Estimation of Digestibility of Straws of Different Barley Varieties Using *in Situ* Method

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Abstract

Crop residues play a great role in feeding livestock. However, no emphasis has been given to improve its nutritional quality and availability through improving crop genetic materials. Crop breeders mainly strive to improve crop yield irrespective of the importance of crop residues as livestock feed. Digestibility study of crop residues of four different barley varieties, namely Lester, Kippen, Chaapais and Morrison was undertaken. The crop residues were ground at 2 mm size using Willy mill. The ground samples were incubated for 0, 2, 4, 8, 12, 24, 48, 72 and 96 hours using nylon bags with a pore size of 40 µm. The bags were immediately washed off with cool tap water and kept in the oven at 60°C for 24 hours. Dry Matter (DM) and Organic Matter (OM) disappearance rates were estimated using differences in DM and OM values between intact and rumen recovered straw samples. There is significant variation ($P < 0.001$) between barley varieties in terms of dry matter and organic matter digestibility straw barley variety Morrison had highest DM and OM digestibility while variety Chaapais had the lowest DM and OM digestibility. DM and OM disappearance rates of straws of all barley varieties increased as time of incubation from 0 to 96 hours. Generally, there was digestibility differences of straws among barley varieties. This indicates the importance of variety in using crop residues for livestock feed.

Key words: crop residue, variety, livestock feed, digestibility, nylon bag.

Introduction

There is heavy reliance on the use of crop residues in Ethiopia (Kabaija and Little.1989) and in Sub-Saharan Africa (Kassu,1989); Kabatange and Kitali, 1989). However, their utilization, conservation and improvement in quality and quantity need more efforts. One of these efforts is through improving crop genetic material in line with improving grain yield.

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Crop breeders are striving to improve grain yield and quality depending upon farmer and market demands. However, emphasis should also be given to improve straw yield and quality to be utilized by ruminant animals. Variety difference can affect straw degradability and its nutrient digestibility to increase animal productivity. The nutritive values of crop residues from a given variety varies widely due to differences in growing conditions (Reed *et al*, 1988), since, different plant morphological fractions vary in nutritive value (Orskov et al, 1988). Differences in the amount of leaf that adheres to the stem at harvesting can substantially change the nutritive value and some of the differences between varieties can be explained by differences in the leaf: stem ratio. The proportion of leaf and stem in the straw, together with variations in chemical composition and microstructure of morphological fractions are responsible for genetic variation in the feeding value of straw (Capper *et al*, 1988). Quality of crop residues could be improved through agronomic practices and varietal selection (Tulseged and Jemal, 1989).

However, Ramzin *et al*, (1986) found that leaf-to-stem ratio only account for about 20% of the difference in nutritive value between two varieties. The largest differences were due to differences in degradability of both stems and leaves. In Syria, farmers have rejected an improved barley variety because its straw was less palatable to sheep than straw from a barley landrace (Nygaard, 1983). Voluntary intake and digestibility studies have confirmed farmers' observation that feeding values of straws differ among varieties (Capper *et al*, 1986).

The main factors affecting the degradability estimates of supplements and feedstuffs for ruminants are the basal diet of cannulated animal and the rate of outflow from the rumen of unfermented feed particles (Mehrez and Orskov, 1977;Orskove *et al*, 1980; Orskov *et al*, 1983). In addition, several other factors can influence the accuracy of nylon bag technique such as sample and bag sizes (Mehrez and Orskov, 1977), sample particle size (Mohamed and Smith, 1977), pore size of bag material (Chapman and Norton, 1982), time of incubation (Orskov *et al*, 1980), washing of the bag (Mehrez and Orskov, 1977), microbial colonization of bag residue (Mathers and Aitchison, 1981), and the level of energy in the diet (Ganv *et al*, 1979).

Additional characteristics of the *in situ* technique that may influence the accuracy were reported by various workers (Hennessy *et al*, 1983; Mehrez *et al*, 1980; Zinn *et al*, 1981), and include characteristic of the meal, its initial processing, the activity of rumen contents, the pH pattern, the lag time, microenvironment within the bag and the lack of adaptation to test feed stuff or roughage level.

The nutritive value of straw is subjected to considerable variation, especially when there are differences in variety. Measurement of degradability of roughage diet

incubated in nylon bag in the rumen is now widely used and reported to be well with animal performance (Orskov, 1989). Feeding trials indicate that genetic variability in straw quality undoubtedly present, and lines with tall plant generally have a lower leaf proportion and lower feeding value than lines with short plants (Ramanzin *et al*, 1986). Several workers have shown that the feeding value of cereal straw can vary significantly between different cereal cultivars (Meherez *et al*, 1977). Sheep fed with teff (*Eragrostis teff*) straw improved their intake after supplementing with *Leucaena lucocephala* (Zewdu *et al*, 2006).The objective of this study is to evaluate dry matter and organic matter digestibility of straw from different barley varieties incubated in the rumen for various hours.

Materials and Methods

Animals

One ruminally fistulated dry cow and a steer were used in this study. The animals were housed in a tie stall barn.

Feeding

Two feeding regimen were used from beginning to end of the trial. Each feeding period covered 14 days. At the beginning 7 days were used for feed adaptation. The next 15 days were trial periods. During the first 7 experimental feeding days the steer was fed protein free basal diet, while the cow was fed protein supplemented (18%CP) diet. This feeding regime was switched during second experimental feeding period, after one-week break to avoid carry over effect.

Test samples

Straws of four barley varieties, namely, Lester, Morrison, Kippen, and Chaapais were used. The straw samples were ground to pass 2 mm sieve (Retsch 2M1 Centrifugal Mill).

Incubation.

Nylon bags with a pore size of 40 µm and inner size of 10X19 cm were used. Bags were weighed before use. Then, the bags were filled with 5g DM of the ground sample and incubated in the rumen for 0, 2, 4, 8, 12, 24, 48, 72 and 96 hours. Four feed samples were prepared from each variety. Incubation was carried out two times before and after switching the feeding regime (during the first and second experimental feeding days). During incubation the nylon bags were inserted into the rumen fistula at different hours and recovered all at once. Metal weight was used to anchor incubated samples in the rumen.

Laboratory analysis

The bags were immediately washed off with cool tap water and kept in the oven at 60°C for 24 hours. The dried residues were weighed along with the bags, and the empty bag weights deducted. One gram of sub samples was taken from each bag and ashed at 600°C for 2 hours (A.O.A.C, 1990) in a muffin furnace using iron crucibles. The Organic Matter (OM) content was determined from the ash residue. Another set of samples were taken from each intact variety, weighed and kept in the oven at 60°C for 24 hours to determine DM. DM of straws were expressed as weight of oven dried straw samples divided by weight of intact straw samples multiplied by 100.

Digestibility estimation

Dry matter and organic matter digestibilities were estimated using differences in DM and OM values between intact and rumen recovered straw samples at different incubation hours. DM of residues was determined by oven drying at 60°C. OM residues were determined by ashing at 500°C until all the carbon has been removed.

Data analysis

Data were analyzed using GLM procedure of SAS (SAS, 2001). Duncan's multiple range tests was used to separate the means.

Results

Least square mean DM and OM disappearance rates are shown in Table 1. There was significant variation ($P < 0.001$) between straws of barley varieties in terms of DM and OM disappearance rates. Straw of barley variety Morrison had the highest (11.2%) DM and OM disappearance rates while variety Chaapais had the lowest ($P<0.05$) DM and OM disappearance rates. Straw varieties Kippen and Lester were intermediate in DM and OM disappearance rates.

Table 1. Least square mean and standard error of barley straw DM and OM disappearance rate.

Variables	Number	DM (g/100g sample)	OM (g/100g sample)
Overall mean	144	28.69	27.48
Varieties			
Lester	36	28.87±o.68^{b}	27.42±0.77^{b}
Morrison	36	31.91± o.68^{a}	31.09±0.77^{a}
Kippen	36	28.50± o.68^{bc}	27.20±0.75^{bc}
Chapaais	36	25.05± o.70^{c}	23.95±0.77^{c}
Incubation time (hrs)			
0	16	9.37±1.02^{i}	8.26±1.12^{i}
2	16	10.44±1.02^{hi}	8.95±1.19^{hi}
4	16	15.16±1.04^{g}	13.65±1.12^{g}
8	16	17.93±1.02^{fg}	15.97±1.19^{fg}
12	16	27.58±1.02^{e}	26.10±1.12^{e}
24	16	34.78±1.02^{d}	34.00±1.12^{d}
48	16	44.07±1.02^{c}	43.35±1.19^{c}
72	16	47.71±1.02^{b}	46.57±1.12^{b}
96	16	50.21±1.02^{a}	49.87±1.12^{a}
Animal			
Cow	72	29.90±0.48^{a}	28.13±0.54
Steer	72	27.26±0.49^{b}	26.70±0.54
R^2		0.97	0.96
CV%		14.27	16.36

Means with different superscripts within columns are significantly different ($P<0.05$).

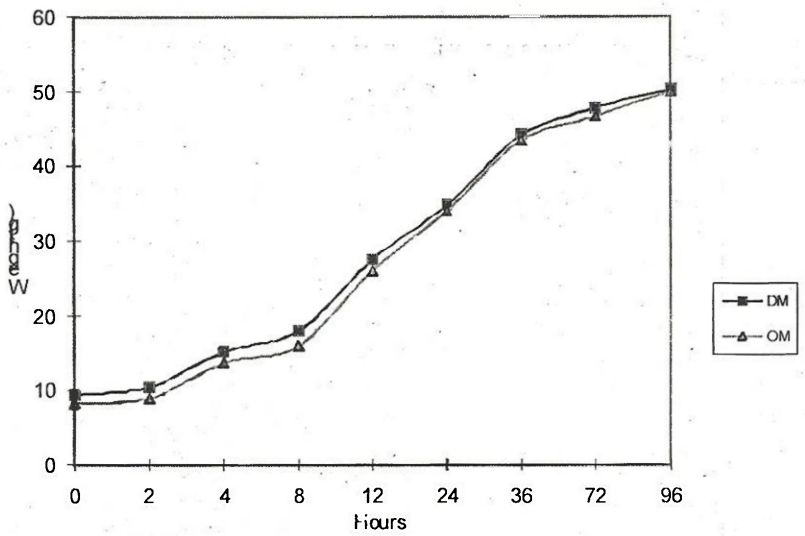

Fig 1.DM and OM disappearance rates at different incubation hours

Least square mean DM and OM disappearance rates at different incubation hours are shown in Table 2. Straw of all varieties had markedly ($P<0.05$) higher DM and OM disappearance rates as compared to the control group. DM and OM disappearance rates at 96 hours of incubation were particularly higher than all incubation hours ($P<0.05$). The disappearance rates of straws of all varieties rose at slower rate from 0 to 8 hours of incubation, and at faster rate from 8 to 48 hours of incubation, and then plateauedoff (Fig 1). Dry matter and organic matter disappearance rates of straws of all barley varieties increased as incubation time progressed from 0 to 96 hours (Figure 2). However, there was no significant variation ($P > 0.05$) between 0 and 2 hours, between 4 and 8 hours and between 72 and 96 hours of incubation. All other incubation period had marked ($P < 0.001$) variation in straw disappearance rates.

Table2. Animal and barley straw variety interactions in DM and OM disappearance rates

Variables	Animal	DM (g/100g sample)	OM (g/100g sample)
Overall mean		28.69	27.48
Varieties			
Lester	Cow	29.93±0.96^{b}	27.94±1.06^{bc}
	Steer	27.81±0.96^{b}	26.89±1.12^{bc}
Morrison	Cow	33.82±0.96^{a}	32.66±1.12^{a}
	Steer	30.00±0.96^{b}	29.52±1.06^{b}
Kippen	Cow	28.43±0.96^{b}	26.76±1.06^{bc}
	Steer	28.56±0.96^{b}	27.65±1.06^{b}
Chaapais	Cow	27.43±0.96^{c}	25.15±1.06^{cd}
	Steer	22.65±0.96^{d}	22.73±1.12^{d}

Least square mean DM and OM disappearance rates for the animal and incubation period (feeding regime) interactions are shown in Table 3. There was significant ($P < 0.001$) variation in DM disappearance rate between the cow and the steer, however, there was no significant ($P > 0.05$) variation in OM disappearance rate between the two animals. The two feeding regimen had no significant variation ($P > 0.05$) both in DM and OM disappearance rates.

Animal and straws of barley variety interaction indicated Morrison variety incubated in the rumen of the cow had markedly higher DM and OM disappearance rates than all other animal and barley variety interactions ($P<0.05$). On the other hand, Straw of Chapaais barley variety incubated in the rumen of the steer showed markedly lower DM and OM disappearance rates ($P<0.05$).

Barley variety and incubation hour interactions indicated variety Morrison had higher disappearance rates of DM and OM throughout all incubation hours, whereas, variety Chapaais had the least disappearance rate (Fig 2 and 3).

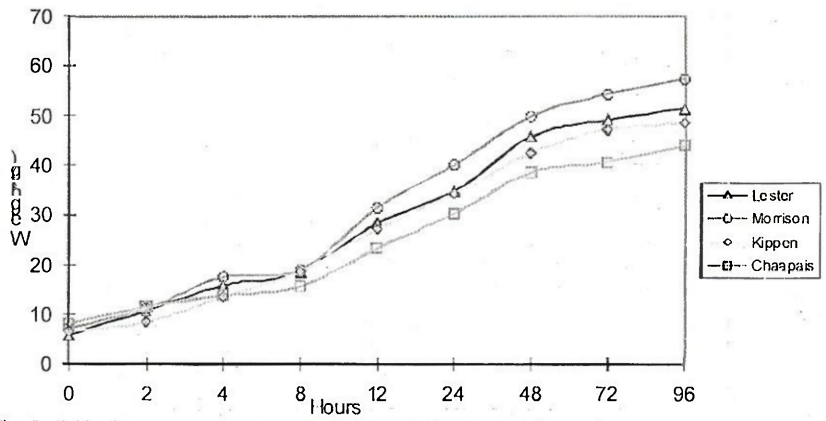

Fig 2. DM disappearance rates of barley straw varieties at different incubation hours

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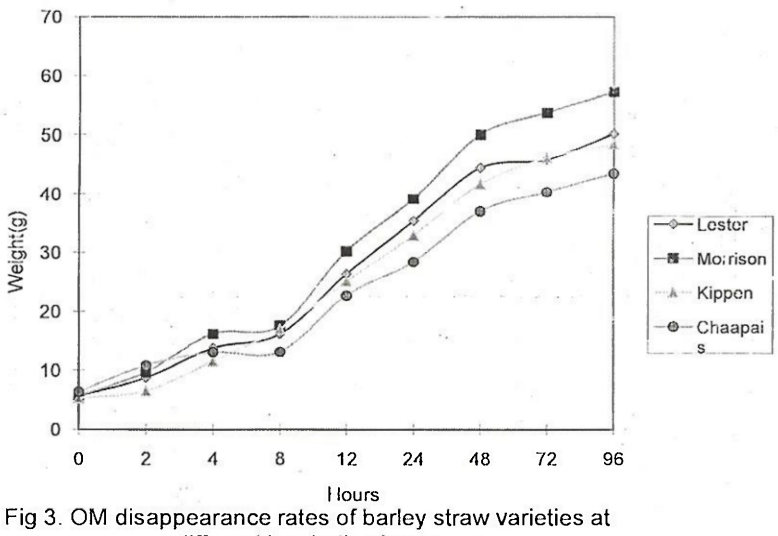

Fig 3. OM disappearance rates of barley straw varieties at different incubation hours

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Animal and incubation time interactions for DM and OM disappearance rates are presented in Table3. Disappearance rates of DM from straws of barley all varieties incubated over 72 and 96 hours in the rumen of the cow was markedly higher ($P<0.05$), while disappearance rates of OM from all the other varieties incubated over 72 hours in the rumen of the steer was markedly higher than all the other animals by incubation hour interactions.

Table 3. Animal and incubation time interactions in DM and OM disappearance rates.

Variables	Incubation time (Hrs)	DM (g/100g sample)	OM (g/100g sample)
Overall mean		28.69	27.48
Cow	0	9.08 ± 1.45^{hi}	6.63 ± 1.58^{hi}
	2	12.01 ± 1.45^{hi}	9.58 ± 1.58^{hi}
	4	16.92 ± 1.45^{g}	14.64 ± 1.58^{g}
	8	19.92 ± 1.45^{f}	17.72 ± 1.58^{f}
	12	29.52 ± 1.45^{c}	27.38 ± 1.58^{c}
	24	34.87 ± 1.45^{d}	34.41 ± 1.58^{d}
	48	45.64 ± 1.45^{c}	$44.77+1.58^{c}$
	72	49.40 ± 1.45^{ab}	47.36 ± 1.58^{abc}
	96	51.78 ± 1.45^{a}	50.67 ± 1.58^{ab}
Steer	*0*	8.87 ± 1.45^{hi}	8.33 ± 1.59^{hi}
	2	9.65 ± 1.45^{hi}	9.89 ± 1.59^{hi}
	4	13.39 ± 1.45^{fg}	12.66 ± 1.59^{h}
	8	15.94 ± 1.45^{f}	14.22 ± 1.59^{g}
	12	25.64 ± 1.45^{e}	24.82 ± 1.59^{f}
	24	34.69 ± 1.45^{d}	$33.58\pm1.59d^{e}$
	48	42.5 ± 1.45^{cd}	41.93 ± 1.59^{d}
	72	46.03 ± 1.45^{ab}	55.78 ± 1.59^{a}
	96	48.64 ± 1.45^{ab}	49.06 ± 1.59^{bc}

Discussion

DM and OM disappearance characteristics in this study are comparable to those obtained for similar feeds by other authors (Orskov *et al*, 1980; Kamande, 1988). Abate (1990) has shown that maize forage harvested and ensiled at different stages of growth differed in degradability, indicating that fibrous materials are less soluble because of the dominance of structural over soluble carbohydrates in the cell wall. Also, Van Soest (1982) has demonstrated that the degree of lignifications has a negative effect on cell wall digestion in forages. Low and slow degradability can limit voluntary feed intake. It is, hence, desirable that roughages such as hay or crop residues be combined with highly soluble feedstuffs; such a combination would stimulate a more active rumen microbial population, which would degrade the fibre faster and hence increase digesta passage rate and DM intake.

The result of this study suggests that the DM and OM disappearance rate increased with increase in incubation time. This could be due to the attachment of rumen micro flora to the straws as time elapsed, increasing in digestion and enhancing disappearance rate. Variations between barley varieties in dry matter and organic matter digest bility may be due to variation in morphological structure of the straw in leaf: stem ratio. Varieties with high leaf: stem ratio will be more easily digested than varieties with low leaf: stem ratio as suggested by Capper *et al* (1986). Similarly, Ramanzin *et al*, (1986) showed variability in the nylon bag disappearance of leaf and stem fractions from different cereal species.

Earlier studies indicated that the genetic variability in straw quality undoubtedly present and lines with tall plant generally have a lower leaf proportion and lower feeding value than lines with short plants (Ramnzin *et al*, 1986). Several workers have shown that the feeding value of cereal straw can vary significantly between different cereal cultivars (Meherez *et al*, 1977). These differences in nutritive value between varieties remain even after ammonia treatment, although the chemical improves the nutritive value of poor quality cultivars (Meherez *et al*, 1980).

DM disappearance rates were significant ($P<0.05$) and OM disappearance rates were not significant ($P>0.05$) between animals in this study. This finding is contrary with earlier work, which indicated minimum variability in DM disappearance between animals (Nocek, 1985). However, Orskov (1982) identified the principal sources of variation for *in situ* trials conducted within a given laboratory as those due to animal, day and bag in the order animal>day>bag. Similarly, Figroid *et al*, (1972) noted that animal was a significant source of variation within *in situ* trials. In contrast other reports indicated that animal effects were either not significant (Weakely *et al*, 1983; Nocek, 1985) or were less important than day effects (Wilkerson *et al*, 1995, Vanzant *et al*, 1996). The technique is generally prone to different sources of errors such as sample size, pore size of the bag and preparation of the sample as suggested

by different workers (Chapman and Norton, 1982; Meherez and Orskov, 1977). However, overall results indicate that there is improvement of dry matter and organic matter digestibility as time of incubation increased.

Conclusion

All barley straw digestibilities increased as time of incubation increased. There was digestibility differences between barley varieties in that barley straw from variety Morrison is more digestible than all other varieties studied. Therefore, this variety is preferred to improve animal performance.

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