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Study on the Chemical Composition, Intake and Digestibility of Maize Stover, Tef Straw and Haricot Bean Haulms in Adami Tulu District, Ethiopia

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ABSTRACT

A study was conducted at two agricultural development sites in Adami Tulu district of Ethiopia to investigate the chemical composition, intake and digestibility of the three major crop residues, namely, maize stover, tef straw and haricot bean haulms produced in the area. Intake and digestibility were determined using nine Borana bulls. Chemical analysis indicated that the by-products have low nitrogen content and are composed of cell wall components with little soluble cell contents. As a result their intake and digestibility were low. Therefore, training of farmers in the application of some crop residue treatment methods and in the use of supplementary feeds is highly recommended.
Key words: crop residue, chemical composition, voluntary intake, digestibility, Borana bulls

INTRODUCTION

Crop residues are among the most widely available, low-cost feeds for ruminants in the majority of developing countries (Smith, 1993). A number of inventories on crop residues, carried out by researchers on a national, regional and global basis (Kossila, 1985; Aregheore and Chimarino, 1992), invariably concluded that large amounts of crop residues are available for livestock feeding, supplying over 20% of ruminant energy requirements.

Preston and Leng (1986) and Smith (1993) stated that most crop residues are deficient in nutritionally essential components, especially protein and energy, and are rather fibrous- 40 to 45% crude fiber (CF). The consequences of such a profile for ruminants are a low intake-1 to 1.25kg dry matter (DM) per 100kg live weight, poor digestibility of the order of 30 to 45%, and a low level of performance. In fact crop residues provide no more than maintenance ration unless they are supplemented with protein and energy rich feeds.

There is no information on the chemical composition, intake and digestibility of crop residues produced in Adami Tulu district, Ethiopia. The determination of the feeding value of the major crop residues produced in an area is essential because, it will be a basis for future research and management programs, it enables the development of appropriate feeding strategies for the residues and indicates the necessity of improving their feeding value. Accordingly, this study was initiated to determine the chemical composition, voluntary intake and digestibility of maize stover, tef straw and haricot bean haulms produced in Adami Tulu district.

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MATERIALS AND METHODS

This experiment was conducted at two agricultural development sites in Adami Tulu district. The district is located in the middle rift valley at 7° 9/ N latitude and 38° 7/ E longitude, and an altitude of 1600 to 1650 meters above sea level. Its climate is semi-arid with a long dry season and erratic rainfall of about 764 mm per annum. The mean annual maximum and minimum temperatures are 27.2°C and 12.7°C, respectively.

Chemical composition of the three crop residues was determined from eleven samples of each of the residues randomly collected, at times of feeding, from different households in the study area. Dry matter (DM) and total ash were analyzed according to the conventional methods given by Association of Analytical Chemists (AOAC) (1970). Percent nitrogen in the samples was determined by the micro-Kjeldhal technique. The cell wall constituents were determined by procedures described by Georing and Van Soest (1979).

Intake and digestibility of the residues were determined using nine Borana bulls divided into three weight groups, light (140 to 198 kg), medium (199 to 250 kg) and heavy (251 to 300 kg). The animals were drenched and sprayed against parasites. Then, each group was individually fed on each of the three crop residues in a switch over design for 7-days adaptation and 7-days collection periods. *Ad libitum* amounts of the residues, with 20 to 25% refusals, were given to the animals as a sole diet. Water and mineral licks were also provided. Voluntary feed intake and apparent digestion coefficient were determined according to the procedures outlined by Osuji *et al.* (1993). Digestible energy and metabolizable energy (DE and ME) were estimated using the equation by Butterworth (1964).

Finally, the intake and digestibility data were subjected to the analysis of variance (ANOVA) according to the standard procedures (Steel and Torrie, 1980). Means were compared using Least Significant Difference (LSD).

RESULTS AND DISCUSSIONS

Chemical composition of the crop residues

Chemical composition of maize stover, haricot bean haulms and tef straw produced in the study area is given in Table 1. The three by-products did not differ ($P > 0.05$) in their DM and organic matter (OM) contents. Maize stover had relatively lower crude protein (CP) content than both haricot bean haulms and tef straw. Fiber analysis indicated that haricot bean haulms had a relatively lower (69.2%) neutral detergent fiber (NDF) and higher (30.8%) neutral detergent soluble (NDS) compared to the other two residues. However, 81.6% and 18.4% of its NDF was acid detergent fiber (ADF) and hemicellulose, respectively. Cellulose component constitutes 42.9, 39.3 and 48% of the ADF percentage of maize stover, tef straw and haricot bean haulms, respectively.

The high values of hemicellulose and cellulose in these crop by-products indicated that they are potential sources of energy. Accordingly, their estimated energy contents ranged from 2.3 to 2.5 kcal DE per g DM or 1.9 to 2.1 kcal ME per g DM. The three residues did not vary widely both in their DE and ME contents. These values are almost similar to the maintenance digestible gross energy requirements of 11 MJ/kg DM reported by Karue (1971) for a 250 kg steer. Stating that maize stover has a high nutrient content and is more digestible than most other straws, McDonald *et al.* (1995) reported a ME value of about 9 MJ/kg DM for maize stover. The results of this study agreed with the general statement made by Preston and Leng (1986) that all cereal straws have low nitrogen content and are composed of cell wall components with little soluble cell contents. The CP content obtained for tef straw in this study was almost similar to the 5.2% reported by Lulseged and

Table 1 Average[1] chemical composition (% of DM) and energy values of the crop residues.

Parameters	Residue type		
	Maize stover	Tef straw	Haricot bean haulms
DM	94.3	94.4	94.4
OM	91.1	91.3	91.5
CP	3.6	5.5	5.4
NDF	76.0	75.6	69.2
NDS	24.0	24.4	30.8
ADF	48.4	46.2	56.5
Hemicellulose	27.6	29.4	12.7
Cellulose	42.9	39.3	48.0
ADL	3.0	3.9	8.3
AIA	2.8	3.0	0.3
DE (Kcal/g DM)	2.5	2.3	2.4
ME (Kcal/g DM)	2.1	1.9	2.0

[1] = Average values represent data from 11 replicate samples

Jamal (1989), but higher by 1.72 percentage units than what was reported by Nuwanyakapa and Butterworth (1987). Its NDF percentage, however, was lower by 4.02 percentage units than what was reported by the latter authors. These differences can be attributed to differences in variety, location and agronomic practices used while growing the crop.

Voluntary feed intake

The average voluntary feed intake by bulls fed on the three crop residues is given in Table 2. The dry matter intake (DMI) of maize stover was lower ($P<0.05$) than that of tef straw and haricot bean haulms. The values were similar to those reported by Preston and Leng (1986) but higher than the 1 to 1.25% of body weight reported by Smith (1993). The daily DMI of maize stover obtained in this trial was almost similar to the 3.11 kg/head reported by Biwi (1989).

Higher DMI of both tef straw and haricot bean haulms led to improved organic matter intake (OMI) by the animals. The values for tef straw and haricot bean haulms were higher ($P<0.05$) than the value for maize stover. Crude protein intake (CPI) was significantly ($P<0.01$) higher for bulls fed on tef straw followed by those fed on haricot bean haulms.

The relatively higher nutrient intake by bulls fed on tef straw and haricot bean haulms than those fed on maize stover could be due to the higher CP and lower NDF contents of these feeds compared to the maize stover. It may also be attributed to the higher DM intakes of these feeds than that of the maize stover. Moreover, the bulky nature of the residues and their low *in vivo* DM digestibility (51 to 55%) could have contributed to their low intake values. Mugerwa *et al.* (1973) showed that a digestibility coefficient below 66% limits intake of tropical forages by grazing animals. However, the low intake of maize stover, despite being more digestible than the other residues, could be due to the physical difference of the residues. The woody stems of the maize stover are likely to cause more feeding problems than the relatively tender stems of both tef straw and haricot bean haulms.

Table 2 Average[1] daily nutrient intake by bulls fed on maize stover, tef straw and haricot bean haulms.

Parameters	Experimental diet		
	Maize stover	Tef straw	Haricot bean haulms
Dry matter intake			
Kg/day	2.9[a]	4.3[b]	3.9[b]
Kg/100 kg LWT	1.4[a]	2.0[b]	1.8[b]
g/Kg $W^{0.75}$	52.0[a]	74.7[b]	69.3[b]
Organic matter intake			
Kg/day	2.6[a]	3.9[b]	3.5[b]
Kg/100 kg LWT	1.3[a]	1.9[b]	1.7[b]
g/Kg $W^{0.75}$	48.4[a]	73.3[b]	64.8[b]
Crude protein intake			
g/day	99.8[a]	242.6 [c]	192.9[b]
g/100 Kg LWT	42.5[a]	119.0 [c]	93.9[b]
g/Kg $W^{0.75}$	1.6[a]	4.6[c]	3.6[b]

[1] = Average values represent data from 9 bulls.
[a b c] = Means in a row followed by different superscripts differ (P<0.05)

Digestibility of the by-products

The *in vivo* digestibility coefficients of the by-products are presented in Table 3. The apparent dry matter digestibility (DMD) coefficients of maize stover and haricot bean haulms were higher (P<0.05) than that of tef straw. However, the value obtained for maize stover was lower than the 59% reported by Ndlovu and Manyame (1989) for unhydrated maize stover. The average *in vivo* organic matter digestibility (OMD) coefficients of the three by-products followed their respective DMD values. The value for maize stover was significantly (P<0.05) higher than the values for the other two by-products. The D-values (OMD expressed on dry matter basis), however, were not statistically different (P>0.05) among the three crop residues.

The digestibility of protein was different (P<0.01) among the three crop residues and was negative for maize stover. The relatively higher CP digestibility coefficients observed for tef straw and haricot bean haulms (21.5 and 26.6%) reflect the relatively high CP content of these by-products, and may also be associated with the difference in protein quality of the by-products. However, such measures are obviously influenced by endogenous nitrogen excretion in the faeces (Boonlom and Boonserm, 1984) and are consequently of limited value. The NDF, cellulose and hemicellulose digestibilies of maize stover and tef straw were higher (P<0.05) than that of haricot bean haulms. This is attributed to the low lignin contents of the two by-products as compared to the lignin content of haricot bean haulms. This was in agreement with what Karue (1975) has found regarding the importance of the degree of lignification in the digestion of fiber by ruminants.

The digestibility of a feed depends on a number of factors some of which are associated with the feed, the animal and the environment under which the animal lives. McDonald *et al.*, (1995) and Crampton and Harris (1969) reported that the digestibility of feeds by farm animals is generally related to the proportion and character of

Table 3 Average[1] apparent digestion coefficients of certain nutrients in maize stover, tef straw and haricot bean haulms.

Parameters	Digestibility coefficient (%)		
	Maize stover	Tef straw	Haricot bean haulms
DM	54.5 ^{a}	50.5 ^{b}	53.0 ^{ab}
OM	59.1 ^{a}	54.4 ^{b}	55.0 ^{b}
D-value	52.6 ^{a}	49.7 ^{a}	49.8 ^{a}
CP	-25.2 ^{c}	21.5 ^{b}	26.6 ^{a}
NDF	59.9 ^{a}	57.8 ^{a}	49.2 ^{b}
ADF	49.6 ^{a}	42.2 ^{b}	47.1 ^{a}
Cellulose	69.7 ^{a}	65.5 ^{ab}	61.3 ^{b}
Hemicellulose	78.7 ^{a}	83.5 ^{a}	57.4 ^{b}

a b c = Means in a row followed by different superscripts differ ($p<0.05$)

1 = Average values represent data from 11 replicate samples

the fiber they contain. In the current study, the higher digestibility of the maize stover compared to that of the tef straw and haricot bean haulms is likely to be associated with its lower lignin content than the two residues. However, haricot bean haulms, despite having higher percentage of lignin than the maize stover, was found to be almost as digestible as the maize stover. It seems that the digestion depressing effect of lignin in haricot bean haulms has been compensated for by its lower NDF and higher NDS proportions as compared to the other two by-products. On the other hand, in spite of having almost similar proportions of NDF and lignin with the maize stover, tef straw was found to be less digestible. In this case, factors other than chemical composition seem to have contributed to the observed variations. Nevertheless, the actual reason calls for further detailed investigation.

CONCLUSIONS AND RECOMMENDATIONS

Like any other by-products, the three crop residues studied in this trial had high proportion of cell wall constituents and low proportion of cell contents. This resulted in low digestibility and intake of the residues. As intake and digestibility can be improved by treating the crop residues, it is essential that farmers be trained in the application of some treatment methods. In this regard, emphasis should be given to the methods which are within the reach of farmers (e.g. physical treatments like chopping, wetting, ensiling with urea or animal manure, and the use of ashes and magadi soda). However, information on the use of ashes and magadi soda is scanty, and deserves future research attention. Besides, as crop residues are generally characterized by the unbalanced nature of the nutrients they supply, a complementary strategy, that of nutrient balancing through supplementation with valuable supplements such as molasses, protein-rich fodder trees, molasses-urea blocks, etc. is highly required to optimize the efficiency of transforming absorbed nutrients into products.

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