RIU

Fussy eaters: improving the benefits of dry-season feed

Validated RNRRS Output.

A newly developed self-selection technique can boost the amount that stall-fed animals will eat. Sorghum stover is a traditional and important dry-season forage in countries like Ethiopia, Tanzania and Kenya. However, it isn't particularly nutritious or palatable—so animals often don't each as much as they should. Research has found, however, that giving animals much more stover than they need allows them to select the tastiest bits of feed. This means that they eat much more. Plus, the feed that they reject isn't wasted, because it can be treated with urea to make it more palatable and then fed to them again. Promoting this simple technique could make a real difference to the lives of smallholders who struggle to keep their animals healthy.

Project Ref: **LPP06:**
Topic: **2. Better Lives for Livestock Keepers: Improved Livestock & Fodder**
Lead Organisation: **Green, E. (Independent), UK**
Source: **Livestock Production Programme**

Document Contents:

Description

LPP06

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Ethiopia, Kenya,

Target Audiences for this content:

Livestock farmers,

A. Description of the research output(s)

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

'Self Selection' and other methods to improve quality of fibrous crop residues (cereal stover and straw) as stall-feed for ruminants

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Livestock Production Programme

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities.

R5188
Reading University (Prof Emyr Owen)
Institutional partners:
Institute of Grassland and Environmental Research, Hurley, UK (Dr A.B. McAllan, Dr Irene Mueller-Harvey);
International Livestock Centre for Africa (ILCA) (now International Livestock Research Institute, ILRI), Addis Ababa, Ethiopia (Prof A.N.Said);
Institute of Agricultural Research, Melkassa Station, Narzret, Ethiopia (Dr Y Kebede);
Alemaya University of Agriculture at Debre Zeit and Hararghe, Ethiopia (Dr G Makonnen and Dr Mulat)

*4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? **(max. 400 words)**. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

Sorghum is a drought tolerant cereal and staple for humans in semi-arid areas, e.g. **Ethiopia**, **Tanzania**, **Kenya**. In sorghum (and **maize** & **millet**), each tonne of grain also generates three to four tonnes of **fibrous crop residue**, i.e. **stover**, but its feeding value is low.

R5188 commenced in 1990 with a socio-economic survey in Eastern Hararghe, Ethiopian Highlands. Farmers stressed the importance of sorghum **stover as dry-season forage** and the need for adoptable **ways to improve feeding value**. Farmers used traditional (white) varieties but complained about **bird damage**. **Bird-resistant (pigmented) varieties** had been developed but were little used – pigmented stover was considered even less palatable than normal. Stover stems were used for fuel and building.

Ten bird-resistant and five traditional cultivars of sorghum were grown at two sites (Highlands and Rift Valley) in 1990 and 1991. Grain yields varied (0.2-3.2 t DM/ha), with differences between cultivar, site and year. **Grain**

yield of bird-resistant cultivars was more than twice that of traditional ones. Similarly, **stover yields** were highly variable (0.8-8.8 t DM/ha) with effects of cultivar, site and year, but there was no clear difference due to bird resistance. **Stover feeding quality varied** widely. The **nutritious leaf plus sheath fractions of stover** ranged from 0.23 to 0.62. Although there were differences due to variety, there was no clear relation between yield of stover and quality, nor between bird resistance and quality, except that bird-resistant cultivars had highest pigmentation (i.e. phenolic content) in the leaf sheath.

Leaf content of stover decreased after **storing** in a heap in the field for 16 weeks after harvesting, as is commonly practised. Stover when **stored in a barn showed no deterioration**. Storage did not affect phenolic content.

A '**Self Selection' stall-feeding strategy** was developed in experiments at ILRI Debre Zeit. Cattle and sheep, when offered twice as much stover as they would eat, consumed more (see table) and grew faster because they were **enabled to select the more nutritious leaf and sheath, and reject stem**. **Chopping improved intake in sheep**, but not cattle.

Stover offered (g/kg body weight daily)	Form of Stover	Relative intake of stover	
		Cattle	Sheep
50	Chopped	105	163
50	Unchopped	127	127
25	Chopped	97	110
25	Unchopped	100	100

With bird-resistant stover **`Self Selection' enabled sheep to reject the pigmented sheath**.

About half the stover (mainly stem) is rejected in `Self-Selection' stall-feeding. Rejected stover could be re-fed after **ammoniation with urea** (Methu,1998).

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	***Technology***	***Service***	***Process or Methodology***	***Policy***	***Other Please specify***
	X		***X***		

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

R5188 focused on improving sorghum stover for feeding ruminants (meat, milk, transport and draught animals). However, 'Self Selection' and other methods of improving quality are potentially applicable to most other fibrous crop residues from cereals (maize and millet stover, straws from wheat, barley and oats). The **potential**

application is therefore vast, throughout the developing world.

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options.
Leave blank if not applicable

Semi-Arid	***High potential***	***Hillsides***	***Forest-Agriculture***	***Peri-urban***	***Land water***	***Tropical moist forest***	***Cross-cutting***
X	*X*			*X*			*X*

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	***Irrigated***	***Wetland rice based***	***Smallholder rainfed highland***	***Smallholder rainfed dry/cold***	***Dualistic***	***Coastal artisanal fishing***
			X	*X*		

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**).*

9.1 R5188 focused on sorghum stover in Ethiopia, and demonstrated (1990-92) choice of cultivar, leaf stripping at 50% flowering stage, barn storage, `Self Selection' (for cattle and sheep) and chopping (sheep only) as methods of improving the stall-feed quality of crop residue.

9.2 Subsequent non-RNRRS research in Kenya (Methu, 1998, Annex 2, Reference 32), with maize stover, demonstrated that stover rejected (mainly stem) by cattle during 'Self Selection' could be improved by ammoniation via urea treatment, and then re-fed to cattle and other ruminants.

9.3 R6619 and R6610 demonstrated the usefulness of manual box baling for transport, storage and feed budgeting of maize stover and other dry forages.

9.4 Manual stripping of leaves and husk off maize stover and stall-feeding these more nutritious fractions were demonstrated in R6619.

9.5 R7351, R6610 and much other non-RNRRS research (e.g. reviewed by Buttery et al., 2005, Annex 2, Reference 23; Smith et al., 2005, Annex 2, Reference 56) demonstrated the importance of supplementing with protein and minerals when feeding crop residues.

9.6 **Much added value to R5188** would be achieved by integrating the methods listed in 9.1-9.5 into a basket of technologies to offer smallholder farmers using RIU approaches such as those described in R7955.

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the *circulated list of RNRRS outputs for which proformas are currently being prepared.*

In East Africa and Southern Africa, suggested clustering would be R5188, R6619, R7955 and R7351 (fibrous crop residues are deficient in available nutrients, particularly protein; R7351 involves a low-cost source of protein supplement).

'Self Selection' and other methods of improving crop residues (R5188) are relevant to 'Community based goat production in Kenya' (R7634) and also to 'Wambui' (R7425).

'Self Selection' and other methods of improving crop residues (R5188) are also likely to be relevant to the cluster 'Promotion of crop residues for fodder' (R8339, R7346, R8296) in India, to 'Smallholder dairying toolbox' (ZC0261) and to 'Small stock toolbox (ZC0243).

Validation

B. Validation of the research output(s)

10. ***How*** *were the output(s) validated and* ***who*** *validated them?*

Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation ***(max. 500 words)****.*

Sorghum cultivars were compared in on-station, statistically valid and analysed experiments, undertaken at two contrasting sites over two seasons, in Ethiopia.

Leaf stripping at 50% flowering stage and stover storage experiments were undertaken on-station, using statistically valid designs.

Statistically valid and analysed stall-feeding experiments were undertaken on-station, with growing cattle and sheep, to develop 'Self Selection' and measure the effect of chopping sorghum stover.

The results of the experiments were validated by on-station researchers and academic examiners (PhD thesis by Osafo, 1993, Annex 1, Reference 1).

Validation by researcher peer group was extensive as evidenced by the large number of publications from R5188 in national and international conference proceedings and scientific journals (Annex 1, References 2-14). Conference presentations and scientific publications on methods of improving crop residues were also made on many occasions to researchers (Annex 2, References 26-28, 30-31, 33-39, 44, 49-54).

Prior to R5188, non-RNRRS, on-station research at ILRI by Aboud et al. (Annex 2, References 16-22) also validated the 'Self Selection' approach with sorghum stover stall-fed to goats and sheep.

Subsequent to R5188, validation of 'Self Selection' stall-feeding for maize stover was made by non-RNRRS, on-station research by Methu (Annex 2, Reference 32).

The 'Self Selection' approach was also validated by researchers for improving the utilisation of sugar cane tops (Annex 2, Reference 43) and cut-and-carried tropical grass (Annex 2, References 59-66).

The 'Self Selection' strategy for stall-feeding sorghum stover developed in R5188 was deemed by FAO, in a manual for research workers (Preston, 1995, Annex 2, Reference 55), to be a novel and adoptable method of improving the feeding value of stovers and other fibrous crop residues.

However, the methods of validation, detailed above, all involved on-station experiments, and validation was largely by researchers and peer reviewed publications, not by end-user beneficiaries, i.e. resource-poor smallholder farmers.

Funding for R5188 totalled only £32,849 and did not include validation by end-user beneficiaries (cf. in 1990, when funding for this project was granted, there was little emphasis on end-user validation and dissemination).

*11. **Where and when** have the output(s) been validated?*

*Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

R5188 was executed in Ethiopia at ILRI (International Livestock Research Institute), Debre Zeit (Ethiopian Highlands), and IAR (Institute of Agricultural Research) Melkassa (Rift Valley) in 1990-93.

End-user beneficiaries were involved in problem identification, at the outset. As these were the early years of the programme. – project funding was limited to on-station research - there was no funding to undertake validation by end users after undertaking the on-station research.

R5188 beneficiaries in Ethiopia were in Semi-arid production systems and would be Moderate Poor and some Extreme vulnerable poor.

It was envisaged that the output would be relevant to Semi-arid, High Potential and Peri-urban production systems in all DFID PSA countries (but especially Kenya, Tanzania, Uganda, Rwanda, Ghana, Nigeria, Zimbabwe) because of the importance of crop residues as dry-season stall-feed.

The outputs were targeted at Smallholder Rainfed Highland and Smallholder Rainfed Dry/Cold farming systems.

Non-RNRRS researchers validated 'Self Selection' stall-feeding with maize stover at the Kenya Agricultural Research Institute, Muguga in 1995-97. The target beneficiaries were smallholder dairy farmers (Rainfed

Highland) in High potential and Peri-urban systems.

Validation of R5188 by peer-group researchers in conference presentations occurred in UK (Annex 1, References 2-3, 5-8), Sweden (Annex 1, Reference 4), Canada (Annex 1, Reference 9), Uganda (Annex 1, Reference 10-11), Kenya (Annex 1, Reference 14).

Current Situation

C. Current situation

*12. **How and by whom** are the outputs currently being used? Please give a brief description **(max. 250 words)**.*

Discussions in Nairobi, 2-4 October, 2006, involving collaborators from Ghana, Kenya, Tanzania, Uganda, Zimbabwe and UK preparing proforma (R5188, R6619, R7955, R7798, R7424, R7351, R6954, ZC0289) concluded:

- Fibrous crop residues/stover are widely available, but inefficiently used by smallholders in dry-season stall-feeding
- Despite a large scientific literature, there is lack of awareness (by extensionists and farmers) of ways of improving crop residues for stall-feeding. This includes ignorance of 'Self Selection' in stall-feeding stover.
- 'Self Selection' stall-feeding is therefore not practised per se, but many farmers offer stover ad libitum to dairy cattle, and the material rejected (mainly stem) is offered to less productive livestock such as sheep or donkeys
- Unknowingly, farmers practise 'Self Selection' when they allow livestock to graze crop residues in the field, after harvesting the cereal. However, such grazing is wasteful because of trampling, but the soil benefits from direct application of manure
- It is common to see large quantities of refusals on smallholder farms when stover is stall-fed
- The nutritive value of refusals could be markedly improved by ammoniation with urea (organic matter digestibility increases from 40%, untreated, to 50%, treated; also nitrogen content increased) and then re-fed. There is much scientific literature on upgrading crop residues by urea treatment (e.g. Annex 2, References 29, 32, 38-39, 46, 55-57)
- Demand for, and use of, methods of improving crop residues will increase as systems move from (current) subsistence to market oriented production. 252 words

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

- Use of fibrous crop residues for stall-feeding during dry-season forage scarcity is occurring throughout the developing world, but the usage is generally inefficient.
- Methods of improving feeding quality, such as 'Self Selection', are not (consciously) practised.

- In many situations, when supplies of crop residues are limited (often due to not conserving because of problems of transport and storage, cf. R6619) the opposite to 'Self Selection' is practised in stall-feeding i. e. restricted amounts of stover are offered, making animals eat the poorer fractions.
- As indicated in Question 12, lack of awareness of technologies amongst extensionists and farmers is a contributory factor.
- But as also indicated in Question 12, the fact that production systems are generally subsistent rather than market oriented is likely to be an important underlying factor.
- These issues, particularly socio-economic aspects, need to be investigated as part of RIU.

*14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading **(max 250 words).***

Answers to Questions 12 and 13 apply here also.

*15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? **(max 350 words).***

As explained in 10, 11, 12 and 13, R5188 was in the very early years of LPP (1990-93); the research was undertaken on-station and there was no funding for end-user/beneficiary evaluation and dissemination.

In 1997 an extension leaflet was produced (see Annex 1, Reference 15), for use by the LPP.

R5188 provided a platform for capacity strengthening for one of the collaborators (Osafo, PhD 1993, See Annex 1, Reference 1).

R5188 also generated many research questions concerning utilisation of crop residues and forages which were addressed in subsequent Reading University PhD studies (Kitalyi, 1993, in Tanzania, Annex 2, Reference 25; Tanner, 1995, in Indonesia [NRI EMC X0183], Annex 2, Reference 58; Methu, 1998, in Kenya, Annex 2, Reference 32).

Current Promotion

D. Current promotion/uptake pathways

*16. **Where** is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion **(max 200 words).***

As far as we know (collaborator meeting in Nairobi, Oct 2-4, 2006) no promotion of 'Self Selection' and other R5188 outputs is currently taking place.

17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, *those relating to policy, marketing, infrastructure, social exclusion etc.* ***(max 200 words)****.*

As explained in 16, and in 12, 13 and 15, R5188 was an on-station research project, and did not have end-user/ beneficiary validation and dissemination components. When R5188 was undertaken (1990-93), the emphasis was on research; there was no funding for components such as end-user/beneficiary validation and dissemination.

Current barriers to adoption are:

- Lack of end-user/beneficiary validation (especially socio-economic aspects) of 'Self Selection' output of R5188 with sorghum stover in Ethiopia, but also applies to maize stover in Ethiopia, Kenya, Rwanda, Tanzania, Uganda, Zimbabwe, Ghana, Nigeria
- Lack of disseminating materials for extensions services and end-users
- In Kenya, the National Livestock Policy (Draft, February 2006, Section 3.5) (Annex 2, reference 41) recognises the need to improve disseminating facilities for research findings
- As indicated in 12 and 13, a general underlying barrier to adoption is that current production systems tend to be subsistent rather than market-orientated
- The increasing demand for milk and meat, now underway in developing countries (The Livestock Revolution, Delgado et al., 1999, Annex 2, reference 24), will require higher levels of productivity per individual animal. This will require better nutrition, and therefore the need for higher quality forages and improved crop residues.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues ***(max 200 words)***

- Production of disseminating material on improving crop residues, for trainers (lecturers, students, NGOs, extension services). A textbook (sequel to ZC0213 Annex 2, reference 54) is required covering fibrous crop residues and other locally available feeds, and feeding strategies for alleviating dry season forage shortages. As indicated in Question 10, there is a large scientific literature on improving crop residues – early research was reviewed in Sundstol and Owen (1984) (Annex 2, reference 57). There has been much more work since then in developing countries (although relatively little on socio-economic aspects), but the publications are scattered and need bringing together in one volume. The Proforma *Networking as a tool to disseminate information and training materials* (incorporating R7798, ZC0289, ZC0304, ZC0305, ZC0213) has also suggested producing such a textbook.
- There is need to have end-user/beneficiary validation of R5188 outputs such as 'Self Selection' and chopping, and also of supplementation and ammoniation (using urea) of rejected stems by smallholder farmers producing milk and meat in Ethiopia (using sorghum and maize stover), and in Kenya and Tanzania (using maize stover). Such validation would also include offering a "basket of technologies" (including box baling R6619 and supplementing e.g. R7351). This validation would also generate disseminating material, and use approaches to RIU described in Output E (e.g. training promotion partners, participatory dissemination) of R7955.

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? ***(max 300 words).***

- If R5188 had been undertaken in the latter years of LPP, the project would have involved validation (including socio-economic evaluation) of the outputs by end-users/beneficiaries.
- The lessons learned in R7955 would also apply to R5188:
    - Making better use of crop residues for dry-season stall feeding, if it could enhance livelihoods, would have wide appeal to smallholders
    - Offering a basket of technology options; promotion partners would select outputs for local dissemination and farmers would select according to need.

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.

- To our knowledge, no impact studies on R5188 outputs have taken place in Ethiopia
- Methu (1998) (Annex 2, Reference 32) calculated (based on his on-station research) that ammoniation using urea treatment of maize stover rejected in 'Self Selection' stall-feeding would by uneconomic in Kenya because of the high cost of urea. Cost-benefit analyses of urea treatment need to be undertaken by end-user validation studies.

21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) ***(max. 500 words):***

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*
- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*
- *Indicate the number of people who have realised a positive impact on their livelihood;*
- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

In view of earlier answers, we are unable to answer this question

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Environmental Impact

H. Environmental impact

*24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? **(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

Greater use of crop residues for animal feeding would reduce biomass burning in situations where residues are not used and considered a waste.

Improved livestock productivity resulting from application of R5188 would generate more manure and better quality manure (particularly if ammoniation via urea was involved, cf. Methu et al. 1997, Annex 2, References 32, 38, 39). The improved animal productivity would mean improved digestion and greater efficiency of energy utilisation resulting in less methane production per unit of product (milk or meat).

*25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? **(max 100 words)***

In (exceptional) situations where crop residues are completely removed from crop land and land not manured (e. g. maize stover in northern Tanzania, cf. R6619) there is concern that soil organic matter content will decrease with increased risk of erosion. Stripping leaves from stover in the field and leaving the less digestible stem for soil incorporation would be a preferred strategy in such situations.

Treatment of refused stover with urea (40 kg/tonne) in ‘Self Selection’ stall-feeding would result in release of some ammonia (about 12 kg) to the atmosphere. This is small compared to the ammonia released during manure and fertiliser application.

*26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? **(max 200 words)***

Conserving crop residues by proper storing for subsequent use obviously increases the capacity of poor people to cope with forage shortages during dry-season droughts.

Future climate changes in Africa are likely to mean that more drought resistant cereals such as millet and sorghum are grown. The outputs of R5188 would be relevant to the crop residues of these cereals, as well as maize.

Annex

ANNEX 1

R5188 publications

1. Osafo, E.L.K. 1993. Sorghum stover as a forage: cultivar effects on yield and effects of chopping, amount offered, supplementation and variety on intake, selection and live-weight gain in Ethiopian sheep and cattle. *PhD Thesis, The University of Reading*.

2. Osafo, E.L.K., Owen, E., Aboud, A.A.O., Said, A.N., Gill, M. and McAllan, A.B. 1991. Feeding sorghum stover to Ethiopian sheep: effect of chopping and amount offered on intake and selection. *Animal Production*, 52, 607.

3. Osafo, E.L.K., Owen, E., Said, A.N., Gill, M., McAllan, A.B. and Sherington, J. 1992. Feeding sorghum stover to Ethiopian, yearling cattle; effects of amount of stover offered and cottonseed cake supplement on intake and growth. *Animal Production*, 54, (3), 501.

4. Osafo, E.L.K., Owen, E., Aboud, A.A.O., Said, A.N., Gill, E.M. and McAllan, A. 1992. Feeding sorghum stover to Ethiopian sheep: effect of chopping and amount offered on growth, intake and selection. In: Lindberg, J.E. (ed), *FAO Network of Cooperative Research on sheep and goats; Proceedings of the Meeting of the Subnetwork Nutrition, Ostersund, Sweden*. Uppsala: Swedish University of Agricultural Sciences, Report 215, 52.

5. Osafo, E.L.K., Owen, E., Said, A.N., Gill, M., McAllan, A.B. and Kabede, Y. 1993. Sorghum stover as ruminant feed in Ethiopia: effect of cultivar, site of growth, pre-harvest leaf stripping and storage on yield and morphology. In: Gill, M., Owen, E., Pollott, G.E. and Lawrence, T.L.J. (ed.) *Animal Production in Developing Countries*. British Society of Animal Production Occasional Publication No 16, 188-189.

6. Osafo, E.L.K., Owen, E., Said, A.N., Gill, M. and McAllan, A.B. 1993. Feeding sorghum stover to Ethiopian sheep and cattle: effect of chopping and amount offered on intake and selection. In: Gill, M., Owen, E., Pollott, G.E. and Lawrence, T.L.J. (ed.) *Animal Production in Developing Countries*. British Society of Animal Production Occasional Publication No 16, 204-205.

7. Khazaal, K., Mueller-Harvey, I., McAllan, A.B., Osafo, E.L.K., Owen, E. and Said, A.N. 1993. Effect of harvesting at different stages of growth and long term storage on phenolics in sorghum stover. In: Gill, M., Owen, E., Pollott, G.E. and Lawrence, T.L.J. (ed.) *Animal Production in Developing Countries*. British Society of Animal Production Occasional Publication No 16, 210-21

8. Osafo, E.L.K., Owen, E., Said, A.N., Gill, M., McAllan, A.B. and Sherington, J. 1993. Feeding chopped sorghum stover to Ethiopian sheep: effects of sorghum variety and amount offered on intake, digestibility and live-weight change. *Animal Production*, 56, (3), 470.

9. Osafo, E.L.K., Owen, E., Said, A.N., Gill, M., McAllan, A.B. and Sherington, J. 1993. Use of chopped sorghum stover as feed for Ethiopian sheep: effects of sorghum variety and amount offered on intake, digestibility and live weight change. In *Proceedings V11 World Conference on Animal Production, Edmonton, Canada*. Volume 3, Abstract 253, 53-54.

10. Osafo, E.L.K., Owen, E., Said, A.N., Gill, M. and Sherington, J. 1994. The effect of variety of chopped

sorghum stover and amount offered on intake, weight-change and digestibility in sheep. In: Programme and Abstracts of the Third Small Ruminant Research Network (SRNET) Biennial Conference, Uganda International Conference Centre, Kampala, Uganda, 5-9 December 1994, 19.

11. Osafo, E.L.K., Owen, E., Said, A.N., Gill, M., and Sherington, J. 1996. The effect of variety and amount offered of chopped sorghum stover on the performance of sheep. In: Lebbie, S.H.B. and Kagwin, E. (ed.) *Small Ruminant Research and Development in Africa*. *Proceedings of the African Small Ruminant Research Network, UICC, Kampala, Uganda 1994*. ILRI (International Livestock Research Institute), Nairobi, Kenya, 177-182.

12. Osafo, E.L.K., Owen, E., Said, A.N., Gill, M. and Sherington, J. 1997. Effects of amount offered and chopping on intake and selection of sorghum stover by Ethiopian sheep and cattle. *Animal Science*, 65, 55-62.

13. Osafo, E.L.K., Owen, E., Methu, J., Abate, A., Tanner, J.C. and Aboud, A.A.O. 1996. Excess feeding of stovers from sorghum and maize for small ruminants and cattle in cereal based integrated farming systems in Africa. In: *Second FAO Electronic Conference on Tropical Feeds Livestock Feed Resources Within Integrated Farming Systems*. Rome: Food and Agriculture Organisation of the United Nations, 1996, 17th paper.

14. Osafo, E.L.K., Owen, E., Ellis, R.H., Said, A.N., Gill, M. and Sherington, J. 1998. Stability of yields of sorghum genotypes: implications for animal production in the tropics. International Conference, *Food, Lands and Livelihoods: Setting Research Agendas for Animal Science*, organised by the British Society of Animal Science and Kenya Agricultural Research Institute held in Nairobi 27-30 January 1998.

15. Owen, E. and Osafo, E.L.K. 1997. Feed sorghum stover (stalks) to cattle, sheep and goats. *Livestock Research Extension Note 1*. Livestock Production Programme, Chatham, Natural Resources International Limited.

ANNEX 2

OTHER REFERENCES

16. Aboud, A.A.O. 1991. Strategies for utilization of sorghum stover as feed for cattle, sheep and goats. *PhD Thesis, The University of Reading*.

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