 N = 2		324 N = 2				
Lignin *	46 N = 2		49 N = 2				
Silica *	100 ± 9 N = 6		15 N = 2		1.6 ± 0.1 N = 6	3.3 N = 1	2.1 N = 2
Calcium *	2.0 ± 0.4 N = 14		3 N = 2	1.7 ± 0.1 N = 6		0.5 N = 1	2.3 N = 2
Phosphrous *	4.0 ± 1.7 N = 6		25 N = 2	2.4 ± 0.4 N = 6			

Cont'd

Table 3. Supplemented rice straw : Chemical value and digestibility of rations.

Rations	Rice straw +rice polishing		Rice straw + peanut cake	Rice straw + rice polishing + maize	Rice straw + rice break	Urea-treated rice straw + urea	Urea-treated rice straw + molasses + urea
Analysis	Cattle	Sheep	Sheep	bran	Sheep	Sheep	Sheep
Magnesium *	3.2 ± 0.6 N = 6		2.2 N = 2				
Potassium *	11.7±4.1 N = 6		14.9 N = 2				
Cobalt ppm *	0.6 N = 2		0.5 N = 2				
Copper	9.1 N = 2		7.5 N = 2				
Zinc ppm	43.8 N = 2		47.3 N = 2				
Manganese ppm	5880 N = 2		5600 N = 1				

Cont'd

Table 3. Supplemented rice straw : Chemical value and digestibility of rations.

Rations	Rice straw +rice polishing		Rice straw + peanut cake	Rice straw + rice polishing + maize	Rice straw + rice break	Urea-treated rice straw + urea	Urea-treated rice straw + molasses + urea
Analysis	Cattle	Sheep	Sheep	bran	Sheep	Sheep	Sheep
Iron ppm	967 N = 2		1103 N = 1				
Sodium ppm	1938 N = 1						
Dry-matter digestibility (%)	59 ± 4 N = 13	47 N = 2	47 N = 2	75 ± 2 N = 6	50 ± 4 N = 6	46 N = 1	50 N = 2
Organic-matter digestibility (%)	74 ± 3 N = 13	55 N = 2	57 N = 2	79 ± 1 N = 6	58 ± 3 N = 6	56 N = 1	59 N = 2

Cont'd

Table 3. Supplemented rice straw : Chemical value and digestibility of rations.

Rations	Rice straw +rice polishing		Rice straw + peanut cake	Rice straw + rice polishing + maize	Rice straw + rice break	Urea-treated rice straw + urea	Urea-treated rice straw + molasses + urea
Analysis	Cattle	Sheep	Sheep	bran	Sheep	Sheep	Sheep
Digestible crude protein*	42 ± 7 N = 13	43 N = 2	107 N = 2	33 ± 1 N = 6	10 ± 3 N = 6	106 N = 1	32 N = 2
Voluntary intake g/kg 0.75	102 ± 22 N = 13	65 N = 2	53 N = 2	137 ± 21 N = 6	69 ± 5 N = 6	40 N = 1	41 N = 2

* g/kg DM

Table 4. Digestibility of rice straw in complete diets compared to rice straw offered alone.

Rations		Species	Organic-matter digestibility (%)
Rice straw	N = 15	Cattle	64± 4
Rice straw	N = 15	Sheep	58± 4
" + peanut cake 500 g/day	N = 8	Cattle	59.6± 2.7
" " 1 kg/day	N = 3	"	59.3± 2.0
" " 250 g/day	N = 2	"	68.4± 0.6
" + rice polishing + maize bran	N = 6	"	80.9± 1.5
" + rice polishing	N = 12	"	73.8± 4.4
" + rice broken grain	N = 6	Sheep	37.1± 5.7

In conclusion, peanut cake raises the nitrogen, energy and phosphorus levels of rations based on rice straw, but should be limited to a maximum of 10 per cent of the diet. The alternative use of urea to correct nitrogen deficiency is a possibility (Table 5).

1.2 Cottonseed

Cottonseed cake and rice straw are both produced in Casamance and Tambacounda. Experiments have shown that these can be fed together to support reasonable levels of production (Table 6).

However, the data are very limited. Table 6 suggests an addition of urea to reach the semi-intensive beef production allowed by the energy level of the ration.

1.3 Agro-industrial by-products of rice

Broken rice, rice polishings and bran total to substantial quantities. When fed alone or in association (w/w) with maize bran, rice polishings give an adequate supplementation to rice straw. Significant ($P<0.05$) improvements in OMD (Table 4) were obtained in a number of experiments. The rations with high levels of energy could support fattening of cattle. Further, the possibility of incorporating urea as a source of nitrogen is an added advantage. Broken rice grain is rich in starch, and can be fed up to 10% in ruminant diets but too high levels have a depressing effect on straw digestibility. This by-product should be reserved for poultry.

1.4 Urea and molasses

It is well documented that urea is a cheap nitrogen source able to improve intake and OMD of low quality roughage. In Senegal, molasses and rice straw are available in the same area (Senegal rice basin). The combination of rice straw, molasses and urea gives a mixture which is well consumed by ruminants. The addition of peanut cake and minerals could allow intensive or semi-intensive beef fattening.

Table 5. Nutritive value of rations based on rice straw.

Rations	Species	Number of trials	g/100 kg BW	Intake g/kg 0.75	Energy OMD	Energy FU kg DM	Protein DCP g/kg DM	Minerals Calcium g/kg DM	Minerals Phosphorus g/kg
RS*	Cattle	15	1872±209	74±9	64±4	0.5±0.0	3± 4	1.9	0.7
RS	Sheep	15	2053±253	48±7	58±4	0.4±0.0	0±13	-	-
RS + cottonseed	"	7	2545±162	60±4	57±4	0.5±0.0	45±10	2.4±0.8	1.9±
RS + peanut cake 500 g/day	Cattle	8	2365±355	95±15	63±3	0.4±0.0	35±9	1.8±0.4	1.1±0
RS + peanut cake 1 kg/day	"	3	2504± 52	100	64	0.5±0.0	76	1.6	1.6
RS + peanut cake 250 g/day	"	2	2485± 16	101	69	0.6±0.0	34	2.3	0.9
RS + rice polishings	"	13	102± 22	102±22	74±3	0.7±0.0	42±7	2.0±0.4	4.0±1
RS + rice polishings	Sheep	2	2890± 95	65	55	0.5±0.1	43	-	-
RS + peanut cake 10 p 100	"	2	2290±143	53	57	0.3±0.1	107	3	2.5
RS + rice polishings + maize bran	Cattle	6	3351±373	137±21	79±1	0.8±0.0	33±1	1.7±0.1	2.4±
RS + rice broken grain	"	6	3007±157	69± 5	58±3	0.4±0.0	10±3	-	-
Urea-processed rice straw + urea 1.5/100	Sheep	1	1695	40	56	0.4	106	0.5	-
RS + molasses urea	"	2	2626±559	61	59	0.4±0.1	32	2.3	

* RS = Rice straw

2 Alkali treatment of cereal straw

2.1 Urea treatment of cereal straw

The treatment of straws with urea improved intake, digestibility and nitrogen concentration in rice, millet, sorghum and maize crop residues (Table 6).

Table 6. Urea treatment of cereal straw comparision of rice, millet, maize, and sorghum straws.

Cereal straws		CP (%)	DMD (p. 100)	Intake g/kg (p 0.75)
Rice straw	Processed	7.9 n=1	54.48±3.76	61.0±9.5 n = 6
	Control	4.5 n=1	42. 8±3.6	47.7±2.8 n = 5
Maize straw	Processed	14.9 n=1	57.2±4.8 n=6	52.6±10.3 n = 6
	Control	3.9 n=1	49.3±2.4 n=6	39.5±4.6 n = 6
Millet straw	Processed	14.10 n=1	58.8±5.5 n=4	56.1±3.4 n = 4
	Control	8.4 n=1	39.2±6.4 n=5	31.5±6.8 n = 4
Sorghum straw	Processed	14.60 n=1	65.1±2.7 n=6	68.4± 3.4 n = 6
	Control	4.2 n=1	47.2±4.7 n=2	49.8± 6.2 n = 5

Compared to maize and sorghum, millet residues gave a superior improvement of intake and digestibility while the first had a higher capacity of nitrogen fixation. The results in Table 8 describe the effect of urea concentration on cereal straw improvement. The optimal level of application was found to be 5 g of urea per 100 g DM of straw.

2.2 NaOH treatment of millet straw

Available results show a positive influence of NaOH treatment levels on millet straw digestibility (Table 7) but chemical composition of the straw did not undergo any changes (Table 8). The incubation time had no major influence on the improvement of the nutritive value of straw. The minimal incubation time was found to be 24 hours.

Table 7. Dry-matter digestibility of millet straw treated with NaOH.

	NaOH concentration (g/kg)			
Incubation time	30	40	50	60
24 hours	52.6	56.1	58.6	62.5
48 hours	52.4	57.6	57.2	62.6
96 hours	52.2	56.4	57.9	62.8

Control = 36 p 100.
Source: ISRA-LNERV (1977).

Table 8. Chemical value of NaOH-treated millet straw.

Millet straw	Analysis g/kg DM (1)	(2)	Dry matter	Ash	Ether extract	Crude fiber	Crude protein	P	Ca	Silica	Nitrogen free extract	ADF	Lignin	Lignin/ ADF	NDF
Control			928	98	12	406	36	1.5	3.14	29	448	546	86	158	802
Mil	30	24	973	132	9	402	41	1.46	3.77	41	415	522	91	174	527
Mil	40	24	978	137	8	410	42	1.52	4.94	29	402	500	90	180	512
Mil	50	24	973	139	9	399	40	1.47	4.12	18	413	510	92	180	507
Mil	60	24	968	157	7	391	39	1.34	4.94	23	407	499	80	160	491
Mil	30	48	948	124	10	398	44	1.43	3.47	23	424	512	78	152	517
Mil	40	48	961	132	9	387	43	1.52	3.72	24	429	525	81	154	520
Mil	50	48	966	142	8	384	39	1.42	3.42	21	427	523	82	157	704
Mil	60	48	955	152	8	394	44	1.36	3.33	18	402	531	78	147	688
Mil	30	96	974	136	9	407	47	1.65	4.27	26	401	526	66	125	794
Mil	40	96	972	142	9	402	43	1.33	4.28	33	404	540	82	152	788
Mil	50	96	971	146	8	364	43	1.36	3.85	27	438	503	74	147	702
Mil	60	96	975	179	7	-	49	1.47	4.54	29	435	489	65	133	678

(1) = NaOH concentration g/kg.
(2) = incubation time hours.
Source: ISRA-LNERV (1977).

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OVERCOMING SOME CONSTRAINTS IN FEEDING CROP BY-PRODUCTS FOR MILK PRODUCTION

K. M. Biwi
Ministry of Agriculture
Department of Livestock Development
P.O.Box 159, Zanzibar, Tanzania

ABSTRACT

Supplementation of concentrate and leucaena to dairy cattle fed on sodium hydroxide "dip"-treated and untreated maize stover was compared with an elephant grass-based diet in a latin square 3x3 change over design using 18 lactating dairy cows. Dry-matter intake, energy intake and milk production were studied.

The dry-matter intake of the test roughages and the ME intake from the total dry-matter intake of treated maize stover-based diet, untreated maize stover-based diet and elephant grass-based diet were 3.37, 3.11 and 4.92 kg DM/cow/day respectively, and 86.50, 75.40 and 81.34 kg MJME/cow/day, respectively. The dry-matter intake of the test roughages and ME intake were significantly different ($P<0.01$) between the treatments.

Actual milk yield and 4 percent FCM for TMS-based diet, MS-based diet and EG-based diet were 7.7, 7.6 and 7.7 kg/cow/day, respectively and 9.5, 8.8 and 9.3 kg/cow/day, respectively. The MS-based diet produced significantly low FCM yield ($P<0.01$); but yield of actual milk was not significantly different ($P<0.05$) between the treatments. Higher concentrate allowance in MS-based diet improved actual milk yield but not FCM.

INTRODUCTION

Inadequate feeding during the dry season is a serious problem in Tanzania because in many areas grazing is the main form of cattle feeding. Judicious use of alternative feeds from crop residues can alleviate the problem of feed availability since straws and stovers are abundantly produced in the country (Kategile, 1982). However, the utilization of these crop residues is beset with inherent constraints of low protein, energy and mineral content which often cause inefficient use of the materials due to unacceptability by animals. Manipulation of feeding practices of these crop residues by moderate supplementation of protein, energy and minerals as well as chemical treatment can overcome these constraints and thus improve intake when fed to ruminants.

In this experiment, home-made concentrate and dried leucaena leaves were used to supplement treated and untreated maize stover fed to lactating dairy cattle for milk production, with elephant grass as a control roughage. Dry-matter intake, ME intake and milk production were measured.

MATERIALS AND METHODS

Study area

This work was carried out at Sokoine University of Agriculture.

Roughages used

The roughages used were maize stover, elephant grass (*Pennisetum purpureum*) and leucaena (*Leucaena leucocephala*). The choice of maize stover was influenced by its abundance after the grain harvest and its potential as a dry season feed. The elephant grass was chosen because it is drought-resistant and grows naturally throughout the year in many areas along water courses. It is also a potential green forage for stall-feeding during the dry period. Leucaena flourishes well in coastal areas and grows naturally in many areas.

Procurement and preparation of the feeding materials

Maize stover was collected from the University Farm after the grain harvest and stored undershed bafore chopping in small pieces using a large hand knife. The sizes were in the range of 4-6 cm to facilitate easy mixing of leaves and stems. The chopped stover was divided into two portions, one for alkali treatment and other portion to be used untreated.

The alkali treatment method employed was the "dip" method developed and described by Sundstol (1981). The chopped maize stover was dipped in 1 per cent sodium hydroxide (NaOH) solution. The ratio of maize stover to solution was 1.15 (W/V). The untreated maize stover was soaked in plain water using the same ratio.

Elephant grass was collected from natural stands mostly along the river courses at the university premises. Vegetative parts were cut everyday and chopped into 4-8 cm to facilitate easy feeding.

Leucaena forage was collected and dried on concrete floor, and packed in bags.

The concentrate was made up of cassava flour, maize bran, cottonseed cake, urea, salt, Macklik supper and Vitamins A and D. The mixture was formulated to have approximately 17 percent crude protein.

Experimental design

The experiment was carried out in a 3x3 latin square change over design, with a set of six (3x3) latin squares (multiple classification including partition into within and between square variances). Eighteen mature cows of medium milk production were selected from the University farm. Three breeds Jersey, Ayrshire and Friesian were used.

There were three experimental periods denoted as P1, P2 and P3. Each period lasted for three weeks and was proceeded by a transitional period of two weeks. At the beginning of the experiment a longer period was required to adjust the animals to reasonable intake of the test roughages, particularly the untreated maize stover.

Feeding of the cows

The basal roughages of supplementary leucaena dried leaves was fed with concentrate at the stalls. Cows on sodium hydroxide-treated maize stover (TMS) and elephant grass (EG) received 0.6 kg concentrate for every 1 kg FCM after the first 4 kg of FCM, while those on untreated maize stover (MS) received 0.75 kg concentrate for each 1 kg FCM after the first 4 kg FCM.

The first feeding for the test roughages TMS, MS and EG commenced immediately after the feeding of concentrate and basal roughages in the morning, and the second feeding was after the evening milking. All the feeds were offered individually to each cow and the weights offered recorded. Refusal of test roughages were weighed the next morning for each individual cow, and daily intake was also recorded.

Measurements

The effects of the diets fed to the cows were measured in the following variables:-

1. Dry-matter and energy intake
2. Milk yield and composition
3. 4% fat corrected milk

Data collection

The dry-matter intake of the test roughages were obtained by the difference between the dry-matter offered and that refused. Total dry-matter intake of the whole diet was recorded.

Morning and evening milk were recorded in kilogrammes and summed to make a total for a day's milk yield for each cow. A sample of milk in the morning and evening for two consecutive days per week was taken and a subsample taken for chemical test. Milk fat content was analysed by the Gerber method (British Standard Institution B.S., 696, 1955). The 4 percent fat-corrected milk was calculated according to Gaines formula as described by Maynard et al (1979). Crude protein content was analysed by Kjeldahl method as outlined by A.O.A.C. (1965) (CP = %N x 6.38).

Statistical analysis

The analysis of variance for latin square design was carried out as described by Snedecor and Cochran 1967; with multiple classification including partition into within (w'n) and between (b'n) squares variance i.e. treatments b'n squares, columns w'n squares and rows w'n squares.

The new Duncan Multiple Range Test was used to compare the treatment means for the variables.

RESULTS AND DISCUSSION

Feed intake

The mean dry-matter intake of the test roughages, total dry-matter intake and metabolisable energy intake by the lactating cows are presented in Table 1.

Table 1. Intake of dietary components, total dry-matter intake and ME intake.

Dietary components	Treatments			
	NaOH "dip"-treated maize stover	Untreated maize stover	Elephant grass	SED
Test roughage (kg/cow/day)	3.87^{a}	3.11^{b}	4.92^{c}	0.11
Total dry-matter intake (kg/cow/day)	8.44^{a}	8.10^{b}	8.62^{ac} NS	0.11
Total ME intake (e) (MJME/cow/day)	86.50^{a}	75.49^{b}	81.34^{c}	2.44

(e) = ME = DE x 0.81 (MAFF, 1975), DE = GE x Energy dig. Coefficient from sheep experiment.

Means within a row with different letters are significantly different ($P<0.01$).

NS = not significant ($P<0.05$).

Mean dry-matter intake of the test roughages

The mean dry-matter intake of the elephant grass, sodium hydroxide "dip"-treated and untreated maize stovers and their levels of significance are shown in Table 1 and illustrated in Figure 1. The dry-matter intake of elephant grass was significantly higher (P<0.01) than that of treated and untreated maize stovers. The intake between the maize stovers also differed by 0.76 kg DM/cow/day, representing an increase of 24.44 per cent in favour of the sodium hydroxide "dip"-treated maize stover. This difference was also significant (P<0.01) and falls within the range reported elsewhere (Greenhalgh et al, 1976; Kristensen, 1981). The intake of sodium hydroxide "dip" treated maize stover in this study was found to be higher than the level reported by Sundstol (1981). However, it was difficult to raise the intake above 4.5 kg DM/cow/day and the maximum arrived at was 4.23 kg DM/cow/day during the pre-experimental period. This confirms the suggestion by Owen (1981) that sodium hydroxide "dip"-treated maize stover can only play a role of supplement, replacer or partial replacer of the other roughages for lactating dairy cows.

Mean total dry-matter intake by lactating dairy cows

Cows had a higher total dry-matter intake of elephant grass-based diets (8.62 kg DM/cow/day) than the sodium hydroxide "dip"-treated maize stover (8.44 kg DM/cow/day) and untreated maize stover (8.10 kg DM/cow/day) based diets. The difference in total dry-matter intake between elephant grass and NaOH "dip"-treated maize stover based diets was not significant (P<0.05), but the differences between these diets and the untreated maize stover-based diet were significant (P<0.01).

The mean total dry-matter intake of elephant grass-based diet in this study was similar to the total dry-matter intake reported by Combellas and Martinez (1982). These authors used elephant grass roughage with supplementation of 3 kg concentrate.

Metabolisable energy (ME) intake

Table 1 shows metabolisable energy (ME) intake of 86.50, 75.49 and 81.34 MJME/cow/day for treated maize stover, untreated maize stover and elephant grass-based diets, respectively. The ME intake of the sodium hydroxide "dip"-treated maize stover-based diet was significantly higher ($P<0.01$) than that of the untreated maize stover-based diet. Similarly the ME intake of the elephant grass-based diet was higher ($P<0.05$) than the untreated maize stover-based diet. Difference in ME intake between sodium hydroxide "dip"-treated maize stover and elephant grass-based diets were also significant ($P<0.05$).

This study indicated that the sodium hydroxide "dip"-treated maize stover-based diet could supply ME better than fresh elephant grass-based diet.

Treatment effects of milk yield and 4% FCM

The mean daily actual milk yield and 4% FCM are presented in Table 2.

Table 2. Mean daily actual milk yield and 4% fat-corrected milk (FCM) as influenced by treatments.

	Treatments			
Milk yield (kg/cow/day)	NaOH "dip"-treated maize stover	Untreated maize stover	Elephant grass	SED
Actual milk yield	7.7^{a}	7.6^{b}	7.7^{a}	0.12NS
4% fat-corrected milk	9.5^{a}	8.8^{b}	9.3^{ac}NS	0.18

NS = not significant (P<0.05).

Means within a row with different letters are significantly different (P<0.05).

Actual milk yield

The actual milk yields were 7.7, 7.6, 7.7 kg/cow/day for treated maize stover, untreated maize stover and elephant grass-based diets respectively, and the differences were non-significant (P<0.05).

There was a general decline in actual milk yield with advancing lactation, particularly with the sodium hydroxide "dip"-treated maize stover and untreated maize stover-based diets. The decline was however small from the first to second period than from the second to third period as illustrated in Figure 2. The fall in actual milk yield for the elephant grass-based diet was inconsistent. There was a decline in the second period and a sharp rise in the third period.

This trend was also reflected in the ME intake. The actual milk yield recorded in this study from the elephant grass-based diet was similar to the yield reported by Combellas and Martinez (1982).

4% fat-corrected milk (FCM)

The 4 percent fat-corrected milk yield was highest (9.5 kg/cow/day) with sodium hydroxide "dip"-treated maize stover-based diet than untreated maize stover (8.8 kg/cow/day) and elephant grass (9.3 kg/cow/day)-based diets. There was no significant difference in 4 percent fat-corrected milk yield between treated maize stover and elephant grass-based diets (P<0.05). However each of these two treatments produced significantly more 4 percent fat-corrected milk (P<0.1) than the untreated maize stover-based diet.

In this study it shows that sodium hydroxide "dip"-treated maize stover was more efficiently utilized for milk production than elephant grass as less dry-matter consumed resulted in more FCM. Improved performance with alkali-treated roughages has also been reported in other studies (Greenhalgh et al, 1976).

Fat and protein content in milk

Table 3 shows fat and protein content as influenced by treatments.

Table 3. Fat and protein content in milk.

	Treatments			
Milk chemical composition (g/100g)	NaOH "dip"-treated maize stover	Untreated maize stover	Elephant grass	SED
Fat	5.60[a]	5.31[b]	5.43[ab]NS	0.10
Crude protein	3.44[a]	3.35[a]	3.43[a]	0.65NS

NS = not significant (P<0.05).
Means within a row with different letters are significantly different (P<0.05).

Fat content

The mean fat content (g/100g) in milk ranged between 5.60-5.43g/100g. The sodium hydroxide "dip"-treated maize stover-based diet produced a higher milk fat content (P<0.05) than untreated maize stover. Similar findings were reported elsewhere (Greenhalgh et al, 1976; Kristensen, 1981). The higher fat content produced by the sodium hydroxide "dip"-treated maize stover-based diet was a reflection of an improved crude fibre digestibility and hence the production of more acetic acid in the rumen.

Protein content

The mean protein contents were 3.44, 3.33, 3.34 g/100g for sodium hydroxide "dip"-treated maize stover, untreated maize stover and elephant grass-based diets, respectively. No significant differences were found between the treatments ($P<0.05$). The values obtained in this study are within the range of documented information (Campbell and Marshall, 1975).

CONCLUSION

Inherent constraints of low protein, energy and mineral availability in crop residues like maize stover cause inefficient use of these materials. Alkali treatment as well as supplementation of different nutrient could be useful in utilizing these crop residues as alternative feed during dry seasons for milk production. This study emphasises the usefulness of these materials.

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THE FEEDING VALUE OF SOME AGRO-INDUSTRIAL BY-PRODUCTS FOR BEEF CATTLE AT BAMBUI CENTRE

T. Beramgoto
Institute of Animal Research
Bambui Experimental Station
P.O.Box 80, Bamenda, Cameroon

ABSTRACT

An investigation of the use of agricultural by-products as cattle feed was conducted at Bambui Experimental Station. Banana forage fed *ad libitum* with mineral supplementation supported maintenance in beef cattle and daily of 9 g for 3 months. Intensive fattening rations with various levels of maize stover, palm kernel cake, cottonseed cake and rice polishing also give promising results. The ration with 34% palm kernel cake was associated with the highest net revenue of 49,735 CFA per head while that with the highest proportion of cottonseed cake corresponded to the lowest but substantial profit of 27,997 CFA per animal. Banana forage and maize stover cannot be used by local smallholders due to the cost of collection, transport and processing. Integrated crop and livestock farming is recommended as a solution.

Importing cottonseed cake from the North for use as cattle feed in the North West Province was uneconomical. The introduction of a commercial feedlot in Douala to take advantage of low transport cost by train may be profitable. Further studies to determine economical location of feedlot and for better ration formulation based on agricultural by-products available in the North West Province are to be considered. Grass (*Brachiaria ruziziensis*) hay and legume (*Stylosanthes guyanensis*) hay produced locally are to be evaluated as dry season cattle feeds in the North West Province.

INTRODUCTION

The use of agro-industrial by-products as animal feed has been a common practice for decades in industrialised nations where millions of tons are produced each year. This development has been the result of intensified research activities designed to find efficient methods of recycling agricultural waste. Chemical (soaking in $NaOH$) and mechanical, pelleting and grinding processing techniques were devised for improving nutritional values of the poorest by-products such as cereal straws (El Hag and Kurdi, 1986).

With the ever-growing world population pressure, making competition between grazing land and crop land a preoccupying reality for political leaders, developing country such as Cameroon have been attempting to adopt this relatively old technology for better management of their agricultural resources. The unavailability of grass during the dry season in areas of the country gives even more importance to agricultural by-products as sources of nutrients for livestock in this period.

In Cameroon, the relative abundance of farm residues (rice bran, rice straw, maize stover, maize cobs etc) in Northern as well as Western provinces of the country (MESRES-IRZ Bambui Centre 1985/86; Fomunyam and Meffeja, 1986), offers a unique opportunity for fast improvement of animal production. According to Fomunyam (1984), the Northwest and Western provinces of Cameroon alone produce about 3080 tons of maize stover, maize cobs, rice straws and rice bran annually.

The Cameroon Institute of Animal Research (IRZ), the main public institution with the mission to develop animal resources in the country, has been trying to take advantage of this situation. It has been making serious research efforts to determine the feeding value of locally available agricultural by-products. The Bambui Animal Research Centre, responsible for the improvement of beef and dairy cattle production in the Western Highlands of the country, one of two main zones of IRZ operations, has been particularly active in this area with some success.

The main objective of this paper is to discuss the constraints to the practical application of positive results obtained by research workers of the Bambui Centre. The specific goals of this study are the following:

- to review research activities on agricultural by-products;

- to study physical constraints to practical use of these by-products by local farmers; and

- to propose alternative strategies to overcome the identified obstacles.

MATERIALS AND METHODS

The feeding value of agricultural by-products was evaluated primarily in an attempt to design a dry season feeding package based on the use of farm residues. Since the management of animal production is location-specific, it is important to give a brief geographic description of the study area to substantiate the underlying concerns.

Location of the study area

The Bambui Experimental Station is located on the high lava plateau of the North West Province of Cameroon about 23 km N.E. of Bamenda. It is situated at latitude 6° N and longitude 10° 15'E. This area experiences the dry and rainy seasons as any other tropical region, but with very peculiar lengths. The dry season lasts from mid-November to mid-March i.e. 4 months. The rainy season starts in mid-March and ends in mid-November (8 months), bringing 2310 mm. The abundant rainfall, combined with a rich volcanic soil, makes the Western Highlands of Cameroon most favourable for agriculture. Most African countries will envy the cool temperatures of Bambui (minimum of 0-15°C, maximum of 24.6°C and monthly average of 20.2°C) and its elevation of 1600-1980 m above sea level coupled with rich natural savannah vegetation.

Review of investigations on nutritional value of major agricultural by-products of Cameroon

Several feeding trials were conducted at Bambui Centre to evaluate the nutritional value of locally available farm residues. Two trials were retained because of their interesting results and also because they made use of major agro-industrial by-products of Cameroon.

The first trial involved the supplementation of banana forage with cottonseed cake and/or dried leaves of *Leucaena leucocephala* as protein sources. The composition of the four diets formulated for the study is shown in Table 1.

Table 1. Diets of banana forage supplemented with cottonseed cake and/or dried leaves of *Leucaena leucocephala*.

Ingredient	Diet			
	1	2	3	4
Banana forage [1]	*ad lib.*	*ad lib.*	*ad lib.*	*ad lib.*
Cottonseed cake (g/head/day)	0	750	0	500
Leucaena dried leaves (g/head/day)	0	0	1500	500
Mineral mixture [2] (g/head/day)	10	10	10	10

1. Banana forage contains 70% pseudo-stem and 30% leaves.

2. Mineral mixture contains 50% table salt and 50% bone meal.

A dozen young bulls of Ngaoundere and Ngaoundere crosses averaging 300 kg of liveweight and 2 years and 6 months of age were used. The animals were randomly divided to 4 groups which were also randomly assigned to the four dietary treatments in a 4 x 4 latin square design.

Banana forage (mixture of dried pseudo-stem and leaves) was chopped and mixed with various levels of protein supplement as indicated in Table 1. Banana forage and water were given *ad libitum*. A known amount of forage was offered to each group daily at 8:00 a.m. and the leftover was weighed the next morning before feeding. Daily feed consumption was recorded.

The trial lasted 107 days including an adaptation period of one week. Animals were weighed fortnightly. Data on daily gain and feed intake were collected and analysed statistically for diet effect. Results presented in Table 2 show that diet 3 with levels of protein and energy far above maintenance requirements was associated with the highest daily gain. Diet 1 with protein content barely enough to meet maintenance need of a 300 kg bull resulted in a daily gain of 8.9 g. These results suggest that banana forage can be a good dry season feed for cattle even unsupplemented. The fact that supplementation with cottonseed cake alone was related to a lower daily gain compared to using *Leucaena* as protein source can be explained by the difference in energy availability (Table 2). Using higher levels of *Leucaena* to supplement banana may be recommended for intensive fattening of beef cattle. Increasing the level of cottonseed cake might not be economical.

Table 2. Effect of supplementing banana forage with cottonseed cake and/or *Leucaena* on intake and growth *.

Parameter	Diet			
	1	2	3	4
Number of bulls	3	3	3	3
Initial liveweight (kg)	306.0**	298.8[a]	296.8[a]	302.5[a]
Final liveweight (kg)	306.6[b]	302.8[b]	307.8[b]	357.1[b]
Ave. daily gain (g)	8.9[c]	142.8[bc]	417.42[a]	357.1[ab]
Ave. daily feed intake (kg DM/bull)	3.08[a]	3.30[a]	3.39[a]	3.55[a]
Ave. daily CP intake (g/bull)	240.0	573.8	615.9	590.53
Ave. daily ME intake (Mcal/bull)	na	2.07	3.84	2.66

* Adapted from Wegad (unpublished data).
** Means of the same row with the same superscript are not significantly different (P > 0.05).
na = not available.

The second nutritional trial considered after reviewing research activities on agricultural by-products at Bambui Centre concerned intensive fattening of beef animals. The three diets used are presented on Table 3. This experiment is interesting because it makes use of most of the agro-industrial by-products of Cameroon. The diets were formulated so as to contain approximately the same level of protein (12.92%). Twenty-seven bulls with liveweight varying between 270 and 284 kg were divided into 3 groups of 9 animals each.

Table 3. Intensive fattening rations with various levels of corn stover and major agro-industrial by-products of Cameroon.

Feedstuff	Ration		
	1	2	3
Corn stover (%)	20	40	80
Rice polishing (%)	40	23.5	10
Palm kernel cake (%)	34	22.5	0.0
Cottonseed cake (%)	3.5	11.5	5.5
Urea (%)	0.0	0.0	2.0
Mineral mixture (%)	2.5	2.5	2.5
CP (%)	12.92	12.9	12.96
ME (meal/kg DM)	2.887	2.57	2.41
Cost (CFA/kg)*	38.87	34.49	23.39

* 1US$ = 295 CFA in 1987.

The three groups were randomly assigned to the three dietary treatments. The results shown on Table 4 indicate that corn stover supplemented with energy feeds (rice polishing and palm kernel cake) and a protein source (cottonseed cake) can be profitable when used to fatten beef animals. The diet with the highest level of palm kernel cake had the highest net return.

Table 4. Profitability of intensive fattening of steers using corn stover, rice polishing, palm kernel cake and cottonseed cake as major feed ingredients.

Parameter	Ration 1	Ration 2	Ration 3
Number of bulls	9	9	9
Initial weight (kg)	268.94	277.28	282.8
Final weight (kg)	365.16	360.50	308.80
Daily gain (g)	859	742	214
Daily intake (kg DM/head/day)	6.25	7.44	7.04
Purchase price [a] (CFA/bull)	87.392.5	90.122.5	92.560.0
Feed cost (CFA/finished bull)	29.880.0	27.450.0	17.502.0
Sale price [b] (CFA/finished bull)	164.340.0	162.225.0	138.960.0
Profit CFA/finished bull	49.735	43.344	27.997

[a] Bulls are purchased at the price of 325 CFA per kg of liveweight. 1US$=295 CFA in 1987.

[b] Finished bulls are sold at the price of 450 CFA per kg of live-weight.

Investigating physical constraints to the efficient use of corn stover, banana forage and agro-industrial by-products found in Cameroon

The methodology used in this study consisted of uninformal questioning of workers of the Centre involved in collecting, transporting and processing of banana forage and corn stover. Financial reports of the Centre were also reviewed to determine the sources of supply and price of rice polishings, palm kernel cake and cottonseed cake. Local suppliers were also interviewed. Questions usually asked were related to sources of supply and difficulty of acquiring, transporting and storing the by-products. Following the interviews, the answers were written out and studied to identify common constraints. Three local suppliers of cottonseed cake, palm kernel cake and groundnut cake were contacted.

RESULTS AND DISCUSSION

Physical constraints of using banana forage and corn stover as beef cattle feed at Bambui Centre

Banana forage and corn stover were proven valuable as cattle feed by researchers at Bambui Centre. However their practical use by local cattlemen remains a problem. Generally these are not crop growers and they do not have proper means of collecting and transporting agricultural residues. For instance, purchasing corn stover from Bali, 45 km away, to feed to animals in Bambui, cost 28 CFA/kg if the farmer provides labour for collection and if one uses his own 2-ton vehicle and buys 40 litres of fuel at 150 CFA/litre (Table 5). Even if the cattleman can afford to acquire the corn stover, he still has to chop it which is very tedious. The mechanical chopper as used at the Centre is not at the reach of smallholders.

Table 5. Cost of acquiring corn stover and banana forage at Bambui Centre.

Parameter	Corn stover	Banana forage
Supply point	Bali	Bambui-Bambili
Price	15 CFA/kg*	30 CFA/plant
Labour for collection	10 CFA/kg	-
Transport cost	3 CFA/kg**	-
Total	28 CFA/kg	30 CFA/plant

* 1US$ = 295 CFA in 1987.

** Transport cost is 3 CFA/kg if one uses his own 2-ton vehicle and buys 40 litres of fuel at 150 CFA/litre.

Banana forage is even more expensive because a plant which contains only 10% dry matter is sold at 30 CFA excluding labour for collection and transport cost. Chopping banana forage is as difficult as corn stover.

A major constraint of adopting banana forage and corn stover is the conflict between their use as manure and their use as cattle feed. These two by-products are very important for improving soil fertility by local farmers who are reluctant to sell them.

There are three alternatives for solving the above conflict and permit the use of banana forage and corn stover as cattle feed in the Bambui area. The first alternative requires an agreement between the crop farmers and cattlemen who will then exchange cattle manure and farm residues. In this case, the problems of transport and processing remain unsolved.

The second alternative calls for a good co-operation between the two communities. Farmers will let cattle into their farms after harvesting their crops. This solution eliminates processing and transport constraints.

The third alternative which requires important social changes, is in favour of integrated crop and livestock farming. Cattlemen have to learn cropping techniques and vice versa.

Obstacles and possibilities of using cottonseed cake as cattle feed in Western Province of Cameroon

The value of cottonseed cake as animal feed has been recognised for decades by many researchers (IEMVT, 1974; MESRES-IRZ, 1983-1984; Church, 1984; MESRES-IRZ-Bambui Centre, 1985-1986). As illustrated earlier results of research conducted under Bambui conditions confirmed this reality. Nevertheless, many obstacles must be overcome by local small cattlemen before they can practically take advantage of the nutritive value of cottonseed cake.

In Cameroon, cottonseed cake is produced in the Northern cities of Maroua, Kaele and Garoua. Bambui Centre is located at 730 km, 655 km and 540 km from Maroua, Kaele and Garoua, respectively. One has to face many problems to transport cottonseed cake from one of these locations to Bambui Centre.

The average cost of buying and transporting 24 tons of cottonseed cake from Kaele to Bambui Centre by road is 95.25 CFA/kg. This includes the purchase price (3,500 CFA/bag of 60 kg), truck lease (35,000 CFA/ton), loading charge (35 CFA/bag) and unloading charge (20 CFA/bag). Major problems related to transport by road are the following:

- truck availability; truck lease depends on truck availability and relationship with the truck owner;
- poor road conditions between Kaele and Bambui Centre in the rainy season;
- competition between domestic and European markets where prices are higher; and
- unsteady supply due to seasonal production of cotton.

Transporting cottonseed cake by train between the two points is even more expensive. The average cost for both purchase and transport in this case is 100.09/CFA/kg which includes the following components:

- purchase of cottonseed cake;
- loading in Kaele;
- truck lease from Kaele to Ngaoundere;
- unloading charge in Ngaoundere;
- train transport charge from Ngaoundere to Nkongsamba;
- loading charge in Nkongsamba;
- truck lease from Nkongsamba to Bambui Centre;
- unloading charge in Bambui.

In view of all these difficulties, using cottonseed cake as protein supplement for beef cattle in the North West Province is uneconomical even for a large commercial livestock enterprise. Using it to supplement dry season feed is the most expensive way to keep animals alive in this part of the country.

CONCLUSION AND RECOMMENDATIONS

The North West Province of Cameroon has a great potential for cattle production. However, local cattlemen have difficulties to feed their animals through the four months of the dry season due to lack of forage in this period. Feeding trials at Bambui Experimental Station showed that banana forage offered ad libitum with a mineral supplement could help animals maintain weight in the dry season and even contribute to average daily weight gain of 9 g. Supplementing banana forage with 1500 g of dried leaves of Leucaena leucocephala per head daily resulted in average daily gain of 616 g and could be recommended for intensive fattening. Daily cottonseed cake supplement of 750 g per head was associated with a substantial weight gain of 574 g/day which did not seem economical.

An intensive fattening trial using various levels of corn stover, rice polishings, palm kernel cake and cottonseed cake gave promising results. The diet with the highest level of palm kernel cake (34%) corresponded to the highest net revenue (49,734.6 CFA per head) while the ration with the largest proportion of corn stover led to the smallest but still substantial profit of 27,996.7 CFA per animal.

Collecting, transporting and processing banana forage and corn stover remain the biggest obstacles to the practical application of these results by small cattlemen. Purchasing, collecting and transporting 2 tons of corn stover on 45 km could lead to a total average cost of 28 CFA/kg while one banana plant with 10% dry matter cost 30 CFA. The best method of eliminating these constraints is integrated crop and livestock farming which will require some social changes since cattlemen have to learn crop growing techniques and vice versa.

Importing cottonseed cake from Northern Cameroon for use in fattening diets or as supplement of dry season rations in the North West Province of the country seemed uneconomical due to its unsteady supply and high transport cost. One plausible solution to this situation is to build a commercial feedlot in Douala and use rail road only to transport cottonseed cake from the North. This arrangement is expected to cut down transport cost substantially. In fact it would be interesting to study the economical location of commercial feedlots in the future considering the points of cattle supply and markets and also the sources of major inputs. A further feeding trial with the application of linear programming for better ration formulation using agro-industrial by-products directly available in the North West Province is being planned. The last alternative being considered for study is the use of hay from grass (Brachiaria ruziziensis) and legume (Stylosanthes guyanensis) produced locally.

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MAIZE STOVER AS A FEED FOR RUMINANTS

T. Smith, C. Chakanyuka[1], S. Sibanda[2] and B. Manyuchi
Department of Research and Specialist Services
Grasslands Research Station
P. Bag 3701, Marondera, Zimbabwe

ABSTRACT

Maize stover, the major crop residue in Zimbabwe, is characterised by a low protein and high fibre content. Little attempt has been made to improve its nutritive value. Two experiments have been completed, the first of which considered the effect of amount of plain untreated stover offered on intake in both cattle and lambs. Stover offered increased from 1.5 - 3.0% of body weight with increased intake at the higher level ($P<0.05$). There was little evidence of selectivity. A supplement of protein increased intake at all rates of offer in lambs.

In the second experiment untreated stover was compared with stover treated with 3, 5 or 7% urea for 5 weeks. In cattle and lambs intakes were greatest with less than 7% urea ($P<0.05$) although digestibility in lambs was greatest with 7% urea ($P<0.05$). These results were supported by measurements of dry matter degradability in cattle, using the nylon bag technique, and _in vitro_ digestibility. The _in vitro_ study confirmed 5 weeks as being the optimum treatment period in the prevailing experimental conditions. Between experiments intake was improved by coarse grinding and it is concluded that physical aspects of collecting and feeding residues should be considered together with alkali treatment and supplementation in order to reduce wastage.

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[1] ARDA, Box Bw 41, Harare, Zimbabwe.
[2] Dept. of Animal Science, University of Zimbabwe, Mt. Pleasant, Harare, Zimbabwe.

INTRODUCTION

Crop residues are characterised by low protein and high fibre content and this limits their nutritive value for ruminants. Nitrogen (N) supplementation increases digestibility and intake. (Campling, Freer and Balch, 1962). Maximum intake of cereal straws occurs when crude protein concentration is 66-85 g/kg dry matter (DM) (Elliott and Topps, 1963; Smith et al, 1980).

Chemical treatment of residues also increases intake and digestibility. The benefits to be gained from alkali treatment of residues have been reviewed by Jackson (1977) and Sundstol (1981). Although Sundstol (1981) and Smith et al (1984) found sodium hydroxide more effective than ammonia, the use of alkali containing N reduces the need for protein supplementation (Smith and Balch, 1984). Treatment with urea has been effective in warm (Saadullah et al, 1981) but not temperate climates (Mason and Owen, 1986; Sherwood and Owen, 1987).

Physical treatment usually implies a reduction of particle size. Greenhalgh and Wainman (1972) demonstrated that although intake was improved, a reduction in digestibility was often associated with physical treatment. Walker (1984) concluded that a combination of chemical and physical treatments would be most effective in upgrading crop residues.

The role of crop residues in ruminant nutrition in Zimbabwe was summarised by Sibanda (1986). Maize stover is the principal residue and is either grazed *in situ* or removed from the land prior to feeding. There has been no attempt to upgrade residues although dry season feed is in short supply. In this study the effects of amount of stover on offer, protein supplement and level and period of urea treatment on nutritive value of maize stover in cattle and sheep were investigated.

Experimental procedure and results

Two experiments were conducted. In the first the effects of varying the amount of maize stover on dry-matter intake (DMI) in cattle and sheep were measured. In the second maize stover was treated with urea and changes in digestibility and intake were assessed by _in vivo_ and _in vitro_ techniques.

The stover (Var SR 52) came from a single batch produced on the station. After harvesting the grain and cob the residue was rotor slashed and baled. In Experiment 1, it was fed direct from the bale to cattle and coarse ground (14 mm screen) when fed to sheep. For Experiment 2, the stover was subdivided into four stacks. One stack was left untreated, the remaining stacks being treated with 3,5 or 7% urea (w/w) and kept wrapped in clear plastic sheeting for 5 weeks. The urea was added as a solution so that regardless of urea concentration 20% of water was added to the stover (w/w). The untreated stover was kept dry to avoid the risk of mould. Small amounts of the stover were treated as above and sealed in plastic bags for 1, 3 or 5 weeks. Treatment dates were staggered so that the stacks and bags were all opened on the same day. Composition of the stover and the climatic conditions during the treatment period are given in Table 1.

Experiment 1

Twenty steers (initial liveweight 224 kg) and 20 lambs (initial liveweight 37 kg) were each ranked according to liveweight and then randomised to give five replicates of four treatments. The treatments were defined as amount of stover offered (1.5; 2.0; 2.5; 3.0% stover DM per day of initial body weight). No other feeds were given except where stated. All animals were individually penned with refusals being taken and fresh feed offered daily.

Table 1. Composition of maize stover fed to cattle and sheep during Experiments 1 and 2 and ambient temperature (°C) and relative humidity (%) during the treatment period of stover for Experiment 2.

		DM	DM basis g/kg DM		
		g/kg	Nitrogen	Acid-detergent fibre	Ash
Expt. 1.	Cattle	936	58	431	45
	Sheep	933	-	-	
Expt. 2.	0% urea	926	58	431	45
	3% urea	913	180	465	49
	5% urea	905	218	443	45
	7% urea	907	324	458	47

		Maximum	Minimum
Temperature (°C)	September	25.5	10.1
		(range 19.6 - 29.6)	(range 4.0 -14.6)
	October	25.6	12.0
		(range 18.5 - 31.0)	(range 8 -15.7)
Humidity (%)	September	79.3*	28.1+
		(range 59 - 100)	(range 13 -62)
	October	86.6*	39.9+
		(range 61 - 100)	(range 20 -85)

* Measured at 6.00 h

\+ Measured at 14.00 h

The steers were grazed on stover for 10 days and were then penned for 50 days. Intake was recorded over the last 30 days. Both total intake (kg DM/d) and g DM/kg $W^{0.73}$/d were in the order 1.5% = 2.0 and 2.5% = 3.0% ($P<0.05$) (Table 2). Chemical composition of refusals was similar to that of the fresh stover.

Table 2. Dry-matter intake of stover*, in cattle and lambs, as affected by the amount offered (Stover DM kg/d as % liveweight).

Stover allocation :	1.5	2.0	2.5	3.0	SE
Cattle :					
Total intake (kg DM/d)	2.17	2.17	2.56	2.58	0.07
Intake g DM/kg $W^{0.73}$	41.5	42.9	49.9	49.0	1.56
Refusals as % of amount offered	31.8	48.5	51.2	59.5	
Sheep : a) No protein					
Total intake g DM/d	325	294	313	400	29.1
Intake, g DM/kg $^{0.73}$	23.2	21.4	22.3	29.1	1.91
Refusals as % of amount offered	41.9	60.6	66.5	64.3	
b) With protein+					
Total intake, g DM/d	376	400	354	493	37.4
Intake, g DM/kg $W^{0.73}$	26.6	29.4	25.3	36.1	2.52
Refusals as % of amount offered	32.8	46.4	62.1	56.0	

* Values shown refer to stover intake alone.
\+ The protein supplement (270 g DM/d) was eaten by all sheep.

Sheep were fed the stover for 28 days with intakes being measured over the last 7 days. Following this all lambs received 270 g DM/d of a protein (15.0% CP) concentrate and the same stover allocation. After a further 14 days, intake was again measured for 7 days.

At the start of the second period one lamb died from a condition unrelated to the experiment and a missing plot value for intake was calculated (Snedecor, 1956). Intake in both measurement periods was greatest at the 3% rate of offer (Table 2). When the periods were combined total DMI of stover and DMI g/kg $W^{0.73}$ were significantly increased at the 3% rate of offer ($P<0.05$). Between the first and second measurement periods mean intake increased by 71 ± 16.1 g DM/d ($P<0.01$). This last difference is probably attributable to the supplement of protein fed in the second period. Changes in the composition of the refusals were small, acid-detergent fibre being lowest at the 3% level of offer (1.5%, 3.0% = 59.9%, 58.1%) and *in vitro* DM digestibility highest at the 2.5% level (1.5%, 2.5% = 0.18, 0.24%).

Experiment 2

In this experiment estimates of the nutritive value of urea treated maize stover were made using steers, lambs and *in vitro* digestibility (Tilley and Terry, 1963).

In order to estimate the pattern of degradability (dg) of the stover and measure DMI in steers, 12 animals were individually fed (8 kg fresh stover/d) to appetite on milled stover which had been treated with either 0,3,5 or 7% urea. No other feeds were offered. After a 20-day adaptation period 10 nylon bags, each containing 5 g of the appropriate dietary stover, were inserted into the rumen of each steer. Two of the bags were withdrawn after 12, 24, 48, 72 and 96 h respectively in order to measure DM loss. Estimates of the dg of stover DM were made using a modification of the non-linear model ($P = a + b(1 - e^{ct})$) proposed by Orskov and McDonald (1979). The degradability of dry matter increased with the level of urea treatment and nitrogen in the treated stover was highly and rapidly degraded (Table 3).

Table 3. Dry-matter (DM) and nitrogen (N) loss (%) from maize stover treated with 0, 3, 5 and 7 percent urea incubated in nylon bags in the rumen of steers.

% Urea levels		Fitted constants for model $P= a+b\ (1-e^{-ct})$			DM and N degradation (%) Incubation time (h)				
		a	b	c	12	24	48	72	96
0	DM	10.4	59.8	-0.02	25.3	37.1	50.9	61.5	64.9
	N	41.9	58.1	-0.006	44.0	52.9	55.7	65.5	66.2
3	DM	17.1	58.5	-0.02	29.4	41.2	53.2	62.1	68.3
	N	81.3	5.8	-0.03	83.2	84.8	85.7	86.8	86.9
5	DM	14.4	66.8	-0.02	28.4	37.8	55.6	62.8	70.2
	N	83.0	7.2	-0.08	87.5	89.2	90.0	89.7	90.6
7	DM	14.2	60.3	-0.03	31.5	43.1	58.4	65.6	72.8
	N	90.0	4.8	-0.04	91.6	93.1	93.9	94.0	95.0

Daily dry-matter intake, measured over the last 10 days of the trial, for the 0, 3, 5 and 7% urea treatments was respectively: 3.99, 5.72, 4.97, 4.27$\pm$0.245 kg/d; 51.6, 66.9, 55.5$\pm$1.96 kg kg $W^{0.73}$.

Digestibility and intake of the stovers was also measured using 16 lambs, ranked according to initial liveweight (mean 44 kg) and then randomised to the four treatments. Twenty-one days of adaptation to the diet was followed by 7 days measurement of intake and then a further 7 days of intake and digestibility measurements.

Intake was similar during the two measurement periods and the data presented are for the 14 days. All the treated stovers were eaten more readily than the control ($P<0.05$), the greatest intake following treatment with 5% urea (Table 4). Digestibilities of dry matter (DM), organic matter (OM) and acid-detergent fibre (ADF) are given in Table 4 with the differences between 0% and 7% significant at $P<0.05$ (Table 4).

Table 4. Intake and digestibility of maize stover, either untreated or treated with 3, 5 or 7% urea, offered to lambs.

		%Urea				
		0	3	5	7	SE
Intake :	g DM/d	437	658	698	583	27.4
	g DM/kg $W^{0.73}$/d	28.3	40.9	44.8	37.4	2.01
	OM g/d	418	626	667	556	26.0
Digestibility :	DM	0.458	0.478	0.535	0.584	0.0240
	OM	0.476	0.491	0.552	0.597	0.0230
	ADF	0.549	0.524	0.604	0.646	0.0202

In vitro digestibility of DM was greatest after 5% treatment with urea and 5 weeks sealed in plastic. An incubation time of 72 h gave higher values than 48 h. Digestibility of acid-detergent fibre was not improved by lengthening the period sealed from one to five weeks but was by the inclusion of urea. Incubation time was 48 h (Table 5).

Table 5. *In vitro* digestibility of maize stover before and after treatment with urea.

	Time of treatment	Time of incubation	% urea treatment 3	5	7
DM	7d	48 h	0.46	0.47	0.47
		72 h	0.52	0.51	0.52
	21d	48 h	0.51	0.53	0.47
		72 h	0.55	0.57	0.53
	35d	48 h	0.53	0.52	0.50
		72 h	0.56	0.58	0.57
			0% urea = 0.46		
ADF	7d	48 h	0.49	0.50	0.44
	21d	48 h	0.52	0.50	0.50
	35d	48 h	0.51	0.46	0.46
			0 urea = 0.444		

DISCUSSION

Treatment of roughage is undertaken to increase intake and digestibility. In the two experiments reported intake was increased by varying the amount of stover offered, feeding protein as a supplement, treatment with urea and by altering the physical form.

Increased intake through increasing the amount of stover offered supports the findings of Wahed and Owen (1986). They found increasing the refusal level of barley straw from 20 to 50% increased

intake in goats by 33%. In Experiment 1 increasing the refusal rate from 31 to 59% increased intake by 19% in cattle. With lambs the refusal rate increased from 42 to 64% of that offered and intake increased 24%. With the high protein concentrate, fed at 21 g DM/kg $W^{0.73}$, refusal rate increased from 32 - 56% of that offered (the amount of stover offered was constant in both periods of the trial with lambs) and intake rose 31%. The overall effect of the protein supplement was to increase stover intake by 23%. The apparent lack of selective feeding, as measured by changes in refusals, probably reflects to some extent the difficulty of sub-sampling a stover with widely divergent components.

It is probable that the higher rates of stover offered were less than those confronting cattle grazing fresh stover. For maximum utilisation maize stover should be collected, rather than grazed in situ, and consideration given to chemically treating refusals (Wahed and Owen, 1987). To minimise wastage troughs permitting little or no spillage should be provided. Trampled or excreta-contaminated stover is of no further use as a feed.

There were differences in DMI between steers receiving the lowest rate of feeding in Experiment 1 and those on control in Experiment 2 (41.5 vs 51.6 g DMI/d/kg $W^{0.73}$ respectively). The amount offered in Experiment 2 (92.5 g/kg$W^{0.73}$) was within the range offered in Experiment 1 (60.7-122.9 g/kg$W^{0.73}$). In the first experiment stover was fed from the bale and in the second it was coarse-milled. Reduction of particle size is known to increase intake of roughages (Nicholson, 1984). The effects of coarse chopping (probably by a hand-operated machine such as a chaff-cutter) should be investigated.

Urea treatment of stover was also beneficial to intake in both cattle and sheep, confirming the responses reported by Saadullah et al (1981). Sheep ate less than steers but urea treatment stimulated intake to a greater extent. With both species peak intake was achieved with less than 7% urea.

Digestibility of DM and OM measured in lambs increased with increasing levels of urea treatment. This response would have been a combination of the effect of alkali on the cell wall of the stover and the effect of N on fibre digestion and microbial protein synthesis in the rumen (Preston and Leng, 1984). The improvement in the digestibility of DM in the rumen (Table 3) following urea treatment confirms this pattern of response since it is envisaged that over 80% of digested OM is apparently digested in the rumen (Grigera-Naon, 1985). Urea treatment boosted the N content of the stovers (Table 1), the high digestibility of urea being reflected in the rapid and large loss of N in the treated stovers.

Increases in digestibility measured in vitro were not as great as those measured in lambs. Rumen liquor was collected from sheep fed hay and the intention to repeat the test using sheep fed stover as donors had to be dropped. However the results indicate that 5% urea left sealed for 5 weeks was the optimum in the prevailing conditions (Table 1).

The relative importance of intake and digestibility can be shown by considering the control and 5% urea treatments in Experiment 2 (Table 3). The intake of digestible OM (DOMI) were 201 and 361 g/d respectively. If intake had increased without a change in digestibility the DOMI would have been raised from 201 to 303 g/d. Therefore, 70% of the total increase came from raised intake and 30% from an improvement in digestibility. This represents a change in metabolisable energy intake from 50% of maintenance to maintenance (MAFF, 1975).

Factors affecting the economics of treating residues include : the availability and or cost of alternative feeds; the nutritive value of the untreated material and the degree of improvement obtained (Smith & Baleh, 1984). Where feed is limited the slaughter value before and after the feeding period should be considered. Plastic sheeting is expensive and cheap methods of ensiling should be sought. Urea is not always available. This study confirms that the physical aspects of handling and presenting the stover to the animal should be considered together with supplementation and alkali treatment.

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CONSTRAINTS TO CEREAL CROP RESIDUE UTILISATION IN CENTRAL TANZANIA

M.A. Kabatange and A.J. Kitalyi
Livestock Production Research Institute
P/Bag Mpwapwa, Tanzania

ABSTRACT

The importance of crop residues in ruminant nutrition in the long dry seasons of semi-arid areas need not be overemphasised. In this paper the existing practices of cereal crop residue feeding of livestock in Central Tanzania is discussed. The physical limitations to its use are highlighted. Production characteristics and nutritive values of three most common cereals in the area are presented.

Stover dry matter (DM) yields of bulrush millet, sorghum and maize were 9661±1343.0, 8244±1491.5 and 7222±479.8 kg/ha respectively. Crude protein (CP) ranged from 3.7 to 5.4 per cent for the different stover fractions at harvesting and from 3.1 to 4.4 per cent at mid-dry season. *In vitro* organic-matter digestibility (IOMD) was 52.6 to 68.3 per cent at harvesting and 46.5 to 63.5 at mid-dry season. Between harvesting and mid-dry season, DM, CP and IOMD of the crop residues declined by 63%, 0.6% and 4.8 per cent respectively. These figures show that both yield and nutritive value are reduced if the residue is left standing in the field after grain harvest. Possible improvement strategies on crop residue utilisation are suggested.

INTRODUCTION

Central Tanzania lies between latitude 4^{o} and 7^{o}S and longitude 33^{o} and 37^{o}E. It covers an area of about 140,000 km^2 in the central semi-arid plateau at an elevation of 750-1500 m above sea level. The mean annual rainfall ranges from 400-800 mm with high variation in amount and distribution. The inhabitants are mainly agro-pastoralists cultivating millets, sorghum, maize and groundnuts as principal crops. Livestock species kept are cattle, sheep, goats and donkeys.

Utilisation of cereal crop residues for livestock feeding, though of major importance in the agropastoral system, has not been fully exploited. The ruminant population depends on natural grasslands for feed, particularly in the wet season. Crop residues form an important feed component in the dry season. In a project "Improvement of Animal Production Systems in Central Tanzania" a study to evaluate the potential value and constraints to utilisation of crop residues for livestock feeding was initiated.

METHODOLOGY

Following the Farming Systems Research (FSR) approach, a diagnostic survey was carried out from June 1985 to May 1986 (Annual Report 1985/86). In the various stages of the diagnostic survey carried out, guidelines followed and questions set in the formal survey aimed at understanding the existing use and management of crop residues. In the following cropping season (1986/87), crop residue production and utilisation was monitored.

Crop residues of the most commonly grown cereals, bulrush millet, sorghum and maize were harvested from selected farmer fields in Berege and Majeseni villages. Two samplings were carried out, the first one at grain harvest, in early June and the second one at mid-dry season, in early September. Plant density and grain yield were estimated from 100 m^2 plots, whereas stover yield, stalk and leaf fractions were estimated from 4 m^2 quadrats. Dry matter (DM), crude protein (CP) and _in vitro_ organic-matter digestibility (IOMD) were determined on the stover fractions.

RESULTS AND DISCUSSION

Table 1 shows farmer responses on use of crop residues for livestock feeding. Use of legume haulms for livestock feeding was negligible. The haulms, mainly groundnut, are produced in the wet season when pasture availability is not critical, and there are practical limitations to their conservation for dry season feeding. Grazing in the crop fields after grain harvest was the most common method of availing the crop residues to livestock (61%, n = 152), though some farmers indicated not to allow animals to graze in the crop fields after harvest. A higher proportion of farmers in the maize zone gave the latter response, alleging that the practice led to reduced grain yields in subsequent crops. None of the respondents indicated that they collect or conserve the residues for later use. Efficient utilisation of the crop residues is limited by the following factors; big herd sizes, long distances from crop fields to kraals/homesteads (4.6 km), lack of transport and low level of technology.

Table 1. Use of crop residues for livestock feeding in the study area (per cent of responses).

Village	n	Cereal stovers	Legume haulms
Banyibanyi	17	59	20
Majeseni	12	25	0
Lenjulu	20	55	0
Mlembule	15	40	0
Berege	20	40	47
Nghambi	17	59	47
Kinusi	16	31	0
Kisima	17	12	0
Chamtumile	18	50	11
Study area	152	41	9

Source : Annual Report (1985/86).

There were wide variations in plant height and density which may be attributed to differences in soil fertility, seed quality, variety and husbandry practices followed. Farmers in the same area were not following uniform recommended crop husbandry practices as exemplified in observations whereby farmers put 7-30 sorghum seeds per planting. This usually resulted in more vegetative growth and low grain yields (Table 2).

Table 2. Grain and stover yields and harvesting indices of bulrush millet, sorghum and maize (kg/ha).

Type of cereal	Sorghum	Bulrush millet	Maize
Grain yield	578 ± 174.5	690 ± 339.2	3633 ± 437.9
Stover yield at grain harvest	8244 ± 1491.5	9661 ± 1343.0	7222 ± 479.8
Harvesting index (%)	7	7	50
Stover quantity at mid-dry season	3206 ± 895.5	1579 ± 527.3	4029 ± 766.7
Utilisation (%)	61	84	44

Variations in grain and stover component yields were high for all the crops studied. The quantities of millet and sorghum crop residues were high compared to other reported values and the corresponding harvesting indices were relatively low (Annual Report, 1983/84; Powell, 1986). This may be due to the practice of planting many seeds resulting into more vegetative growth. High variations in stover yields are common in traditional farms due to differences in management practices. Values ranging from 0.6 to 10 tons/ha have been reported (Annual Report, 1983/84). Loss in stover during the mid-dry season was high, particularly with millet and sorghum stover. The higher loss in these crops could be due to exposure to grazing on these fields than in the maize fields. It had been noted earlier that some farmers, particularly those in the maize growing zone, did not allow livestock into their fields. However, figures on utilisation are to be taken with caution because not all crop residue loss was due to grazing. Losses due to wind shatter and by termites might have been substantial but were not measured. Further investigation to quantify such losses is needed.

Crude protein and digestibility of crop residues are important indicators of their nutritive value and these are summarised in Table 3.

The cereal crop residues investigated showed that CP values ranged from 3.7 to 5.4 per cent at harvesting and from 3.1 to 4.4 per cent at mid-dry season. In both periods the protein content was marginal-to-deficient and not adequate for ruminal microbial breakdown of ingested forage. Values obtained for CP are lower compared to a study carried out in Botswana (Annual Report, 1983/84) probably because there was no fertiliser use in this area. The IOMD values were high for the leaf fractions compared to the stalk or whole stover. Similar trends have been observed by other workers (Powell, 1986; Annual Report, 1983/84). Maize stovers had the highest IOMD followed by sorghum and millet in decreasing order. A decline in crude protein content and digestibility of the stover fractions as the dry season advanced was noted. In general there was a decline of 0.6 and 4.8 per cent in CP and IOMD, respectively.

Table 3. Crude protein and IOMD of bulrush millet, sorghum and maize stover fractions.

	At harvesting		At mid-dry season	
Crop residue	CP%	IOMD%	CP%	IOMD%
Sorghum whole stover	5.0	60.3	3.8	52.7
Sorghum stalk	3.7	56.6	4.2	54.1
Sorghum leaf	5.4	62.8	4.4	58.5
Bulrush millet whole stover	4.4	56.0	4.0	48.3
Bulrush millet stalk	4.4	52.6	3.6	46.5
Bulrush millet leaf	4.5	63.2	4.3	54.1
Maize whole stover	3.9	63.2	3.1	60.4
Maize stalk	4.3	60.0	3.9	58.9
Maize leaf	5.0	68.3	3.6	63.5

CONCLUSION

The information gathered from the diagnostic survey and the study clearly shows that there is underutilization and inefficient use of the crop residues. Further, there is need for development of technological packages on proper use of this feed resource. Harvesting and transporting crop residues to homesteads/kraals would be very difficult because the materials are bulky. There is therefore a need for introducing economical harvesting, collection, handling, transportation and storage methods.

On improvement of the quality of crop residues, introduction of forage legumes in the feeding system would be the most practical. Under stall-feeding practices value of various forage legumes such as Leucaena, Stylosanthes, and Trifolium species in improving the nutritive value of crop residues have been tested (Mohamed-Saleem, 1985; Butterworth, 1986). Inclusion of a grain legume such as Dolichos lablab and pigeon pea in the cereal fields for grazing with crop residues after grain harvest is another possibility.

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GRAIN YIELD AND NUTRITIVE VALUE OF CROP RESIDUES FROM THREE VARIETIES OF MAIZE (ZEA MAYS L) CROP

J.E. Fleischer, A.R. Barnes, B. Awumbila,
K. Amaning-Kwarteng and C.K. Tieku
Department of Animal Science
University of Ghana
Legon, Accra, Ghana

ABSTRACT

An experiment was carried out to find the grain and crop residue yields, the nutritive value of the crop residues, the harvest and potential utility indices of three varieties of maize.

The maize varieties used were "Ex-Volta", Pol.-16 and "Legon Composite 4". The maize seeds were sown after ploughing and harrowing and fertilised with a compound fertiliser (20%N 20% P_2O_5 and 20 K_2O) and also sulphate of ammonia. All three varieties were harvested at 65, 95 and 125 days after planting. After harvesting, the grains were reserved. Both the grains and crop residue were dried and weighed. The crop residue was then analysed for crude protein content, cell wall constituents and *in vitro* dry-matter digestibility. The harvest index of the grain and the potential utility of the whole crop was then calculated.

Grain yield of the three varieties, Ex-Volta, Pol.18 and Legon Composite 4 increased from 1.04, 0.56 and 0.03 t ha^{-1} at the initial harvest to 4.87, 5.67 and 4.07 t ha^{-1} at the final harvest. On the contrary there was a significant ($P< 0.01$) decline in the crop residue yield of all three varieties with advancing growth. The crop residue:grain ratio ranged between 1.1 and 1.8:1 for the three varieties at different stages of growth.

The various botanical fractions showed a mixed trend of development. Whereas the leaves continuously declined with

advancing growth period, other parts increased or decreased initially and later showed an opposite trend of development.

Crude protein content declined considerably with advancing age in all three varieties and all were below 8%. Cell wall constituent on the contrary increased with advancing age and only the difference in ADL between Ex-Volta and Composite 4 was significant.

In vitro dry-matter digestibility significantly ($P<0.01$) declined from 80% to 64% with advancing age. No varietal differences were observed. Harvest index of grain increased with advancing age. Ex-Volta and Pol.-16 had a significantly higher harvest index than Composite 4. Potential utility index was very high (78-82%) and remained constant throughout the growth period. No varietal differences were however observed.

INTRODUCTION

The natural grasslands constitute the main feed resources for ruminants in many countries. However, whereas land area under grazing has remained constant over the years, communal grazing areas have been subjected to increasing livestock population pressure and fluctuating rainfall (Qureshi, 1986). Thus fluctuating feed resources continues to hamper animal production. This means that alternative feed resources unsuitable for human consumption but which can be valuable for animal feeding purposes must be given more attention (Lenlen and El-Harith, 1985; Fleischer, 1986). One such feed resource is the maize crop residue.

Maize (*Zea mays* L) is one of the crops widely grown by most peasant farmers in the West African subregion. It is estimated that grain yields range between 0.2 and 2.7 mt ha^{-1} (FAO, 1983, 1986). Powell (1985) estimated that the straw:grain ratio of maize was 2:1. This means that twice as much crop residue as grain which could be a very important feed for the ruminants is produced.

The maize crop residue consists of various plant fractions which have different nutrient contents and digestibilities (Hacker and Minson, 1981; Fleischer et al, 1987). However, not much work has been carried out on crop residue variation between different maize varieties.

The objectives of this study therefore were to find the grain yield, crop residue yield, nutritive value of the crop residue, the harvest index of the crop and the potential utility index of whole crops from different maize varieties.

MATERIALS AND METHODS

The experiment was carried out at the Department of Animal Science, University of Ghana at Legon. The area has a subhumid climate. The annual rainfall is 934.2 mm p.a. bimodally distributed. The major season begins in March/April and ends in July while the minor season is from September to November. Temperatures are fairly uniform with a maximum and minimum of 32.5 $\pm$ 1.7 and 27.7 $\pm$ 1.1^{o}C respectively. Relative humidities are high during the rainy season, being 90-100%, but may drop to about 40% or below during the dry season. Potential evapotranspiration is about 1800 mm p.a.

The soil is part of the Nyibenya-Hacho complex which is light-textured clay and free-draining (Brammer, 1960; Hall and Jenik, 1979).

Planting material

Three varieties of maize were used. These were "Ex-Volta", "Pol.-16" and "Legon Composite 4" which mature at 65, 95 and 125 days, respectively, after planting. Germination tests performed prior to sowing indicated 95% germination for all three varieties.

Cultivation and harvesting

The experiment was laid out in a completely randomised design. After ploughing and harrowing the field was divided into plots each of 4.50 m x 3.50 m. Each plot was assigned to each variety. Seeds of the three varieties (obtained from the Crop Science Department,

University of Ghana, Legon) were sown at the rate of three seeds per hill in rows. Planting distances were 0.75 m between rows and 0.25 m within rows. Two weeks after planting, the plants were thinned to one plant per hill, and a compound fertilizer (20% N, 20% N P_2O_5 and 20% K_2O) applied at the rate of 100 kg ha^{-1}. Six weeks after planting, the field was top-dressed with sulphate of ammonia (21% N) at the rate of 50 kg ha^{-1}. The field was hand-irrigated at regular intervals, and weed clearing was done manually using the hoe and cutlass.

Harvesting of plants was done at 65, 95 and 125 days post-planting. At harvest, the plants were separated into grain and crop residues. Some of the crop residues were further separated into leaves, leaf sheaths, stems, husk, cobs and tassel. These plant fractions were then dried in the oven at 70°C for more than 48 hours and weighed. After weighing samples were bulked and ground with a Wiley Mill to pass through 1 mm sieve and stored until analyses.

The ground crop residues were analysed for crude protein by the Kjeldhal method, for cell wall constituents by the method of Goering and Van Soest (1970) and in vitro dry-matter digestibility (IVDMD) by the method of Minson and McLeod (1972).

The harvest and potential utility indices of the crop were calculated as follows:

$$\text{Harvest Index } (HI_{(g)}) = \frac{\text{Grain yield (kg ha}^{-1}) \times 100}{\text{Total above ground plant dry-matter yield (kg ha}^{-1})}$$

$$\text{Potential utility index (UI)} = \frac{\text{Grain yield (kg ha}^{-1}\text{)} + \text{Digestible dry-matter yield of crop residue (kg ha}^{-1}\text{)} \times 100}{\text{Total above ground plant dry-matter yield (kg ha}^{-1}\text{)}}$$

RESULTS

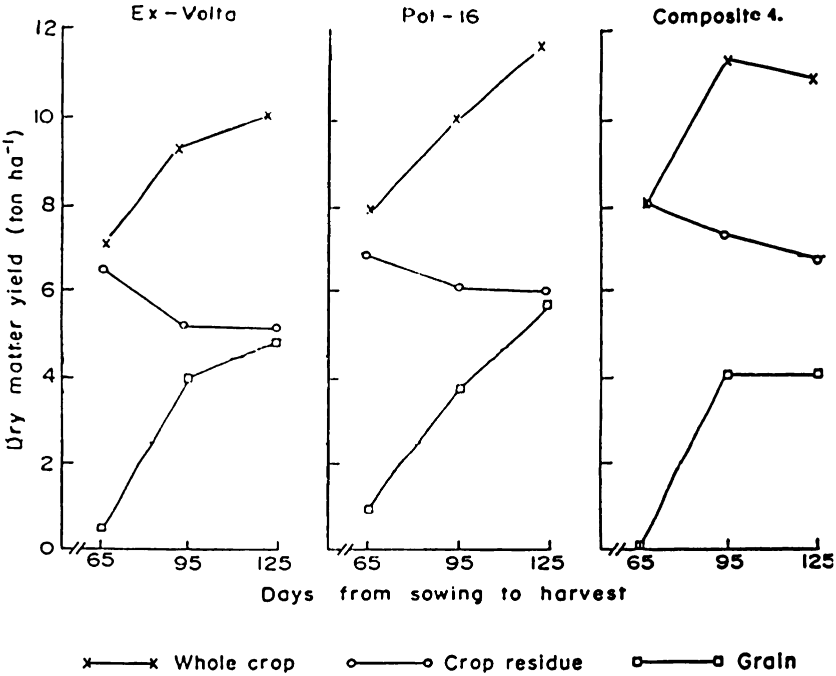
Yield

Grain and crop residue yield of the three maize varieties at different harvests are shown in Figure 1. Total dry-matter yield increased with increasing growth period (P=0.01) but did not significantly differ (P> 0.05) among varieties.

Grain yield increased significantly (P< 0.01) with increasing growth period. At the initial harvest, the grain yield of the three varieties Ex-Volta, Pol.-16 and Legon Composite 4 was 1.04, 0.56 and 0.03 and increased to 4.87, 5.67 and 4.07 t ha^{-1} respectively at the final harvest. Except for the difference between Legon Composite 4 and the others which was statistically significant (P<0.05), none of the varietal differences in grain yield was statistically significant (P< 0.05).

Crop residue yield significantly decreased (P< 0.01) with increasing growth period. The magnitude of the decreases was 21.2%, 11.8% and 14.7% for Ex-Volta, Pol.-16 and Legon Composite 4 respectively. Significant differences (P< 0.01) were also observed among varieties. Legon Composite 4 gave the highest yield of crop residue. This was followed by Pol.-16. At the second and third harvests when the maize fairly matured, the ratio of crop residue to grain was 1.3 and 1.1, 1.6 and 1.1, 1.8 and 1.7 to 1 for Ex-Volta, Pol.-16 and Composite 4, respectively.

Figure 1. Whole crop, grain and crop residue yield of three varieties of maize at different growth periods.



Changes in the percentage composition of the various morphological fractions of the crop residues are shown in Figure 2. The trend of developmental changes was mixed for the various botanical fractions. The proportion of leaves continuously declined in all varieties with advancing growth period. On the contrary, the other fractions either increased initially and later declined or declined initially and later increased.

Proportional yields of the various botanical fractions of the residues are shown in Figure 3. Except for a few such as tassel, cobs and husks, the amounts of the various plant fractions decreased (P>0.05) with advancing growth period. Slight varietal differences were also observed but these were not statistically significant (P> 0.05).

Chemical analyses

Chemical composition of the crop residues are shown in Table 1. Crude protein content declined considerably (P<0.01) with increasing growth period. On the contrary, only slight and non-significant (P>0.05) varietal differences were observed.

The cell wall constituents i.e. NDF, ADF, cellulose and ADL contents significantly increased (P< 0.01) with increasing growth period. Ex-Volta had the highest amount of cell wall constituents at the initial harvest but a mixed trend was observed at the later harvests. These varietal differences in neutral-detergent fibre, acid-detergent fibre and cellulose were however, not statistically significant (P>0.05). Ex-Volta had a significantly higher ADL content (P<0.05) than Composite 4. The differences between the other two were however, not significant.

In vitro dry-matter digestibility (IVDMD) of the crop residues is shown in Table 2. IVDMD decreased significantly (P< 0.01) with increasing growth period. Ex-Volta had similar IVDMD as Composite 4 and these were about 1-4% higher than that of Pol.-16 at the second or third harvest. These differences were however, not statistically significant (P> 0.05).

Figure 2. Percentage of botanical fractions of three varieties of maize at different growth periods.

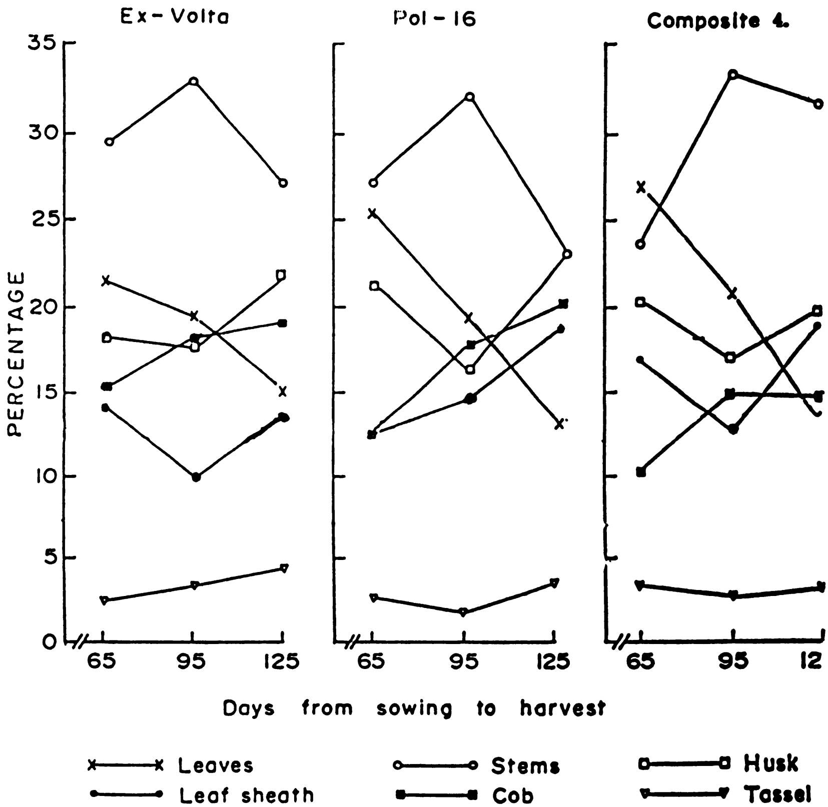


Figure 3: Botanical fractions of the crop residue of three varieties of maize at various stages of harvest.

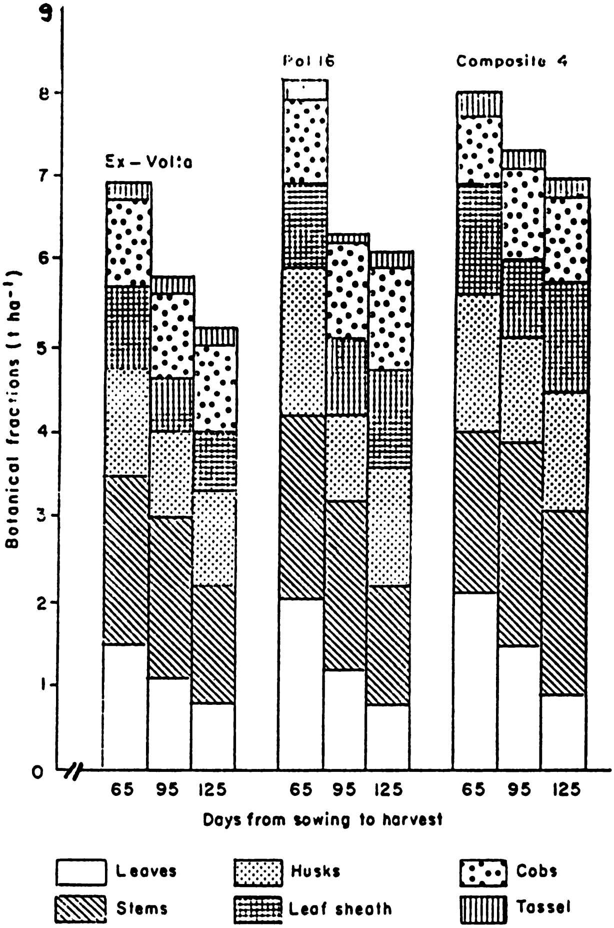


Table 1. Chemical composition of three varieties of maize crop residues at different harvests (in % dry-matter basis).

Chemical constituent	Days from sowing to harvest	Ex-Volta	Pol.-16	Legon Composite 4
Crude protein	65	5.66	7.00	7.61
	95	2.75	3.47	3.09
	125	2.68	2.74	2.60
Neutral-detergent fibre	65	63.78	59.07	59.00
	95	79.92	79.32	77.26
	125	49.58	47.12	49.49
Acid-detergent fibre	65	33.73	31.82	31.62
	95	45.63	45.61	42.85
	125	49.58	47.12	49.49
Cellulose	65	27.28	25.86	26.60
	95	36.63	36.58	34.64
	125	38.48	37.65	40.02
Acid-detergent lignin	65	6.45	5.96	5.02
	95	9.00	9.03	8.21
	125	11.10	9.47	9.41

Table 2. *In vitro* dry-matter digestibility of three varieties of maize crop residues at different harvests (in % dry-matter basis).

Days from sowing to harvest	Varieties: Ex-Volta	Pol.-16	Composite 4
65	80.1	80.0	80.2
95	67.9	63.6	67.0
125	64.5	63.5	65.6

Harvest index of grains (HI) and potential utility index (UI) of the whole crop are shown in Table 3. Harvest indices significantly increased ($P<0.01$) with increasing growth period particularly between the first and harvest. There were no significant differences between the harvest indices of Ex-Volta and Pol. -16 but these two were significantly higher ($P<0.05$) than those of Composite 4.

Table 3. Harvest index of grain (HI(G)) and potential utility index (UI) of whole crop of three varieties of maize.

Days from growing to harvest	Harvest index (%)			Potential utility index (%)		
	Ex-Volta	Pol.-16	Composite 4	Ex-Volta	Pol.-16	Composite 4
65	8.2	13.1	0.4	81.7	82.6	80.3
95	43.3	38.4	35.7	81.8	77.6	78.8
125	48.7	48.3	37.2	81.7	81.1	78.4

No significant differences ($P> 0.05$) were observed in the potential utility index of the maize crop residue between varieties and advancing maturity. The potential utility however, remained fairly constant and far higher than the harvest indices.

DISCUSSION

The increase in dry-matter yields with increasing growth period is consistent with other published results (Raymond, 1969; Lutz et al, 1971). The particularly low grain yield of Composite 4 at the first harvest could be attributed to the fact that it was harvested too early relative to its maturity stage (125 days). Ex-Volta had relatively low grain yield considering that its postulated maturity period was 65 days post-planting. The results obtained suggested that the best time of harvesting this variety of maize might be at least 95 days and not 65 days post-planting.

The final grain yields of 4.87, 5.87 and 4.07 t ha^{-1} for Ex-Volta, Pol.-16 and Legon Composite 4 varieties, respectively, are higher than the range of reported grain yields of between 0.20 and 2.7 t ha^{-1} (FAO, 1983, 1986). They are however, still lower than the potential maximum yield of 6.25 t ha^{-1} indicated by Dadson (1975). These differences could be due to a number of factors including genotype, environment, cultural and economic constraints which may determine the adoption of a particular cropping system and also for minimising the influence of the limiting factors (Loomis and Gerakis, 1975).

With advancing growth there was a decrease in the yield of crop residue. While this may partly have been due to old leaves falling off and some losses of plant tops (Westselaar and Farquhaar, 1980), it may also partly be due to a change in the physiological state of the plant resulting in a shift in the source-sink relations in the distribution of photosynthates (Wareing and Patrick, 1975).

The observation that no significant differences were found among varieties means that the grain yields were the same and therefore, at least within a similar ecological zone, any of the varieties may be used. This observation was however, contrary to those of Giesbrecht (1969) and Lutz et al (1971) who noted that late varieties of maize do better than early varieties when water and nutrients are not limiting.

The changes in the botanical fractions of the crop residue were similar to that observed with Green Panic and Rhodes grass (Fleischer, 1986) which are also in the grass family. The slight varietal differences observed were however, due to the different time lag in the occurrence of physiological changes in the different varieties.

Changes in the crude protein content followed trends similar to published results (Gonske and Keeney, 1969; Fleischer, 1986, 1987). These were mainly due to the fact that with advancing maturity plant fractions with structural roles increase while at the same time soluble components of the protein are transferred to more actively growing points. Unfortunately, the crude protein contents of the crop residues at both the 95th and 125th day harvests were lower than the threshold value of 8.0% indicated by Milford and Minson (1966). Consequently, it can be expected that intake and utilization of the crop residues would be low unless supplemented with a nitrogen-rich source.

Changes in the cell wall constituents also followed a trend similar to other published results (Fleischer, 1986, 1987). The low values of cell wall constituents at day 65 was because the plants had just moved from the vegetative to the reproductive phase. Also beyond that period the bulk of the crop residues was made up of stems, leaf sheaths, cobs and husks all of which either offer structural support and/or protection either to the plant or the grain (Esau, 1965). Thus, they contain mainly structural carbohydrates which give them strength to fulfil their roles.

IVDMD declined with advancing growth period. This is consistent with many published reports (Raymond, 1969) and it is because with increasing maturity the crop residue is largely composed of plant fractions with structural roles and therefore lower digestibility (Hacker and Minson, 1981; Fleischer, 1987).

Even though Ex-Volta was about 1.6% units higher in ADL at the third harvest compared to either Pol.-16 or Composite 4 it had slightly more soluble cell wall constituent than the others. A similar observation has been made by others (McLeod and Minson, 1974; Fleischer, 1987). The non-significant difference in digestibility among varieties is contrary to the observations made by Reed et al, (1986) who, working with twenty-four varieties of sorghum, observed that the high grain-yielding varieties can also give a reasonable amount of crop residues with high nutritive value. In the present experiment, even though Pol.-16 gave the highest grain yield, Composite 4 gave the highest crop residue yield with the highest digestibility.

CONCLUSION

The present work has shown that grain yield of the three varieties of maize increased with increasing growth period. Consequently, harvest index also increased with advancing growth period. On the contrary, significant decline with advancing growth period as well as varietal differences were observed in the crop residue yield. Nevertheless, the ratio of crop residue to grain was 1.1 - 1.8:1.

Except for a few morphological fractions which differed in their contribution to the total crop residues, small but non-significant varietal differences were observed.

Crude protein content decreased with advancing growth period but the varietal differences were not significant. Nevertheless, the crude protein contents were below the critical levels necessary to influence intake. Again, all the cell wall constituents increased with advancing growth period. However, except for the ADL content of Ex-Volta which was significantly higher ($P < 0.05$) than that of Composite 4, no significant varietal differences were observed.

In vitro dry-matter digestibility declined with advancing growth period but there were no significant varietal differences.

Potential utility indices were the same for the three varieties of maize and did not vary with advancing growth period. The values were also higher than those of the harvest indices suggesting that farmers could increase their income if the crop residues was also used as animal feed.

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STUDIES ON THE UTILIZATION OF BREWERS DRY GRAINS AND WHEAT OFFALS BY CALVES

F.I. Ogundola
Institute of Agricultural Research and Training
P.M.B. 5029, Moor Plantation, Ibadan, Nigeria

ABSTRACT

Digestibility, metabolism and rumen studies were conducted to study the growth performance of 24 calves fed concentrates consisting of 20, 40 and 60% levels of both brewers' dry grains (BOG) and wheat offals (WO) to replace maize in a 16-week trial period.

There were no trends established between dry matter, total digestible nutrient and energy intakes and levels of BDG and WO except the digestible crude protein intake which increased 8.6-9.5 g/W kg $^{0.75}$ with increasing levels of BDG & WO in the ration.

The growth rates of 0.26, 0.27, 0.24 and 0.31 kg/day of calves on diets A, B, C and D respectively were positively but not significantly ($P>0.05$) correlated ($r = 0.99$).

The N intake (av. 49.7 g/day) and N retention (av. 52.5%) were high and increased as the level of BDG and WO increased in the ration.

The rumen pH ranged between 6.4 and 6.8 and was not different among the diets. The NH_3-N levels were high in all the diets (av. 14.0 mg/100 ml) showing that N was not limiting and enough to support the growth of the calves. The total VFA showed no particular trend but moderate accumulation and averaged 9.8 m-equiv/litre. However, the acetic acid level (av. 73%) was high enough to furnish energy for the N utilisation. For the individual acids, no definite pattern was established in relation to the supplemental levels of BDG and WO.

The growth made by the calves indicated that both N and energy were not limiting even at 60% substitution level.

INTRODUCTION

In view of the rapidly growing population and declining grain production in Nigeria there is an increased need to utilise agro-industrial by-products and crop wastes to feed livestock. Furthermore, it is becoming increasingly difficult to supply cereal grains to the livestock industry.

Recently a large number of breweries and flour mills have been established in almost all the states of Nigeria from which large quantities of brewers' dried grains (BDG) and wheat offals (WO) become available as sources of energy and protein for livestock feeding. Adebowale (1985) reported that about 100,000 and 320,000 tons of wet brewers' grains and wheat offals were available from the brewery and flour milling industries. Some of the breweries have facilities for drying the grains while others have none. The dried grains are made available free to livestock farmers to avoid environmental pollution while the cost of a tonne of wheat offals is about 25% of the cost of a tonne of maize.

Adebowale and Ademosun (1981) and Ogundola (1987) analysed some samples of the BDG and WO and found that generally they contain about 20% and 15% crude protein as well as 21 KJ/g and 17 KJ/g gross energy respectively. These values are higher than those of maize and guinea corn which are commonly used as energy sources in rations for livestock.

This paper reports on the metabolism and rumen studies using different levels of BDG and WO as maize replacement in rations for young growing calves.

MATERIALS AND METHODS

Twenty-four white Fulani (Zebu) calves aged between 14 and 16 months were selected from the flock of the Institute's Research Farm for the experiment. The average weight of each animal was 81 kg.

Before the digestibility experiment, the animals were kept on concrete floor pens and zero-fed 3 kg of grass (*Cynodon nlemfuensis*) and a daily allowance of 1.5 kg of the test diets (concentrates) A, B, C and D in groups of six, for 16 weeks to evaluate their feed intakes and growth rates. After the trial, 12 calves were selected for the metabolism and rumen studies. All the calves were housed in specially constructed metabolic cages to facilitate separate collection of faeces and urine. The animals were fed at the same rate with three on each test diet. A preliminary period of 14 days was allowed before faeces and urine collection which lasted 7 days was started. Fresh clean water was available *ad lib* in plastic buckets placed at the corner of each metabolic cage.

Faecal collection

Faecal collection was done by means of collection bags fitted with harness and the total weight of faeces voided weighed and recorded. A sample of the faeces voided daily was taken, dried in the oven at 80^{o}C for 24 hours. The daily dried faeces for each animal over the 7- day collection period were bulked. The samples were then milled and stored in airtight bottles until required for analysis. Urine was collected over 5 ml of 10% mercuric chloride solution in a plastic container. The daily volume was measured every morning and 10% aliquot taken for nitrogen and energy determinations. Samples not ready for immediate analysis were kept in a deep freezer at -5^{o}C. The methods for the collection of feed refusals and faeces were as described by Oyenuga (1961).

Fresh faeces, herbage fed and residues meant for proximate analysis were dried at 80^{o}C in a forced-draught electric oven for 3 days and later milled in a Christy-Norris hammer mill fitted with 2 mm sieve. The milled samples were later analysed for their proximate analysis.

Sampling of the rumen liquor

Rumen samples were collected during the last 3 days of the collection period by putting the collection tube through the mouth into the rumen using the method of Alexander (1964) as modified by Mba and Olatunji (1971). The sampling lasted 5 minutes during which about 200 ml of rumen liquor was obtained. The samples were taken one hour before and one hour after feeding. They were then stored in a deep freezer at -5°C until required for analysis.

Analytical procedure

The AOAC (1970) procedures were used for the proximate constituents in feed and faeces, nitrogen in urine and volatile fatty acids (VFAS). Individual fatty acid was determined on the Beckman's Gas-liquid Chromatography model 65. The pH was measured on pH Meter E520 using glass reference electrodes. The gross energy of faeces and feed was determined in a Gallenkamp ballistic bomb calorimeter while gross energy in urine was determined by drying a known volume soaked in a pre-weighed ashless filter paper over P_2O_5 in a desiccator reweighed after drying followed by bombing.

All data were subjected to analysis of variance (Steel and Torrie, 1960). Regression analysis was thereafter used to measure the trend of association (r-value) between BDG and wheat offals level in diet (X) and nutrient (Y).

RESULTS

The brewers' dried grain and wheat offals used in the metabolism and rumen studies had crude protein of 18.3% and 12.1%, 17.4 and 14.8% crude fibre; 4.5 and 4.2% ether extract; 6.4 and 7.1% ash; and 19.4 and 17.9 KJ/g respectively (Table 1).

Generally values for voluntary dry matter (DM), digestible crude protein (DCP), total digestible nutrient (TDN) and energy intakes are high in all the four diets (Table 2). However, there are not significant negative correlation between DM intake (r -0.65), and energy intake (r = -0.088) but significant negative correlation existed between TDN (r = 0.94) and level of supplementation of BDG and WO in the diets. But there is a positive correlation between DCP intake and level of supplementation (r = 0.99). There was no established trend in the intake of nutrients between the four diets. The weight gained by the calves were moderately high (0.24-0.31 kg/day) on all the diets while a non-significant correlation (r = 0.03) was obtained between these gains and level of supplementation of BDG and WO.

Table 1. Composition of experimental diets.

Ingredients (%)*	A	B	C	D
Maize	77.5	57.5	37.5	17.5
Groundnut cake	15.0	15.0	15.0	15.0
Palm kernel meal	5.0	5.0	5.0	5.0
Dry brewers' grain	0.0	10.0	20.0	30.0
Wheat offals	0.0	10.0	20.0	30.0
Chemical composition (%) on DM basis				
Crude protein	13.96	15.03	16.13	17.21
Crude fibre	3.20	5.71	8.21	10.71
Ash	2.40	3.23	4.06	4.89
Nitrogen-free extratives	71.45	64.80	58.20	51.6
Gross energy (MJ/Kg)	15.49	15.97	16.53	17.09

* All diets contain 1% bone meal, 0.5% salt, 1.0% mineral/vitamin mixture. Cynodon nlemfuensis had a chemical composition of 6.4% crude protein, 27% crude fibre, and 17.9 MJ/Kg gross energy. Composition of min/vit mixture as quoted by Ogundola (1984).

Table 2. Intake and growth rate of calves.

Diet	DM intake 0.75 g/^{W}kg	DCP 0.75 g/^{W}kg	TDN 0.75 g/^{W}kg	Energy intake ME/Kg DM	Growth rate kg/day	Cost/kg ration (N)
A	92.8	8.6	81.3	67.8	0.26	1.31
B	90.2	8.9	74.0	60.1	0.27	1.22
C	93.4	9.3	72.8	67.8	0.24	1.14
D	86.5	9.5	69.5	64.4	0.31	1.05
Mean±SE	91.7±2.7	9.1±0.4	74.4±4.3	65.0±3.2	0.27±0.03	1.18±0.1
r-value	0.84^{ns}	0.99^{**}	-0.95^{*}	-0.08^{ns}	0.53^{ns}	-0.99^{***}

ns = not significant.
* = significant at 5%.
*** = significant at 0.1%.
N = unit of local currency.

There was no definite trend in the digestibilities of the various components as the level of BDG and WO increased in the diet (Table 3). However, non-significant negative correlations were obtained between dry-matter, crude protein and crude fibre digestibilities and level of supplementation. Energy digestibility however correlated positively (r = 0.30) but not significantly with levels of BDG and WO in the diet.

Table 3. Mean coefficient of apparent digestibilities.

	(%) of diets			
Diets	DM	CP	CF	Energy
A	68.8	73.4	70.2	76.8
B	66.3	70.7	68.4	73.2
C	69.7	72.0	65.7	74.6
D	61.9	70.9	69.6	78.0
Mean±SE	66.7±3.0	71.8±1.1	68.5±1.7	75.7±1.9
r-value	-0.64[ns]	-0.29[ns]	-0.29[ns]	0.30[ns]

ns = not significant.

At the end of the trial, all the animals were in positive nitrogen balance (Table 4). Intake of N increased with the level of supplementation (43.6-54.7g/day). Also faecal-N and urinary-N excretion increased with the levels of BDG and WO levels in the diet as shown by the (r) values. However, though N retention positively correlated (r =0.85) with level of BDG and WO in the diet, it was not significant (P>0.05).

Table 4. Nitrogen utilisation by calves.

Diets	A	B	C	D	Mean±SE	r value
Nitrogen intake (g/day)	43.6	47.9	52.4	54.7	49.7±4.3	0.99*
Faecal-N(g/day)	9.8	10.4	10.9	11.2	10.6±0.53	0.99*
Urinary-N (g/day)	11.4	13.0	13.3	14.1	13.0±0.98	0.96*
N-retention (g/day)	22.4	24.5	28.2	29.4	26.1±2.8	0.98*
N-retention(% of intake)	51.4	51.1	53.8	53.7	52.5±1.3	0.86[ns]

ns = not significant.
* = significant at 5%.

There were non-significant ($P>0.05$) positive correlations between the various contents and levels of BDG and WO in the diet as shown by their r values (Table 5). Rumen pH varied between 6.4 and 6.8, ruminal-NH3-N 11.7-15.4 mg/100 ml. Total VFA 9.6-10.1 m-equiv/litre, acetic acid 69-76%, propionic Acid 14.8-20% and butyric acid 5.2-12.1% in all the diets. However, only ruminal NH_3-N content exhibited a gradual increase with the level of supplement in the diet.

Table 5. Mean rumen pH, NH_3-N, total and individual VFAs of the calves.

Diets	Rumen pH	Ruminal NH_3-N	Total VFA	Acetic acid (%)	Propionic acid (%)	Butyric acid (%)
A	6.8	11.7	9.9	69.4	19.2	11.4
B	6.5	14.8	9.7	74.8	20.0	5.2
C	6.4	14.2	10.1	76.0	17.2	6.8
D	6.5	15.4	9.6	73.1	14.8	12.1
Mean±SE	6.6 ± 0.15	14.0 ±1.4	9.8 ±0.19	73.0 ±2.5	17.8 ±2.0	8.9 ±2.9
r value	-0.75^{ns}	0.83^{ns}	-0.29^{ns}	0.55^{ns}	-0.89^{ns}	0.14^{ns}

ns = not significant.

DISCUSSION

Consumption of feed by the calves was generally high in the four experimental diets A,B,C and D and even compared with NRC(1966) recommendation for calves of similar weight. This showed that the feeds were well accepted by the calves. However, DM consumption of calves on diet D with 30% each of BDG and WO recorded the lowest value. This appeared to agree with Adebowale's (1985) report that supplementation of BDG above 25% tended to depress DM consumption, and that the BDG should be in wet form because calves generally consumed the wet BDG than the dry one at this level of supplementation.

The high digestibility coefficient obtained for the DM, CP, CF and energy reflected the high CP in the diet which ranged between 14 and 17% and is known to affect particularly the digestibilities of DM and CF. The daily weight gains of the calves (0.24-0.31 kg) on the different diets were high compared to earlier report by this author. The observations of Fehr et al (1976) and Naude and Hofmeyer (1981) that high feed intake and high growth rate positively affect feed utilisation efficiency is adequately supported by the present findings. The growth made by calves on rations B, C and D indicated that both CP and energy were adequate in the diets and the highest rate of (0.31 kg/day) was recorded on ration D.

In all the diets, there was a positive correlation between N intake and N retention. The latter seemed to increase with the level of BDG and WO substitution. All the animals were therefore in positive N balance, indicating that the N contents of BDG and WO were well utilised by the calves.

The results of the rumen studies showed a generally high ruminal NH_3-N (11.7-15.4 mg/100ml) & fairly low acetic acid levels of 69-76%. These high NH_3-N levels would support high microbial growth which in turn will lead to efficient utilisation of N in the diet. These findings agree with the explanation of Mba and Olatunji (1972) that acetic acid depression enhance N retention and reduces absorption of NH_3-N. The relatively low acetic acid level and the high growth rate recorded in this trial agreed with Mba et al (1971) observation.

CONCLUSION

The experiment has shown that both BDG and WO which are abundant in Nigeria could be incorporated in the diet of growing calves up to 60% of the ration without adverse effect on nutrient digestibility and utilisation. However, inclusion of BDG above 30% may have to be in wet form. The greatest hope for the utilisation of these by-products lies in the fact that they need no further processing before they could be used as feed. However, most of the flour mills and breweries are located in the coastline of the country, and government should now force new flour mills and breweries to be established in the hinterland to reduce transportation costs to large livestock population areas. In addition, breweries with no drying facilities should be compelled to install drying plants to make more BDG available for livestock. From experience, the more frequently one calls at the source of any agro-industrial by-product centre, the more likely one is asked to pay some money for whatever quantity one collects even though the owners may have no particular use for such products. Government should enforce price control to keep the price of BDG and WO very low to encourage their use as a livestock feed.

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THE EFFECT OF MAIZE BRAN ON VOLUNTARY INTAKE AND DIGESTIBILITY OF PIGEON PEA (CAJANUS CAJAN) PODS BY GOATS

J.A. Ayoade
Department of Animal Science
University of Malawi
P.O. Box 219
Lilongwe, Malawi

ABSTRACT

Three male Malawi local goats (about 19 kg) were used in a 3 x 3 Latin Square design experiment to investigate the effect of maize bran supplementation on the voluntary intake and digestibility of pigeon pea pods by goats. The treatments were: (a) *ad libitum* pods; (b) treatment a (i.e. *ad libitum* pods) plus 100 g maize bran/goat/day; and (c) treatment a plus 200 g maize bran/goat/day. The voluntary dry-matter intake and digestibility of pigeon pea pods by goats were improved with maize bran supplementation, but not statistically significant (P>0.05). It is concluded that pigeon pea pods supplemented with maize bran could be used as a dry-season ration for goats in the villages when good quality forages are scarce.

INTRODUCTION

A study with sheep (Bell, 1978) suggested that pigeon pea pods as a sole diet are of low nutritive value and that the inclusion of small amounts of high quality pangola grass (*Digitaria decumbens*) considerably improved the nutritive value. Utilization of maize bran to supplement pigeon pea pods would be particularly appropriate for small-scale as well as large farms in Malawi. Large amounts of maize bran are produced in the villages resulting from the use of maize as staple crop. The objective of this study was to investigate the effect of maize bran supplementation on voluntary intake and digestibility of pigeon pea pods by goats.

MATERIALS AND METHODS

Three male Malawi local goats (about 19 kg) were used in a 3 x 3 Latin Square experiment to investigate the effect of maize bran on voluntary intake and digestibility of dried pigeon pea pods by goats. The treatments were (a) *ad libitum* dried pods; (b) treatment a (i.e. *ad libitum* pods) plus 100 g maize bran/goat/day; and (c) treatment a plus 200 g maize bran/goat/day. At the beginning of the experiment, the animals were treated for parasites and were confined in individual metabolism crates throughout the experiment. The experiment was divided into three 14-day periods consisting of a 9-day preliminary period followed by a 5-day collection period. Maize bran was fed at 0800 hours daily and the pigeon pea pods were given three hours later. No mineral supplements were given. Clean drinking water was made available daily. Feeds (offered and refusals) samples were analysed for dry matter, ash and crude protein while faecal samples were analysed for dry matter and ash using the AOAC (1970) procedures. Data were subjected to analysis of variance.

RESULTS AND DISCUSSION

The chemical composition of the pigeon pea pods and maize bran used in the study (Table 1) is similar to that used by Bell (1978). The dry-matter, organic matter and crude protein contents of the maize bran are also within the range reported for maize bran from some Central Malawi villages (Ayoade, unpublished).

Table 1. Proximal chemical composition of pigeon peas and maize bran (as fed basis)

	Dry matter (%)	Crude protein (%)	Ash (%)	Gross energy (MJ/kg)
Pigeon pea pods	91.7	7.0	4.7	14.8
Maize bran	88.9	9.6	2.4	1.9

The voluntary dry-matter intake (DMI) and digestibility of pigeon pea pods by goats are presented in Table 2.

Table 2. Voluntary intake and digestibility of pigeon peas (Cajanus cajan) pods as affected by maize bran supplementation.

	Level of maize bran supplementation (g/goat/day)			
	0	100	200	*SEx
Daily dry-matter intake				
(pods) g	385.7	356.8	329.8	24.0
g/100 kg body weight	2460.3	2179.5	2054.8	147.8
g/ kg $W^{0.75}$	48.8	43.7	40.8	3.0
Daily total dry-matter				
intake g	385.7	445.4	491.7	30.0
g/100 kg body weight	2460.3	2770.5	3075.4	82.8
g/ kg $W^{0.75}$	48.8	55.3	60.9	2.3
Daily free water				
intake (litres)	0.53	0.66	0.50	0.05
Digestibility (%):				
Dry-matter	46.0	51.7	55.0	1.1
Organic matter	49.7	54.9	55.9	2.6

* Significant at P>0.05.

The voluntary DMI of pigeon pea pods by goats was reduced while the total DMI by the goats was increased with maize bran supplementation (Table 2). However, these differences were not statistically significant. All animals lost weight while on pigeon pea pods alone and maintained their body weight or gained weight slightly while on the supplemented treatments. This indicates that pigeon pea pods alone did not meet the maintenance requirements of the goats. Similar observations were obtained by Bell (1978) when pigeon pea pods alone were fed to sheep. The maintenance of body weight and slight body weight gain by goats while on the supplemented treatment indicate the importance of supplementation of pigeon pea pods if maintenance of growth is to be realised in the animals (Bell, 1978).

There were no significant differences among the treatments in the mean daily free water intake of the goats (Table 2). However, there was tendency for a greater free water intake for animals fed pigeon pea pods plus maize bran compared to those fed pigeon pea pods alone.

Supplementation with maize bran improved digestibilities of dry matter and organic matter of pigeon pea pods by goats ($P>0.05$). This agrees with the findings of Bell (1978), Ayoade and Tambala (1984), Devendra (1982) and Mosi and Butterworth (1985) who reported improved digestibility of low quality roughages through concentrate/high quality forage supplementation.

The results of the study indicate improved utilization of pigeon pea pods by goats with maize bran supplementation. When compared with the results of Bell (1978), the goats utilized pigeon pea pods alone better than the sheep. It is concluded that pigeon pea pods supplemented with maize bran could be used as a dry season ration for goats by the small-scale farmers when good quality forages are scarce.

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THE OPTIMUM LEVEL OF ROUGHAGES IN THE DIETS OF SHEEP

A.M. Nour, A.R. Abou Akkada, A.A. Nour and Awad Mabrouka
Department of Animal Production, Faculty of Agriculture
University of Alexandria, Alexandria, Egypt

ABSTRACT

Five groups of male lambs each of nine head Rahmany Barki were used to investigate the effect of different levels of corn stover (10, 30, 50, 70 and 90%) in pelleted diets on the growth performance and feed utilisation by lambs.

The results showed that voluntary feed intake, average daily gain and feed utilisation were significantly decreased by increasing the level of corn stover in the diet from 10 to 90%.

The digestibilities of DM, OM and CP were decreased by increasing the level of corn stover in the diet (with the exception of the diet containing 70% corn stover), however, crude fibre digestibility increased by increasing the level of corn stover.

The results recommended a pelleted diet containing 70% corn stover for growing lambs to achieve a good growth with lower cost of meat production. The cost of feed per one kg gain was 1.25, 1.12, 1.08, 0.91 and 5.88 LE for diets containing 10, 30, 50, 70 and 90% corn stover respectively.

INTRODUCTION

There is a shortage of about 5-6 million tons of TDN which are required to secure better nutritional status of farm animals in Egypt.

On the other hand, the utilisation of the agro-industrial by-products (13-14 million tons DM/annum) can easily fulfil the present shortage in the amount of TDN needed to cover in animal feed requirements.

Corn (Zea mays L.) is grown (about 2 million feedans) in Egypt mainly for grain and it is the general farm practice to leave the ears on the stovers in the field until the grains are almost completely dry. The dry corn stover (about 4.3 million tons/annum), therefore is not suitable for animal feeding and is only used as fuel. It has been shown that corn stover can be successfully ensiled without any significant change in its nutritive value (Soliman et al, 1975 and 1977).

Shehata and Nour (1985) found that pelleting of rice straw with concentrates, molasses, urea and minerals can provide a suitable complete diet for use on large farms in Egypt. The main objective of this work was to study the effect of different levels of corn stover in pelleted diets on the digestibility of nutrients. Feed intake, growth performance and cost of meat production from sheep.

MATERIALS AND METHODS

Corn stover constituted 10, 30, 50, 70 and 90% of complete pelleted diets, the compositions of which are shown in Table 1.

Forty five Barki lambs of about 26 kg each were allotted randomly to five groups each of nine head. Each group was fed on one of the five experimental diets ad lib. plus one kg fresh berseem per head daily/(213 g DM) at 9 a.m.; water was offered. Feed refusals were collected daily and weighed. The experiment lasted for 75 days, and the animals were weighted every two weeks before being fed or watered.

Table 1. Composition % of pelleted diets containing corn stover.

	Diet				
	1	2	3	4	5
	Per cent				
Corn stover	10	30	50	70	90
Urea	-	0.25	0.5	1	1.5
Soyabean by-products	20	20	20	20	-
Wheat bran	30	20	10	-	-
Milling by-products	30	20	10	-	-
Molasses	8	8	8	8	8
Calcium carbonate	1.4	1.4	1.4	1.4	1.4
Salt	0.5	0.5	0.5	0.5	0.5
Mineral mixture	0.1	0.1	0.1	0.1	0.1

Digestibility and N-balance trials were conducted during the last two weeks of the experiment on three animals from each group chosen randomly. Animals were fitted with nylon bags and harnesses for complete collection of faeces, and urine was collected daily in jars containing 5 ml concentrated HCl. Faeces were collected daily, mixed thoroughly, weighed and 10% of each day's collection was used for dry-matter determination. The samples collected over the period (7 days) were combined, ground, and kept for chemical analysis.

The volume of urine was measured daily & a 10% portion of each urine collection was kept for determination of urinary nitrogen.

Analysis of diets, faeces and urine were carried out according to the methods of AOAC (1970).

The cost (LE/ton) of feed ingredients in the experimental diets is shown in Table 2.

Statistical analyses were conducted according to Snedecor and Cochran (1967).

Table 2. Cost (LE/ton) of feed ingredients in the experimental diets.

	Diet				
	1	2	3	4	5
Corn stover	3	9	15	21	27
Urea	-	0.55	1.1	2.2	3.3
Soybean meal	50	50	50	50	-
Wheat bran	36	24	12	-	-
Milling by-products	36	24	12	-	-
Molasses	6.4	6.4	6.4	6.4	6.4
Calcium carbonate	0.56	0.56	0.56	0.56	0.56
Salt	0.25	0.25	0.25	0.25	0.25
Mineral mixture	0.50	0.50	0.50	0.25	0.25
Total cost (LE/ton)	132.70	115.26	97.81	80.66	37.76

1 LE=0.44 US$

RESULTS AND DISCUSSION

Chemical analysis of the corn stover and the 5 diets are shown in Table 3.

Digestibility determinations (Table 4) showed that the digestibilities of dry-matter (DMD), organic matter (OMD), crude protein (CPD) and nitrogen-free extract (NFED) were significant ($P<.05$); however, crude fiber digestibility (CFD) was significantly ($P<0.01$) increased by increasing the level (%) of corn stover in the diet. The digestibility coefficient of corn stover alone was CP, 36%; EE, 59%; CF, 67% increased and NFE, 60% and its nutritive value was: TDN 48.78% and DP, 1.8%, as reported by Badr (1960). Thus corn stover is a low quality feed, principally because of its high percentage of lignocellulose, low percentage of protein and the deficiency of readily available carbohydrates which limit microbial activity in the rumen.

Table 3. Chemical analyses (%) of corn stover and the tested diets.

	Corn stover	Diet no. 1	2	3	4	5
Dry-matter	85.2	91.13	89.34	90.57	91.02	91.02
Organic matter	91.49	88.88	90.08	90.41	90.09	89.33
Crude protein	5.4	11.33	11.18	11.03	11.59	9.27
Crude fiber	33.2	15.45	17.90	18.05	25.87	28.31
Ether extract	1.45	2.84	1.82	1.42	1.28	1.05
Ash	8.51	11.12	9.92	9.59	9.19	10.67
Nitrogen-free extract	51.7	59.26	59.28	59.91	51.35	50.73

The nutritive value of the tested diets (Table 4) was decreased by increasing the level of corn stover.

Dry-matter intake and liveweight changes of the lambs during the 75-day growth period are shown in Table 5. All lambs gained weight during the feeding experiment. Statistical analysis showed that the average total and daily gains were significantly influenced by increasing the level of corn stover in the diet. The body weight gains from diets containing 70 and 90% corn stover were significantly decreased ($P<0.01$). However, the differences between the diets containing 50 and 70% or 30 and 50 or 10 and 30% corn stover attained significance at 5% level (Table 5). The weight gain was very low with the diet containing 90% corn stover (Diet 5), providing nutrients sufficient virtually only for maintenance. The feed utilisation (feed/gain ratio) was greatly improved by increasing concentrates in the pelleted feed from 10 to 30%. These differences were highly significant ($P<0.01$), but that between the diets containing 30 and 50% was not significant.

Chemical analysis % of berseem

DM	OM	CP	CF	EE	NFE
88.04	87.31	17.49	26.92	2.46	40.43

Table 4. Feed intake (g/head/day), digestibility (%) and nutritive value (%) of different pelleted diets.

	Diet				
	1	2	3	4	5
Feed intake g/head/day	1443 ±297	1331 ±107	1326 ± 76	1257 ± 52	1223 ± 26
Digestibility %					
Dry-matter	64.01 ±3.12	60.47 ±3.78	54.49 ±3.02	63.07 ±3.86	50.25 ±5.6
Organic matter	65.22 ±2.98	62.00 ±3.19	55.72 ±5.96	64.65 ±3.58	51.81 ±2.04
Crude protein	55.66 ±1.42	54.94 ±2.58	53.27 ±4.03	55.51 ±2.41	47.83 ±11.8
Crude fiber	53.58 ±10.26	49.36 ±8.22	47.68 ±4.76	63.34 ±3.32	57.64 ±4.43
Ether extract	55.92 ±8.1	59.76 ±1.86	44.79 ±6.65	59.61 ±1.77	54.49 ±4.34
Nitrogen-free extract	72.03 ±0.62	67.00 ±1.6	64.98 ±1.03	63.34 ±3.32	50.69 ±4.41
Nutritive value %					
DCP	6.81 ±0.17	6.72 ±0.33	6.43 ±0.5	6.98 ±0.27	5.1 ±0.87
TDN	60.59 ±0.81	60.43 ±3.98	54.22 ±2.19	54.2 ±1.52	48.32 ±4.29

Table 5. Growth performance of the growing lambs fed on different diets containing corn stover.

	Diet no.				
	1	2	3	4	5
No. of animals	9	9	9	9	9
Initial weight (kg/head)	26.44	26.83	25.89	26.61	27.11
	±6.07	±6.27	±5.13	±5.10	±4.45
Final weight (kg/head)	37.5	36.39	33.56	32.83	27.61
	±7.13	±9.02	±8.73	±6.75	±4.06
Feeding period (days)	75	75	75	75	75
Gain (kg)	11.06	9.56	7.70	6.89	0.5
	±2.22	±3.87	±4.56	±3.47	
Average daily gain (g/head/day)	147 ±30	127 ±50	102 ±60	92 ±46	6.0 ±13
Average feed intake* (g/head/day)	1387	1231	1123	1041	935
Feed gain ratio	9.44	9.69	11.01	11.31	155.83
Cost of one kg gain from feed (LE/kg)	1.25	1.12	1.08	0.91	5.88

*Feed intake from the pelleted diets plus 212 gm dry matter from
berseem in fresh form daily.

It is relevant to note in this context that for the maintenance of adult ruminant, the characteristics desirable in the feed are:-

(1) crude protein level which is above 6-7%.
(2) dry-matter digestibility of about 50-55% and DMI of the order of 1.7% of the body weight.

Preston and Leng (1984) showed the following nutritional factors merit attention in order of priority:-

(1) fermentable energy
(2) fermentable nitrogen
(3) micronutrients (especially S, P and B vitamins)
(4) roughages (for adequate rumen function)
(5) by-pass protein, and
(6) by-pass energy.

To overcome the nutritional constraints of corn stover, supplementation with concentrates (energy, protein minerals etc) and green fodder were tried in order to find suitable combinations that are both acceptable and beneficial to the growth of lambs.

The foregoing data indicate that increasing the level of concentrate from 10 to 30% in the diet was sufficient to provide enough nutrients to increase the weight gain of the animals from just above maintenance (6 g/head/day) when fed on Diet 5 to a moderate level of growth (96 g/head/day) when fed on Diet 4. More increase in the average daily gain was achieved by increasing the level of concentrates. However, the rates of increase in weight gain were lower than that obtained by adding 30% concentrates.

El Shinnawy and Abou Raya (1983) reported that pelleting mixtures including maize stalks seemed to increase the feeding value of the mixture to an extent greater than would be calculated from the individual ingredients. Pelleting mixtures results in a satisfactory intake when directly fed to lambs, and the increased feed density and more efficient packing capacity reduces transporting expenses.

Table 2 shows that the diet containing 90% corn stover was cheap (37.76 LE/ton), and that containing 10% corn stover was the most expensive (132.7 LE/ton). However, the cost of production of 1 kg gain from the tested feeds (Table 5) showed that the most economical mixture was that containing 70% corn stover (0.91 LE/kg).

Thus the present results indicate that the pelleted diet containing 70% corn stover is a suitable diet for feeding growing lambs in Egypt.

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RESPONSE OF THE WEST AFRICAN DWARF SHEEP TO DIETS BASED ON PROCESSED CASSAVA PEELS AND *GLIRICIDIA SEPIUM*

A.A. Adegbola, O.B. Smith and V.O. Asaolu
Department of Animal Science
Obafemi Awolowo University
Ile-Ife, Nigeria

ABSTRACT

Three experimental diets consisting of 100% *Gliricidia sepium*; 80% ensiled cassava peel plus 20% *Gliricidia*, and 80% dried cassava peel plus 20% *Gliricidia* were fed to 12 West African Dwarf (WAD) sheep on an *ad libitum* basis for 12 weeks.

Animals fed on *Gliricidia* alone consumed 1044 g DM per day to produce 106 g weight gain per day over the 12 weeks, while those fed on the ensiled cassava peels with *Gliricidia* consumed 716 g DM per day to achieve a weight gain of 81 g/day. Animals fed on the dried cassava peel based diet performed poorest consuming 642 g DM per day and gaining 59 g/day.

The higher dry-matter intake and better growth rate of the animals fed on the ensiled cassava peel based diet over those of animals on dried cassava peel-based diet were attributed to lower prussic acid content as well as the sweet and pleasant odour of the ensiled cassava peels.

INTRODUCTION

In towns and villages where sheep and goats are kept in the backyard production system, it is usual to give them whole cassava chips in the mornings or evenings. These animals obtain their protein supplements from browsing and scavenging around the village. One of such browses available to sheep is *Gliricidia sepium*. This plant is mostly used as stakes in yam production or in the construction of sheds which provide shade during the dry season. The rapidly growing stems are occasionally cut and laid on the ground for sheep and goats.

As pointed out in an earlier report (Adegbola and Asaolu, 1986), cassava peel is rapidly becoming an important by-product for small ruminant feed. It is available from the local processing of cassava root for "gari", a local fermented meal product. It has also been observed that villages with substantial numbers of small ruminants have experienced a boom in sheep production especially where adequate browse is available. Cassava peel is higher in crude protein than the cassava root meal (Oyenuga, 1968).

Recently, a number of studies evaluating cassava peels in comparison to maize-based diets have been reported in the literature for poultry (Adeyanju and Pido, 1978), sheep (Adebowale, 1981) and pigs (Obioha and Anikwe, 1982). However, in none of these studies was cassava peel used as the main energy source. The main objective here therefore was to study the response of sheep to the use of cassava peel as the main energy source using *Gliricidia sepium* as a supplement.

MATERIALS AND METHODS

In a 12-week feeding trial, twelve 5 to 7-month old animals, consisting of six rams and six ewes, were randomly allotted to three treatments of four replicates each. The animals were dewormed and sprayed against ectoparasites before being allotted to the treatments. The first diet was 100% *Gliricidia* (leaves with dark and soft stems); the second diet was 80% ensiled cassava peels plus 20% *Gliricidia*; while the third diet was 80% dried cassava peels plus 20% *Gliricidia*. Water and mineral-salt licks were always provided for the animals. The animals were adapted for 14 days to the experimental diets prior to the commencement of the trial.

The cassava peels were obtained periodically from gari processing plants in Oyo, and were derived from a bitter variety of *Manihot esculenta* Crantz.

Fresh cassava peels were air-dried for 0, 2, and 4 days before ensiling. It was shown that the most desirable odour and the lowest pH was produced from peels dried for two days before ensiling for 14 days (Table 1). This method was adopted for the production of the silage used in the feeding experiment.

Subsequently, the peels were air-dried to about 60% moisture content (Table 1) and ensiled in 200-litre drums which had earlier been perforated at the bottom to permit adequate drainage. The internal sides of the drums were lined with black polythene sheets before filling with the wilted peels. The peels were then compacted, covered with black polythene sheets and weighted down with heavy stones. The silages were opened at the end of 12 weeks.

Table 1. Optimum level of moisture in cassava peel to be ensiled based on odour and pH.

Diets	Odour[a] (Score given)	pH
1. 33.53% DM (fresh peel)	18	4.66
2. 60.28% DM (cassava peel after 2 days air-drying)	27	3.90
3. 85.47% DM (cassava peel after 4 days air-drying)	16	5.79

Key (a) <u>ODOUR (30 points)</u>	<u>Possible score</u>
1. DESIRABLE: Clean, pleasant with no indication of putrefaction	26-30
2. ACCEPTABLE: Somewhat strong, yeasty, fruity or musty, slight burnt odour, sweet	16-25
3. UNDESIRABLE: Strong burnt or caramelised odour indicating excessive heating. Sliminess and a putrid odour indicate improper fermentation. Very musty or mouldy odour with excessive mould visible	5-15

Dried cassava peels were obtained after sun-drying fresh peels for between 6-10 days depending on weather conditions, without any problem of deterioration from fungal infection (Table 2). The content of hydrocyanic acid (HCN) in the fresh peels, as well as dried and ensiled peels were determined using the method of Grace (1977).

Gliricidia sepium was harvested daily from the University Teaching and Research Farm.

Feed samples were collected for analysis at the start, middle and end of the experiment, stored at $-5^{o}C$, and pooled for analysis.
All data were statistically tested using the Analysis of Variance Method (Steel and Torrie, 1960), and significant differences were subjected to Duncan's new Multiple Range Test.

RESULTS

Animals fed on *Gliricidia* alone consumed an average of 1044 g DM per day while those fed on the ensiled cassava peel plus *Gliricidia* consumed 713 g DM per day and those fed on the dried cassava peel plus *Gliricidia* consumed 642 g DM per day (Table 3).

Table 2. Effect of sun-drying on the proximate composition of cassava peels.

Proximate contents (%DM)	Drying period (days) 0	2	4	6	8	10	12	14	Standard deviation
Dry-matter	33.53	60.28	85.47	84.73	85.18	87.34	86.59	87.0	±4.37
Crude fibre	20.50	21.65	22.00	21.90	21.65	21.80	22.0	21.50	±0.68
Ether extract	1.63	1.25	1.15	0.98	0.99	0.99	0.88	0.90	±0.48
Ash	3.50	4.32	4.38	3.95	3.50	4.0	3.50	4.18	±0.59
Crude protein	2.80	2.10	2.67	2.59	2.18	2.43	2.75	2.34	±0.49
Nitrogen-free extractive	71.57	70.68	69.45	70.58	71.68	70.78	70.87	71.08	±0.80
Energy (kcal/g)	4.76	4.67	4.67	4.65	4.67	4.68	4.66	4.67	±0.18

Table 3. Dry-matter intake an rate of gain of sheep after 12 weeks.

Diet	Average rate of gain (gm/animal/day)	Average dry-matter intake (gm/animal/day)
Gliricidia	106.41[a](3.87)	1044.24[d](28.70)
80% dried cassava peel + 20% _Gliricidia_	59.20[b](5.78)	642.14[e](47.07)
80% ensiled cassava peel + 20% _Gliricidia_	80.89[c](4.03)	713.97[f](47.75)

Different low case superscripts in the same column, indicate significant differences ($P < 0.05$).

The daily rate of gain was 106 g/day for animals fed on _Gliricidia_ alone while those on the _Gliricidia_ fodder plus ensiled cassava peel gained 81 g/day, about 37% more than their counterparts fed on the dried cassava peels with _Gliricidia_ which gained 59 g/day.

It was also observed that animals fed on the dried cassava peel plus _Gliricidia_ diet consumed the diet in the proportion of 64:36, and not in the ratio of 80:20 offered. On the other hand, animals fed on the ensiled cassava peel plus _Gliricidia_ consumed the diet in the proportion of 73:27, which is close to the ratio in which the feed was offered.

DISCUSSION

The observed higher intake recorded for animals on the ensiled cassava peel diet may be due to a lower content of prussic acid in the ensiled cassava peel compared with the dried peel. Analysis showed that while the fresh peel contained 956 mg

HCN/kg DM, the dried peel contained 378 mg HCN/kg DM. The ensiled peel contained only 162 mg HCN/kg DM (Table 4). Thus, while drying reduced the HCN content of cassava peel by 60%, ensiling reduced it by 83%. The observed higher intake may also be due to the sweet and pleasant acid (lactic acid) smell of the cassava peel silage. Morrison (1959) had pointed out that silages, even from plants with coarse stalks such as corn and the sorghums, are eaten practically without waste. On the other hand, a considerable part of the dry corn or sorghum fodder is usually wasted, even if it is of good quality.

Table 4. HCN content of fresh cassava peels, dried cassava peels and ensiled cassava peels.

Cassava peels	HCN content (mg HCN/kg DM)
1. Fresh	956
2. Ensiled	162
3. Dried	378

The high level of intake of Gliricidia sepium as well as its high nutritive value (Carew, 1982; Mba et al, 1982) were responsible for the faster growth rates of the animals fed on Gliricidia alone.

The growth rates recorded for animals on the cassava peel-based diets were significantly lower ($P < 0.05$) than those for animals on Gliricidia.

CONCLUSION

From the results so far obtained, it is suggested that ensiled cassava peel supplemented with Gliricidia sepium can be fed in a production diet to West African Dwarf sheep with no adverse effects on animal performance.

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UTILIZATION OF *GLIRICIDIA SEPIUM* AND CASSAVA PEELS BY WEST AFRICAN DWARF (WAD) GOATS IN NIGERIA

O. J. Ifut
Department of Animal Science
University of Ibadan
Ibadan, Nigeria

ABSTRACT

Three diets - 100% *Gliricidia sepium* (T-1), 100% cassava peels (T-2) and 70% *Gliricidia sepium* plus 30% cassava peels (T-3) - were fed to 12 intact bucks of the West African Dwarf (WAD) breed in a completely randomised experiment. Four bucks were randomly assigned to each diet treatment. The experiment lasted 90 days.

Treatment effect on dry-matter intake (DMI) was significant ($P<0.05$). Goats on T-3 consumed the highest dry matter (DM), organic matter (OM), nitrogen (N), acid-detergent fibre (ADF) and neutral-detergent fibre (NDF), digestible DM (DDM), digestible OM (DOM), digestible ADF (DADF) and digestible NDF (DNDF) while those on T-2 consumed the least. Goats on T-1 had the highest digestible N intake (DNI).

Goats on T-3 digested DM, N, ADF and NDF most ($P<0.05$); those on T-2 digested OM most; they also had negative N digestibility and digested ADF and NDF least ($P<0.05$). Goats on T-1 digested DM and OM least ($P<0.05$).

The highest ($P<0.05$) body weight gain was by goats on T-3 while those on T-2 were losing weight daily.

Gliricidia sepium was the most and cassava peels the least ($P<0.05$) efficiently utilized as sole diets by goats.

Estimated meat yield per treatment was highest for animals on T-3.

The intake, digestibility and utilization for weight gain of *Gliricidia sepium* by goats were increased by supplementation with cassava peels.

INTRODUCTION

Goats are one of the few important trypanotolerant livestock species in the humid zone of Nigeria. Many households in the humid parts of Nigeria keep an average of 4 to 5 goats while larger numbers are kept in the savanna parts of the country. The estimated goat population in Nigeria is 26.0 million (FAO, 1985).

One major constraint to goat production in Nigeria is the low level of available nutrients. The extent to which feed is available is a limitation to livestock production industry in Nigeria (Adegbola, 1982; Olubajo and Oyenuga, 1974).

Gliricidia sepium is a fast-growing, perennial, leguminous browse plant whose other desirable characteristics have been documented by Thomas (1961), Chadhokar (1982), Falvey (1982) and Sumberg (1984). Its utilization as livestock feed started receiving attention in Nigeria only fairly recently, for example by the International Livestock Centre for Africa (ILCA, 1983), Ademosun et al (1985), Mba et al (1982) and Onwuka (1983). It has 17.4 - 34.5% DM on 'as fed' on fresh basis; other contents on DM basis are OM (81.9 - 92.3%), crude protein (CP) (19.4 - 26.1%), NDF (30.8%), ADF (18.5 - 44.4%), crude fibre (CF) (12.7 - 32.5%) and lignin (7.3 - 29.6%) as reported by King (1986), Ngone (1985), Mani (1984), Onwuka (1983), Chadhokar and Sivasupiramaniam (1983), Carew (1983), Gbankoto (1982) and Oakes and Skov (1962).

Cassava peels are a major by-product of the cassava tuber processing industry. In parts of Nigeria where cassava is grown and the tubers processed, the peels are largely un - or under-exploited as livestock feed. Cassava peels have been reported to have the following composition: residual DM, 86.5 to 94.5%; OM, 89.0 to 93.9%; CP, 4.2 to 6.5%; and CF 10.0 to

31.8% (Onwuka, 1983; Carew, 1982; Adegbola, 1980; and Oyenuga, 1968).

The average intake of Gliricidia by goats has been reported as 21.3 (range = 10.8 to 31.8) $g.kg^{-0.75}.d^{-1}$ DM (Ademosun et al, 1985; Onwuka, 1983; Carew, 1983). Mba et al (1982) reported intake values ranging from 31.4 to 50.2% for kids on Gliricidia while Onwuka (1983) reported gains of 20 $g.d^{-1}$ for goats on sole Gliricidia diet.

Information on intake and utilization of cassava peels and Gliricidia fed together to goats is rather scanty. The perennial and multipurpose nature of Gliricidia and underutilization of cassava peels as goat feed, formed the basis of the present study. The research was, therefore, undertaken to investigate the influence on intake, digestibility and utilization of cassava peels with Gliricidia sepium fed to WAD goats.

MATERIALS AND METHODS

Animals and their management

Twelve intact bucks, aged 6 to 9 months and weighing an average of 6.05 kg (range = 5.0 to 10.0 kg), from the University of Ibadan Teaching and Research Farm, were first rid of their internal and external parasites using appropriate drugs. They were then housed in previously disinfected individual metabolism cages. They were offered liberal but known quantities of the experimental diets daily for a 21-day preliminary period to adapt the animals to the diets and the cage environment.

Cool fresh water and salt lick were offered free choice in the cages. During this period, the daily voluntary feed intake was determined. Total faeces and urine from the experimental animals were collected during the next 7 days (day 22-28) and the last 7 days (day 84 - 90). Confinement and feeding continued to day 90. Animals on diet T-2 were removed from the experiment after day 28 in order to save the animals from imminent death due to excessive loss of body weight. The animals were weighed once a week (on the same day of every week at about the same time of day) in the morning before feeding and watering so as to minimise error due to "gut fill".

Feeds

Fresh Gliricidia sepium branches (about 1.2 m long and 1.5 cm thick) with leaves and branchlets were obtained daily from ILCA, Ibadan, between April and July, 1985. Cassava peels were obtained fresh from local cassava grating plants in and around the University of Ibadan campus. The cassava peels were sun-dried for 3 to 4 days, depending on the intensity of the sun, packed into jute bags and stacked away in the store on some raised wooden planks until required for feeding.

Diets

The diets fed to the goats were 100% Gliricidia sepium (T-1), 100% sun-dried cassava peels (T-2) and 70% (w/w) fresh Gliricidia sepium plus 30% cassava peels (T-3). The amount of each diet offered to each experimental animal ensured a 5% leftover. Residues were collected after a 24 h feeding, weighed and the voluntary intake determined.

Sampling of the feeding stuff

Samples of G. sepium and cassava peels offered and rejected during the collection period were taken daily dried and stored in bottles fitted with air-tight screw caps and kept in a dark cupboard until required for analysis.

Faecal collection

Total faeces were collected in the mornings before feeding and watering during day 22-28 and the last 7 days of the experiment. The two 7-day faecal samples for each experimental animal were thoroughly mixed, milled in a laboratory hammer mill to pass a 0.6 mm sieve and put in sealed polythene bags. These were then stored in a cupboard at room temperature until required for analysis. 5 g of the milled faeces were dried in an oven at 100-105^{o}C for 48 h to determine residual moisture.

Urine collection

Total urine excreted by each experimental animal was collected daily in the morning before feeding and watering and stored in a deep freezer at -5^{o}C. At the end of the 7-day collection period the sample collections were bulked for each animal and subsamples taken for analysis.

Analytical procedure

Chemical

The milled samples of Gliricidia, cassava peels and faeces were analysed for DM, OM and N according to A.O.A.C. (1975) procedures and ADF and NDF according to the methods of Goering and Van Soest (1970) and Van Soest and Robertson (1980).

RESULTS AND DISCUSSION

The chemical composition of the experimental diets is shown in Table 1. The chemical components of Gliricidia and cassava peels of this study compared favourably with values reported in literature (Adegbola, 1980; Oyenuga, 1968, Onwuka, 1983; Carew, 1983; Chadhokar et al, 1983).

Intake

The DM and nutrients intake by WAD goats is summarised in Table 2. The highest DM and nutrient intakes were from T-3 diet probably because the combination was palatable. The lowest DM intake (DMI) from the peels (T-2) could possibly not be due to the ADF and NDF content because these were lowest for the peels. An inverse relationship has long been reported between the DMI and the fibre content of feeds (Reid and Klopfenstein, 1983; Leaver, 1974). The lignin content of the peels could also apparently not be responsible for the least DMI from T-2 because lignin content was highest in Gliricidia and 1.6 times that of the peels (Table 1). The least DMI from T-2 was probably due to the lowest N content of the peels. This is supported by Rajpoot et al (1981), Malechek and Provenza (1981) and Preston and Leng (1986) who had earlier reported that the low N content of feeds significantly ($P<0.05$) reduced the DMI of such feeds. The present study, however, seemed to indicate that the relationship between dietary N content of feed and the feed DMI per metabolic size was rather weak ($r=0.03$, $P>0.05$). Nonetheless, the positive though weak relationship between N (or CP) and DMI of diet was similar to the much higher $r=0.86$ ($P<0.01$) reported by Lippke (1980).

Table 1. Chemical composition of Gliricidia sepium and cassava peels diets fed to West African Dwarf goats.

Chemical component	Diets T-1	T-2	T-3
DM			
'As fed' SD	31.04 ± 0.58	86.41 ± 0.17	47.65 ± 0.46
Residual SD	87.27 ± 0.58	87.28 ± 0.17	87.27 ± 0.46
On DM basis SD			
OM SD	91.25 ± 1.29	89.25 ± 1.84	90.66 ± 1.46
ADF SD	28.27 ± 3.65	23.85 ± 3.52	26.95 ± 2.98
NDF SD	41.45 ± 3.43	34.27 ± 4.33	39.30 ± 3.70
N SD	3.76 ± 0.05	0.96 ± 0.38	2.92 ± 0.15
Lignin SD	13.64 ± 6.55	8.39 ± 4.15	12.07 ± 5.85

When dietary N content was correlated with the absolute DMI of the animals, the relationship was highly significant and negative ($r= -0.43$, $P< 0.01$). This seems to make some (biological) sense in terms of nutrient density of the diet because it suggests that an animal offered a low-N diet would tend to consume more of the diet in order to derive more of the needed N from the feed. However, this argument was not supported in the present study because the lowest DMI (Table 2) was recorded for goats on the lowest N-containing diet (T-2). Neither was the linear relationship between N and DMI per metabolic size of goats impressive nor significant ($P>0.05$).

Table 2. Dry-matter and nutrients intake ($g.kg^{-0.75}.d^{-1}$)* by West African-Dwarf goats fed *Gliricidia sepium* and cassava peels.

Intake of nutrient	Treatment 1	2	3
Dry-matter intake	46.30b	41.45b	76.01a
Organic-matter intake	42.95b	37.69b	67.50a
Nitrogen intake	1.80a	0.43b	1.48a
Acid detergent fibre intake	18.69a	8.30b	20.45a
Neutral detergent fibre intake	27.69b	10.94c	36.89a

* Means with the same letter in each row are not significantly different (P>0.05).

The significance of the relationship between dietary N and DMI might be through the indirect involvement of dietary N with DM digestibility (DMD). Low N in feeds affects nutrient balance which itself affects digestibility and, therefore, intake. Thus, the less the N content of a feed, the lower the level of its consumption, the poorer the balance of nutrients, the slower the rate of its digestion, and the longer it remains in the gastro-intestinal tract. Preston and Leng (1986) suggested a probable complication of N in rumen ammonia production level and microbial growth and activity.

The present result, therefore, suggests that it is unreasonable to feed sun-dried cassava peels as sole diet to domestic animals, especially goats.

Digestibilities

The apparent digestibility coefficient (ADC) for DM and other nutrients are presented in Table 3. The DMD of T-2 and T-3 was similar (P>0.05) but significantly different (P<0.05) from that of T-1. The rather low (54.2%) DMD and OMD (56.8%) recorded for goats on T-1 was close to 57.1% DMD reported by Onwuka (1983) who fed only dried leaves of Gliricidia to WAD goats. This could have been due to its highest lignin content (Table 1). This is supported by McDonald et al (1973) and Nastis and Malechek (1981) who concluded that lignin generally lowered feed DMD. The highest DM and OM digestibilities of T-2 were probably due to its lowest intake since digestibility and intake are inversely related (Van Soest, 1982; Wagner and Loosli, 1967).

Diets had significant influence (P<0.05) on N-digestibility. The N in T-3 was digested most. This suggested that the fermentable OM in the peels apparently encouraged higher N digestibility (McDonald et al, 1973).

Nitrogen digestibility of T-2 was negative due, probably, to the low N content (Table 1) of the peels. This is because ADC of dietary N is, to a large extent, dependent upon the proportion of N in the feed. Consequently, T-2 actually reduced the digestible N supply of the goats (McDonald et al, 1973). Also the level of N ADC could have been due to the level of feed intake (Owens and Berger, 1983).

The ADF of T-1 and T-3 was digested by goats to about the same extent (Table 3). The NDF digestibility by goats on T-1, T-2 and T-3 was, however, significantly different (P<0.05). The high NDF ADC by animals on T-3 tended to suggest that NDF was digested better when both Gliricidia and cassava peels were fed simultaneously in the ratio of 7:3.

Table 3. Dry-matter and nutrients digestibility coefficients (%)* by West African Dwarf goats fed Gliricidia sepium and cassava peels.

Nutrient	Digestibilty coefficient (%)		
	T-1	T-2	T-3
Dry-matter digestibility	54.21b	71.95a	74.34a
Organic matter digestibility	56.78b	77.35a	76.57a
Nitrogen digestibility	56.50a	-6.40b	57.30a
Acid-detergent fibre digestibility	42.89a	33.38b	46.15a
Neutral-detergent fibre digestibility	48.22b	36.61c	67.67a

* Means with the same letter in each row are not significantly different (P>0.05).

The digestible DM intake (DDMI) and intake of other digestible nutrients by goats is summarised in Table 4. The DDMI was significantly different (P<0.05) for all dietary treatments. The highest DDMI value of 56.4g. $kg^{-0.75}.d^{-1}$ was recorded for goats on T-3. The superiority of T-3 over T-1 and T-2 was observed in the amount of DOM and DM consumed from the diets. This suggested that supplementation of Gliricidia with cassava peels was beneficial to goats. It is, therefore, suggested that Gliricidia and cassava peels, when they must be fed to goats, be offered in suitable proportions to ensure maximum utilization of the feeding stuffs.

Table 4. Digestible dry-matter and nutrient intake ($g.kg^{-075}.d^{-1}$)* by West African Dwarf goats fed <u>Gliricidia</u> <u>sepium</u> and cassava peels.

Component intake	Treatment 1	2	3
Digestible dry-matter intake	25.38b	31.08b	56.44a
Digestible organic matter intake	24.84b	29.17b	51.66a
Digestible nitrogen intake	1.03a	-0.03b	0.85a
Digestible acid-detergent fibre intake	8.15a	2.68b	9.44a
Digestible neutral detergent fibre intake	13.80a	4.22b	24.93a

* Means with the same letter in each row are not significantly different (P>0.05).

Nitrogen utilization and body weight changes as well as efficiency of feed utilization and estimated meat yield by goats on the experimental diets are shown in (Tables 5 and 6) respectively. N-balance among goats on T-1 and T-3 was similar (P>0.05); that of T-2 was negative ($-0.04\ g.kg^{-0.75}.d^{-1}$) probably due to the low N content (Table 1) of T-2 and the negative DNI (Table 4) from T-2. Consequently, the goats on T-2 were losing an average of 54.8 g daily and the trial had to be suspended after the initial collection period. It is, therefore, unreasonable and uneconomical to feed sole cassava peels diets to goats. Goats on T-3 were superior to those on T-1 (54.2 versus 50.0 $g.d^{-1}$) in average daily weight gain. This could probably have been due to a better balance of nutrients resulting from the feeding of <u>Gliricidia</u> and cassava peels simultaneously in the ratio of 7:3.

Table 5. Nitrogen utilization ($g.kg^{-0.75}.d^{-1}$)* and body weight changes ($g.d^{-1}$) in West African Dwarf goats fed *Gliricidia sepium* and cassava peels.

	Treatment		
	Gliricidia	100%	70/30
Nitrogen intake	1.80a	0.43b	1.48a
Faecal N Loss	0.77a	0.45b	0.63a
Absorbed nitrogen	1.03a	-0.03b	0.85a
Urinary N loss	0.26a	0.02b	0.07b
Nitrogen balance	0.77a	-0.04b	0.78a
Body weight change	50.0b	-54.77c	54.16a

* Means with the same letter in each row are not significantly different (P>0.05).

In Nigeria the average annual yield of cassava tubers is 21.1 $t.ha^{-1}$ (Hahn and Chukwuma, 1986). Since the peels constitute 20.0% of the tuber (Hahn et al, 1986), this means that about 4.22 tonnes of cassava peels per hectare are available annually for feeding ruminants, especially goats. The inclusion of 30% or less (depending on availability) of such peels would support weight gains as shown in Table 6 among goats. For example, a 6-month-old goat weighing 6.1 kg initially, when fed a T-3 diet containing 70% *Gliricidia* and 30% cassava peels and gaining an average of 54.2 $g.d^{-1}$ for one-year would weigh 25.9 kg at the end of the period, thus gaining 19.8 kg. This 25.9 kg goat, one and half years old, would have, at 51% dressing percentage (Akinsoyinu, 1974), a carcass weight of 13.2 kg which is equivalent to the edible goat meat for the one-year growth period.

Table 6. Efficiency of feed utilization* and estimated goat meat yield ($kg.yr^{-1}$)* among West African Dwarf goats fed <u>Gliricidia sepium</u> and cassava peels.

Treatment	1	2	3
Dry-matter intake ($g.kg^{-0.75}.d^{-1}$)	46.30	41.45	76.01
Body weight change ($g.d^{-1}$)	50.99	-54.77	54.16
Feed efficiency	0.91b	-0.76c	1.40a
Weight gain ($kg.yr^{-1}$)	18.6	-20.0	19.8
Estimated meat yield ($kg.yr^{-1}$)	9.5a	-10.2b	10.1a

* Means with the same letter in any row are not significantly different (P>0.05).

Earlier workers have indicated inclusion of cassava peels to varying degrees in livestock feeds. Adegbola (1980) concluded that 10% cassava peels meal inclusion in pig ration induced fastest rate of gain and highest feed conversion efficiency. Onwuka (1983), on the other hand, concluded that 25% cassava peels:75% browse was the best proportion for goats in terms of intake, digestibility and other performance parameters. In the present study, a 30% level of cassava peels has been shown to be beneficial to goats. These studies suggest that the actual amount of cassava peels suitable for inclusion in goat feeds is a subject for further research. Ensiling of cassava peels as a means of preservation and the nutritional value of the product should be given research attention.

Further research work is needed to relate annual yields of <u>Gliricidia</u> and cassava peels fed as sole or combined diets to the production of goat meat from such diets in Nigeria.

CONCLUSION

Gliricidia was richer in and, therefore, a better source of dietary N than cassava peels when the two feedingstuffs were fed either as sole or combined diets to goats.

Sun-dried cassava peels were easier to pack and kept longer in storage.

Feeding _Gliricidia_ and cassava peels in a 7:3 ratio encouraged maximum intake, digestibility, utilization and highest body weight gain.

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EVALUATION OF CASSAVA FLOUR AND GROUNDNUT CAKE AS CONCENTRATE SUPPLEMENTS FOR WEST AFRICAN DWARF GOATS

R.M. Njwe[1] and F.O. Olubajo[2]
[1]Dept. of Animal Science, Dschang University Centre
B.P. 96, Dschang, Cameroon
[2]Dept. of Animal Science, University of Ibadan
Ibadan, Nigeria

ABSTRACT

Forty-eight West African Dwarf goats ranging from 9 to 12 months and weighing between 9 and 15 kg were fed fresh Guatemala grass and various combinations of graded levels of cassava flour (0, 100, 150 and 200 g/day) and groundnut cake (0, 50, 100, and 150 g/day) as concentrate supplements in a split-plot design.

Incorporating increasing combined levels of both supplements in goat rations increased dry-matter, crude protein and cell contents intake; and decreased intake of cell walls, acid detergent fibre and cellulose. While it positively affected the digestibility of dry matter, crude protein and cell contents, the effect on cell walls, acid detergent fibre and cellulose digestibilities was negative.

Each increment in the level of groundnut cake and cassava flour in goat rations resulted in an increase in liveweight gain. Maximum liveweight gain was obtained with animals fed either a combination of 200 g of cassava flour with 100 g of groundnut cake (52 g/day) or 200 g of cassava flour with 150 g of groundnut cake (62 g/day) as supplement to fresh Guatemala grass.

Goats receiving 0 to 50 g concentrate supplement lost weight consistently as a result of inadequate energy and protein intakes.

INTRODUCTION

Nutrition is one of the major factors responsible for the low productivity of small ruminants in Cameroon. Generally, undernutrition is more acute in the dry season than the wet season. Many agricultural and agro-industrial by-products are available but are not fully exploited for the feeding of livestock. Among these products are cassava flour and groundnut cake. For profitable use of these products as concentrate supplements for livestock, optimum levels have to be determined through feeding trials. The objective of this experiment was to determine the optimum combination of groundnut cake and cassava as concentrate supplements to adult West African Dwarf goats.

MATERIALS AND METHODS

Forty-eight West African Dwarf goats ranging from 9 to 12 months and weighing between 9 and 15 kg were used for this experiment. They were previously maintained on Guatemala grass and limited quantities of concentrate at the University farm at Nkolbisson. Deworming and tick control was carried out before the experiment began.

The animals were divided into 16 groups, represented a treatment in a split-plot design consisting of four main plots (cassava flour levels) and 4 subplots (groundnut cake levels).

Fresh Guatemala grass (*Tripsacum laxum*) was fed in different combinations with cassava flour (0, 100, 150 and 200 g per animal per day) and groundnut cake (0, 50, 100 and 150 g per animal per day). Each concentrate supplement contained bicalcium phosphate at a rate of 1%. The chemical composition of the experimental diets is shown in Table 1.

Table 1. Chemical composition of Guatemala grass and the experimental diets.

	% DM	% CP	% CW	% CC	% ADF	% AD lignin	% Cellulose	% Total ash	Energy (Kcal/g)
F1	92.48	8.80	63.54	36.46	47.30	8.35	39.49	5.87	4.63
Groundnut cake	86.76	50.41	17.56	82.44	4.76	0.90	3.86	7.16	4.96
F2	90.18	11.17	70.63	29.37	38.55	6.88	31.67	5.69	4.54
E1 P0	87.14	1.66	12.69	87.31	3.55	0.79	2.76	2.25	4.63
E1 P1	87.64	16.33	14.34	85.66	3.97	0.79	3.18	5.16	4.74
E1 P2	88.12	25.96	15.03	84.97	4.19	0.83	3.36	5.69	4.70
E1 P3	88.75	29.56	15.41	84.59	4.25	0.81	3.44	5.94	4.65
F3	91.36	8.09	68.83	31.17	43.76	9.58	34.18	6.36	4.63
E2 P0	86.44	1.68	12.64	87.36	4.66	0.79	3.87	2.26	4.33
E2 P1	87.73	14.30	13.94	86.06	3.88	0.82	3.06	4.94	4.70
E2 P2	88.13	20.96	14.62	85.38	4.03	0.80	3.23	5.29	4.52
E2 P3	88.26	26.01	15.16	84.84	4.15	0.90	3.35	5.67	4.76

Cont'd

Table 1. Chemical composition of Guatemala grass and the experimental diets.

	% DM	% CP	% CW	% CC	% ADF	% AD lignin	% Cellulose	% Total ash	Energy (Kcal/g)
F4	92.44	10.41	67.77	32.23	45.28	6.70	38.58	6.08	4.66
E3 P0	86.13	1.54	12.66	87.34	3.53	0.78	2.75	2.17	4.96
E3 P1	86.31	15.27	13.69	86.31	3.83	0.85	2.98	5.25	4.54
E3 P2	86.88	16.11	14.29	85.71	3.96	0.80	3.16	5.47	4.66
E3 P3	87.52	21.13	14.82	85.18	4.04	0.80	3.25	5.39	4.44

F1, F2, F3 and F4 represent Guatemala grass fed at various periods of the experiment.

E1, E2 and E3 represent the 100, 150 and 200 g/head/day of cassava flour.

P0, P1, P2 and P3 represent the 0, 50, 100 and 150 g/head/day of groundnut cake.

DM = dry matter

CP = crude protein

CW = cell walls

CC = cell contents

ADF = acid-detergent fibre

AD lignin = acid-detergent lignin.

Animals were maintained in individual metabolic cages during the entire experimental period of 42 days. Due to the availability of only 12 metabolic cages, 4 treatments were run at a time until the 16 treatments were completed. The daily portion of concentrate was given in individual troughs at 08.00 hours while chopped fresh Guatemala grass was also offered in a grass trough at 09.00 and 16.00 hours. Fresh drinking water and salt licks were provided ad libitum in all the cages. The animals were weighed at weekly intervals during the experimental period. During the last 7 days of the experimental period faeces and urine were collected.

Dry-matter, ash and crude protein content of forage, concentrates and faeces were analysed according to A.O.A.C. (1970) methods; while cell contents, cell walls, acid-detergent fibre, acid- detergent lignin and cellulose were analysed as described by Goering and Van soest (1970). Urinary nitrogen was determined by the macro-Kjeldahl and Markam micro-distillation method. Gross energy of feeds, faeces and urine was determined with the Gallenkamp ballistic oxygen bomb calorimeter. Methane energy production was estimated according to the equation of Blaxter and Clapperton (1965) while metabolic faecal nitrogen was analysed by the detergent method proposed by Mason (1969). Statistical analysis of data was carried out according to the procedures of Steel and Torrie (1960) while differences between treatments were determined using the least significance difference test.

RESULTS AND DISCUSSION

Table 2 presents dry-matter and nutrients intake by West African Dwarf goats fed basal Guatemala grass and various concentrate supplements. Generally as more concentrate was consumed by goats there was a corresponding decrease in forage dry-matter intake indicating a preference for concentrate intake to grass.

An increase in the level of groundnut cake in concentrate supplements increased total dry-matter intake by goats. Animals offered 150 g (P) groundnut cake per day consumed 63.16 g/day/$W^{0.75}$ kg compared to 58.80, 48.17 and 48.47 g/day/ $W^{0.75}$kg, respectively, for those fed 100 (P2) 50 (P1) and 0 (P0) grammes of groundnut cake per day. Dry-matter intake by goats fed 200 g of cassava flour (E_3) was 62.24 g/day/$W^{0.75}$kg which was significantly ($P<0.05$) higher than all the other treatments (E_0, E_1 and E_2) with values ranging from 51.29 g/day/$W^{0.75}$kg. The inter action of cassava flour and groundnut cake was not significant on dry-matter intake. Goats fed mixed concentrate of 200 g cassava flour and 150 g groundnut cake consumed the highest quantity of dry-matter (72.88 g/day/$W^{0.75}$kg). This value was not significantly different from dry-matter intake by animals on supplements consisting of a mixture of 150 g cassava flour and 150 g groundnut cake (63.93 g/day/$W^{0.75}$kg) or 200 g cassava flour and 100 g groundnut cake (69.39 g/day/$W^{0.75}$kg) but significantly ($P<0.05$) higher than all other treatments. The lowest levels of dry-matter intake were obtained with animals fed Guatemala grass only or supplemented with 50 g groundnut cake or either 100 or 150 g cassava flours; intake ranging from 43.98 to 49.51 g/day/$W^{0.75}$kg.

Table 2. Feed intake by West African dwarf goats fed combinations of graded levels of groundnut cake (P) and cassava flour (E) as concentrate supplements.

Treatments	DM	CP	CW	CC	ADF	CE
Effects of <u>groundnut cake</u>						
P_0	48.47 C_1	3.47 D_1	25.94 A_1	23.92 D_1	15.60 A_1	12.81 A_1
P_1	48.17 C_1	6.53 C_1	22.64 B_1	26.86 C_1	12.95 B_1	10.57 B_1
P_2	58.80 B_1	9.69 C_1	25.15 A_1	34.30 B_1	14.21 A_1 B_1	11.53 B_1
P_3	63.16 A_1	12.39 A_1	25.61 A_1	38.70 A_1	14.25 A_1 B_1	11.61 B_1
SE	1.37	0.19	0.82	0.67	0.48	0.38
CV (%)	8.69	7.98	11.43	7.48	11.76	11.34
LSD	4.01	0.54	2.40	1.95	1.41	1.11
<u>Effects of cassava flour</u>						
E0	52.28 B	8.50 A	33.22 A	23.68 D	20.79 A	17.15 A
E_1	51.29 B	8.09 A	22.69 A	28.08 C	11.45 C	9.19 C
E_2	52.79 B	7.12 B	21.46 B	31.73 B	12.17 BC	9.53 C
E_3	62.24 A	8.36 A	21.97 B	40.29 A	12.60 B	10.65 B
SE	0.82	0.18	0.47	0.51	0.26	0.25
CV (%)	5.20	7.79	6.58	5.72	6.41	7.48
LSD	2.84	0.63	1.64	1.77	0.92	0.87

Cont'd

Table 2. Feed intake by West African dwarf goats fed combinations of graded levels of groundnut cake (P) and cassava flour (E) as concentrate supplements.

Treatments	DM	CP	CW	CC	ADF	CE
<u>Combinations</u>						
Eo Po	47.51 efg	4.18 gh	35.23 a	17.32 g	22.73 a	18.76 a
Eo P1	43.98 g	6.56 ef	28.98 bc	19.42 g	18.26 b	15.06 b
Eo P2	55.58 cde	10.28 b	33.88 ab	26.24 e	21.00 ab	17.33 ab
Eo P3	62.06 bcd	12.99 a	34.82 a	31.73 cb	21.16 ab	17.46 ab
E1 Po	45.66 fg	3.78 h	24.39 cd	21.27 fg	12.86 cde	10.54 cdef
E1 P1	47.28 efg	6.38 f	21.39 def	25.89 e	10.85 def	8.90 efg
E1 P2	55.64 cde	8.35 cd	34.11 cd	31.77 cd	12.04 cdef	9.24 defg
E2 P3	54.25 def	11.87 a	20.86 def	33.39 c	10.07 ef	8.04 fg
E2 Po	45.13 fg	2.57 i	21.57 def	24.03 ef	13.15 cde	10.31 cdef
E2 P1	49.86 efg	5.39 fg	23.16 d	27.25 de	13.12 cde	10.26 cdef
E2 P2	52.25 ef	8.59 cd	17.60 ef	34.76 c	9.41 f	7.37 g
E2 P3	63.93 abc	11.95 a	23.70 cd	40.64 b	12.99 cde	10.19 cdef
E3 Po	55.63 cde	3.36 hi	22.57 de	33.06 c	13.68 cd	11.63 cd
E3 P1	51.59 efg	7.78 de	16.99 f	34.61 c	9.57 f	8.06 fg
E3 P2	69.39 ab	9.57 bc	25.00 cd	44.42 ab	14.39 c	12.17 c
E3 P3	72.38 a	12.75 a	23.33 d	49.05 a	12.75 cde	10.76 cde
SE	2.74	0.37	1.64	1.34	0.97	0.76
CV (%)	8.69	7.98	11.43	7.48	11.76	11.34
LSD	8.02	1.08	4.79	3.90	2.83	2.23

N.B. Figures in column with the same letter script are not significantly different (P >0.05).

The overall mean total dry-matter intake of 54.51g/day/$W^{0.75}$kg by goats from this investigation agree with the 57.73g/day/$W^{0.75}$kg reported by Awah (1982) with goats of similar age. The improvement in goats' dry-matter intake when increased levels of either cassava flour or groundnut cake (or both) were incorporated in their diets agrees with the findings of Akinsoyinu (1974), Adegbola (1974), and Crabtree and Williams (1971). The high levels of total dry-matter intake with high levels of dietary crude protein agrees with reports by several authors (Adegbola, 1974; Blaxter and Wainman, 1964; Elliot and Topps, 1963).

The improvement in dry-matter intake is attributed to the stimulating effect of the readily available concentrate nitrogen on the multiplication, digestive and fermentative activity of rumen microbial population. The larger surface area for the activity of digestive enzymes and faster rate of passage through the rumen and gut are factors that could contribute to increased dry-matter intake when increasing levels of concentrates are fed to goats.

Increasing the quantity of groundnut cake in diets resulted in a corresponding significant ($P<0.05$) increase in crude protein intake by goats from 3.47 (P_o) to 12.39 g/day/$W^{0.75}$kg (P_3). The effect of increasing dietary levels of cassava flour on crude-protein intake by goats was not consistent. The interaction of cassava flour and groundnut cake on crude protein intake was not significant. Maximum crude-protein intake (12.99 g/day/$W^{0.75}$) was registered with goats fed Guatemala grass and 150 g groundnut cake only (E_oP_3), while the lowest intake was obtained with those maintained on grass supplemented with 150 or 200 g cassava flour (2.57 and 3.36 g/day/$W^{0.75}$kg, respectively).

The increase in crude-protein intake as the level of groundnut cake in goat rations was raised agrees with the reports of Akinsoyinu (1974). The diminishing effect on crude-protein intake by increasing levels of cassava flour may be a result of a dilution effect or decreasing concentration of crude protein per gram of concentrate consumed by goats.

Intake of concentrate supplement significantly ($P<0.05$) depressed intake of cell walls by goats. The interaction of cassava flour and groundnut cake on cell walls intake was significant ($P<0.05$). Animals fed only forage had the highest level of cell wall intake. The declining contribution of forage to total dry-matter intake as concentrate level was raised could be responsible for the lower cell walls intake by goats fed mixed rations of forage and concentrate. The same explanation is valid for the relatively higher intake of acid-detergent fibre and cellulose by goats fed only grass compared to those on diets of grass and concentrates.

Each increase in the level of groundnut cake or cassava flour in goat diets caused significant ($P<0.05$) increases in the intake of cell contents. This may be attributed to the increasing importance of this fraction in the diet as more concentrate was consumed. Cell contents constitute 82 to 87% of concentrates used in this study.

The digestibility of dry-matter and other feed constituents by dwarf goats is indicated in Table 3. The digestibility of dry-matter, crude protein, cell contents and energy was improved by feeding goats with combined graded levels of cassava flour and groundnut cake; while that of cell walls, acid-detergent fibre and cellulose was decreased. The highest digestibility of dry-matter (76.04%) was obtained with goats fed the highest levels of groundnut cake and cassava flour (E_3P_3) while the least values were registered with goats maintained on forage only (63.31%) or forage plus 50 g groundnut cake (60.06%).

Incorporating increasing levels of groundnut cake in goat rations resulted in corresponding increases in digestible and metabolisable energy intake. Similarly, each increment in cassava flour level in goat rations resulted in an improvement in digestible metabolisable energy intake (Table 4). Maximum digestible energy intake was obtained with goats fed 150 g groundnut cake with 200g cassava flour (235.69 Kcal/day/$W^{0.75}$), whereas minimum intake was in goats fed forage only (131.56 Kcal/day/$W^{0.75}$kg) or forage plus 50g groundnut cake (108.14 kcal/day/$W^{0.75}$kg).

All animals gained weight except those fed forage only or forage plus 50 g groundnut cake. Generally, increasing the level of groundnut cake and cassava flour resulted in increased weight gain. Liveweight loss recorded ranged from -4 g/day for animals fed solely on forage to -11 g/day for those fed forage and a supplement of 50 g of groundnut cake. The highest rates of liveweight gain were observed with goats fed 200 g cassava flour with 100 g groundnut cake (52g/day) and 200 g of cassava flour with 150 g groundnut cake (60 g/day). These values were significantly ($P<0.05$) higher than all other treatments. In terms of weight gain, the advantage of these concentrate supplements are obvious. Low energy intake and negative nitrogen balance may be responsible for the liveweight losses obtained with goats fed solely on forage or forage supplemented with minimum does of groundnut cake.

Table 3. Digestibility % of feed constituents by West African Dwarf goats fed a combination of graded levels of groundnut cake (P) and cassava flour (E) as concentrate supplement.

Treatment	DMD*	CPD*	CWD*	CCD*	ADFD*	CED*	END*
Effects of groundnut cake							
Po	68.81 B1	55.49 C1	62.21 A1	74.86 B1	53.16 A1	54.98 A1	67.52 A1B1
P1	66.56 C1	74.04 B1	60.21 A1	73.16 B1	45.03 B1	47.78 B1	66.91 B1
P2	71.97 A1	78.48 A1	60.91 A1	81.03 A1	49.24 A1B1	51.98 A1B1	69.87 A1
P3	72.28 A1	79.96 A1	59.11 A1	81.20 A1	45.90 A1	49.44 B1	69.69 A1
SE	0.67	0.71	1.22	1.18	1.81	1.76	0.81
CV (%)	3.33	3.45	7.55	5.28	12.01	11.72	4.11
LSD	1.97	2.08	3.96	3.45	1.81	5.14	2.38
Effects of cassava flour							
Eo	64.56 C	70.89 BC	62.65 A	74.34 C	59.03 A	61.08 A	59.15 B
E1	70.11 B	71.70 B	63.51 A	74.55 C	42.31 B	45.55 B	70.60 A
E2	71.71 AB	74.05 A	61.64 A	78.04 B	46.51 B	47.77 B	70.66 A
E3	73.23 A	69.33 B	54.82 B	83.31 A	45.49 B	49.79 B	73.58 A
SE	0.51	0.59	1.40	0.88	1.53	1.22	0.88
CV (%)	2.50	2.85	8.01	3.92	10.93	8.29	4.47
LSD	1.75	2.04	4.86	3.04	5.29	4.23	3.08
Combinations							
Eo Po	63.31 gh	59.91 i	66.20 ab	68.09 f	64.90 a	64.50 a	59.81 f
Eo P1	60.06 h	70.17 fgh	59.49 bcd	70.24 ef	55.62 abc	58.28 abcd	52.55 g
Eo P2	66.54 fg	76.97 bcde	61.70 abcd	78.53 abcd	57.42 ab	60.10 abc	61.42 f
Eo P3	68.32 ef	79.55 abcd	63.23 abc	78.34 abcd	58.16 ab	61.43 ab	62.81 ef

Cont'd

Table 3. Digestibility % of feed constituents by West African Dwarf goats fed a combination of graded levels of groundnut cake (P) and cassava flour (E) as concentrate supplement.

Treatment	DMD*	CPD*	CWD*	CCD*	ADFD*	CED*	END*
E1 Po	68.72 ef	50.37 j	65.91 ab	79.87 def	43.94 cde	48.38 cde	67.70 cde
E1 P1	70.05 def	74.50 efg	68.83 a	70.84 def	42.94 de	45.39 e	74.11 ab
E1 P2	71.22 bcde	80.46 abc	64.59 abc	76.26 cde	42.06 de	44.74 e	71.27 abcd
E1 P3	70.91 bcdef	81.47 ab	54.71 de	80.22 abc	40.28 e	43.68 e	69.30 abcde
E2 Po	70.18 def	57.42 i	59.20 bcd	75.83 cde	53.84 abcd	52.06 bcde	69.03 bcde
E2 P1	67.90 ef	84.77 a	63.93 abc	73.83 cde	42.88 de	43.57 e	68.84 de
E2 P2	74.90 abc	81.06 ab	60.07 abcd	81.92 ab	46.89 bcde	50.99 bcde	73.58 ab
E2 P3	73.94 abcd	82.94 a	62.63 abcd	80.58 ab	42.44 de	44.46 e	73.93 ab
E3 Po	73.67 abcd	57.27 i	57.55 bcd	84.63 ab	49.97 bcde	54.97 abcde	73.52 ab
E3 P1	68.19 ef	68.71 h	48.60 e	77.72 abcde	38.66 e	43.90 e	74.83 a
E3 P2	75.22 ab	75.44 def	57.30 bcd	85.26 a	50.59 bcde	52.10 bcde	73.21 abc
E3 P3	76.04 a	75.88 cdef	55.85 cde	85.64 a	42.74 de	48.20 de	72.76 abc
SE	1.34	1.42	2.64	5.28	3.63	3.51	1.63
CV (%)	3.33	3.45	7.55	2.36	13.01	11.92	4.11
LSD	3.93	4.17	7.72	6.91	10.61	10.27	4.76

N.B: Figures in a column with the same letter script are not significantly different ($P>0.05$).

* DMD = dry-matter digestibility
* CPD = crude-protein digestibility
* CWD = cell-wall digestibility
* CPD = cell-contents digestibility
* ADFD = acid-detergent fiber digestibility
* CED = cellulose digestibility
* END = energy digestibility

Table 4. Energy intake and live weight gain by West African dwarf goats fed combinations of graded levels of groundnut cake (P) and cassava flour (E) as concentrate supplement.

Treatments	GE	DE*	ME*	DLWG (G)	AWT (KG)	MWT (KG)
<u>Effect groundnut cake</u>						
P_0	220.34	149.10 C1	110.91 C1	13 D1	12.73	6.78
P_1	223.24	150.67 C1	112.69 C1	17 C1	12.30	6.56
P_2	264.24	184.93 B1	136.78 B1	31 B1	12.08	6.48
P_3	291:15	203.80 A1	158.59 B1	40.A3	12:60	6:68
CV (%)	-	9.66	9.58	28.68	-	-
LSD	-	14.04	10.33	6.22	-	-
<u>Effects of cassava flour</u>						
Eo	245.30	146.45 C	109.75 C	5	12.62	6.70
E1	233.97	165.36 B	122.97 B	26	11.88	6.39
E2	243.64	173.23 B	128.62 B	22	13.49	7.04
E3	276.59	203.34 A	149.63 A	45	11.71	6.32
SE	-	3.24	2.28	2.35	-	-
CV (%)	-	6.53	6.19	6.19	-	-
LSD	-	11.25	7.92	7.92	-	-

Cont'd

Table 4. Energy intake and live weight gain by West African dwarf goats fed combinations of graded levels of groundnut cake (P) and cassava flour (E) as concentrate supplement.

Treatments	GE	DE*	ME*	DLWG (G)	AWT (KG)	MWT (KG)
Combinations						
Eo Po	219.95	131.56 fg	98.31 fg	-4	12.74	6.74
Eo P1	204.77	108.14 g	81.46 g	-11	12.69	6.72
Eo P2	261.60	159.72 cde	119.74 def	11 f	12.73	6.74
Eo P3	293.89	186.39 bc	139.47 bcd	25 de	12.32	6.58
E1 Po	208.53	141.10	105.61 ef	11 f	11.28	6.15
E1 P1	219.46	162.65 cde	120.75 def	26 de	10.78	5.95
E1 P2	258.12	184.33 c	136.76 cd	38 bcd	11.94	6.42
E1 P3	249.76	173.00 cd	128.77 de	30 cde	13.53	7.05
E2 Po	204.88	141.10 df	104.87 f	10 f	14.78	7.53
E2 P1	232.36	154.98 cde	115.43 def	15 ef	13.58	7.07
E2 P2	240.21	177.24 c	131.45 d	22 ef	12.20	6.53
E2 P3	297.12	219.62 a	162.71 ab	41 bc	13.40	7.01

Cont'd

Table 4. Energy intake and live weight gain by West African dwarf goats fed combinations of graded levels of groundnut cake (P) and cassava flour (E) as concentrate supplement.

Treatments	GE	DE*	ME*	DLWG (G)	AWT (KG)	MWT (KG)
E3 Po	247.98	182.34 c	134.83 d	35 cde	12.13	6.49
E3 P1	236.40	176.91 c	133.11 d	37 cd	12.13	6.49
E3 P2	298.13	218.42 ab	159.18 abc	52 ab	11.45	6.22
E3 P3	323.84	235.69 a	171.39 a	62 a	11.13	6.09
SE	-	9.60	7.07	4.26	-	-
CV (%)	-	9.66	9.58	28.68	-	-
LSD	-	28.01	20.66	12.45	-	-

N.B: Figures in a column with the same letter script are not significantly different ($P > 0.05$).

*Kcal/day/$W^{0.75}$kg

GE = gross energy
DE = digestible energy
ME = metabolisable energy
DLWG = daily liveweight gain
AWT = average weight
MWT = metabolic weight

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COMPARISON OF FEED UTILIZATION BY WEST AFRICAN DWARF SHEEP FED SODIUM HYDROXIDE TREATED SOYABEAN PODS SUPPLEMENTED WITH SOYABEAN FLOUR OR FRESH NAPIER GRASS FED ALONE OR WITH SOYABEAN FLOUR

R.M. Njwe and Godwe
Department of Animal Science
Dschang University Centre
Dschang, Cameroon

ABSTRACT

A comparison of feed utilization and liveweight gain was carried out with adult West African Dwarf sheep fed sodium hydroxide (NaOH) treated dry soyabean pods supplemented with soyabean flour; or fresh Napier grass fed alone or supplemented with soyabean flour.

There were no significant differences in the intake of dry-matter and proximate feed constituents between sheep fed alkali-treated soyabean pods supplemented with soyabean flour and those fed fresh Napier grass plus soyabean flour. Sheep fed only Napier grass consumed significantly more crude fibre but less dry-matter, crude protein, ether extract and nitrogen-free extract than those on the other diets.

The digestibility of dry matter, organic matter, crude fibre and nitrogen-free extract were similar for sheep fed solely on Napier grass and those fed on fresh Napier grass plus soyabean flour. The digestibility of crude protein and ether extract by sheep fed only on Napier grass was significantly lower than the other treatments. All experimental animals had positive nitrogen balance.

Liveweight gain was similar for sheep fed fresh Napier grass supplemented with soyabean flour (77 g/day) and those provided NaOH-treated soyabean pods plus soyabean flour (79 g/day). Animals fed solely on Napier grass gained 41 g/day which was significantly lower than the other treatments.

INTRODUCTION

The commencement of the soyabean project in the Western Province of Cameroon in 1981 has resulted in increased production of the crop. The primary aim of the project was to provide the human population adequate plant protein and cooking oil. However, the livestock sector has a lot to benefit from the project, especially as the cake resulting from oil extraction will be used in livestock rations. Crop residues such as leaves and pods can also be used to feed livestock. The use of these by-products in feeding livestock in the Western Province is of particular significance since the increasing density of the human population is rapidly taking over pasture land for cultivation of food crops. Semi-intensive or intensive small ruminant production is the best alternative available to farmers if this activity has to continue.

The objective of the present study was to compare feed utilization by local sheep fed Napier only, Napier grass plus whole undefatted soyabean flour and NaOH treated dry soyabean pods plus whole undefatted soyabean flour.

MATERIALS AND METHODS

Nine adult West African dwarf sheep were selected from the flock of experimental sheep at the Dschang University Centre farm for this study. The flock of sheep had been on adequate plane of nutrition and received adequate health care. The animals were randomly divided into three groups - T1, T2, and T3 in a completely randomised design with group mean weights of 17.73$\pm$ 2.25, 18.10$\pm$1.99 and 18.16$\pm$1.92 kg, respectively. The experimental treatments (diets) were as follows:-

- T_1 - Control (fresh *Pennisetum purpureum* or Napier grass only).
- T_2 - Napier grass plus 250 g ground undefatted soyabean/animal/day.
- T_3 - Sodium hydroxide-treated dry soyabean pods plus 250 g ground undefatted soyabean /animal/day.

Dry soyabean pods were treated with 4% NaOH solution by sprinkling the solution (800 ml/kg) on the pods using a water sprinkling can and manually mixing them to uniform wetness. The mixture was then covered with polyethylene sheets and jute bags for 24 hours after which the pods were dried in the sun and packed in jute bags until required for feeding animals.

Animals in each treatment were group-fed during the first 5 weeks of the experiment. During the last two weeks they were transferred into individual metabolic cages to facilitate digestibility studies. Freshly cut Napier grass and NaOH-treated soyabean pods were fed to animals twice daily at 9:00 and 16:00 hours, while ground undefatted soyabean was fed once daily at 9:00 hours in a separate feeding trough. The chemical composition of Napier grass, dry soyabean pods and undefatted soyabean are indicated in Table 1. Water and salt licks were provided ad libitum in each cage. The weights of feed fed residues were daily recorded and their dry-matter contents were determined.

The adaptation period in cages was one week. This was followed by a 7-day collection period during which faeces and urine of each animal were collected and measured every 24 hours. Ten percent mercuric chloride solution was used to prevent the loss of ammonia in urine during collection and storage. Urine samples were stored in corked bottles in a deep freezer while daily faecal samples were dried in a laboratory oven for 48 hours at 60°C and stored in polyethelene bags until the time of analysis.

Table 1. Chemical composition of the experimental diets (% dry matter).

	As fed			On organic-matter basis (%)			
	Dry-matter	Ash	Organic matter	Crude protein	Crude fiber	Ether extract	Nitrogen free extract
Pennisetum purpureum (Napier grass)	16.11	17.07	88.94	16.97	33.83	3.81	34.33
NaOH-treated dry soyabean pods	92.02	12.33	87.67	17.47	30.97	3.21	36.02
Undefatted soyabean flour	90.72	5.62	94.38	37.62	10.03	23.15	23.58

Feed and faecal samples were analysed for dry-matter and other feed constituents according to A.O.A.C. methods (1975). Urine nitrogen was analysed using the micro-Kjeldahl method.

Statistical analysis of experimental data was carried out according to the methods of Steel and Torrie (1960) and significant differences between treatments were determined using Duncan's Multiple Range Test (1958).

RESULTS

Table 2 shows the intake of dry matter and nutrients by West African Dwarf sheep. Dry-matter intake was 66.98, 74.82 and 75.31 g/day/$W^{0.75}$kg for sheep fed solely fresh Napier grass (T_1), Napier grass plus undefatted soyabean flour (T_2) and NaOH-treated dry soyabean pods plus undefatted soyabean flour (T_3), respectively. Sheep fed only on Napier grass consumed significantly ($P<0.05$) less dry-matter than the other two treatments. However, the values for animals fed undefatted soyabean flour supplement were similar.

Table 2. Dry-matter and nutrients intake by West African Dwarf sheep on the three experimental diets.

Group means	T1	T2	T3
	Napier grass with no supplement	Napier grass + undefatted soyabean meal	NaOH treated soyabean pods + undefatted soyabean meal
Dry matter	590.20±9.80	699.53±8.01	701.38±4.64
g/day/$W^{0.75}$kg	68.98±5.06b	74.82±5.09a	75.31±6.44a
Organic matter	524.86±8.72	634.65±7.14	630.12±4.07
g/day/$W^{0.75}$kg	59.57±1015b	67.83±4.60a	67.65±5.77a
Crude protein	100.15±1.66	165.50±1.38	168.34±0.81
g/day/$W^{0.75}$kg	11.36±0.86b	7.70±1.22a	18.06±1.50a
Crude fibre	199.66±3.29	182.67±2.71	169.72±1.39
g/day/$W^{0.75}$kg	22.66±1.71a	19.55±1.39ab	18.23±1.59b
Ether extracts	22.48±0.37	70.50±0.31	67.73±0.13
g/day/$W^{0.75}$kg	2.55±0.19b	7.54±0.53a	7.26±0.59a
Nitrogen-free extracts	202.55±3.36	215.72±2.75	224.42±1.67
g/day/$W^{0.75}$kg	22.98±1.74b	23.95±1.70ab	24.70±2.08a
Initial liveweight (kg)	17.77±5.40	18.10±4.00	18.16±4.07
Final liveweight (kg)	19.93±5.18	22.17±3.82	22.33±4.25
Average weight (kg)	18.85±2.49	20.13±1.84	20.16±1.92
Metabolic weight($W^{0.75}$kg)	9.01±0.88	9.48±0.68	9.49±0.69
Liveweight gain (g/day)	41±7b	77±5a	79±3a

N.B. Values in a row with same letter script are not significantly different (P>0.05).

There was a direct relationship between dry-matter and crude protein intakes. Crude-protein intake by sheep fed only Napier grass (11.36 g/day/$W^{0.75}$) was significantly (P<0.05) lower than in sheep fed the grass plus undefatted soyabean flour (17.70g/day/$W^{0.75}$) and those fed NaOH-treated soyabean pods plus undefatted soyabean flour (18.06 g/day/$W^{0.75}$kg).

The trends of organic-matter and ether-extract intakes were similar to those of crude protein. Crude-fibre intake by sheep on the control treatment (T_1) was significantly (P<0.05) higher than those on T3 (22.66 and 18.25 g/day/$W^{0.75}$ kg respectively) but similar to those on T2 (19.55 g/day/$W^{0.75}$kg). The same trend was observed for intake of nitrogen-free extract.

Table 3 shows the digestibility of dry matter and nutrients. The digestibilities of dry matter at 68.82% and 96.67% were similar for sheep fed Napier grass alone and those on Napier grass plus undefatted soyabean flour. Dry-matter digestibility by sheep fed on Napier plus undefatted soyabean flour was significantly (P<0.05) higher than in two NaOH-treated dry soyabean pods plus undefatted soyabean flour (66.72%) which was in turn similar to the control treatment.

The highest value of crude-protein digestibility was recorded with animals fed Napier grass and undefatted soyabean flour (83.04%) which was not statistically significant to 79.70% obtained with sheep fed soyabean pods plus undefatted soyabean flour. The value for sheep on the control treatment T1 (74.88%) was significantly (P<0.05) lower than in T2 but not statistically significant(P>0.05) to T3.

Table 3. Percent digestibility of dry matter and other nutrients by West African Dwarf Sheep (%) on the tested diets.

Group means %	Treatments T1	T2	T3
Dry matter	68.89±4.23ab	69.67±1.06a	66.70±2.36b
Organic matter	72.53±4.67ab	73.34±1.22a	67.77±2.15b
Crude protein	74.88±2.72b	83.04±0.43a	79.70±1.09ab
Crude fibre	75.29±3.82a	65.36±3.66b	62.13±1.58b
Ether extract	59.18±5.12b	83.89±2.66a	83.85±2.73a
Nitrogen-free extract	70.13±4.78a	69.18±1.98ab	60.89±2.51b

N.B. Values in a row with same letter script are not significantly different (P>0.05).

Crude-fibre digestibility by sheep fed on T1 (95.29%) was significantly (P<0.05) higher than those on T3 (62.13%) and on T2 (65.36%).

On the other hand, ether-extract digestibility by sheep on T1 (58.18%) was significantly (P<0.05) low when compared to T2 and T3 treatments which had similar values (83.89 and 83.85%). The digestibility of nitrogen-free extract by sheep on T1 and T2 (70.13 and 69.18% respectively) were similar. However, T1 was significantly (P<0.05) higher than T3 (60.89%).

Utilization of dietary nitrogen by West African Dwarf sheep is indicated in Table 4. Nitrogen intake and digested nitrogen by animals on T1 were significantly (P<0.05) lower than the other two treatments which were of similar values. This was also the case with nitrogen balance. None of the experimental animals had negative nitrogen balance.

Average daily weight gain by sheep is indicated in Table 2. Live weight gain by animals on T1 (41 g/day) was significantly (P<0.05) lower than those on T2 (77 g/day) or those on T3 (79 g/day). Treatments fed undefatted soyabean flour supplement had similar values.

Table 4. Nitrogen balance of West African Dwarf Sheep on the experimental diets.

	Treatments		
Group means %	T1	T2	T3
Nitrogen intake (g/day)	16.03±0.27b	26.48±0.22a	26.93±0.13a
Faecal nitrogen (g/day)	4.04±0.47b	4.47±0.104b	5.46±0.35a
Digested nitrogen (g/day)	11.98±0.33b	22.01±0.26a	21.47±0.29a
Urinary nitrogen (g/day)	10.34±0.56a	9.83±0.68a	7.89±0.25b
Nitrogen balance (g/day)	1.64±0.61b	12.18±0.42a	13.58±0.41a

N.B. Values in a row with same letter script are not significantly different ($P>0.05$).

DISCUSSION

Dry-matter intake by West African Dwarf sheep ranged from 66.98 to 75.98 g/day/$W^{0.75}$kg. These values are higher than those reported by Namadiga (1983). The increase of dry-matter intake with addition of protein supplement can be attributed to the protein stimulating effect on microbial digestive activity of cellulose. When nitrogenous compounds are deficient in a diet or when only small amounts are present, the growth of rumen microbes in the rumen is greatly inhibited and may lead to inefficient feed utilization.

The improvement of the digestibility of dry-matter, crude protein and ether extract in the present study agrees with those of Briggs and Heller (1942) from feeding large amounts of cottonseed meal in fattening lamb rations.

The decrease in crude fibre digestibility observed during this investigation may be attributed to a substitution effect of readily digestible undefatted soyabean flour.

The fact that all experimental animals were in positive nitrogen balance is a reflection of adequate dietary protein even when Napier grass was the only diet at T1. Animals on fresh Napier grass gained on the average 41 g per day during the experimental period. The high nutritive value of Napier grass at the beginning of the wet season (16.97% crude protein) can be responsible for this performance.

Soyabean pods treated with NaOH and undefatted soyabean flour to sheep promoted weight gains similar to that by animals fed on Napier grass and undefatted soyabean flour. Kpounoho (1986) fed untreated dry soyabean pods with cottonseed meal to local dwarf sheep and observed slight weight losses or at the best body weight was maintained. The utilization on NaOH-treated soyabean pods in the present study appears to stimulate higher dry-matter intake and therefore some liveweight gain (79 g/day). Improvement of straw utilization by NaOH treatment has also been indicated by Kategile et al (1979). The optimal treatment rate by NaOH has been reported to be 4% (Klopfenstein et al, 1972 and Hasimoglu et al, 1969).

It may be concluded that supplementation of Napier grass with undefatted soyabean flour feed intake gave adequate levels of improved digestibility and weight gain compared to the Napier grass fed alone. It is possible to maintain sheep on dry soyabean pods treated with NaOH solution and undefatted soyabean flour particularly during the dry season when grass of good nutritive value is scarce.

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PROCESSED AND UNPROCESSED SORGHUM STOVER IN BEEF FINISHING RATIONS

T.A. Mohammed, A.E. El-Tayeb, A.F. Mustafa and H.M. Khogali
Department of Animal Nutrition, Institute of
Animal Production, University of Khartoum
P.O. Box 32, Khartoum North, Sudan.

ABSTRACT

Two eight-week feeding trials using entire male cattle were conducted to evaluate the effects of incorporating processed and unprocessed sorghum stover in traditional concentrate diets used for finishing cattle in the Sudan. In the first trial milled sorghum stover was used to replace the concentrate mix at the rate of 0, 25, 35 and 45% (W/W). In the second trial the experimental animals were offered unprocessed sorghum stover *ad lib* in addition to the concentrate mix which was offered at 100, 75, 65 and 55% of the *ad lib* level of intake.

The first trial showed that incorporation of milled sorghum stover in the diets had no effect on the performance of the animals.

Animals in all treatments consumed an amount of feed equivalent to 3.0% of their body weight and gained at an average rate of 1.40 kg/d.

The results of the second trial showed that the intake of unprocessed sorghum stover increased as the amount of concentrate offered was decreased. The rate of gain of the experimental animals was not affected by the treatment and was about 1.0 kg/d. However, the efficiency of feed utilisation was higher when the animals were offered the concentrate mix *ad lib* than when the concentrate mix was limited.

INTRODUCTION

The Sudan ranks among the top African countries owning livestock. Statistics indicate that there are about 21 million tropical livestock units (TLU) composed respectively of 15.0, 16.0, 12.0 and 2.3 million head of cattle, sheep, goats and camels. Most of those livestock are kept under extensive management systems and are fed exclusively on rangeland grazing resources.

Livestock commercial offtake rates were low prior to 1973 and have been increasing since. Today it is estimated that 2.61 million TLU are transported annually to feedlots in the major urban centres for finishing before slaughter or export. Approximately 60-70% of the animals finished are cattle.

Cattle are finished on ad lib feeding of concentrate rations composed of equal parts of ground sorghum grain and cottonseed cake for a period of 8 weeks. The availability of the two ingredients and the simplicity of the formulation are the reasons behind the popularity of this feeding regime. However, recent increased local and export demands for sorghum grain and cottonseed cake elevated prices to levels that limited the expansion of the growing feedlot operations in the country.

Arable farming in the Sudan has grown considerably since independence in 1956, and areas under cultivation today are estimated at 15-20 million feddan producing 7-9 million tons of crop residues, of which 60-70% is sorghum stover. The bulk of the sorghum stover produced is of little use to cultivators and is normally disposed of by means other than feeding to animals.

A research project was initiated in the Sudan by IDRC with the intention of maximising the use of agro-industrial by-products in livestock feeds. Results of on-farm trials conducted during the earlier phases of the project (Mohammed Salih, 1986) suggested the possibility of incorporating relatively high levels of processed and unprocessed sorghum stover in beef finishing rations.

The objective of the on-station trials reported in this paper was to investigate the effects of partial replacement of the traditional concentrate ration with processed and unprocessed sorghum stover. The trials were designed in response to the reactions of feedlot operators involved in on-farm trials during earlier stages of the project.

MATERIALS AND METHODS

Twenty-four feeder bulls, 5-6 years old and of the western Sudan type were used in each of the trials for a finishing period of 8 weeks. The bulls used in each of the trials were stratified according to body weight into 8 groups of 3 bulls each. In each trial the groups were allotted randomly to four treatments (2 groups/treatment).

In trial 1, chopped and milled sorghum stover was incorporated into the traditional basal concentrate mixture at rates of 0, 25, 35 and 45%, and offered *ad lib*. Ingredients and chemical composition of the diets are shown in Table 1.

Table 1. Ingredient and chemical composition of diets used in trial 1.

	Level of milled sorghum stover (%)			
Item	0	25	35	45
Ingredient composition (%)				
Ground sorghum grain	49.5	37.0	32.0	27.0
Cottonseed cake	49.5	37.0	32.0	27.0
Milled sorghum stover	-	25.0	35.0	45.0
Salt	1.0	1.0	1.0	1.0
Chemical composition (%DM)				
DM	95.5	94.4	95.4	95.5
OM	91.2	88.4	88.6	88.3
CP	22.8	18.2	16.8	15.4
ADF	25.0	28.4	32.5	34.1
EE	4.2	3.4	3.1	3.9
Ash	4.3	6.0	6.8	7.2

In trial 2, unprocessed sorghum stover was offered *ad lib* to all animal groups together with the traditional basal concentrate mixture at 100, 75, 65 and 55% of the *ad lib* intake. The *ad lib* intake of the traditional concentrate mixture was adjusted weekly. The unprocessed sorghum stover and the traditional concentrate mixture were offered simultaneously in two adjacent mangers once in the morning and refusals were collected the next morning. Chemical composition of the traditional concentrate mixture and sorghum stover used in trial 2 are presented in Table 2. Feeds were analysed using standard methods (AOAC, 1980).

Intake of the complete diets (trial 1), concentrate mixture and unprocessed stover (trial 2) were recorded daily and animals were weighed weekly. At the end of each week feed conversion ratios were computed.

Table 2. Chemical composition of traditional concentrate mixture[1] and sorghum stover[2] used in trial 2.

Item	Traditional concentrate mixture	Sorghum stover
DM	95.5	95.7
CP	22.8	3.5
ADF	25.0	35.5
Lignin	6.2	11.5
Price LS/ton	717.8	200.0

1. The traditional concentrate mixture is composed of 49.5% sorghum grain, 49.5% cottonseed cake and 1.0% salt.
2. Cost of milling sorghum was LS 75/ton.

Data were analysed using analysis of variance (Steel and Torrie, 1980). When differences were significant (P<0.05) Duncan's multiple range test was employed to detect differences among treatment means.

RESULTS

Performance parameters of bulls used in trial 1 are presented in Table 3; treatments had no effect on dry-matter intake, rate of body weight gain or food utilisation. Irrespective of the treatment daily feed consumption and rate of body weight gain average 131 g/kg metabolic body weight and 1.4 kg, respectively. Average feed conversion (kg feed/kg gain) was 7.7.

Performance parameters of bulls used in trial 2 are presented in Table 4. They show that treatment significantly ($P<0.05$) affected dry-matter intake and feed utilisation but had no effects on rate of body weight gain. It was observed that total dry-matter intake progressively increased ($P<0.05$) as the amount of concentrate offered was decreased. Feed consumption/kg metabolic body weight increased from 117 g for the ad lib and 75% ad lib treatments to 126 g for the 65 and 55% ad lib treatments. The increase in the total dry matter was a result of increased ($P<0.05$) consumption of unprocessed sorghum stover as the amount of concentrate offered was reduced. The consumption of unprocessed sorghum stover increased from 1.0 kg when concentrate was offered ad lib to 3.5, 5.1 and 6.2 kg when the concentrate was offered at 75, 65 and 55% ad lib respectively. A decrease in concentrate offered by 1 kg is substituted for by consumption of approximately 1.5 kg of unprocessed sorghum stover. The feed conversion ratio was significantly ($P<0.05$) lower for bulls offered the concentrate ad lib than bulls offered other treatment.

Table 3. Performance of bulls used in trial 1.

Parameter	Level of milled sorghum stover(%) 0	25	35	45	SE
Initial body weight (kg)	364.0	365.0	363.4	365.2	4.7
Final body weight (kg)	443.0	442.3	442.6	445.0	6.2
Finishing period (weeks)	8.0	8.0	8.0	8.0	-
Daily gain (kg)	1.41	1.38	1.41	1.43	0.4
Daily feed intake (kg)	10.44	11.04	10.70	11.38	0.4
Daily feed intake ($g/kg^{0.75}$)	125.3^{a}	132.5^{bc}	128.8^{ab}	136.6^{c}	1.7
Feed intake (% body wt)	2.9	3.0	2.9	3.1	0.04
Feed conversion (kg feed/kg gain)	7.4	8.0	7.6	7.9	0.11
Cost of feed (LS/kg gain)	5.31	4.86	4.28	4.10	-

Values with the same letter script are not significantly different (P>0.05).

DISCUSSION

El Hag and Kurdi (1986) concluded that milled sorghum stover could be included in beef finishing rations to levels not exceeding 30% (W/W). In this study milled sorghum stover was incorporated in concentrate finishing rations to levels as high as 45% (W/W) without negative effects on basic performance parameters. This is in agreement with Lamming et al (1966) who used milled barley straw as a substitute for maize in beef finishing rations. It was concluded that the traditional system of feeding (concentrate mix *ad lib)* is wasteful; since the replacement of the concentrate mixture with milled sorghum stover to levels as high as 45% had no effect on feed consumption, rates of body weight gain and feed utilisation.

Under the prevailing conditions in the Sudan the milling of sorghum stover is inconvenient to some users and definitely increases the costs of production. Nevertheless it was thought that the feasibility of using high levels of milled sorghum stover as a substitute for the concentrate mix in traditional beef finishing rations would be more tempting to feedlot operators.

Table 4. Performance of bulls used in trial 2.

Parameter	Traditional concentrate mixture offered (% *ad lib*)				SE
	100	75	65	55	
Initial body weight (kg)	313.8	313.2	313.2	313.8	5.1
Final body weight (kg)	375.4	363.6	374.8	375.4	3.0
Finishing period (weeks)	8.0	8.0	8.0	8.0	-
Daily gain (kg)	1.1	0.9	1.1	1.1	0.1
Daily DM intake (kg)	9.5	9.7	10.5	10.5	0.5
Daily sorghum stover intake (kg)	1.0[a]	3.5[b]	5.1[c]	6.2[d]	0.4
Daily concentrate intake (kg)	8.5	6.2	5.4	4.3	0.3
Substation rate (conc. roughage)	-	1.5	1.6	1.5	-
Feed intake (% body wt)	2.7	2.7	2.9	2.9	-
Daily feed intake (g/kg $^{0.75}$)	117.0	119.0	125.0	128.0	-
Feed conversion (kg feed/kg gain)	8.6[a]	10.8[b]	9.5[c]	9.5[c]	0.3
Cost of feed (LS/kg gain)	5.73	5.73	4.43	3.92	-

Values with the same letter script are not significantly different (P>0.05).

Studies on the use of unprocessed sorghum stover in beef cattle rations are scarce. Lofgreen et al (1981) demonstrated that calves given concentrate diets consumed significantly less feed than those given limited concentrate and roughage free choice. In this study (trial 2) the feeding of limited amounts of all concentrate diet stimulated bulls to consume more of the unprocessed sorghum stover which resulted in higher total dry-matter intake.

Montgomery and Baumgardt (1965) observed that ruminants adjust their voluntary feed intake to their physiological demands for energy. In this study it was noted that bulls consumed more of the unprocessed sorghum stover than the replacement increment from the concentrate.

Average daily gains were the same for all treatment groups used in trial 2. This confirms the earlier conclusion that the systems based on the exclusive feeding of an all-concentrate diet is wasteful. Bulls fed the limited concentrated diets not only gained at similar rates as those offered the concentrate diet ad lib, but had the additional advantage of consuming significantly ($P<0.05$) greater amounts of unprocessed sorghum stover.

Lister et al (1968) reported that feed per unit gain was significantly ($P<0.05$) greater for steers fed roughage only compared with those fed roughage plus a high concentrate diet. In trial 2 the feed conversion ratio was significantly ($P<0.05$) better for bulls fed the concentrate diet ad lib than for those fed limited concentrate amounts together with unprocessed sorghum stover. However, it must be borne in mind that the inexpensive unprocessed sorghum stover represented a significant proportion of the feed consumed in the latter diets. It is apparent that these diets would be adopted more by feedlot operators looking for convenience and reduced production costs.

It was concluded that the traditional system of free choice concentrate feeding is wasteful. Concentrates could be replaced by as much as 45% with milled or unprocessed sorghum stover without undesirable effects on the performance of finishing bulls.

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HYDRATION AS A MEANS OF IMPROVING UTILIZATION OF MAIZE STOVER FED TO STEERS

L. R. Ndlovu and Z. Manyame
Department of Animal Science
University of Zimbabwe
P.O. Box MP 167
Mt Pleasant
Harare, Zimbabwe

ABSTRACT

Maize stover chopped to particles 4-6 cm in length was fed to steers either soaked in water (1 kg stover/1.5 l) for 24 hours or unsoaked. For each main roughage, four protein supplements were provided viz. control, urea, soyabean meal or blood-treated soyabean meal plus urea.

Soaking increased ($P<0.05$) intake of dry matter (DM) (4.8 vs 3.7 kg/d) but apparent DM digestibility and rumen digestion kinetics were not affected by soaking ($P>0.05$). Protein supplementation increased ($P<0.05$) DM intake (4.9 vs 4.4 kg and 3.8 vs 3.4 kg) for hydrated and unhydrated stover, respectively. Apparent DM digestibility and nylon bag degradability were, however, not affected by protein supplementation ($P>0.05$).

It was concluded that soaking *per se* has a potential to overcome constraints to intake of maize stover, particularly in situations where protein sources are scarce or expensive.

INTRODUCTION

Most of the ruminant livestock in Zimbabwe depend on maize stover as the main energy source during the dry season. Voluntary feed intake of this roughage is usually low mainly because the stover is harvested at a very mature stage and allowed to dry extensively before being fed to the animals. Maturity increases cell wall constituent fractions (for instance) and decreases protein content; both factors are inimical to digestion of a forage. Dryness increases time spent chewing per bolus (Welch, 1982) and thus reduces total intake.

Hydration has a potential to overcome these constraints. Soaking causes swelling of cell wall structures and thus should make them more accessible to cellulolytic microbes. In addition it reduces the dustiness and dryness of the feed. However, results from experiments where rice straw was soaked or wetted have been unequivocal as to the effects of this treatment (Doyle et al, 1986).

The main objective of this experiment was to investigate the effect of hydration on the utilization of maize stover by steers. The second objective was to investigate if there were any interactions between protein (source) and soaking.

MATERIALS AND METHODS

Animals and diets

Eight Hereford-Cross steers, two years old and fitted with permanent rumen cannulae were randomly assigned to two 4 x 4 Latin squares. Each square represented hydration or lack of it of the maize stover, the basal diet. Hydration was effected by soaking stover in water at the rate of 1 kg stover/1.5 litres of water for 24 hours.

Unsoaked stover was wetted with an equal amount of water at feeding. The chemical composition of the stover used was: dry-matter (g/kg) 890; neutral-detergent fibre (g/kg DM) 930; organic matter (g/kg DM) 978.9; crude protein (g/kg DM) 22.9.

Three protein supplements plus a control (no protein) were the treatments imposed in each square. The protein supplements were:

(i) urea (30 g/kg of stover)
(ii) soyabean meal (300 g/d), and
(iii) urea (30 g/kg of stover) plus blood-treated soyabean meal (250 g/d).

Blood-treatment was effected by coating soyabean meal with blood at a rate of 1 litre blood/2 kg soyabean meal and baking the mixture at 88°C for 36 h in an oven. Urea was dissolved in water before adding to stover and sprinkled at the time of feeding.

The animals were held in individual stanchions and fed twice daily (0800 and 1600 h); orts were weighed and sampled in the morning. Water and a commercial salt lick containing trace minerals were available all the time. Rubber mats were used for bedding to facilitate cleaning and collection of faecal samples.

Measurements

The periods were 33 days long and the schedule of activities is shown in Table 1. During measurement of *ad libitum* intake, the animals were offered 20% more stover than their previous day's intake. The total collection method was used to measure digestibility while rumen digestion parameters were measured using the nylon bag technique (Orskov and McDonald, 1979) with up to 96 h incubation in the rumen.

Table 1. Schedule of activities in each period.

Day	Activity
1-10	Adjust animals to diet
11-20	Measure *ad libitum* intake
21	Dose with chromium-mordanted fibre
21-27	Total faecal collection with subsamples for rates of passage measurements
28-32	Nylon bag incubation and removal
33	Empty rumens, weigh digesta sample and return to animal

Laboratory and statistical analysis

Dry matter (DM) of stover, orts and faeces was determined by drying at 100^{o}C overnight.

Data from the nylon bag technique were analysed using the equation $p = a + b\ (1 - e^{-ct})$ where p is total amount that has disappeared from the bag at time ti, a is the amount lost through washing, b the amount that in time will degrade and c the rate at which the b fraction degrades.

Statistical analysis appropriate for a double Latin square that accounts for the effects of square, animals, periods and protein supplements (Snedecor and Cochran, 1967) was used. Treatment means were compared using t-tests.

RESULTS

Intake

Hydration increased intake (P<0.05) by 23% while protein supplementation increased (P<0.05) intake by 11% (Table 2). There was no interaction (P>0.05) between hydration and protein supplements. Protein type had no effect on intake (Table 2).

Apparent digestibility

Both hydration and protein supplementation had no effect (P>0.05) on apparent dry-matter digestibility though unhydrated stover tended to have higher digestibility (Table 3).

Table 2. Dry-matter intake of hydrated and unhydrated stover supplemented with nitrogen.

Protein Source	Stover intake (kg/d) Hydrated	Unhydrated
Control	$4.4^{a,f}$	$3.4^{b,f}$
Urea	$4.9^{a,g}$	$3.7^{b,g}$
Soyabean meal	$4.8^{a,g}$	$4.3^{b,h}$
Urea + blood-treated soyabean meal	$5.0^{a,g}$	$3.5^{b,g}$
Standard error of mean	0.086	

a,b, means in a row with different superscripts differ significantly (P<0.05).

f,g,h means in a column with different superscripts differ significantly (P<0.05).

Table 3. Apparent digestibility of dry matter of hydrated and unhydrated stover supplemented with nitrogen.

	Apparent digestibility (%)	
Protein source	Hydrated	Unhydrated
Control	49.87	59.03
Urea	51.10	52.10
Soyabean meal	47.51	50.45
Urea + blood-treated soyabean meal	48.60	45.41
Standard error of mean	8.826	

Rumen digestion parameters

Soyabean meal decreased the 'a' fraction for hydrated stover but had no effect on the 'a' fraction of the unhydrated stover (Table 4). Urea decreased (P<0.05) the 'b' fraction in the hydrated stover and all the protein supplements tended to increase the rate of degradation though only significantly for the hydrated stover (Table 4). The patterns of DM degradation for the hydrated and unhydrated stovers are shown in Figures 1 and 2 respectively. In both cases only the control treatments show a distinct deviation from the other treatments.

DISCUSSION

Hydration increased intake but had no effect on digestibility, a result that agrees with those obtained by Chatuverdi et al (1973) who used soaked wheat straw. However, Devendra (1983) reported negative effects on intake and digestion of wetted rice straw by sheep. This discrepancy in research results may be due to differences in species of animals and straw used. On the other hand, it may be caused by differences in soaking and as such it merits further research. Data on soaking maize stover were not found in the literature.

Supplementation of poor quality roughages with nitrogenous material is a common practice among farmers, often leading to increased intakes. Our results showed a similar effect though the low level of response (about 10%) was disappointing. The supplements were chosen to represent a rumen-degradable non-protein nitrogen source, a rumen-degradable protein nitrogen source and a combination of a rumen-degradable nitrogen source and a rumen-undegradable nitrogen source. No differences in intake, digestibility or rumen digestion kinetic parameters were noted between all the nitrogen sources.

All the rates of digestion for the 'b' fractions were similar but this may have been caused by high variabilities within each treatment, thus masking any possible real differences. Further experiments on this issue are in progress.

Table 4. Rumen digestion parameters of hydrated and unhydrated stover supplemented with nitrogen.

Protein source	'a' (%) Hydrated	'a' (%) Unhydrated	'b' (%) Hydrated	'b' (%) Unhydrated	'c' (%) Hydrated	'c' (%) Unhydrated
Control	$12.3^{a,f}$	$12.6^{a,f}$	44.3	35.77	2.55^{f}	2.98^{f}
Urea	$12.7^{a,f}$	$10.8^{a,f}$	36.53	35.46	4.09^{g}	4.66^{g}
Soyabean meal	$7.7^{b,g}$	$11.2^{a,f}$	40.80	34.32	4.38^{g}	5.04^{g}
Urea + blood-treated soyabean meal	$6.6^{b,g}$	$11.0^{a,f}$	39.14	39.62	4.68^{g}	4.84^{g}
Standard error of mean	2.36		2.32		0.166	

a,b means in the same row within the same fraction with different superscripts differ significantly (P<0.05).

f,g means in the same column with different superscripts differ significantly (P<0.05).

Figure 1. Dry-matter disappearance from hydrated maize stover incubated in nylon bags in the rumen of steers.

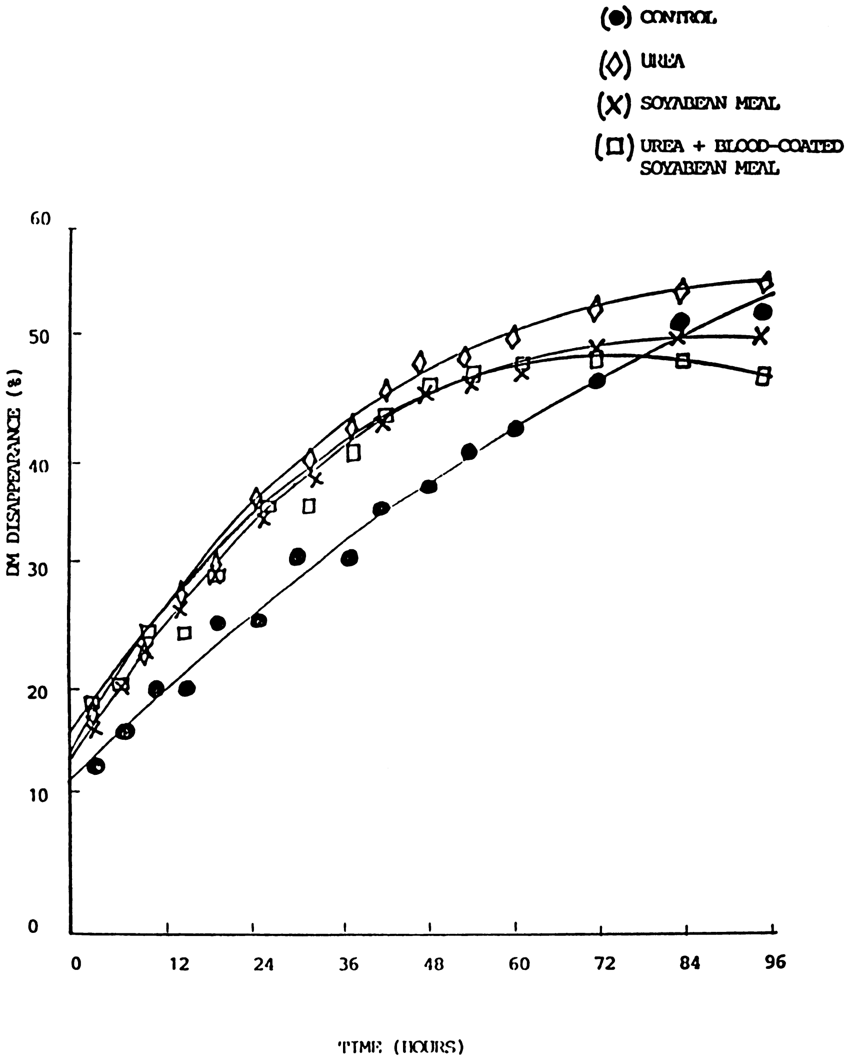
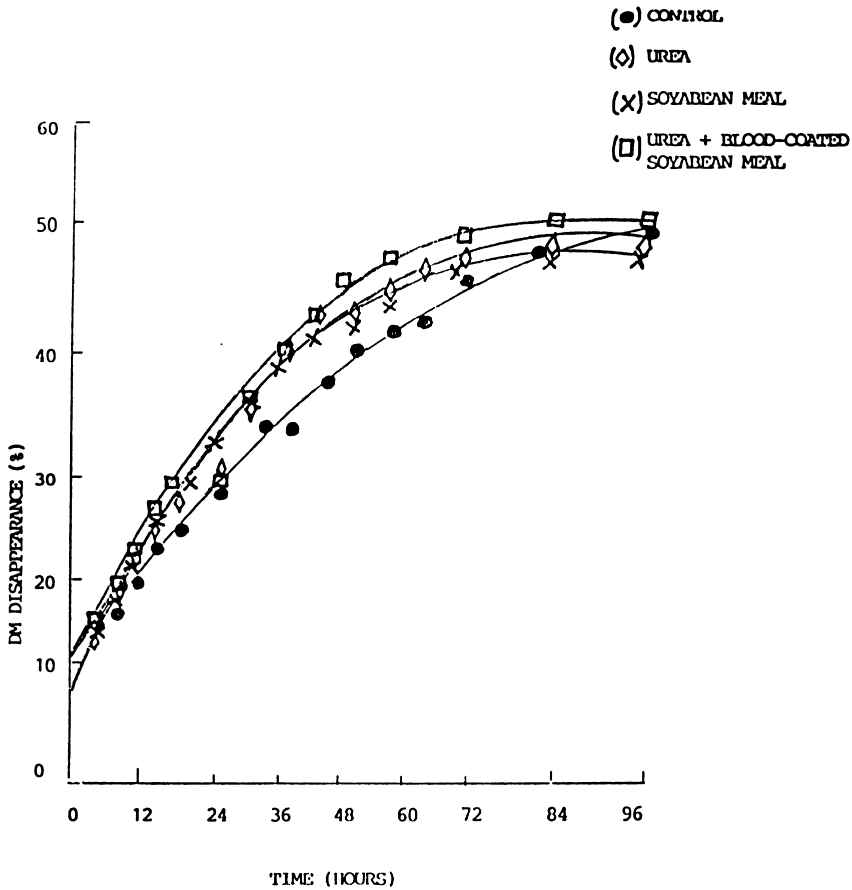


Figure 2. Dry matter disappearance from unhydrated maize stover incubated in nylon bags in the rumen of steers.



CONCLUSION

Hydration increased DM intake but had no effect on apparent DM digestion and on nylon bag degradation parameters. Protein supplementation increased DM intake over and above that due to hydration but the response was low. In situations where nitrogen sources are scarce or expensive, hydration offers a cheap and unhazardous method of increasing intake of maize stover.

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IMPROVING THE INTAKE AND UTILIZATION OF BY-PRODUCT-BASED DIETS

M. A. El-Naga
Faculty of Agriculture, University of Alexandria
Alexandria, Egypt

ABSTRACT

The voluntary feed intake or chopped corn stalks was improved (23%) by just increasing moisture content from 30 to 60%. Due to such treatment, sheep performance turned from losing 54 g/head/day to gaining 21.3 g/head/day. Addition of 5% linseed meal doubled the consumption of corn stalks and resulted in a daily gain of 53 g/head/day. Such percentage of linseed meal was comparable to 20% concentrate mixture supplement.

Supplementation of the urea treated corn stalks with 1.5% urea and 3% molasses improved the intake by 63%. Supplements varied in their effect on consumption, however, it did not affect the TDN content of the supplemented diet.

Recognising the deficient minerals in a by-product based diet (by mineral balance trials) and supplementing the diet with the recognized deficient amounts of minerals, resulted in improving the TDN content, the rate of body weight gain and the kg feed/gain ratio.

INTRODUCTION

Feed intake of agricultural by-products is mostly below the required level to maintain the animal's body weight. Its tough texture, poor digestibility and nutrient deficiencies all contribute to its low level of consumption.

This present paper describes some approaches to improve both the voluntary feed intake of by-products based diets and the efficiency the animal utilizes such diets. Moistening, supplementing and compensating for deficient minerals were tried as feasible methods of improvement.

MATERIALS AND METHODS

Experiment 1. Effect of moistening the by-product-based diet on its voluntary feed intake by sheep

A group (10 animals) of Barki male sheep of an average body weight of 30 kg was fed a diet of chopped (3-5 cm) corn stalks to which molasses, urea, vitamin A and minerals were added (Table 1). Moisture content of this diet was 30%. It was increased by water addition in two steps, e.g., 47 and 60% voluntary feed intake was measured at the three moisture levels. Measurement of intake was made in the third week of each treatment.

Table 1. Composition of the corn stalks diet.

Ingredients	Per cent
Chopped corn stalks	86
Molasses	10
Urea	1.5
Vitamin A	0.1
Mineral mixture*	2.4
Crude protein	7.9
TDN	52

* Composition of the mineral mixture was (%): 36 magnesium sulphate, 0.8 zinc oxide, 1.2 manganese oxide, 14 ferrous chloride and 48 bone meal.

Experiment 2. Effect of some supplements on the voluntary feed intake

Chopped corn stalks were fed to a group (10 animals) of 32 kg Barki male sheep for two weeks. Voluntary feed intake was measured during the last 5 days of the two weeks experimental period. Supplements which are shown in Table 2 were tested in sequence. The TDN content of the diet with each supplement was conventionally estimated using two male sheep.

Table 2. The tested supplements to the corn stalks-based diet.

1. Corn stalks (CS)
2. 1% urea + 0.1 % vitamin A
3. 30% concentrate mixture*
4. Treatment with 5% urea solution
5. 1.5% urea + 3% molasses
6. 0.3 phosphoric acid + 0.1% minerals**
7. 20% concentrate mixture + 1% Ca carbonate + 0.1% minerals
8. 5% linseed meal

* Contains (%): 2 g cottonseed meal, 30 yellow corn, 30 wheat bran, 5 rice bran, 3 molasses, 1 salt and 2 Ca carbonate.

** Contains (%): 36 magnesium sulphate, 0.8 zinc oxide, 1.2 manganese oxide, 14 ferrous chloride and 48 bone meal.

Experiment 3. Effect of compensating for recognised deficient minerals on the TDN content and on the performance of buffalo calves fed the same diets after mineral supplementation.

Three diets containing rice straw at a rate of 40 to 55% (Table 3) were fed to three groups (10 heads per each diet) of buffalo calves. Growth rate and the kg feed/gain ratio were measured. The initial body weight of the animals was about 200 kg. Digestibility and mineral balance trials were conducted conventionally on two male animals. The recognised deficient mineral amounts were added to each diet and all parameters were measured again.

Table 3. Composition of the experimental diets.

Ingredients	Per cent		
	1	2	3
Rice straw	40	55	43
Berseem has	10	25	-
Concentrate mixture*	40	7.5	14
Molasses	6	8	8
Urea	1.5	1.5	2
Minerals and vitamin A	2.5	3	3
Horsebean straw	-	-	30

* Composition of concentrate mixture (%): 29 cottonseed meal, 30 yellow corn, 30 wheat bran, 5 rice bran, 3 molasses, 1 salt and 2 Ca carbonate.

RESULTS

Experiment 1. Effect of moistening a corn stalks-based diet on its consumption by sheep

About 23% improvement in sheep intake was induced by just adding water to the by-products diet (Table 4). The body weight change was negative before moistening and it turned to positive at 15 g/head/day (Table 4). Improvement due to raising moisture from 30% to 47% was less than that due to increasing it to 60%.

Table 4. The voluntary feed intake (on DM basis) and body weight changes of sheep fed chopped corn stalks of different moisture contents.

	Voluntary	body weight	
Moisture content %	Feed intake	Change (g/head/day)	kg feed/gain ratio
30	258	-54	-
47	280	0.0	-
60	319	15	21.3

Experiment 2. Effect of some supplements on the voluntary feed intake and TDN content of the corn stalks-based diet

Table 5 shows the response of voluntary feed intake of sheep and TDN content of the corn stalks-based diet to different supplements. Urea supplementation at the rate of 1% improved the feed intake by about 25%. Combining urea treatment with urea addition resulted in 63% improvement in intake. Supplementation with concentrate mixture (30%) resulted in 47% increase in the intake. Combining concentrates with minerals raised the rate of improvement to 78%. Linseed meal at a rate of 5% was as effective in improving intake almost as 20% concentrate mixture plus minerals.

Table 5. Effect of different supplements on the voluntary feed intake and TDN content of corn stalks-based diet.

Added supplement	Voluntary feed intake (g/head/day)	T D N % on DM basis
1 - No supplement	563	54
2 - 1% urea and 0.1% vit. A	706	55
3 - 30% concentrate mixture	832	56
4 - Treatment with 5% urea	814	54
5 - Treatment with 5% urea + 1.5% urea + 3% molasses	920	56
6 - Treatment with 5% urea + 0.3% phosphoric acid + 0.1% minerals*	774	54
7 - 20% concentrates mixture** + 1% Ca carbonate + 0.1% minerals	1003	56
8 - 5% linseed meal	968	55

* Its content is (%): 36 magnesium sulphate, 0.8 zinc oxide, 1.2 manganese oxide, 14 ferrous chloride and 48 bone meal.

** Its content is (%): 25 cottonseed meal, 30 corn, 30 wheat bran, 5 rice bran, 3 molasses, 1 salt and 2 Ca carbonate.

Experiment 3. Effect of adjusting the mineral pattern of the diet according to the results of balance experiments, on the diet's nutritive value and efficiency

The results of some mineral balance experiments are shown in Table 6. The negative balances of some minerals were corrected by adding the corresponding deficient amount of salt to the diet.

Table 6. Balance of some minerals measured on buffalo calves fed the three experimental diets.

	Diet number		
Mineral (g/head/day)	1	2	3
Ca	-10	-14	-13
P	14	7	4
Na	2	13	5
K	12	16	-13
Fe	-2	-1	-1
Cu	0	0.2	-1
Zn	0	0	0
Mg	1	2	2
Mn	-0.1	0	0.4

The TDN contents, body weight gain and the kg feed/gain ration, measured before and after this adjustment are presented in Table 7. Diet 3 showed more mineral deficiencies than the other two diets. Accordingly, it benefited more from compensating for the recognised deficient minerals. This could be judged from the improvement of daily body weight gain and kg feed/gain ratio (Table 7).

DISCUSSION

Increasing the moisture content of corn stalks improved its intake, and resulted in better utilization of the consumed amount. It is just some calculated amount of water, added to the diet of sheep losing weight that turned the situation to gaining weight. The details of such a phenomenon is not understood yet. This is a point that needs to be investigated further to make better use of it with tough by-products feed. The present results in this connection draw the attention to try levels of moisture higher than that presently tested (60%). It is thought that this is the simplest and cheapest method of treating poor quality by-products.

Table 7. The TDN, body weight gain and kg feed/gain ratio measured on buffalo calves fed the three experimental diets, before and after adjusting the mineral pattern of the diets.

Item	Diet number 1	2	3
TDN(%):			
Before	51	51	58
After	59	61	64
Gain (kg/head/day):			
Before	0.65	0.68	0.25
After	0.87	0.79	1.10
Kg feed/gain ratio:			
Before	8.4	13.9	24.2
After	6.4	10.0	7.1

Ammonia treatment showed to be very effective in improving the level of voluntary feed intake of chopped corn stalks. Supplementing the ammonia-treated material with urea (1.5%) again improved the level of voluntary feed intake. The alkaline treatment helped through the process of delignification or dislocation, while urea addition enriched the protein level in the diet. However, linseed meal at a level of 5% was equivalent or even better than the combined alkaline treatment and urea addition. The cheaper of these two treatments would be the clue to improving the intake and perhaps the better utilization of such by-products. It was very interesting to observe that TDN content of any of the supplemented (Table 5) diets was almost constant. Since the rate of defecation is a reflection of the rate of ruminal outflow, it could be concluded that the tested supplements (Table 5) exerted its improving effect on intake by increasing the rate of ruminal outflow without increasing the extent of digestion.

The approach of investigating the mineral balance on a diet and supplementing the diet with the deficient amounts of minerals showed to be very effective in improving the feeding value of the by-products based diets (Table 7). The accumulated experience in this connection showed the significance of adjusting the Ca/P and the adequacy of K and Na. This approach showed frequently that minerals which may be estimated in a diet would not necessarily be of value for the animal because they may be unavailable to a certain degree or even completely. This means that some diets would contain high levels of some minerals even though there may be a need to supplement with such minerals. Availability of minerals is suggested to be estimated besides the estimation of the minerals themselves. This will be an important clue to the improvement of the by-products consumption and utilization.

THE DEGRADATION OF UNTREATED AND TREATED MAIZE COBS AND COCOA POD HUSKS IN THE RUMEN

A.K. Tuah[1] and E.R. Orskov[2]

[1] Department of Animal Science, Fac. of Agric. U.S.T., Kumasi, Ghana
[2] Rowett Research Institute, Bucksburn, Aberdeen, Scotland, U.K.

ABSTRACT

The dry-matter disappearance (DMD) values of untreated, 3.5% ammonia-treated and water-soaked maize cobs and cocoa pod husks were determined in the rumen of cannulated steers using the nylon bag technique. Although cocoa pod husks contained a higher level of lignin (26.38%) than the maize cobs (9.60%), the DMD values of the untreated cocoa pod husks were greater than those of untreated corn cobs for all the incubation periods (of 44% and 34% at 48 h). Ammonia treatment of maize cobs increased the DMD values but soaking it in water for 24 h before incubation had no significant effect. Cocoa pod husks were not improved by ammonia treatment.

The maize cobs and cocoa pod husks were treated with different levels of sodium hydroxide, 0,6,8,10 and 12 g/100 g of product and incubated in the rumen of four sheep for 48 h. Sodium hydroxide treatment significantly ($P<0.01$) increased the DMD values of the products. Washing the products after sodium hydroxide treatment did not significantly ($P<0.05$) affect the DMD values of the maize cob. With cocoa pod husks, washing after sodium hydroxide treatment caused a significant ($P<0.01$) reduction in the DMD values because of losses of soluble fractions during washing.

INTRODUCTION

In many tropical areas there is a problem of inadequate feed supply during the dry season. Agricultural wastes and by-products could be fed to ruminants during this season to offset the detrimental effects of inadequate nutrition on reproduction and growth.

In Ghana, there are large quantities of cocoa pod husks and maize cobs which could be fed to ruminants but are allowed to waste. Ghana produced 639,000 metric tonnes of dry cocoa pod husks in 1982 (Tuah et al, 1985) and about 95,000 metric tonnes of maize cobs in 1984 (FAO, 1984). Collection of maize cobs is easier than that of maize stalk which is left in the field where the maize is harvested while the cobs are gathered before dehusking and shelling.

Very little work has been done in Ghana to evaluate these by-products as ingredients in ruminant diets (Otchere et al, 1983; Tuah et al, 1985; Adomako and Tuah, 1987). This study was therefore undertaken to determine in *in situ* degradation characteristics of the two by-products.

The effects of soaking, ammonia and sodium hydroxide treatments on the degradation of the by-products in the rumen were also studied.

MATERIALS AND METHODS

Cocoa pod husks and maize cobs

The cocoa pod husks was prepared from fresh ripe pods as described by Tuah et al (1985). The maize cobs were obtained from the Ghana Seed Company, Kumasi and they were from an assortment of Ghanaian varieties both materials were sun-dried prior to handling.

The cocoa pod husks and the maize cobs were ground through a laboratory hammermill with a screen size of 2.5 mm. About 0.5 kg each of these products was treated with anhydrous ammonia as described by Orskov et al (1983) using 3.5 g NH_3/100 g of product. Samples of the products (100 g each) were treated with different quantities of sodium hydroxide dissolved in 100 ml of water. The levels of sodium hydroxide applied were 0,6,8,10 and 12 g NaOH per 100 g of air-dry weight of the material. The treated samples were kept in polythene bags in a laboratory (about 20°C) for 48 h. After this period each sample was divided into two halves: one half was dried in an oven for 48 h at 60°C. The other half was put into nylon bags and washed in a washing machine for about 15 minutes. They were then dried at 60°C for 48 h.

Animal feeding and management

Three rumen-cannulated steers (average weight 474 kg) and four rumen- cannulated sheep (average weight 63 kg) were used. The type of cannual and the procedures for cannulation are as described by Ganev et al (1979). The management and feeding of the animals were as described by Tuah et al (1986).

Procedures of incubation for the determination of dry-matter disappearance (DMD)

Samples (2 g each) of untreated, ammonia-treated and water-soaked maize cobs and cocoa pod husks were incubated in the same manner as described by Tuah et al (1986). The equation of Orskov and McDonald (1979) was used to describe the course of digestion of each sample. The a,b,c, and asymptote values for each sample were determined. For the NaOH treated samples, they were incubated for 48 h in the rumens of sheep.

Chemical analysis

The untreated cocoa pod husks and maize cobs were analysed for nitrogen (N) by the automated Kjeldahl method of Davidson et al (1970) and dry matter (DM) by the AOAC (1975) method. They were also analysed for acid-detergent fibre (ADF), neutral-detergent fibre (NDF) and lignin using the methods of Van Soest (1963) and Van Soest and Wine (1967). The hemicellulose content was estimated as the difference between NDF and ADF (NDF-ADF). The cellulose content was estimated as the difference between ADF and lignin (ADF-lignin). Cell content was estimated as 100-NDF.

Statistical analysis

The data were subjected to statistical analysis using the two-way analysis of variance for the steer experiments and split-plot analysis of variance for the sheep experiment (Snedecor and Cochran, 1976).

RESULTS

Chemical composition of the products

Table 1 contains the chemical composition of the untreated maize cobs and cocoa pod husks (Table 1 near hear). When these products were treated with ammonia, the nitrogen contents increased from 0.50 to 1.29% for maize cobs and from 1.12 to 3.53% for cocoa pod husks.

Degradation characteristics of the untreated and treated products

The degradation characteristics of untreated, ammonia-treated and water-soaked maize cobs and cocoa pod husks are shown in Table 2. (Table 2). Soaking the samples in water for 24 h increased the moisture content of the maize cobs to 76.7% and that of cocoa pod husks to 93.0%. Ammonia treatment of the maize cobs increased its DMD values. The increases were significant at 72 h ($P<0.05$) and 96 h ($P<0.01$) (Table 2).

Ammonia treatment of the cocoa pod husks significantly ($P<0.05$) increased the DMD value only at the 12 h incubation period. The DMD values of the ammonia-treated samples were less than those of the untreated samples at 48, 72 and 96 h incubation periods, the difference being significant ($P<0.05$) at 72 h.

Soaking the maize cob samples for 24 h before incubating in the rumen did not markedly increase the DMD values compared to the untreated samples. The DMD values of water-soaked cocoa pod husks were very low after correcting for soaking losses and therefore were not included in the statistical analysis of the cocoa pod husks data.

Table 1. Chemical composition of untreated maize cob and cocoa pod husk.

	Chemical constituent (g/100 g DM)								
	DM(%)	Ash	ADF	NDF	Lignin	Cellulose	Hemicellulose	Nitrogen	Cell content
Maize cob	93.27	1.96	47.61	93.96	9.60	38.01	46.35	0.50	6.04
Cocoa cob Husk	89.50	10.02	50.62	59.34	26.38	24.24	8.72	1.12	40.64

DM = dry matter.
ADF = acid-detergent fibre.
NDF = neutral-detergent fibre.

Table 2. Degradation characteristics of untreated, ammonia-treated and water-soaked maize cob and cocoa pod (fitted values in parentheses).

	DMD values at the various incubation periods (g/100 g DM incubated)						Asymptote (g/100 g DM incubated)	a	b	c	RSD
	12	18	24	48	72	96					
Untreated maize cob	11.4	12.8	25.0	34.4	45.2	51.7					
	(10.9)	(16.2)	(21.0)	(35.7)	(45.2)	(51.4)	62.6	-1.74	64.3	0.0182	3.12
Ammonia-treated maize cob	18.6	26.0	37.4	42.5	55.8	63.1					
	(21.1)	(26.5)	(31.4)	(46.3)	(55.9)	(62.1)	73.4	8.3	65.1	0.0182	4.40
Water-soaked maize cob	11.5	15.1	26.7	39.4	45.6	48.8					
	(10.4)	(18.2)	(24.4)	(39.5)	(45.9)	(48.6)	50.6	-11.0	61.6	0.0356	2.31
SED	1.57 NS	2.59 NS	2.7 NS	2.06 NS	1.69 **	0.11 **					
Untreated cocoa pod husk	27.0	27.3	33.7	43.7	51.0	52.2					
	(25.5)	(29.7)	(33.3)	(43.7)	(49.7)	(53.1)	57.6	15.1	42.5	0.0234	1.90

Table 2. Degradation characteristics of untreated, ammonia-treated and water-soaked maize cob and cocoa pod (fitted values in parentheses).

	DMD values at the various incubation periods (g/100 g DM incubated)						Asymptote (g/100 g DM incubated)	a	b	c	RSD
Ammonia-treated cocoa pod husk	31.0	32.5	36.9	40.8	41.2	44.4					
	(30.8)	(33.5)	(35.7)	(40.7)	(42.7)	(43.4)	43.9	23.0	20.9	0.0389	1.35
SED	0.65^{*}	1.42^{NS}	1.45^{NS}	3.49^{NS}	1.10^{*}	1.88^{NS}					
Water-soaked cocoa pod husk	2.7	3.9	12.3	24.8	28.0	28.5					
	(0.8)	(7.0)	(11.9)	(23.2)	(27.7)	(29.4)	30.5	-16.9	47.4	0.0389	2.36

RSD = residual standard deviation.
DMD = dry-matter disappearance.
SED = standard error of difference.

NS = not significant.
* = $P<0.05$.
** = $P<0.01$.

The effects of different levels of ammonia and sodium hydroxide treatments of maize cobs and cocoa pod husks on 48 h DMD values are shown in Table 3. The DMD values were significantly ($P<0.01$) affected by the level of sodium hydroxide treatment. For the maize cobs, washing the samples after sodium hydroxide treatment had no significant ($P<0.05$) decreasing effects on the DMD value (means: 72.6% for unwashed and 63.3% for washed, SED 6.48). For the cocoa pod husk, washing the samples after sodium hydroxide treatment significantly ($P<0.01$) reduced the DMD values (means 35.7% for the washed and 43.9 for the unwashed, SED 2.58).

Table 3. The effect of different levels of sodium hydroxide treatment and ammonia treatment on the 48 h DMD values of maize cob and cocoa pod husk.

	48h DMD values (g/100 g DM incubated) Level of sodium hydroxide (%)						
	0	6	8	10	12	Ammonia-treated	SED
Maize cob (not washed)	35.6	68.9	81.0	85.3	90.6	45.3	3.36**
Maize cob (washed)	32.0	60.0	79.0	82.4	84.2	ND	2.21**
Cocoa pod husk (not washed)	40.6	41.6	43.5	47.5	59.2	39.4	1.49**
Cocoa pod husk (washed)	26.5	28.8	36.2	39.7	47.5	ND	1.28**

DMD = dry-matter disappearance.
SED = standard error of the difference.
ND = not determined.
** = $P<0.01$

DISCUSSION

Degradation characteristics of untreated and water-soaked maize cobs and cocoa pod husks

At all the incubation periods the untreated cocoa pod husk had higher DMD values than the untreated maize cobs although the lignin content of cocoa pod husks was about three times higher than that of maize cobs. This to some extent disagrees with the theory of physical encrustation and entrapment of nutrients within lignified cell walls which Van Soest (1982) also disagrees with. With the maize cobs, most of the material was cell wall while the cocoa pod husk had a cell content of about 40.6% compared to 6.04% for the maize cobs. The hemicellulose content of the maize cobs was very high (46.4%) compared to that of cocoa pod husk (8.7%). Hemicellulose is more closely associated with lignin than any other polysaccharide fraction and is believed to be bonded to phenolic constituents (Van Soest, 1982). The cellulose and the hemicellulose of the maize cobs may therefore not be made readily available for microbial degradation, thus decreasing its DMD value. The cocoa pod husk on the other hand had high cell contents which were readily soluble. The dry-matter losses after 24 h soaking were 25.6% for cocoa pod husk and 3.0% for maize cob.

The cell wall of cocoa pod husk is relatively rich in pectin (about 11% of whole product on DM basis), which is totally digestible in the digestive tract of the sheep (Adomako and Tuah, 1987) and low in hemicellulose. Adomako (1975) reported that cocoa pod husk has very short fibres. It is therefore interesting to note that it has a high lignin content. It is possibly not totally lignin but also some amounts of condensed tannins. Further work to characterise this "lignin" will be pursued.

Bateman and Fresnilo (1967) reported that in vivo dry-matter digestibility of cocoa pod husks ranged from 32.3 to 39.7% which were close to the 24 h and 48 h DMD values observed in the present trial.

Kevelenge et al (1983) reported that the organic matter digestibilities of maize cob incubated in rumen fluid for 24, 48, 72 and 96 h followed by 48 h acid-pepsin digestion were about 8, 15, 26 and 50% respectively. Except for the 96 h period these values of Kevelenge et al (1983) were lower than those obtained in the present trial although the lignin content of their maize cobs was lower than that used in the present trial (5.8% vs 9.60%).

In the present trial soaking in water for 24 h did not increase the DMD values of the maize cobs at the various incubation periods as postulated by Kevelenge et al (1983).

With cocoa pod husk, soaking in water for 24 h caused reduction in the DMD values at the various incubation periods when soaking losses were corrected for because great quantities of cell contents were dissolved in the water. There seems to be no advantage in soaking any of the products, especially cocoa pod husks.

Degradation characteristics of ammonia-treated maize cob and cocoa pod husk

The DMD values of the ammonia-treated maize cobs were significantly improved only at 72 h ($P<0.05$) and 96 h ($P<0.01$) incubation periods compared to the untreated or water-soaked samples. It seems that anhydrous ammonia was not very effective in improving the DMD values of the maize cobs used in this trial.

Nelson et al (1984) using maize cobs containing 40% moisture reported the 48 h DMD values of 2, 3 and 4% ammonia-treated samples to be 61.30, 61.69 and 65.94% respectively. These values were higher than the 48 h DMD values for ammonia-treated maize cobs obtained in this trial. In the present trial, the moisture content of the maize cob was 6.4%. Kiangi and Kategile (1981) reported that moisture content of straws (20 or 40%) had less effect on the rate of ammonia treatment in improving their nutritive values. Borhami and Sundstol (1982), however, reported that if moisture content of straw was not above 2.5% then it adversely affected the improvement in its nutritive value with ammonia treatment. It is most likely that with maize cobs, the least moisture content for ammonia treatment to be effective would be higher than that of cereal straw. The optimum level of moisture content of maize cobs for ammonia treatment will be studied.

Cocoa pod husk was not responsive to ammonia treatment except at the 12 h incubation period although it caused an increase in the N content of the product (1.12% to 3.53%). Van Soest (1982) reported that grass lignin linkages are more susceptible to mild alkali treatment than those of wood or non-grass forages due to the higher content of ester and a lower content of methoxyl groups compared to that of non-grass lignin. The ester linkages between lignin and carbohydrates are more easily cleaved by alkali than the other linkages. Cocoa is a dicotyledonous plant which possibly explains the unresponsiveness of its lignin to ammonia treatment.

Effect of level of sodium hydroxide treatment of maize cob and cocoa pod husk on their 48 h DMD values

The level of sodium hydroxide treatment significantly ($P<0.01$) improved the 48 h DMD values of maize cobs. The highest level of treatment resulted in the highest DMD value. When the sodium hydroxide-treated samples were washed after treatment to reduce the sodium content the DMD values were not significantly ($P<0.05$) reduced compared to the unwashed samples. The slight reduction in the DMD values of the samples after washing could be due to losses of water-soluble fractions and solubilised phenolic compounds.

Kategile and Frederiksen (1979) reported in vivo organic-matter digestibility of 10% sodium hydroxide-treated maize cobs to be 32.4%. Nagole et al (1983) reported that treatment of maize cobs with 4.5% sodium hydroxide increased in vivo dry-matter digestibility from 44.7 ± 1.6 to 54.2 ± 2.0%.

The sodium hydroxide-treatment significantly ($P<0.01$) increased the DMD values of the cocoa pod husks. Washing the treated samples reduced significantly ($P<0.01$) the DMD values compared to unwashed samples. This is because during the washing process some of the soluble digestible portions were lost.

CONCLUSION

The DMD value of maize cobs could be increased with sodium hydroxide treatment and excess sodium could be washed from the sample without affecting its nutritive value. Anhydrous ammonia treatment was not very effective in increasing the DMD value possibly due to the low moisture content. Cocoa pod husks did not respond to anhydrous ammonia treatment but was responsive to sodium hydroxide treatment. The lignin content per se of a product is not directly related to the DMD values as shown by cocoa pod husks and maize cobs in the present trial.

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POTENTIAL OF AGRICULTURAL BY-PRODUCTS AS SOURCES OF MINERAL NUTRIENTS IN RUMINANT DIETS

E. Kabaija and D.A. Little
International Livestock Centre for Africa
P.O. Box 5689, Addis Ababa, Ethiopia

ABSTRACT

Several crop residues and agro-industrial by-products, available in Ethiopia as potential ruminant feeds, were examined in relation to their potential to supply essential dietary minerals. In absolute terms, cattle diets based on crop residues are unlikely to supply adequate Na, and are marginal-to-deficient in P, Cu and possibly Zn, but these problems, except for Na, seem rectifiable by the inclusion of appropriate proportions of by-products in the ration. This however, takes no account of the possibility that mineral might be rendered to some degree unavailable through its association with e.g. indigestible fibre.

Thus the apparent availability of minerals was assessed, firstly following sequential extraction *in vitro* in neutral, acidic and alkaline solutions to simulate conditions respectively in the rumen, abomasum and small intestine, and secondly by analysis following intraruminal incubation in nylon bags for 48 h; there was in general good agreement between the two methods. However, it is notable that the *in vitro* method removed Ca from roughages much more efficiently, while the reverse was true for the oilseed cakes, due possibly to differing extents to which Ca is bound to fibre.

The apparent availabilities of Ca from wheat and teff straws *in vivo* when fed to sheep were very similar to the values obtained *in sacco*, much more so than for other minerals. It was noted that roughage diets with low apparent mineral availability had much of their intrinsic minerals in association with faecal fibre. These could not be removed by water. It may thus be useful to pay close attention to the

balance of minerals in diets based on fibrous crop residues whose utilisation may have been improved through chemical treatment of NPN supplementation.

INTRODUCTION

Feeding of agricultural by-products and crop residues to livestock in the tropics is a common practice especially during the dry season when the available pasture is of low quality. These by-products have been evaluated mainly for their potential as sources of energy and protein. Their role as sources of mineral nutrients has received little attention. Under most production systems in Africa, ruminant animals rarely receive mineral supplements with the occasional exception of common salt. Where multiple mineral supplements are available, it is common to find some of them with essential minerals either deficient or possibly in excess.

Strategies being proposed for future improvement in animal production in Africa include identification and specification of crop residues and agro-industrial by-products as livestock feeds (Cianci and Hashi, 1985) and definition of improved means of utilising them, since these materials have a potential role to play in improving future animal production in Africa. Thus these feedstuffs need to be fully assessed for their suitability as livestock feeds, and any constraints that may limit their utilisation identified. Samokhin (1981) suggested that large amounts of coarse feedstuffs of cereal straw may reduce the degree of utilisation of the minerals in the feedstuffs. This could be due to large amounts of plant cell wall materials that are resistant to digestion in the gastrointestinal tract and which may shield nutrients from being assimilated. This study was undertaken to characterise various agricultural by-products for content and utilisation of essential minerals.

MATERIALS AND METHODS

Samples were obtained of several agro-industrial by products, mainly straws, brans and oilseed cakes, that are available in

Ethiopia as potential ruminant feeds. They were dried at 80°C, ground through a 1 mm stainless steel sieve and digested using H_2SO_4 and H_2O_2 for determination of K, Na, Ca, Mg, Mn, Fe, Zn and Cu by atomic absorption spectrophotometry (Perkin Elmer, 1982), and for N and P following Kjeldahl digestion using an autoanalyser (Chemlab Instruments, 1980).

Apparent availability of minerals in these materials was examined:

a) *In vitro*, using an adaption of the procedure described by Naga (1986), in which 2 g samples were successively extracted with neutral, acidic and alkaline solutions to simulate pH conditions respectively in the rumen, abomasum and small intestine. The solutions were respectively 900 ml distilled deionized water + 36 g NH_4HCO_3(pH 6.8), 0.05M HCl + 0.09M KCl(2.1) and 0.1M $NaHCO_2$ (8.3), and the samples were incubated at 37°C for 12 h in each of them. The residues were drained, dried and analysed as above, and the degree of disappearance of each mineral calculated by difference and expressed as a percentage.

b) *In vivo*, by incubating 5 g samples of each material in nylon bags (120 x 80 mm, pore size 20 um) in the rumen of a fistulated ox for 48 h. The ox was fed a ration of meadow grass hay *ad lib*, 600 g noug cake/day and free access to a multi-mineral block. After removal of the bags from the rumen they were washed under hot running distilled water until the washings were clear, dried at 100°C for 24 h, the residues analysed and calculations made as above.

In order to estimate the proportions of mineral removed from a fibrous feed during complete *in vivo* digestion, three rations based respectively on meadow hay, teff and wheat straw were formulated (Table 1) and fed to rams in wooden metabolism cages. Each diet was fed to 4 randomly allocated sheep (approx. 8 months old and weighing 21 kg) for 21 days following which total faecal collections were made for 6 days, using canvas faecal bags fitted with plastic liners. The faeces were collected each morning, thoroughly mixed and 100 g samples taken for analysis. Total feed intake was also determined during this period, and the sheep had free access to distilled water

throughout. Mineral determinations were made as described above, and neutral detergent fibre analysed using the method of Goering and Van Soest (1970). To quantify the amount of minerals associated with faecal fiber, 0.5 g faecal sample in 9.5 ml of distilled water at 36°C were centrifuged for 10 minutes at 2000 r.p.m, the residue drained of excess water, oven-dried and analysed for residual minerals as described above.

Table 1. Composition and digestibility of experimental diets (dry-matter basis).

	Diet type		
	Meadow hay	Teff straw	Wheat straw
Meadow hay - chopped (g/kg)	650	-	-
Teff straw - chopped (g/kg)	-	650	-
Wheat straw - chopped (g/kg)	-	-	650
Urea-molasses mixture 10% urea (g/kg)	350	350	350
Total nitrogen (g/kg)	22.0	19.0	18.4
NDF (g/kg)	468	463	461
Dry-matter intake (g/day)	677	612	467
Faecal output (g/day)	176	197	163
Faecal NDF (g/kg)	615	627	688
Dry-matter digestibility (g/kg)	740	680	650

RESULTS AND DISCUSSION

Mineral contents of the feedstuffs are shown in Table 2. All the feedstuffs had adequate quantities of K except for sorghum bran and brewer's dried grains (BDG) whose K content was below the dietary critical level of 6.5 g/kg given by NRC (1984) for beef cattle. Low K content in BDG has been reported by workers elsewhere (NAS, 1971), and could be a contributory factor in lowering the nutritional value of diets with BDG levels exceeding 40% (Couch, 1976). It may thus be necessary to undertake K supplementation if ruminant diets contain more than 40% BDG and especially if crop residue feeding is involved. Most of the feedstuffs were deficient in Na with the exception of oats straw, poultry wastes, molasses and cottonseed cake whose Na contents were above the levels of 0.7 to 1 g/kg considered by most workers (Morris, 1980; Underwood, 1981 and Little, 1987) to be the critical range for cattle. Based on the data shown, it would be beneficial to offer supplementary Na if most of the feedstuffs are fed to livestock especially the crop residues.

Levels of Ca below 3.0 g/kg were found in most oilseed cakes and cereal brans. Levels below 2 g/kg are likely to be inadequate by most standards (NRC, 1984, 1985; ARC, 1980). The very high P content relative to Ca in oilseed cakes could exacerbate the low Ca effect. Though ruminants have been found to tolerate very wide Ca to P ratios in instances where Ca is higher (Leuker and Lofgreen, 1961), there is little information on the effect of higher P content relative to Ca in diets of ruminants. In poultry, higher P in diets with adequate Ca resulted in leg bone abnormalities (Smith and Kabaija, 1985) which was probably due to the impairment observed in Mn metabolism. The case deserves investigation in ruminants.

Underwood (1981) considered a dietary P level of 1.7 g/kg to be marginal for grazing animals. Little (1980, 1985) indicated a figure of 1.4 g/kg to be the minimum required for growing cattle.

The present data show most cereal straws to be marginal-to- deficient in P and supplementation with P to such diets is likely to be beneficial. Animals on smallholder units which may receive concentrate feeds may have adequate P if offered high protein oil seed cakes or cereal brans.

Table 2. Mineral content of agricultural by-products used as ruminant feeds (dry-matter basis).

Feedstuff	K	Na	Ca (g/kg)	P	Mg	Fe	Mn	Zn (mg/kg)	Cu
Wheat straw	14.8	0.3	4.1	1.3	1.5	325	78	11	3.0
Barley straw	10.7	0.5	4.6	1.9	1.4	1175	90	12	5.0
Teff straw	11.7	0.3	4.3	1.6	1.9	170	59	26	6.5
Linseed straw	10.7	0.6	7.7	1.3	1.0	103	71	24	14.0
Rough pea straw	21.5	0.4	11.4	1.7	1.9	418	52	28	11.0
Oats straw	17.7	2.0	3.9	1.7	1.8	196	191	17	14.0
Maize stover	17.8	0.5	3.3	1.7	2.5	408	61	24	5.9
Coffee pulp	17.0	0.5	6.5	1.8	1.1	742	34	12	6.0
Wheat bran	11.2	0.4	1.2	6.3	5.2	163	172	75	7.6
Sorghum bran	6.0	0.4	0.6	6.1	2.2	163	29	25	5.0
Broiler litter	14.2	6.0	15.7	7.2	5.3	149	451	150	49.0
Cage layer excreta	14.6	5.5	30.5	18.9	7.2	186	601	547	24.0
Noug cake	11.4	0.2	3.5	6.6	5.3	272	160	84	24.0
Sunflower cake	10.8	0.1	1.9	6.8	4.9	189	42	94	16.0
Rapeseed cake	9.8	0.3	4.7	13.4	4.3	161	169	89	13.0
Cottonseed cake	12.5	1.4	1.8	9.6	4.8	56	21	56	11.0
Groundnut cake	10.6	0.3	1.0	7.1	3.9	1183	58	51	15.0
Linseed cake	10.5	0.5	6.5	9.0	4.6	149	144	70	31.0
Brewer's dried grains	0.2	0.4	4.1	5.3	4.8	403	71	109	12.0
Molasses	58.4	1.4	11.2	1.1	2.1	359	21	26	17.2

Levels of Mg, Fe and Mn in most feedstuffs were much higher than the levels of 1 g, 50 mg and 40 mg/kg respectively proposed as adequate for grazing animals (McDowell, 1985). The straws could however offer marginal Mg in case of high producing animals. Kemp (1960) proposed 0.20% Mg in herbage as the lowest safe level while Metson et al (1966) showed with beef cattle that a safe level of Mg in the forage may be even higher than 0.25%. McDowell et al (1978) considered 30 mg/kg to be a critical level of dietary Zn, although the ARC (1980) suggested that concentrations of 12-20 mg/kg are adequate for growing cattle. The cereal straws and coffee pulp may thus constitute a marginal supply of Zn. The necessity for supplementary Zn needs to be kept under review particularly for sheep which require some 35 mg Zn/kg diet (ARC, 1980).

The dietary requirement of cattle for Cu is considered to lie in the range of 8-14 mg/kg (ARC, 1980; NRC, 1978; NRC, 1984). The cereal straws and brans will provide deficient-to-marginal levels of this element. This situation may be exacerbated by high Fe levels in the straws (Standish et al, 1971) that may be both intrinsic to the feed as well as from soil contamination. It is thus necessary to consider Cu supplementation when straw-based diets are fed to cattle. This may, however, not be necessary for sheep, as this species' requirement is only about 5 mg/kg.

The in vitro availability of Ca, Mg, Fe, Mn, Zn and Cu from the feedstuffs is shown in Table 3. K and Na availabilities were not estimated because KC1 and $NaHCO_3$ were components of the extracting solutions. Availabilities of Ca, Mg and Mn were high in most feedstuffs especially straws. Availabilities of Fe, Zn and Cu were low. Low Fe availabilities have been reported before in non-ruminant diets (Underwood, 1977) but little is known of the physiological availability of iron from feeds to ruminants. Low Zn and Cu availabilities could exacerbate deficiencies of these elements particularly in straws where their concentrations were marginal-to- deficient. The method used in the present study does not accurately represent conditions in the digestive tract because factors involved in the kinetics of mineral elements are very complex and difficult to duplicate in vitro. The method is, however, an attempt at the characterisation of the nature of mineral forms found in the feedstuffs.

Table 3. *In vitro* mineral availability (%) from agricultural by-products.

	Ca	Mg	Fe	Mn	Zn	Cu
Wheat straw	73	86	31	67	11	57
Barley straw	76	76	25	65	19	41
Teff straw	80	89	38	77	28	49
Maize stover	79	84	27	59	8	38
Oats straw	72	83	49	74	24	55
Coffee pulp	45	54	15	32	25	19
Wheat bran	83	94	45	88	62	56
Sorghum bran	100	77	8	55	32	28
Brewer's dried grains	61	93	31	52	30	29
Noug cake	11	55	22	32	27	21
Sunflower cake	42	77	41	48	14	37
Rapeseed cake	6	56	19	38	18	31
Cottonseed cake	72	83	36	43	33	42
Groundnut cake	50	87	51	45	41	49
Linseed cake	60	43	34	26	33	27
Cage layer excreta	37	35	5	8	22	38
Broiler litter	24	55	11	13	15	31

Percentage mineral disappearance from most feeds *in sacco* was high for K, Na and Mg (Table 4). Similar findings were reported by Rooke et al (1983) who observed high values for Na, Mg and K from silages incubated in nylon bags in rumen of cattle. This probably is due to these elements existing in readily soluble ionic forms. Lower values observed in this study for Mn, Fe, Zn and Cu are comparable to those reported in tropical forages by Kabaija and Smith (1988). It is likely that some bacteria remain in the bags after washing. The quantities of minerals introduced through such contamination has not been estimated for the trace elements, although Rooke et al (1983) did so for macro-elements. They did not, however, show how much of the introduced minerals were likely to be subsequently removed by washing of the bags after incubation.

Table 4. Mineral disappearance (%) from the feedstuffs incubated *in sacco* in ox rumen.

	K	Na	Ca	Mg	Fe	Mn	Zn	Cu
Wheat straw	81	80	22	67	35	49	32	54
Oats straw	84	73	28	83	39	52	19	62
Barley straw	68	87	36	79	35	49	41	49
Teff straw	72	86	29	68	39	32	25	51
Maize stover	63	91	37	84	31	44	34	68
Coffee pulp	77	72	60	75	39	43	41	51
Wheat bran	89	88	51	77	58	56	35	81
Sorghum bran	83	85	49	72	50	39	40	62
Noug cake	93	81	81	84	32	21	60	63
Cottonseed cake	97	92	93	82	35	45	46	39
Linseed cake	91	89	88	75	28	52	28	46
Groundnut cake	96	85	85	68	44	33	32	56
Sunflower cake	91	81	81	77	41	46	49	54
Cage layer excreta	83	67	67	79	19	29	31	49
Broiler litter	83	73	52	81	37	22	23	55

Results of the digestibilities of minerals in the hay and straws studied (Table 5) closely resembled those obtained with the *in sacco* study. High values were obtained for K, Na and Mg and low values for most micro-elements. Much of the minerals in the test diets were mainly from the hay or the straws except in the case of Cu where molasses may have contributed considerable quantities. Minerals such as K and Na whose residual content in faecal fibre was low, had high apparent availability while those such as Ca and Mg and all the micro-elements whose faecal fibre content was high had low-to-medium (<50%) apparent availabilities. Kabaija (1985) reported increased mineral secretion as the dietary NDF level was increased from 155 to 600 g/kg in the diets of sheep. Given the fact that most crop residues are marginal-to-deficient in several essential elements and that they contain high fibre which may lower utilisation of the minerals, it would be necessary to pay close attention to the mineral balance of ruminant diets based on fibrous crop residues whose utilisation may have been improved through chemical treatment of NPN supplementation.

Table 5. Mineral digestibility in sheep fed low quality roughages sprayed with molasses-urea mixture (dry-matter basis).

Roughages	K	Na	Ca	Mg	Fe	Mn	Zn	Cu
			(g/kg)				(mg/kg)	
Meadow hay diet								
Dietary mineral content	21.0	2.0	5.9	2.1	1069	140	32.5	12
Faecal mineral content	2.6	0.9	11.3	3.7	3044	664	80	23
Apparent availability (%)	97	88	50	54	26	-24	36	50
Faecal fibre mineral content (mg/kg)	211	30	7000	1100	1976	548	56	15
Teff straw diet								
Dietary mineral content	19.4	1.3	4.2	1.3	198	46.6	31.1	15.0
Faecal mineral content	3.6	0.9	9.1	2.2	523	116	68	18.5
Apparent availability (%)	94	77	31	46	15	19	19	61
Faecal fibre mineral content (mg/kg)	68	22	4100	500	447	100	53	11
Wheat straw diet								
Dietary mineral content	22.8	1.9	3.6	1.2	218	23.3	23.1	11.5
Faecal mineral content	8.6	2.2	8.1	2.0	479	36.5	47	15
Apparent availability (%)	87	60	21	42	23	45	29	55
Faecal fibre mineral content (mg/kg)	53	20	4100	600	412	21	39	11

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THE PRESERVATION OF BANANA CROP RESIDUES
THROUGH ENSILING PROCESS

N. H. Sheikh
Department of Animal Production
Faculty of Agriculture, Somali National University
P.O. Box 801, Mogadishu, Somalia

ABSTRACT

A study to assess the susceptibility of banana crop residues (stems and leaves) to ensiling was undertaken in order to utilize this material during the dry season when feed is in short supply.

Four treatments of ensiling banana crop residues were examined: direct-cut silage (material with 90% of moisture); direct-cut silage treated with sugar-cane molasses at a rate of 5% of fresh weight; wilted (material with less than 70% of moisture); wilted and treated with molasses (5% of fresh weight).

The chemical composition of banana crop residues has shown material high in moisture content and low in water-soluble carbohydrate is not suitable to be ensiled without treatment prior to ensiling. Wilting to more than 30% DM and the addition of molasses gave a satisfactorily ensiled product.

INTRODUCTION

In many tropical countries like Somalia, the main constraint aside from water is the lack of sufficient feed during the dry season. This fact hinders the development of the livestock sector in Somalia and makes the settlement of the nomads almost impossible.

Substantial amounts of agricultural by-products, such as banana and sugar-cane, are produced annually in Somalia. However, this forage is presently underutilized. The potential for by-product feeding in Somalia is great and its efficient utilization can contribute in large degree to the development of the Somalia livestock industry.

Fresh banana crop residues are already used as animal feed in some tropical countries (Johri and Shrivastava, 1967). However, a large portion of these crop residues are lost each year as a result of poor conservation methods.

The objective of this study was to determine the possibility of ensiling banana crop residues with or without additives in order to increase its utilization as animal feed throughout the year.

MATERIALS AND METHODS

The banana crop residues used in this study were harvested from two year-old plants of the "Poyo" variety after the fruit was harvested. The plants were in good vegetative condition, under normal management practicies for production of banana fruits. The distance between rows and plants was 2 x 4 m, giving a plant density of 5000 per hectare. Before the material for ensiling was collected, representative samples of banana crop residues were taken to estimate the total mass of this material per unit area. About 50 plants were randomly removed. The whole plant as well as stems and leaves were weighed separately. The latter was done to determine the ratio between the two components. These operations were conducted in the field with a portable balance.

Since direct-cut banana crop residue has a very high moisture content (80-90%), it was proposed to evaluate the suitability of this material for ensiling alone as well as treated with additives. Molasses was used as an additive in this study, because it is a good source of soluble carbohydrate and is available in large quantities as a by-product of the sugar-cane industry, usually close to banana plantations.

The following four treatments were applied in this study:

1. Direct-cut silage (high moisture material 80-90%).

2. Direct-cut silage treated with sugar-cane molasses (5% of fresh weight).
3. Wilted silage (more than 30% of DM).
4. Wilted silage treated with molasses (5% of fresh weight).

Initially the whole banana crop residues were cut manually and chopped into lengths of 2 cm or less in order to obtain well-packed material. The chopped materials of Treatments 3 and 4 were wilted prior to ensiling by laying them in the sun for about 8 hours until the moisture content was reduced to below 70%.

Four micro-silos each having a capacity of 100 kg of wet chopped material were uniformly filled with banana crop residues. The filling was done in layers, with each layer being tightly packed to reduce air space. During the packing operation molasses was uniformly spread on each layer of Treatments 2 and 4 at a rate of 5% on fresh weight basis.

All four silos were opened after 45 days, and a 2 kg sample from each silo was drawn for proximate analysis (AOAC 1974) and determination of pH. In addition other visual and olfactory tests such as colour and presence or absence of mould, and tests of acceptability to goats, were made.

RESULTS AND DISCUSSION

The average weight of the whole banana plants after removal of the bunch was 28 kg, while the average weights of stems and leaves were 22.6 kg and 5.9 kg respectively, giving a ratio between them of 4:1, confirming the good vegetative condition of the plants and the excellent variety used in this study.

The total mass of crop residues per unit area is about 890 t/ha/year of fresh weight (around 89 t of DM/ha/year). Total area of banana plantations in production in Somalia is 4700* ha implying a potential annual yield of forage available for livestock use of over 4 million tons.

* Source: Somali Fruit Company, 1986.

The chemical compositions of banana stems and leaves are presented in Table 1, for material in this study and that of Johri and Shrivastava (1967). The data from the present study illustrate the high moisture content in both banana stems and leaves, particularly the former. Crude protein and ether extract were higher in leaves, while crude fibre and N-free extract were similar in both fraction. These data indicate that banana stems are less nutritious than leaves. The nutrient content of banana leaves indicates that this forage is much better than many tropical forages found in Somalia (Yanelli, 1984).

Table 1. Chemical composition of banana stems and leaves on a dry-matter basis (%) in this study and in that of Johri and Shrivastava (1967).

		Stems	Leaves
Moisture	%	92.08	83.58
		on dry-matter basis	
Crude protein	%	2.70 (2.4)	8.50 (12.2)
Ether extract	%	0.85 (2.3)	3.55 (8.1)
Crude fiber	%	30.05 (20.5)	31.20 (25.0)
N-free extract	%	46.60 (60.5)	43.70 (38.9)
Ash	%	19.80 (14.3)	13.00 (15.8)
Calcium	%	1.35 (1.16)	1.04 (1.78)
Phosphorus	%	0.44 (0.22)	0.19 (0.14)

The analyses from the four treatments, before and after ensiling are given in Table 2, and pH and other visual and olfactory evaluation such as colour, odour, and absence or presence of mould are given in Table 3.

Table 2. Chemical composition of banana crop residues (mixed stems) and leaves on dry-matter basis, before (1) and after (2) ensiling.

		Treatment							
		Direct-cut		Direct-cut with molasses		Wilted		Wilted with molasses	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Crude protein	%	5.75	4.55	3.85	4.60	4.80	5.90	3.80	5.30
Ether extract	%	2.10	2.15	1.05	1.85	1.85	2.30	0.80	1.40
Crude fiber	%	31.70	35.50	18.95	31.50	29.20	32.15	18.30	29.20
N-free extract	%	41.85	39.50	54.75	42.55	36.00	37.80	58.50	42.60
Ash	%	18.60	18.45	21.40	19.40	28.15	21.85	18.60	21.50
Ca	%	2.32	2.38	1.66	2.55	2.13	2.73	1.77	2.44
P	%	0.16	0.10	0.10	0.09	0.11	0.11	0.09	0.10

Table 3. Physical and chemical characteristics of ensiled banana crop residues after 45 days.

	Treatment			
	Direct-cut	Direct-cut with molasses	Wilted	Wilted with molasses
Colour	Dark brown	Dark brown	Dark brown	Light brown
Odour	Unpleasant	Unpleasant	Almost unpleasant	Pleasant
Dry matter (%)	12.95	11.03	32.80	31.46
pH	5.8	5.4	6.1	4.1
Mould growth	Yes	Yes	Yes	No

From visual observation the colour in Treatments 1, 2, and 3 were dark brown with unpleasant odour, probably due to the accumulation of butyric acid. The dark colour intransified following contact with air direct-cut silage was found to be unsuitable for ensiling because of its high moisture content and low content of soluble carbohydrate. For that reason the reduction of moisture and the addition of molasses could be considered an appropriate intervention to obtain a successful ensiling.

The pH of Treatments 1, 2 and 3 remained relatively high (5.8; 5.4; 6.1 respectively). The colour of Treatment 4 (wilted silage and treated with molasses) was light brown in colour with a pleasant odour of lactic acid. No visible mould growth was observed and the pH was lower (4.1).

When the ensiled materials were offered to goats *ad libitum* they refused to eat the silage from Treatments 1 and 2 where secondary fermentation was marked (unpleasant odour), but the materials from Treatments 3 and 4 were consumed.

CONCLUSION

There are large quantities of banana crop residues available in Somalia with substantial potential for contributing to its livestock industry. Even though this by-product alone is a poor quality feed, it becomes extremely important for maintenance purposes during the dry season when little or no grass is available.

From this experiment it was concluded that banana crop residues are likely to ferment successfully when the moisture content is reduced to below 70% prior to ensiling and a fermentable carbohydrate source such as molasses is added.

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SOLUTIONS TO THE PRACTICAL PROBLEMS OF FEEDING COCOA-PODS TO RUMINANTS

O.B. Smith
Department of Animal Science
Obafemi Awolowo University
Ile - Ife, Nigeria

ABSTRACT

Data is presented showing that cocoa-pods, a by-product of cocoa processing could be used as a ruminant feed. The widespread nature of cocoa-processing sites which makes it difficult and expensive to collect and transport the cocoa-pods to sites of utilisation, and the need to grind the pods prior to feeding are identified as the main physical constraints while the high cell wall and low cell content of the material constitute the main nutritional constraints to its effective utilisation.

One way of overcoming part of the physical constraint is to develop technologies that would permit the use of the pods at the main sites of production. Chemical treatment using ash solutions of crop residues, ensiling the material with poultry manure or urea, and strategic supplementation with fermentable nitrogen and good quality forages are suggested as strategies to overcome the nutritional constraints to the utilisation of cocoa-pods as a ruminant feed.

INTRODUCTION

The competition between man and his animals for food such as cereals, pulses and oil seeds is partly responsible for the ever-increasing livestock feed costs. In developing countries, the production of these feed items is too low to meet demands, and as in all such situations, where demand exceeds supply, the cost of these items has continuously soared. Research efforts have therefore been directed towards finding alternative sources of nutrients for livestock, using materials that cannot be directly consumed by man. This approach may alleviate man-animal competition and reduce animal feed costs particularly for ruminants which can utilise fibrous crop residues and by-products of cereals, pulses and oil seed processing.

Enormous quantities of these materials which are usually not eaten by man, are produced annually on the farm after crop harvesting and in the food processing industry (Table 1). Many of these materials are currently being evaluated on a worldwide basis in order to determine their suitability as livestock feeds. Cocoa-pod produced after the removal of the cocoa beans from the fruit, is one such crop residue being evaluated in Nigeria as a potential feed for ruminants. The pod forms about 75 - 80% of the weight of the fruit, and from estimates of cocoa production in Nigeria, about 1 million tonnes of dried pod could be available annually on Nigerian cocoa plantations for feeding ruminants.

Table 1. Available quantities of major crop residues in Africa.

Crop	Residue	
	Type	Quantity ('000 tonnes)
Maize	Stover	62,000
Sorghum	Stover	48,600
Rice	Straw	9,300
Sugar-cane	Tops	17,070
Groundnut	Haulms	8,200
	Husk	1,250
Cocoa	Pods	9,710
Banana / plantain	Leaves	15,020
	Pseudo stems	32,700
Cassava	Tops	45,000

According to published values, the dried pod may contain about 6-10% crude protein, 24-42% crude fibre, 49-61% nitrogen-free extracts, 9 - 16% ash, made up primarily of potassium salts (Owusu-Domfeh, 1972; Gohl, 1975; Devendra, 1977; Otchere et al, 1983; Smith and Adegobola, 1985). This nutrient profile is similar to that of many tropical grasses (Ademosun and Kolade, 1973). The material therefore has good potential as a feed ingredient particularly for ruminants.

This report presents results obtained to date, at the Obafemi Awolowo University, Ile-Ife, Nigeria, to develop a feeding strategy using cocoa-pod in ruminant diets, followed by a discussion of identified constraints and suggested solutions to its efficient utilisation.

Preliminary experimental studies

Three cattle growth trials and two digestion studies (cattle and sheep) constituted the first series of experiments. In the cattle growth trials, local cattle (Keteku, N'Dama and Muturu) found mainly in the cocoa-growing areas of Nigeria were used as experimental animals. Using standard experimental procedures, the animals were allocated into control and test groups, and fed their respective diets for periods of 98 to 112 days. The control and test diets as shown in Table 2 were maize or guinea-maize based, and were similar, except that the cereals were replaced in graded amounts with cocoa-pod at 20, 30, 40, 50 and 60%.

For the sheep digestion studies, the total collection method was used, while the indicator method, using acid-insoluble ash as an internal maker, was used for the cattle study. The digestibility of diets containing 0, 15, 30, 45, 60 and 75% pod (sheep) and 0, 20, 40% pod (cattle) were determined. Cocoa-pod digestibility in sheep where six levels of the material were used was determined by extrapolation.

Table 2. Composition of diets fed to growing cattle in two trials.

	Diets						
		First trial			Second trial		
Ingredients (% as fed)	Control 1	20% pod	40% pod	Control 2	30% pod	50% pod	60% pod
Maize	-	-	-	69.4	38.9	20.0	8.9
Sorghum vulgare	62.3	43.2	24.4	-	-	-	-
Cocoa pod	-	19.2	38.4	-	30.5	50.0	60.2
Dried brewers' grains	19.5	19.5	19.3	14.6	14.5	15.0	14.4
Wheat offals	-	-	-	10.5	10.5	8.0	10.5
Molasses	11.7	11.6	11.5	-	-	-	-
Groundnut cake	4.7	4.7	4.7	3.4	3.6	5.0	3.5
Dicalcium phosphate	0.4	0.7	0.9	-	-	0.8	-
Bone meal	-	-	-	1.0	1.5	-	1.0
Oystershells	0.9	0.6	0.3	0.6	-	0.5	-
Salt	0.3	0.3	0.3	0.3	0.3	0.5	0.3
Vitamin - trace mineral mix	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Growing cattle consumed cocoa-pod diets as much as they did the control diets even at the highest level of inclusion (60%) (Table 3). Pod dry-matter intake averaged 2.4% of body weight, while total dry-matter intake was about 3 to 4% of body weight.

Table 3. Cattle response to grain substitution with cocoa-pod.

	Diets						
	First trial			Second trial			
Parameters	Control 1	20% pod	40% pod	Control 2	30% pod	50% pod	60% pod
Dry-matter intake (kg/day)							
- Cocoa-pod	-	1.4	3.2	-	1.7	2.3	3.3
- total feed	5.2	5.5	5.6	5.3	5.2	4.6	5.6
Growth rate (kg/day)	0.8	0.6	0.5	0.7	0.6	0.4	0.2
Feed / gain	6.5	9.2	11.2	7.6	8.7	11.5	28.0

There was a negative correlation between level of dietary pod and growth rate and efficiency of utilization parameters (Figure 1). Thus, growth rate declined and feed conversion became less efficient as dietary pod level increased. A regression of dietary pod level on growth rate gave the following equation, Y = 0.82 - 0.009X, with an r value of -0.97 where Y = growth rate and X = dietary pod level. A similar trend of decreasing dry-matter digestibility with increasing dietary pod level, mainly due to the low digestibility of pod dry-matter (23%) is indicated in Table 4.

Table 4: Digestibility of cocoa-pod based diets by ruminants (%).

	% dietary cocoa-pod (cattle)			% dietary cocoa-pod (sheep)						
Nutrients	0	20	40	0	15	30	45	60	75	100[1]
Dry-matter	76.9	62.3	58.6	19.7	76.7	66.1	53.1	50.0	35.8	22.7
Organic matter	-	-	-	80.6	78.0	67.6	54.0	49.0	36.5	22.9
Crude protein	73.0	62.7	57.2	73.2	72.3	70.4	60.9	61.6	56.8	50.8
Acid-detergent fibre	53.8	38.7	35.2	-	-	-	-	-	-	-

[1] By extrapolation.

At the end of these first series of experiments, it was possible to identify a number of constraints that might reduce the effective utilisation of cocoa-pod as a feed ingredient, or make the adoption of feeding strategies built around cocoa-pod difficult. These constraints can be described as being physical or nutritional.

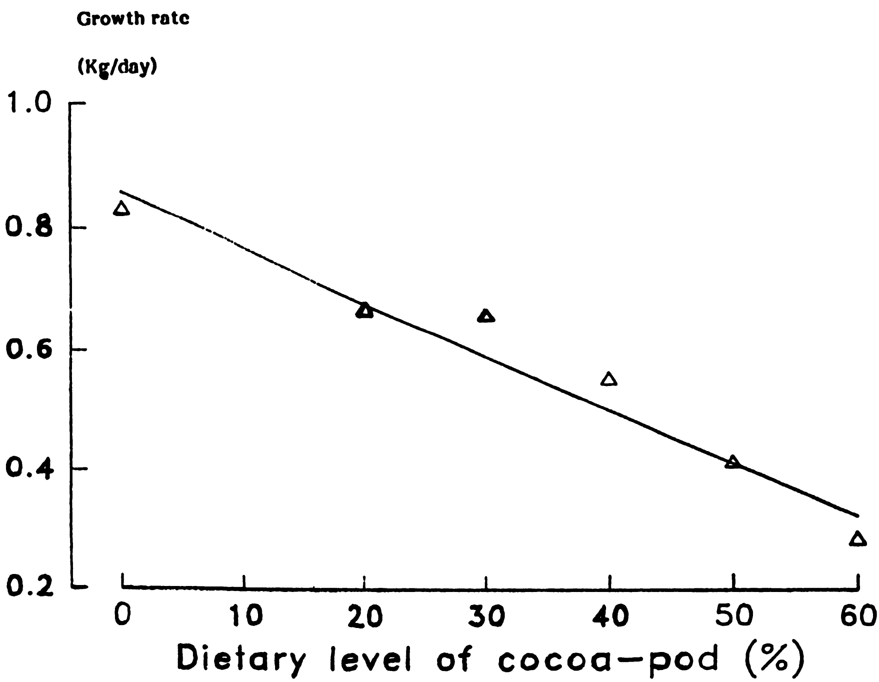
Strategies for eliminating physical constraints

As indicated earlier, about one million tonnes of cocoa-pods are generated annually on Nigerian cocoa plantations. It is difficult to assess what amount is available for animal feeding. Most of the available pod is annually wasted because cocoa-growing and processing is to a large extent carried out by individual smallholders scattered all over the cocoa-producing area. Many of the farms are not easily accessible, and when accessible may not produce enough pods to encourage setting up a collection service. The lack of easily accessible processing centres in areas where large amounts of pod can be collected is one of the major constraints to the utilization of pod as animal feed.

Smith (1984) indicated that transportation costs for collecting pods from sites of production to the site of utilisation accounted for 78% of the total cost of producing a tonne of dried pod for feeding. The farther apart the production sites are from each other and from the sites of utilisation, the higher the transportation costs, and the less attractive the use of pod will become.

If it were possible to centralise cocoa processing, a large part of the constraint of collection and transportation could be overcome. This, however, does not appear feasible. A more practical solution would be to use the pod at or near the site of production. The major target users would therefore have to be the cocoa farmer or his neighbour keeping a few goats and sheep. On the other hand feed manufacturers who may want to use the material in compounded ruminant diets or as an energy diluent in pellets or finishing swine feeds may contract cocoa farmers to supply dried pods once or twice a year, much as maize growers now supply maize to feed manufacturers.

Figure 1. Correlation between level of dietary pod and growth rate.



Cocoa-pod has to be processed before being fed to livestock. Processing requirements are minimal, but may still constitute a constraint in the rural setting. The material contains up to 75% moisture and may have to be dried before feeding. However, drying may not constitute any constraint, since the major cocoa harvesting period coincides with the dry season, and the pods can easily be sun-dried. After drying, it has to be reduced to appropriate particle sizes for livestock by grinding.

Three different types of hammermills have been used to reduce the particle size and these have proved suitable. Grinding, where it requires electricity, may constitute another constraint in a village setting. Nevertheless, when properly dried, cocoa-pod is very brittle, and can be easily broken up into small particles by trampling. It is possible to reduce particles to sizes small enough to feed with other ingredients. On the farm, trials need to be carried out to evaluate this in terms of acceptability to both the farmer and the animal.

Strategies for eliminating nutritional constraints

The generally low nutritional value of cocoa-pod is a major constraint to its being used efficiently as animal feed. It is low in protein (6%) and high in cell wall components (57% ADF, 66% NDF and 24% lignin) (Smith et al, 1987). This poor nutrient profile accounts for its low rumen degradability ($T1/2 = 288$ hr) and overall poor digestibility, and may constitute a constraint to optimally utilising the material as a feed ingredient. Two proven strategies are suggested as remedies to this nutritional constraint - chemical treatment and supplementation.

Alkaline treatment of cocoa-pod

Chemical treatments of fibrous crop residues, similar in composition and nutritive value to cocoa-pods, have reportedly improved their utilisation to such an extent as to make their utilisation as feed ingredients feasible and profitable (Jackson, 1977; Doyle et al, 1986). None of the proven chemicals such as sodium hydroxide, calcium hydroxide, potassium hydroxide and ammonia are suitable for our target users because of the high cost and scarcity of the chemicals and hazards associated with their use. A suitable alternative which, under limited testing, appears as effective as sodium hydroxide is the caustic ash solution of some crop residues. Cocoa-pod ash, for example, contains about 44 mg of potassium per kg, and according to Adebowale (1985) the ash solution contains about 21 and 29% OH ions in the form of NaOH and KOH respectively.

This property was effectively exploited by Smith et al (1987) who used different concentrations of cocoa-pod ash solutions as a chemical to treat cocoa-pod in an attempt to improve its feed value. As shown on Table 5, a linear increase in the rumen degradability of cocoa-pod treated with its own ash solutions of increasing concentration was observed. More significantly, the improvement in rumen degradability obtained by cocoa-pod ash solution treatment was similar to that obtained by using NaOH solutions of equivalent alkalinity. The authors also reported that treated cocoa-pod-based diets were better digested by both goats and sheep than untreated pod-based diets (Table 6).

Table 5. Rumen degradability of treated cocoa-pod.

Nutrients	% NaOH solution				% pod ash solution			
	2	4	6	8	2	4	6	8
Dry matter	34.8	41.1	47.6	52.6	37.2	46.3	54.8	55.4
Acid-detergent fibre	24.6	33.8	38.6	42.5	26.7	35.9	44.2	46.6
Neutral-detergent fibre	15.0	25.9	35.7	36.5	15.3	29.8	44.7	41.7

Table 6. Digestibility of treated cocoa-pod by goats and sheep (%).

	Sheep		Goats	
	Control diet[†]	Test diet	Control diet	Test diet
Dry matter	45.2	54.5	46.3	59.8
Acid-detergent fibre	12.4	30.7	31.0	36.2
Neutral-detergent fibre	15.6	39.5	37.9	40.2

[†] Control diets contained 50% untreated cocoa-pod, while test diets contained 50% treated cocoa-pod. Other ingredients are as shown on Table 2. (50% cocoa-pod diet).

This treatment method has the potential to remove a major constraint to the efficient utilisation of cocoa-pod as a livestock feed. The technology should be attractive to cocoa-farmers who generate cocoa-pod on their farms. The technology involved is simple, and the farmers are used to handling the ash which is used locally as a base for soap manufacture. Another treatment method which may improve the feed value of pod, is ensiling pod with poultry manure or urea. Both manure and urea would liberate ammonia which has been shown to effectively improve the utilisation of fibrous residues through ammoniation of cell walls (Doyle et al, 1986). We have, however, not evaluated this technique.

Forage supplementation

A second strategy suggested for eliminating the nutritional constraint associated with the feeding of cocoa-pod is that of supplementation with suitable forage to enhance rumen function. According to Preston and Leng (1981) supplementation of crop residue based diets with fermentable nitrogen and forages will ensure an adequate rumen ecosystem that will improve the utilisation of the residue.

Tables 7 and 8 show the results of two forage supplementation studies that were carried out in sheep and cattle.

Table 7. Effect of forage supplementation of cocoa-pod-based diet on nutrient digestibility by sheep.

Item	Control sheep[1]	Test sheep
Feed intake (gDm/day)		
Basal diet	735.0	645.0
<u>Centrosema</u>	-	19.0
Total	735.0(80g/kg $W^{0.75}$)	664.0(70g/kg $W^{0.75}$)
Digestibility (%)		
Dry matter	57.0	60.0
Organic matter	59.6	61.0
Crude fibre	34.0	37.0
T1/2 of dry matter (hrs)	288.0	182.0

[1] Both control and test sheep were fed a 50% cocoa-pod-based diet. Test sheep were offered freshly cut <u>Centrosema</u> daily.

Table 8. Response of cattle fed on cocoa pod-based diets to *Gliricidia* supplementation.

Item	Control cattle[1]	Test cattle
Feed intake (kg DM/day)		
Cocoa-pod	4.6	4.6
Gliricidia	-	0.2
Total	4.6	4.8
Daily gains (kg/day)	0.4	0.4
Feed/gain	11.5	12.0

[1] Control and test cattle fed 50% cocoa-pod-based diet. Test cattle were offered freshly cut *Gliricidia* daily.

In the sheep study, some improvement in the utilisation of the pod-based diet due to forage supplementation was obtained, although poor-to-medium quality *Centrosema* was used, in order to simulate the quality likely to be available to target users. Better forage material may therefore further improve cocoa-pod utilisation. We could not confirm the above speculation with the cattle study because of poor intake of *Gliricidia* by the test cattle. We conclude, as suggested by Preston (1982) that for forage supplementation to enhance the utilisation of crop residues, the forage should be of good and digested. Although we have not experimented with fermentable nitrogen supplementation of cocoa-pod-based diets, theoretical considerations suggest that the strategy may enhance cocoa-pod utilisation.

CONCLUSION

All of the strategies suggested for alleviating the physical and nutritional constraints to the efficient utilisation of cocoa-pod in ruminant diets were carefully selected to ensure that they are within the reach of the target users - the small-scale farmer. Some of these strategies have been evaluated on an experimental basis, and results obtained showed that they have the potential to achieve the set objectives. These, as well as those yet to be evaluated need to be tested on farm in order to fully assess their value.

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COCOA-POD SILAGE AND COCOA-POD GRASS SILAGE IN GOAT AND SHEEP NUTRITION

F. O. Olubajo,[1] M.M. Asonibare[1] and
E. O. Awolumate[2]

[1] Department of Animal Science, University of Ibadan
Ibadan, Nigeria

[2] Cocoa Research Institute of Nigeria (CRIN), Idi-Ayunre
Ibadan, Nigeria

ABSTRACT

Six digestion trials were conducted with West African Dwarf bucks and Dwarf rams to study the utilisation of cocoa-pod silage and of graded levels of cocoa pod - elephant grass silages consisting of the following treatments : (1) 100% elephant grass silage (control); (2) 50:50; (3) 25:75; (4) 15:85; (5) 10:90, grass : cocoa-pod (fresh basis), respectively; and (6) 100% cocoa-pod silage.

The cocoa-pod silage contained approximately 5.7% crude protein (CP), 22% crude fibre (CF) and a mean energy value of 4.4 kcal/g in contrast to the grass silage with a composition of 4.8% CP, 32% CF and 4.7 kcal/g of energy.

Results indicated that on metabolic-weight basis more digestible dry matter (DDM; $P<0.01$), digestible energy (DE, $P<0.001$) cellulose or hemicellulose was consumed from the control diet. Intake of digestible nitrogen was also significantly ($P<0.001$)higher for the contol diet than for any of the silages. More nitrogen (N) was excreted when either treatment 2 or treatment 3 was fed indicating that the N content of these treatments was metabolised less efficiently while N - retention was similar and slightly positive for all treatments.

Sheep consumed more ($P<0.001$) DM and energy, and significantly ($P<0.05$) higher DM and DE than goat. Both species were similar in their intake of digestible N. However, more N ($P <0.01$) was excreted by sheep showing that this

species metabolised the N content of the diets less efficiently. Nitrogen retention by both species was similar. Additional sources of protein supplement are required in all diets for better performance.

INTRODUCTION

Cocoa-pod is a by-product of the cocoa harvesting industry. It forms about 80% of the cocoa fruit and it is essentially a waste product except for the negligible amount used in the manufacture of local soap. Oguntuga (1975) and Awolumate (1982) have given chemical composition of cocoa-pod while Adeyanju et al (1975a,b) have reported the use of the dried pod as a substitute for maize in swine ration, in milk production of dairy cows and in the maintenance ration of sheep and goat or at various levels in the starter diets of chicks up to six weeks of age (Adegbola et al 1977).

The object of this investigation was to study the nutritive and replacement values of fresh cocoa-pod silage and cocoa pod - grass silage.

MATERIALS AND METHODS

Silage preparation

The following silage treatments were prepared from fresh cocoa pods and elephant grass (*Pennisetum purpureum*) at a fairly advanced (full flower) stage:

1. 100% elephant grass (*Pennisetum purpureum* as control)

2. 50% grass + 50% cocoa-pod

3. 25% grass + 75% cocoa-pod

4. 15% grass + 85% cocoa-pod

5. 10% grass + 90% cocoa-pod

6. 100% cocoa-pod

For each batch of silage preparation the grass which was at the fairly advanced stage of growth was cut fresh, chopped into 2-6 cm lengths. Cocoa-pods were collected immediately the beans and mucilage were removed from the fruits, chopped into small bits and both grass and pods were weighed (on wet basis), thoroughly mixed and made to pass through a chopper and packed according to the ratio required in double-layered polythene bags fitted into 198-litre drums. After compressing thoroughly the content of each drum was sealed, weighted down with about 15-20 cm layer of dry earth and heavy stones and ensiled for at least 12 weeks before it was fed.

Representative samples were taken from each batch of fresh mixture for dry-matter determination and proximate analysis.

Digestion trials

Six animals consisting of three West African Dwarf bucks weighing between 20.0 and 23.2 kg (mean 21.4 $\pm$ 1.34 kg) and three West African Dwarf rams ranging from approximately 18.2 to 32.3 kg (mean 23.5 $\pm$ 6.26 kg) were used in the digestion trials.

The digestibility trial of the grass silage (control diet) consisted of 12 days of preliminary and seven days of collection periods while each subsequent feeding trial was of seven days of preliminary and seven days collection duration.

During the digestion trials each experimental animal housed in a digestibility crate designed for easy collection of urine, was harnessed with a faeces-collection bag four days before the commencement of actual collection. Each animal group was used as its own control and for each of the other treatment digestion trials.

The top 4 - 5 cm layer of silage in each drum was discarded and representative samples were taken from top to bottom, cut into small bits and after mixing well, subsamples were taken for dry-matter and pH determinations and for chemical analysis. During the first preliminary period each animal was offered 2.73 kg of the test diet on the first day and was increased as necessary to allow for *ad libitum* intake in subsequent days. During collection period the amount offered was restricted to about 95% of the mean intake of each animal during the preliminary period.

Each day's feed was offered between 0800 and 0830 hours and at 1600 hours. Fresh tap water and salt lick was supplied *ad libitum*. Faeces from each animal was collected twice daily just before the morning and afternoon feeds were offered, weighed, mixed thoroughly and approximately 20% from morning and afternoon collections composited and taken to the laboratory and treated like the samples of feed offered. Orts from the previous day's feed was collected once daily just before offering morning feed, weighed, mixed and representative samples were taken for dry-matter determination. Urine from each animal was collected and with 10 ml of H_2SO_4 in the last three days of each collection period. Total volume of urine excreted by each animal was measured every morning and 10% aliquot taken and bulked for the three-day period for nitrogen and energy determination. The urine samples were stored in a deepfreezer at -5^{o}C until required for analysis.

Analytical procedures

Dry-matter of the silages, faeces, and ort was determined by drying weighed duplicate samples in a forced air electric oven at 90^{o}C to constant weight. The pH was determined from squeezed silage juice samples by means of Radiometer Copenhagen glass electrode pH meter. Gross energy (GE) of feed and faeces was determined in a Gallenkamp ballistic bomb calorimeter using benzoic acid as standard. GE in urine was estimated by drying a known volume soaked in a pre-weighed ashless filter paper over P_2O_5 in a desiccator, re-weighed after drying, followed by bombing. The AOAC (1970) procedures were used for the determination of the proximate constituents in the feed, faeces and urine. Acid detergent lignin was estimated according to Van Soest (1963) and cellulose by the method of Crampton et al (1960). Statistical analyses were based on factorial design as described by Steel and Torrie (1960) with the six treatments serving as the main treatments, the species as subtreatments and the animals as replicates. Metabolisable energy was estimated by multiplying digestible energy by a factor of 0.81 (ARC, 1965).

RESULTS

The chemical composition of the pre-ensiled mixtures and of the resulting silages from them is shown in Table 1 and 2 respectively. The data in Table indicated that the mean dry-matter (DM) content of the elephant grass at harvest was slightly below the 30% or above known to result in silage of good quality. Increased replacement of the grass with fresh cocoa-pod led to decreased DM content of the pre-ensiled mixtures due to the high moisture content of the fresh cocoa-pod. Replacement of the grass with cocoa-pod resulted in an improvement in the N content of the silages by approximately 23.8% up to the 75% cocoa-pod inclusion and was slightly lower in the other treatments. Similarly, ensilage of cocoa-pod with elephant grass led to an increase in the nitrogen-free extract (NFE) but to a decrease in CF, lignin, and other constituents of the silages. Addition of cocoa-pod to grass did not improve fermentation of the grass as there was little or no difference between the pH values of the grass silage (control) and those of grass-cocoa pod silages. Ensiling cocoa-pod for a period of 12 weeks (or longer) showed little or no change.

Table 1. The proximate composition of pre-ensiled treatments (%).

	Treatment					
	1 100% grass	2 50/50	3 25/75	4 15/85	5 10/90	6 100%
Dry matter	28.84	22.55	19.02	18.84	20.99	18.20
Organic matter	85.57	88.01	92.09	91.25	89.16	87.35
Ash	14.43	11.99	7.91	8.75	10.84	12.65
Crude protein	7.65	7.62	7.51	7.49	7.59	6.46
Ether extract	2.35	1.95	1.93	1.75	0.94	0.90
Crude fibre	34.31	31.24	29.28	28.09	27.16	24.38
NFE	41.26	47.20	53.37	53.92	53.47	55.62
Lignin	8.23	7.60	7.18	7.85	6.44	2.29
Hemicellulose	25.21	21.95	20.76	18.12	22.03	22.12
Cellulose	30.90	26.62	26.75	24.51	24.78	25.31
Energy (kcal/g)	4.730	4.786	4.993	4.809	4.977	4.575

Table 2. Proximate composition of the silages (%).

	Treatment					
	1 100% grass	2 50/50	3 25/75	4 15/85	5 10/90	6 100% cocoa-pod
Dry matter	19.16	16.94	22.22	20.21	18.09	14.56
Organic matter	83.05	85.04	89.70	88.18	86.21	82.52
Ash	16.95	14.94	10.30	11.82	13.79	17.48
Crude protein	4.78	5.92	5.92	5.46	5.69	5.69
Ether extract	2.10	1.55	1.52	1.10	0.77	0.75
Crude fibre	32.21	29.35	27.24	26.10	25.12	22.40
NFE	43.96	48.22	55.02	55.52	54.63	53.68
Lignin	8.21	7.56	7.12	6.80	6.40	5.20
Hemicellulose	24.10	21.30	19.91	18.7	21.56	21.32
Cellulose	36.01	28.50	30.00	29.00	28.50	30.50
Energy (kcal/g)	4.714	4.675	4.984	4.592	4.837	4.374
pH	5.35	5.25	5.08	5.10	5.12	7.70

Feed and nutrient intake

On metabolic-weight basis (g/ kg $W^{0.75}$) mean daily consumption of DM and of DDM was significantly (P<0.01) higher for the control diet than for either the cocoa-pod silage or any of its combinations with grass (Table 3). The pattern of intake of digestible cellulose or hemicellulose was similar to that of dry-matter intake. The data in Table 3 also indicated that the mean DE. value of 212 kcal/ kg $W^{0.75}$ for the control diet was significantly (P<0.001) higher than the mean value of 73 kcal/ kg $W^{0.75}$ for the cocoa-pod silage. While the energy content of the grass silage was approximately 73% digestible the corresponding value for the cocoa-pod silage was approximately 33%.

The significantly (P<0.01) higher intake of dry-matter from the control diet by the experimental animals could be due to the intake of significantly higher (P<0.001) digestible energy from this diet (Table 3) when compared to any of the silages resulting from its combinations with the cocoa-pod. Blaxter (1961) have suggested that digestibility is an important determinant of ad libitum intake of feeds and that the amount of roughage consumed by sheep fed ad libitum, is closely related to the energy digestibility of the feed and that increased energy digestibility leads to increase in dry-matter intake.

The significantly lower energy and digestible-energy intake values obtained for the cocoa-pod silage and of the 15:85, and 10:90 grass/cocoa-pod silage was probably due to the lower energy value and the high moisture content of the cocoa-pod in these silages. Intake of energy from cocoa-pod silage which was 76% of the intake from the control diet resulted in only 34% of the digestible-energy intake of the latter.

Table 3. Mean daily intake of nutrients (g/kg $W^{0.75}$) by experimental animals.

Nutrient	Treatment 1	2	3	4	5	6	S.E
Dry matter	62.7^{a}	54.9^{bc}	57.0^{b}	45.6^{d}	48.8^{de}	50.9^{ce}	2.37^{***}
Digestible dry matter	40.7^{a}	25.9^{b}	27.7^{b}	22.6^{b}	19.9^{b}	26.7^{b}	5.46^{**}
Crude protein	3.0^{b}	3.3^{ab}	3.9^{a}	2.5^{c}	2.9^{bd}	2.9^{b}	0.12^{***}
Digestible crude protein	1.4^{a}	1.0^{b}	0.9^{bc}	0.5^{d}	0.6^{cd}	0.4^{d}	0.18^{**}
Cellulose	22.5^{a}	15.6^{b}	11.1^{b}	13.2^{c}	13.8^{c}	15.5^{b}	0.85^{***}
Hemicellulose	8.3^{a}	5.0^{b}	5.2^{b}	2.6^{cd}	2.6^{cd}	3.3^{bd}	0.12^{***}
Energy (kcal/ kg $W^{0.75}$)	292^{a}	257^{bd}	273^{ab}	209^{c}	236^{cd}	222^{c}	14.61^{***}
DE (kcal/Kg $W^{0.75}$)	212^{a}	124^{b}	138^{b}	101^{c}	101^{c}	73^{c}	15.91^{***}
ME (" ")	171^{a}	100^{b}	112^{b}	82^{b}	82^{b}	59^{b}	19.21^{***}

Values in the same row followed by the same letter are not significantly different.
** = $P<0.01$; *** $P<0.001$.

Nitrogen utilization

Though there was a significant ($P<0.05$) improvement of approximately 13% in the N intake of the 25:75 grass/cocoa-pod silage over that of the control diet (Table 4), intake of this nutrient in other silages with higher proportion of cocoa-pod was depressed. Similarly, substitution of grass with cocoa-pod did not significantly ($P>0.05$) depress the digestible N up to the 75% level of inclusion but significantly depressed digestible N at ($P<0.01$) about 75% level. Cocoa-pod contained the lowest amount of N. The degree of depression rose as the proportion or level of cocoa-pod increased. Similarly results of depressed intake of dry-matter and digestible nutrients when cocoa-pod was substituted for maize in either sheep and goat, swine or beef cattle rations, have been reported (Adeyanju et al, 1975a,b; Fraps, 1946; Adeyanju et al, 1977; Bateman et al, 1967; Glover et al, 1958).

Table 4. Nitrogen utilization by sheep and goat.

	Treatment						
	1	2	3	4	5	6	S.E.
N Intake (g/ kg $W^{0.75}$)	0.48^{ab}	0.52^{c}	0.54^{c}	0.40^{de}	0.44^{ae}	0.46^{a}	0.2^{***}
Output							
Faecal N (" ")	0.26^{b}	0.37^{a}	0.39^{a}	0.32^{ab}	0.35^{a}	0.39^{a}	0.04^{***}
Urine N (" ")	0.118^{a}	0.096^{ab}	0.118^{a}	0.053^{ab}	0.055^{ab}	0.050^{bc}	0.03^{**}
Absorbed N(" ")	0.22^{a}	0.16^{ac}	0.15^{ac}	0.08^{bc}	0.10^{b}	0.07^{b}	0.04^{**}
N retained(" ")	0.10^{a}	0.05^{a}	0.03^{a}	0.03^{a}	0.04^{a}	0.02^{a}	0.04 N.S.
Retention as % of absorption	45	31	20	38	40	29	-

Values in the same row followed by the same letter script are not significantly different.

** = $P<0.01$; *** = $P<0.01$.

Nitrogen retention was positive, low and similar (P>0.05) for all treatments studied. Approximately 45% of N absorbed and 21% of N consumed was retained by the experimental animals when fed the control diet while the corresponding values for cocoa-pod silage were approximately 29% and 4% respectively. The relatively low N utilization from cocoa-pod silage of from any of its silage combinations could not be attributed to its concentration either in the pre-ensiled mixtures or in the resulting silages.

Sheep consumed more (P<0.001) dry-matter, nitrogen and energy and higher energy (P<0.05) than goat. Both species were similar in their intake of digestible N.

DISCUSSION

The low dry-matter (DM) content obtained for elephant grass is in agreement with the results of other workers elsewhere which have consistently shown that at between 4 and 8 weeks of regrowth the DM content of elephant grass is below 20% and at 24 weeks, when in full bloom, a mean of 36.7% was obtained in the humid zone of south-western Nigeria (Oyenuga, 1957; Olubajo and Oyenuga, 1974; Olubajo, 1981). The depressed dry-matter content of the pre-ensiled grass-cocoa-pod mixtures was as a result of the high moisture content of the cocoa-pod when compared to that of elephant grass (control), while cocoa-pod replacement led to an increase in nitrogen-free extract as a result of the higher content of this nutrient in the cocoa-pod. The slight decrease in the crude protein content of the ensiled products may be attributed to loss of volatile nitrogen products (such as ammonia) from protein fermentation. The high pH values of the silages are attributable to the limited available soluble carbohydrates in the ensiled mixtures as well as to the high ash content (alkali-forming cations Ca^{++}, K^{+} and Na^{+}) in the pre-ensiled mass most especially in the 100% cocoa-pod which may have inhibited or lowered the activities of acid-forming lactobacilli thereby limiting the level of lactic acid production in the ensiled mass.

The relatively low N utilization of cocoa-pod silage or of any of its grass silage combinations could not be attributed to its concentration either in the pre-ensiled mixtures or in the silages when compared with that of the control diet as its concentration was similar in all the treatments. It could however, be due to the presence of as yet unidentified inhibitors in the cocoa-pod. Awolumat (1982) was of the opinion that pesticides used in plant protection, tannins, theobromine and polyphenols if present in cocoa-pod can affect the voluntary intake, digestion and metabolism in animals. They also decrease palatability and digestibility of protein. Chlorogenic acid present in cocoa components is found to cause motor activity in ruminants and rats affecting decreased weight and feed conversion efficiency. This may account for the low values obtained for the cocoa-pod diets. The similarity in the digestible nitrogen and digestible dry-matter intake by sheep and goat obtained in the present study confirms similar reports by Adeyanju et al (1976), while the report of Burroughs et al (1950) showed that sheep utilized crude protein in cocoa-pod rations better than goat. They also reported higher apparent digestibilities of all feed nutrients studied, by sheep.

However, more nitrogen ($P<0.01$) was excreted by sheep in the present investigation, showing that sheep metabolised N content of the diets less efficiently. Nitrogen retention by both species was similar ($P<0.05$).

Though the period for each digestion trial was too short for any meaningful appraisal of the effect of the various diets on the live weight changes of the experimental animals, the limited data obtained during the experimental period indicated that despite the slight positive nitrogen retention by each species of animals from all treatment diets goats made significantly ($P>0.01$) more live weight gain on the average than sheep (+0.012g vs - 0.05g/ kg $W^{0.75}$) per head per day respectively.

CONCLUSION

The high moisture content of cocoa-pod and low soluble carbohydrate content resulted in silages of high pH and high moisture content.

Cocoa-pod kept for more than 24 hours becomes mouldy under humid conditions and results in mouldy, unpalatable silage when ensiled alone or in combination with grass.

These and the possibility of its commercial use as a source for furfural production may be the major constraints for its use as a source of animal feed in the future just as molasses has been diverted to the production of alcoholic drinks thereby making its cost prohibitive for inclusion in animal feed rations.

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THE EVALUATION OF BREWERS DRIED GRAINS (BDG) IN POULTRY RATIONS
1. BREEDER CHICKEN RATIONS

R. Fombad and J. Mafeni
Institute of Animal Research
Mankon, Bamenda, Cameroon

ABSTRACT

In an attempt to establish the optimum level of brewers dried grains (BDG) from a Cameroonian brewery that can be incorporated in breeder rations without adverse effect on productive performance, a study was carried out with 120 laying hens and 12 cocks of Isa Commercial breed. A complete randomised design was utilised in which the dietary treatments contained 0, 10, 20, and 30% levels of BDG was fed. Feed and water were provided *ad libitum* over the 5-month experimental period. Parameters such as egg production, egg weight, feed intake, albumen height, egg shell weight, semen quantity, fertility and hatchability of fertile eggs were measured.

Results showed that when BDG was fed at 30% level in the ration, the hen-day production (50.6%) was significantly ($P<0.05$) depressed than when the 0% level (56.2%), 10% level (56.9%) and 20% level (56.7%) were fed. There was a significant increase in egg weight with the increased level of BDG in the ration. Also the feed intake per bird per day was significantly ($P<0.05$) and progressively increased with increasing levels of BDG. No significant difference was noticed between treatments for ratio of shell weight to egg weight, albumen height and semen quantity for birds fed the 0,10,20 and 30% levels of BDG. Although the amount of feed to produce a dozen eggs increased significantly ($P<0.05$) as the level of BDG increased in the diet, it was noticed that the cost of feed required to produce a kilogram of eggs was progressively reduced as the level of BDG increased in the ration viz 455, 420, 406, 401 CFA (1US$ = 295CFA) for 0,10, 20 and 30% levels respectively. It would appear that the 30% level of BDG can be tolerated but the 20% level of BDG was most appropriate for breeder birds.

Constraints on the use of this by-product include bulkiness of the wet grains, drying procedure and its high fibre content.

INTRODUCTION

In Cameroon, one of the limitations to the expansion of the poultry industry is the high cost of protein and energy ingredients such as fish meal, decorticated cottonseed cake, maize and guinea corn. In order to reduce this high cost, efforts are being directed to the use of non-conventional feed ingredients. Brewers dried grains (BDG) a by-product of the beer industry might offer a suitable cheap substitute. Despite the increasing number of brewers in Cameroon, knowledge about the use of brewery by-products is almost non-existent. The problem facing most of the breweries is that of disposing the wet grains. Current disposal practices include free donations of wet grains to any interested persons staying within the 25-km radius from the brewery or payment of contractors by the breweries to collect and dump the bulky daily output of the wet grains. Currently the wet grains are used as manure, and a few farmers in the Western province feed it to pigs.

BDG however contains a wide variety of essential nutrients which are required in feed formulation for poultry. Couch (1978) and Ewing (1965) analysed some BDG samples and found that it contained over 20% crude protein, about 6% ether extract, over 15% crude fibre and about 4% ash. Almquist (1972) found that BDG contained 25% crude protein and that it was fairly rich in essential amino acids i.e. 0.9% lysine, 0.4% methionine, 0.4% tryptophane, 1.2% phenylalanine, 1.1% threonine and 1.6% valine. It is therefore higher in protein and amino acids than corn. Its use as animal feed does not call for competition between man and livestock as in the case of corn and other ingredients.

The use of BDG in poultry feed would not be without constraints. The product is collected with moisture content of about 80% which increases its bulkiness. It needs to be dried before incorporation in poultry rations. Sun-drying is the most common method used and this method requires large space and large polythene sheets for drying. During drying the wet grains have to be spread in a thin layer and frequently turned to avoid fermentation which could result in lowering the nutritive value of the by-product. The turning process is tedious and time consuming. The present study was conducted to evaluate the use of BDG in breeder poultry rations.

MATERIALS AND METHODS

A total of 120 laying hens and 12 cocks of Isa Commercial breed were used in this trial. The layers which had been in lay for 120 days were randomly divided into four equal treatment groups of 30 birds each and these were further divided into five replicate groups of 6 birds each. The cocks were divided into four dietary groups of 3 cocks each. The hens and cocks were placed in cages in pairs and singly, respectively. The wet grains were collected from Baffoussam, 90 km from Mankon Station and sun-dried for 72 hours on black polythene paper and stored in jute bags. Before the BDG and corn were used in the formulation of the rations, a sample of each was analysed for proximate composition and amino acid profile (Table 1a and 1b).

Table 1a. Proximate composition of brewers dried grains and corn (dry-matter basis).

Ingredient	Brewers dried grains	Corn
Crude protein (%)	27.7	9.1
Crude fibre (%)	15.7	2.9
Ether extract (%)	7.2	4.3
Ash (%)	3.8	1.2

Table 1b. Amino-acid composition of BDG and corn used in the rations.

Feedstuffs	Amino-acid composition (%)											
	Arginine	Cystine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Phenylanine	Threonine	Tryptophan	Tyrosine	Valine
Corn (yellow)	0.45	0.09	0.18	0.45	0.99	0.18	0.09	0.45	0.36	0.09	-	0.36
Brewers dried grain	1.30	-	0.50	1.50	2.30	0.90	0.40	1.30	0.90	0.40	1.20	1.60

A complete randomised design was utilised in which the four dietary treatments (Table 2) containing 0, 10, 20 and 30% levels of BDG were fed. In the formulation of the diets, the other ingredients were adjusted to maintain iso protein, energy, calcium and phosphorus levels as BDG was increased. Palm oil was used to balance the energy levels.

The birds were transferred to their cages and left for a week to adjust to the cage environment; within which period they were fed a normal layer diet without BDG. Thereafter, birds were fed for a week the experimental diet before data collection started. Feed and water were provided ad libitum and record for feed consumption was kept. Eggs were collected daily and records of daily egg production and egg weight for all replicate groups were kept through the five months duration of the trial. Average hen-day production was calculated. Two eggs from each replicate group were taken daily at random, weighed, broken and albumen height was measured as an indication for egg quality (using a Haugh Unit gauge). The egg shells from the broken eggs were washed and dried in an oven at 60°C overnight and weighed. The egg shell was expressed as a percentage of the egg weight.

Semen were collected from the cocks by the massage technique (Quin and Barrou, 1937). The semen quantity from each cock was measured, then the semen from the same dietary group was pooled and inseminated to the corresponding hens offered the same diet. Approximately 0.1 ml of whole semen (estimated to contain 8×10^8 spermatozoa, Yousif et al, 1984) was inseminated into each hen. The artificial insemination was done usually in the evenings, at about 4.00 p.m. when it was assumed that the hens have laid and it was repeated at intervals of 7 days.

Table 2. Composition of experimental rations.

Ingredient	% level of BDG			
	0	10	20	30
Corn (yellow)	63.5	57.5	49.5	42.3
BDG	0	10.0	20.0	30.0
Cottonseed cake	17.5	13.0	9.0	4.7
Fish meal	5.6	5.6	5.6	5.6
Palm oil	2.1	3.1	5.1	6.7
Bone meal	3.0	3.0	3.0	3.0
Calcium carbonate	7.1	6.6	6.6	6.5
L-Lysine	0.2	0.2	0.2	0.2
Layer concentrate[1]	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
Total (kg)	100	100	100	100
<u>Analysis</u> <u>(dry-matter basis</u>)				
Crude protein (%)	17.8	17.7	17.7	17.8
Crude fibre (%)	3.5	4.4	5.3	6.2
ME (kcal/kg), calculated	2949.9	2931.3	2931.3	2929.5
Calcium (%)	4.4	4.5	4.5	4.4
Phosphorus, total (%)	0.78	0.77	0.77	0.75

[1] SADE (Cameroon) layer concentrate supplied per kg the following:

Vitamin A 9000 IU; vitamin D_3 1800 IU; vitamin E 14.4 mg; Vitamin K 1.4 mg; vitamin B_1 1.0 mg; vitamin B_2 4.1 mg; Vitamin PP 18 mg; calcium patothenate 9 mg; vitamin B_6 1.8 mg; Vitamin B_{12} 0.02 mg; folic acid 0.7 mg; biotin 0.06 mg; choline chloride 300 mg; BHT antioxidant 120 mg.

The eggs from each dietary group were marked after collection, identification and stored in a cool room (18°C) for two weeks before incubation. On the seventh day of incubation the fertile eggs were detected by candling the eggs using a locally made candler. The hatchability was calculated by the number of fertile eggs.

The different rations were analysed for their proximate analysis using methods outlined by A.O.A.C. (1975). Data collected were subjected to statistical analysis (Steel and Torrie, 1980) and significant means were tested according to Duncan's Multiple Range Test (Duncan, 1958).

RESULTS AND DISCUSSION

The results on the laying performance (Table 3) show that feeding up to 20% of BDG did not significantly affect the hen-day production. However, the laying performance was significantly ($P<0.05$) depressed when the ration containing 30% BDG was fed. The average hen-day production percentages for the 0, 10, 20, and 30% levels of BDG were 56.20, 56.88, 56.65, and 50.59, respectively. These results are contrary to the findings of Onwudike (1981) who reported that the laying performance was not significantly affected when BDG was fed up to 40%. Although the amino acid levels of diets were increasing as the BDG levels in the rations increased, the fall in egg production at 30% levels of BDG in the ration may be caused by high crude fibre level of the ration at this level.

Table 3. Calculated amino acid composition of experimental diets.

Amino acid	Level of BDG (%) in the rations			
	0	10	20	30
Arginine	1.25	1.12	1.09	1.04
Cystine	0.26	0.48	0.49	0.48
Histidine	0.45	0.40	0.38	0.37
Isoleucine	0.79	0.85	0.90	0.94
Leucine	1.75	1.90	2.03	2.14
Lysine	0.96	0.95	0.96	0.96
Methionine	0.27	0.28	0.33	0.38
Phenylalanine	0.87	0.85	0.82	0.80
Threonine	0.65	0.65	0.65	0.66
Tryptophan	0.21	0.21	0.22	0.23
Tryrosine	0.09	0.21	0.33	0.45
Valine	0.79	0.84	0.88	0.93

The egg weight progressively increased with the level of the BDG in the rations. Birds fed the ration containing 10% level of BDG laid significantly ($P<0.05$) larger eggs than those on the control ration (62.30 versus 60.76 g respectively). Also feeding 30% level of BDG significantly ($P<0.05$) increased the egg weight (63.95 g) as compared to (62.30 g) in the ration containing 10% level of BDG. There was, however, no significant difference in egg weight for birds fed the 20 and 30% levels of BDG. The improved egg size may be due to the increase of amino acid pattern (Table 4) caused by increased

BDG levels in the rations which may increase the egg protein synthesis and hence larger egg sizes. This could be in part as a result of higher linoleic acid level which correspond to higher BDG levels. Bragg quoted by North (1972) stated that increasing the linoleic acid in chicken diets could raise the deposition of polyunsaturated fatty acids in the egg yolk from a basic level of about 5% to approximately 28%. The average feed intake per bird per day significantly ($P<0.05$) increased with increasing levels of BDG. The average feed intake for the 0, 10, 20 and 30% levels of BDG were 100.71, 111.69, 122.97 and 130.51 g respectively. This same trend was noticed by Owudike (1981). The trend in feed intake could not be related to the energy levels of the rations since the rations were about iso caloric. One of the possible reasons for this difference in intake could be the greater tendency for the birds to spill the feed in search of grains when higher levels of BDG were fed.

There were no significant differences noticed between treatments for the ratio of shell weight to egg weight, albumen height and semen quantity for birds fed the 0, 10, 20 and 30% levels of BDG. The egg shell did not then contribute to the difference in egg weight. The various levels of BDG did not also affect the quantity of semen produced by the cocks. Although the fertility percentage increased with increased levels of BDG in the rations (Table 4) this increase was not significantly different between dietary treatments. The percentage hatch of fertile eggs increased by the increase in the level of BDG in the diets. The hatchability for fertile eggs from birds fed BDG was significantly ($P<0.05$) greater than those of the control group (Table 4).

Table 4. Effect of feeding brewer dried grain on breeder chickens performance.

Traits	Levels of BDG (%)				
	0	10	20	30	$\pm$ SEM^{+}
Av. hen-day production (%)	56 .20^{a}	56.88^{a}	56.65^{a}	50.59^{b}	1.33*
Av. egg weight (g)	60.76^{c}	62.30^{b}	62.51^{ab}	63.95^{a}	0.42*
Av. feed intake/bird/day (g)	100.71^{d}	111.69^{c}	122.97^{b}	130.51^{a}	1.67*
Ratio of shell weight:egg weight (%)	9.59	9.87	9.88	9.40	0.210^{ns}
Albumen height (haught unit)	101.68	101.15	102.39	104.87	1.109^{ns}
Semen quantity/cock (ml)	1.41	1.01	1.05	1.13	0.153^{ns}
Fertility (%)	58.51	59.33	58.81	58.94	1.23^{ns}
Hatch of fertile eggs (%)	67.20^{c}	75.84^{b}	80.93^{a}	81.32^{a}	1.30*

Means with the same superscript are not significantly different at ($P<0.05$).

* = significant differences among treatment means ($P<0.05$).

ns = no significant differences.

SEM = standard errors of means.

However, the hatchability for the 20 and 30% levels of BDG in the rations was significantly (P<0.05) greater than those of 10% levels of BDG (80.93, 81.32 versus 75.84%, respectively). Kienholtz and Jones (1967) attributed this improved fertility and hatchability of fertile eggs to an unidentified factor in BDG.

A view of the economic analysis of feeding (Table 5) shows that feeding above 20% level of BDG significantly (P<0.05) increased the amount of feed required to produce a dozen eggs. It was also noticed that the cost of feed required to produce a kilogram of eggs was progressively reduced for 0, 10, 20 and 30% levels of BDG in the rations. The cost was 455, 420, 407, 401 CFA respectively. This reduction in price with increase in the level of BDG was a result of the fact that BDG cost was less than corn, 40 vs 100 FCFA a kg, respectively.

Table 5. Economic analysis of feeding BDG to breeder birds.

Economic analysis	Levels of BDG (%)				
	0	10	20	30	±SEM
Cost/100 kg of ration (CFA)[1]	15,698	15,013	14,529	13,982	
Cost of feed/dozen eggs (CFA)	315	328	393	479	
Cost of feed/kg eggs (CFA)	455	420	406	401	
Kg feed/dozen eggs[2] (kg)	2.01[b]	2.19[b]	3.04[a]	3.43[a]	0.065

Means with the same superscript are not significantly different at (P<0.05).

[1]295 CFA is equivalent to 1 US dollar.

[2]Only the kg feed/dozen eggs was analysed statistically.

CONCLUSION

The results showed that 30% level of BDG can be tolerated in layer diets but 20% level of BDG in the rations would be the most appropriate level for breeder birds. With the high fermentation properties of the wet grains drying should be done only in the dry season and it is hoped that drying houses would be designed to dry the wet grains in the rainy season. This is to assure an all year round dried grains that would not stand the risk of contamination as a result of long storages.

The major limitation to the use of this by-product in poultry rations was its high fibre content. The high fibre content resulted in lower digestibility of the rations containing high amounts of BDG.

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EFFECTS OF INCORPORATING RUBBER SEED MEAL SUPPLEMENTED WITH BLOOD MEAL IN BROILER RATIONS UNDER TRADITIONAL CONDITIONS

Nouke and H.N. Endeley
C.R.Z. Wakwa, B.P. 65, Ngaoundere-Cameroon
Ministere de l'Enseignement Superieur et de la
Recherche Scientifique (M.E.S.R.E.S.)
Direction Generale, Yaounde, Cameroon

ABSTRACT

A trial was carried out to investigate the effects of the incorporation of rubber seed meal supplemented with blood meal as sources of plant and animal protein on the performance, feed intake and the carcass of poultry birds from day-old chicks to 12 weeks under traditional system of management.

Unsexed 300 Jupiter chickens were randomly divided into 4 groups each of 75 birds. Four diets representing different levels of rubber seed meal (RSM) and blood meal (BM):- R0 with 0% RSM and 0% BM; R10 with 10% RSM and 8% BM; R20 with 20% RSM and 6% BM and R30 with 30% RSM and 4% BM were fed _ad libitum_ throughout the experimental period. Results showed significant differences between treatments indicating the superiority of the diet supplemented with 30% RSM and 4% BM.

INTRODUCTION

During the past years the world's population has greatly suffered from food problems, and more particularly from protein deficiency in the diet. According to the Food and Agriculture Organization (F.A.O., 1982) a third of humanity suffers from quantitative malnutrition. This is crucial in Africa where the daily ration of 11 grammes of protein is far from the physiological minimum of 30 grammes as recommended by the F.A.O. In order to solve this problem of animal protein deficiency, developing countries have to improve on their animal husbandry. This could be done by good managerial techniques, and by improving the plane of nutrition. Alternative sources of feed ingredients should be found which are not utilised by the human population and which, at present, might not have found wider use in animal feeding.

The objective of this study was to investigate the effects of the incorporation of rubber seed meal supplemented with blood meal as source of protein in broiler rations in replacement of cottonseed cake and groundnut cake under stimulated traditional management conditions on chicken growth, feed consumption, efficiency of feed utilisation, mortality rates and the characteristics of the carcass often slaughtered.

MATERIALS AND METHODS

These studies were conducted in the teaching research farm of the National Advanced School of Agriculture (N.A.S.A) at Nkolbisson (Yaounde, Cameroon).

Animal material and lodging

Unsexed 300 Jupiter day-old chicks weighing an average of 36.24 ± 4.01 g were used in this study.

These chicks were randomly divided into 4 groups each of 75 chicks corresponding to 3 levels of experimental rations and a control group. The groups were shared into identical lodges measuring 4x2 meters made of wood, the roof covered with zinc and a concrete floor covered with wood sharings. Around each lodge was a pasture surrounded with wire meeting. Heating during the starter period was done using two paraffin lamps per lodge.

EXPERIMENTAL RATIONS

Preparation of blood meal

The used blood was collected from the Central Abattoir in Yaounde immediately after cattle were slaughtered. After collection, the blood was boiled immediately in a cask for 45 or 60 minutes in order to let water evaporate and destroy any parasites. After boiling it was then dried in an oven at 68-83°C for 5 to 6 days, and then ground into flour.

Preparation of rubber seed meal

The rubber seeds were bought from the local market. After manual decortication, the kernels were boiled for 45 min. to reduce the potential toxicity. They were then dried at 55°C for 72 hours and later ground into brown flour.

Diet formulation and chemical composition of these diets are presented in Table 1 and 2, respectively.

Table 1. Composition (%) of the experimentals diets.

Diet ingredients	R0	R10	R20	R30
Maize	60	50	36	24
Wheat bran	8	20	26	30
Concentrate	10	10	10	10
Cottonseed cake	10	-	-	-
Groundnut cake	10	-	-	-
Rubber seed meal	-	10	20	30
Blood meal	-	8	6	4
Phosphate dialcaline	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

Table 2. Chemical composition of the experimental rations (calculated).

Composition (%)	Rations			
	R0	R10	R20	R30
Dry matter	88.36	87.05	88.30	88.66
Crude protein	20.70	21.20	21.00	20.00
Crude fiber	3.70	2.34	2.47	2.58
E.M.A.	4.72	7.20	10.74	14.32
Ash	5.37	5.05	5.28	5.47
Ca	1.25	1.28	1.28	1.21
P	0.86	0.84	0.89	0.98
Energy (cal)	2846	2986	3030	3115

N.B. R0 ration with 0% of rubber seed cake and 0% of blood meal.

R10 Ration with 10% of rubber seed meal (RSM) and 8% of blood meal (BM).

R20 Ration with 20% of RSM and 6% of BM.

R30 Ration with 30% of RSM and 4% of BM.

Management

Each experimental group was offered its corresponding diet ad libitum and they had free access to water. Hygienic conditions were followed to keep the drinkers and feeders always clean.

Feeds offered were weighed. At the end of the week the residues were weighed and deduced from the introduced amounts. The chickens were weighed weekly before being given food. All mortality cases were registered.

Carcass analysis

After the three-month experimental period, five chickens were taken from each group for carcass analysis. The following measurements were taken into account:

- Weight of blood
- Weight of edible carcass
- Chemical composition.

Data collected were statistically analysed using the randomised complete design, while significantly different means were identified using the Duncan Multiple Range test (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Chicken growth

a. Starter period

Table 3 presents the weekly weights of birds on each of the experimental diets. The highest growth was achieved on the control diet followed by diets R30, then R20 and R10. Statistical analysis revealed significant treatment effects on the growth performance of the birds ($P<0.05$).

It was observed that at the end of the experiment (12^{th} week), the trend of growth noticed during the starter period persisted during this period with groups R0 and R30 having higher average weekly body weights. Statistical analysis revealed significant differences between the average weekly weights in each treatment ($P<0.05$) as shown in Table 3.

Results obtained in this study showed that average weekly body weight increased with increasing levels of RSM during the starter and grower periods. Statistical analysis indicated significant differences between treatments. Buvanendran and Siriwardence (1970) reported that as incorporation levels of RSM went up to 30%; growth decreased. Rajaguru et al (1971); Tchounken (1982) and Nzumo (1983) also reported that growth decreased as RSM incorporation levels increased in poultry rations.

Table 3. Average weekly weights (g/bird) over the experimental period.

Weeks diets		1	2	3	4	5	6	7	8	9	10	11	12
R0	X	46.80	84.47	130.75	232.16	276.69	590.08	903.85	1143.36	1409.50	1627.08	1908.77	2211.47
							a						a
	SD	5.09	17.29	42.81	69.70	121.32	162.96	266.41	259.74	287.85	340.01	375.68	426.22
R10	X	43.54	67.51	90.60	130.68	206.57	272.30	396.02	553.05	789.05	985.92	1270.96	1498.03
							b						b
	SD	5.63	12.17	24.64	41.01	67.01	98.80	114.29	177.20	200.28	966.40	299.73	135.86
R20	X	58.19	77.47	122.60	184.51	231.01	370.31	519.65	698.27	820.25	1105.25	1300.07	1556.14
							c						b
	SD	5.34	11.14	28.33	51.43	76.85	134.97	193.07	239.96	300.94	369.23	451.07	499.94
R30	X	54.95	83.03	127.68	182.92	269.62	408.76	633.30	768.19	1016.39	1266.30	1555.00	1795.00
							d						c
	SD	4.72	12.95	28.88	52.86	86.69	137.16	178.95	238.76	248.08	287.00	331.34	372.56

N. B. X = average weekly weight.
SD = standard deviation.
In columns 6 and 12 scripts with the same letters are not significantly different at $P<0.05$ levels.

Average weekly body weight gain

Table 4 showed that during the first 6 weeks the higher average weight gains were noticed in treatment R0 (control) followed by groups R30 and R20. No statistical differences ($P<0.05$) among treatments were observed, but the lowest average weight gain was recorded in treatment R10. During the second 6 weeks R0 continued as the superior treatment followed by R20 then R30. Statistical analysis showed that higher weight gains were obtained in treatment R0 and the lowest in R10 but·these differences were not significant. (Table 4). The total weight gain over the whole period showed significant differences between treatments R0; R20 and R30 ($P<0.05$). The individual weekly weight gains showed no significant differences between the four treatments except in group R10. These results agree with those of capital et al (1971).

Table 4. Average weekly body weight gain (g/poulet/week).

Diets	Starter period 1st-6th week	Finition period 7th-12th week	Entire period 1st-12th week
R0	$103.71 \pm 65.64_a$	$270.75 \pm 243.13_a$	$194.92 \pm 99.45_a$
R10	$33.87 \pm 21.45_b$	$180.45 \pm 47.55_b$	$121.82 \pm 81.84_b$
R20	$66.33 \pm 39.48_a$	$224.53 \pm 47.13_a$	$152.62 \pm 12.84_b$
R30	$68.56 \pm 37.71_a$	$222.49 \pm 47.72_a$	$152.52 \pm 88.10_b$

N.B. In column, numbers script with the same letter are not significantly different at $P<0.05$ level.

Feed consumption

Feed consumption increased when rate of blood meal decreased in the diets (Table 5). During the first period (1st-6th week) the group without seed meal recorded higher feed consumption. Statistical analysis revealed a difference between treatments R10 and R20 on the one hand and R30 and R20 on the other. In the 2nd six weeks the same trend of the 1st period continued but without significance.

Table 5. Average weekly feed consumed (kg).

Diets	Starter period 1st-12th week	Finition period 7th-12th week	Entire period 1st-12th week
R0	$289.94 \pm 16.47_{a}$	$980.51 \pm 14.17_{a}$	$622.98 \pm 34.01_{a}$
R10	$130.70 \pm 86.43_{b}$	$620.94 \pm 20.33_{b}$	$398.10 \pm 29.20_{b}$
R20	$189.00 \pm 81.88_{bc}$	$616.67 \pm 14.22_{b}$	$421.82 \pm 24.42_{bc}$
R30	$209.98 \pm 16.68_{c}$	$716.19 \pm 10.65_{c}$	$486.09 \pm 27.54_{c}$

N.B. In column, numbers script with the same letter are not significantly different at $P<0.05$ level.

Over the whole experimental period, it was confirmed that the blood meal combined with rubber seed meal had a depressing effect on feed consumption; a finding that agrees with Spring and Day (1981).

Efficiency of feed utilisation

Table 6 summarises the average weekly feed utilisation efficiency during the trial period. The best feed conversion was noticed in R0 and the lower in R20 with no significant differences between treatments. The present results confirmed those of Rajaguru et al (1971), and Tchounken and Tchouboue (1982). The starter period got the highest mortality (1%, 1, 6%, 0% and 0%) respectively for R0, R10, R20 and R30.

Table 6. Average weekly feed utilisation efficiency.

Diets	Starter period 1st-6th week	Finition period 7th-12th week	Entire period 1st-12th week
R0	$2.90 \pm 0.66_a$	$3.42 \pm 0.86_a$	$3.19 \pm 0.82_a$
R10	$3.87 \pm 1.50_a$	$3.41 \pm 0.70_a$	$3.59 \pm 0.90_a$
R20	$3.32 \pm 0.92_a$	$3.47 \pm 0.85_a$	$3.40 \pm 0.90_a$
R30	$3.05 \pm 0.17_a$	$3.39 \pm 0.92_a$	$3.23 \pm 0.71_a$

N.B. In column, numbers script with the same letter are significantly different at $P \leq 0.05$ level.

Carcass analysis

a. Edible carcass

The highest average edible carcass weight was recorded on R0 while the lowest was on Diet R10 as shown in Table 7. Statistical analysis revealed significant differences between treatments from R20 on the one hand and R30 on the other (P<0.05). Birds from the control group had significantly higher weight than those of the treatments. These results agree well with those of Tadle et al (1955).

Table 7. Edible carcass (kg).

Diets	Replications A	B	C	D	E	Mean (g)
R0	2462.70	2377.90	2178.00	2188.50	1996.20	2240.66_a
R10	1583.20	1602.30	1999.30	1762.60	1611.30	1631.74_b
R20	2128.70	1964.40	2317.80	1733.10	1991.80	2025.17_a
R30	2169.60	1653.10	2054.50	1617.80	1617.80	1819.02_b

N.B. In column, numbers script with the same letter are not significantly different at $P \leq 0.05$ level

b. Chemical composition

Chemical analysis of carcass showed that R30 gave the best result in terms of protein content. Fat content varied from 25.36% for R30 to 34.40% for R10 group. It would appear from the results that as rubber seed meal increased in the diets, the protein content of the carcass increased.

CONCLUSION AND RECOMMENDATIONS

From the results obtained in this investigation on the effects of incorporation of rubber seed meal (RSM) supplemented with blood meal (BM) as sources of protein in broiler rations under traditional management conditions, it appeared that the diet of 30% RSM supplemented with 4% BM gave the best results without any adverse effects on performance. It might be suggested from the present investigation that in future studies, it would be necessary to deal with the level of RSM supplemented with BM at levels less than 5%. This may provide more information on the effects of incorporation of these by-products in poultry rations.

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THE EFFECT OF WATER LETTUCE (*PISTIA STRATIOTES* L) AS A SUBSTITUTE FOR WHEAT MIDDLINGS IN BROILER FINISHING RATIONS

Y. Manjeli; J. Tchoumboue and J. Djoukam
Department of Zootechnie
Centre Universitaire de Dschang
Cameroun

ABSTRACT

One hundred 6-week-old broiler chickens with average weight ranging from 892 to 921 g were randomly distributed into 5 groups of 20 each in a completely randomised design. Each group was fed one of the following experimental rations containing 0, 5, 10, 16 and 20 % water lettuce (*Pistia stratiotes* L) as a substitute for wheat middlings for 4 weeks.

The best performance in terms of feed efficiency (2.74) was obtained with birds fed, the ration containing 10% water lettuce. The average daily weight gain was 44.56 g/day and cost per kg live weight gain was 284 CFA (US$ = 295 CFA in 1987).

This preliminary study indicated that 10% water lettuce may be recommended in finishing rations of broiler chickens.

THE USE OF ORGANIC MANURE IN AQUACULTURE. I. POLYCULTURE OF TILAPIA (OREOCHROMIS NILOTICUS) AND AFRICAN CATFISH (CLARIAS LAZERA) IN EARTHEN PONDS RECEIVING CHICKEN MANURE WITHOUT SUPPLEMENTAL FEEDING

D. Nguenga

Institute of Animal Research (IRZ)
Foumban Piscicultural Research Station
P.O. Box 255, Foumban, Cameroon

ABSTRACT

An experiment was conducted at the Foumban Piscicultural Research Station in order to evaluate the efficiency of chicken manure on fish yields. The polyculture was composed of Tilapia (*Oreochromis niloticus*) and African catfish (*Clarias lazera*). Three 400-m^2 ponds were used and loaded with 1.75 fish/m^2. Chicken manure was applied at a rate of 40 kg dry matter per hectare pond per day at the start of the experiment. Waste allowance was adjusted biweekly with an addition of 20 kg dry matter/ha. Ponds were manured 6 days a week. Cow manure (150 kg dry matter/ha) and mineral fertiliser, NPK 20, 10 and 10 (100 kg/ha) were applied alternatively at 2-week intervals in order to strengthen the effect of chicken manure. Throughout the experimental period no other supplemental feeds were added to the ponds. Additional water was only added to replace losses due to seepage. The mean survival rate was about 66%. Fish kills were probably due to predation by birds during the dry season. The total fish biomass was 3.4 tonnes per hectare per year. This zootechnical value reveals that Tilapia and Clarias can thrive on natural foods (the manures and NPK used) in ponds (zooplankton and phytoplankton) without other supplemental feeding.

GOAT KEEPING

Mrs. E. Tendo
BP. Mbengwi, Momo Division
Bamenda, Cameroon

I thank you for the opportunity given to me to speak to you about my goat farm. My husband and I are parents of eleven children. And so in 1946 I started rearing goats in order to help our large family have enough meat, especially during the Christmas and New Year celebrations. The second reason was so that I could get manure to apply to my yam and maize in my gardens. It helps greatly with more food and I use the same piece of land every year. I do not need to buy fertilizer. I started with 6 goats: 5 nannies and 1 buck. Now I have 24 adult females: 6 young females and 10 young males, in all a total of 40 goats. I do not keep milk goats because I have no labour.

When I started goat rearing my children and I used to tether or tie them singly in various places where we found good grass. In the evening, we would loosen and let them into an old abandoned house for the night. But we could not increase the number because of frequent transfers of my husband who was a civil servant.

When my husband retired in 1984, we acquired a large piece of land of our own. I then started to increase the number of our goats. We built a small fence and a goat shed for them. But we still tethered them wherever grazing was available and only brought them into the small fence and shed in the evening. This is now getting to be a big problem as I have to do the job alone when the children return to school.

In the rainy season there is enough grass around our compound for the goats but in the dry season there is not enough grass and they grow thin. In the dry season we let them drink once a day. We do this by taking water in a pan or basin to where we have tied them. We sometimes give them salt.

Recently, I heard from the research people that it was good to feed our goats with cassava peelings or waste, maize stalks, groundnut or haulms which we used to throw away or bury in the farm as manure. This advice has really helped our goats to grow well especially in the dry season when there is very little grass for the goats. Also in this way, I can keep the goats in the little fence and feed them with these farm wastes. It also reduces the burden of tying them and solves the problem of destroying food crops when they break open from the tethers.

I just allow them to breed on their own. That is, the buck lives with the nannies and mates them any time. I do not control the mating or breeding. And when I find a good male I buy it and sell the old one. The adult female produces a kid every year.

Usually when any of the goats has scabies or some other diseases I take them to the Veterinary Clinic for treatment. Sometimes I treat them myself, especially if it is diarrhoea, by using medicine for humans for this disease.

I usually take my goats to the local market and sell them when I need money. When my children come on holidays, I kill one to celebrate their good results. We eat some during Christmas and New Year celebrations. When I visit my children who are now married and working in Yaounde, I take a goat as a gift to them.

The big problem I face in goat farming is the lack of money to build a good large fence and a shed to keep the goats in permanently, for I really want to increase the flock up to over a hundred. It is very difficult for me to apply for a loan. I need technical advice on how to apply for a loan. I also need technical advice on how to build fences and a goat shed. The other problem is that there is no good grass in the dry season for the goats. I just let them eat whatever they can find. I am very happy about my goat farm because it helps us increase our family income, pay school fees, buy clothes, eat fairly adequately and solve other family problems.

I take this opportunity to thank the organisers of this workshop for giving me the chance to be here and the Ministry of Women's Affairs in Mbengwi, Momo, who have given me the encouragement to come to this meeting. Goat rearing is a traditional thing for men but now with their encouragement and advice many women will find it easy to keep goats. Thank you.

RECOMMENDATIONS OF THE FOURTH ANNUAL ARNAB WORKSHOP

1. The role of small ruminants as important utilizers of by-products should be recognised. Account should also be taken of their selective nature.

2. Caution should be exercised in extrapolating data from one species to the next, e.g. goats vs cattle, sheep vs cattle. It is recommended that more production studies involving the comparison of different species of equivalent physiological maturity be undertaken.

3. Development of simple machinery such as choppers or chaff-cutters would be beneficial in reducing by-product particle size and assist in the harvesting process. Collaboration with agricultural engineers on the design and use of appropriate machinery is called for.

4. Transport is recognised as a major constraint, both on-farm and on a regional basis where by-products may be located in a different area to livestock. This question will need to be addressed and where applicable integration of crop and livestock systems is recommended using a systems approach. It is also recommended that more thought be given to the transference of technology to farmers and extension personnel.

5. The limitations of conventional statistical methods in the design, execution and interpretation of on-farm livestock experiments needs to be addressed in order to come up with appropriate solutions.

6. ARNAB members are urged to consult expert statisticians or biometricians for help in the design and analysis of experiments. Where expert advice is not available in national agricultural systems (NARS) researchers may like to send their research protocols/proposals to ILCA, through the ARNAB Co-ordinator for advice and possibly subsequent analysis of data.

7. The importance of standardising feed description through the use of the International Network of Feed Information Centres (INFIC) system would be desirable so that ARNAB members speak the same "language". This would help to unravel the causes of a lot of conflicting results on apparently similar materials. It is suggested that ILCA/ARNAB act as the coordinator for this excercise.

8. The need to collaborate with agronomists to get information on grain: stover ratios in order to obtain accurate inventories of by-products is stressed and to get information on the roles and effectiveness of multipurpose food crops. Available data from FAO and from NARS should be used.

9. Research on harvesting and storage of crop residues should be encouraged and researchers pay attention to the economic, labour and other logistical problems which are likely to arise.

10. Processing of crop residues can improve utilization and there is a need to consider appropriate methodologies and technologies for different situations and locations. Some of the processing methods considered should include ensiling, drying, alkali treatment if economical, and hydration.

11. Antiquality factors which may limit the utilization of otherwise nutritive by-products need to be specified and quantified to enable appropriate solutions to be found.

12. Supplementation of by-product with appropriate materials has long been accepted as a way of improving utilization of these residues. The materials which may be used include:

    a) legume crop residues
    b) browse legumes, e.g. gliricidia, sesbania and leucaena
    c) forage legumes, e.g. lablab and others that may be appropriate in the mixed farming system
    d) NPN and protein nitrogen

e) energy e.g. molasses, bran and other agricultural industrial by-products such as oil cakes

f) mineral supplements.

13. There is a need to study the possible anti-nutritional factors of some materials cited above; i.e. supplementation of by-product with appropriate materials.

14. The use of by-products in non-ruminant feeding systems should be encouraged, but consideration should be given to toxic substances which may be passed, through animal products, to human beings.

15. Alternative and compatitive uses of by-products should be borne in mind so as to diversify research to other products which show more potential as livestock feeds.

16. Finally, there is a dire need to follow up recommendations of workshops through early implementation. It is recommended that ARNAB secretariat expedite the circulation of recommendations perhaps within two months of the Workshop, instead of waiting until the publication of the proceedings. It is also noted that in spite of reminders to the authors only a few papers were trimmed to the theme of the Workshop which was spelt out as "Overcoming constraints to the efficient utilization of agricultural by-products as animal feed". It is recommended that in future it is important to stick to the theme of the workshop to save time on editing.

LIST OF PARTICIPANTS

BOTSWANA

Berhane Kiflewahid
Animal Production Research unit
P.Bag 0033, Gaborone

BURKINA FASO

Kassu Yilala
Semi-Arid Food Grain Research and Development
Co-ordination Office, OAU/STRC
B.P. 1783, Ouagadougou

CAMEROUN

T. Beramgoto
Institute of Animal Research
Bambui Experimental Station
P.O.Box 80, Bamenda

R. Fombad
Institute of Animal Research
Mankon, Bamenda

R.T. Fomunyam
Institute of Animal Research
Mankon, Bamenda

J. Mafeni
I R Z Mankon,
P O Box 125, Bamenda

Y. Manjeli
Department zootechnie,
Centre Universitaire de Dschang
B.P. 96, Dschang

Cont'd
S.E. Mbomi
IRZ, Mankon, B P 125
Bamenda

D. Nguenga
Institute of Animal Research (IRZ)
Foumban Piscicultural Research Station
P.O.Box 255, Foumban

R.M. Njwe
Department of Animal Science
University Centre, B.P. 96, Dschang

M.Y. Nuwanyakpa
Bamenda Animal Feed Company
B.P. 428
Bamenda

Nouke
C.R.Z. Wakwa
B.P. 65, Ngaoundere-Cameroon
Ministere de l'enseignement superieur
et de la recherche scientifiqe (M.E.S.R.E.S)
Directeur Generale
Yaounde

C.W. Talbott
Heifer Project International
P.O.Box 467
Bamenda

E.N. Tambi
Institute of Animal Research
Bambui P.O.Box 80
Bamenda

E. Tendo
B.P. Mbengwi
Momo Division, Bamenda

Cont'd

EGYPT

M.A. El-Naga
Faculty of Agriculture
University of Alexandria
Alexandria

A.M. Nour
Department of Animal Production
Faculty of Agriculture
University of Alexandria, Alexandria

ETHIOPIA

E. Kabaija
International Livestock Centre for Africa
P.O.Box 5689, Addis Ababa

Lulseged Gebrehiwot
Institute of Agricultural Research
P.O.Box 2003, Addis Ababa

A.N. Said
International Livestock Centre for Africa
P.O.Box 5689, Addis Ababa

GHANA

D. Adomako
Cocoa Research Institute, P.O.Box 8
TAFO (Akim)

J.E. Fleischer
Department of Animal Science
University of Ghana
Legon, Accra

Cont'd

A.K. Tuah
Department of Animal Science
Faculty of Agriculture
University of Science and Technology
Kumasi

KENYA

B.H. Dzowela
PANESA-ILCA, P.O.Box 46847
Nairobi

J.A. Kategile
IDRC, P.O.Box 62084
Nairobi

E.K. Odhuba
Animal Production Research Centre, Muguga
Kenya Agricultural Research Institute
P.O.Box 21, Kikuyu

MALI

S. Debrah
ILCA, BP. 60
Bamako

MALAWI

J. A. Ayoade
Department of Animal Science
University of Malawi
P.O.Box 219, Lilongwe

L.P. Nkhonjera
Department of Animal Health and Industry
Lilongwe

Cont'd

NIGERIA

A.A. Adegbola
Department of Animal Science
Obafemi Awolowo University
Ile-Ife

O.J. Ifut
Department of Animal Science
University of Ibadan

F.I. Ogundola
Institute of Agricultural Research and Training
P.M.B. 5029, Moor Plantation
Ibadan

M.B. Olayiwole
National Animal Production Research Institute,
Ahmado Bello University, P M B 1096
Zaria

F.O. Olubajo
Department of Animal Science
University of Ibadan
Ibadan

O.B. Smith
Department of Animal Science
Obafemi Awolowo University
Ile-Ife

SENEGAL

K.P. Abassa
EISMV, BP 5077
Dakar

Cont'd

S. Fall
Departement de recherches sur les productions
et la sante animales
Institute Senegalais de Recherches
Agricole (ISRA)
Laboratoire national de l'elevage de recherches
veterinaires (LNERV)
BP 205, Dakar-Hann

SOMALIA

Nuh Hussein Sheikh
Department of Animal Production
Faculty of Agriculture
Somalia National University
P.O.Box 801, Mogadishu

SUDAN

T.A. Mohammed
Department of Animal Nutrition
Institute of Animal Production
University of Khartoum
P.O.Box 32, Khartoum

TANZANIA

K.M. Biwi
Ministry of Agriculture
Department of Livestock Development
P.O.Box 159, Zanzibar

M. Kabatange
Livestock Production Research Institute
Private Bag
Mpwapwa

Cont'd
A.J. Kitalyi
Livestock Production Research Institute
Private Bag
Mpwapwa

G.I. Mlay
Department of Rural Economy
Sokoine University of Agriculture
P.O.Box 3004, Morogoro

N.A. Urio
Animal Science and Production Department
Sokoine University of Agriculture
P.O.Box 3004, Morogoro

UNITED KINGDOM

E. Owen
Department of Agriculture
University of Reading
Earley Gate, P.O.Box 236, Reading RG6 2AT

ZIMBABWE

J.M. Chesworth
University of Zimbabwe
Department of Animal Science
P.O.Box MP 167, Mount Pleasant
Harare

L.R. Ndlovu
Department of Animal Science
University of Zimbabwe
P.O.Box MP 167, Mount Pleasant
Harare

S. Sibanda
University of Zimbabwe
P O Box MP 167, Mt Pleasant
Harare

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