NUTRITIVE VALUE OF STRAW

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SUMMARY

The energy content of a feed can be described as gross energy (GE), digestible energy (DE), metabolisable energy (ME) or net energy (NE) for maintenance (NE_m), growth (NE_g) or lactation (NE_l). This paper describes straw in respect of the various energy fractions and the factors responsible for the low energy availability from straws.

INTRODUCTION

Straws and stovers are potential energy feeds because of their high cellulose and hemicellulose contents. Unfortunately the energy in the cellulose and hemicellulose is only partly available to animals, because of poor digesti-bility due to inhibitory elements in the straws. The energy value can be expressed in different ways as shown in Table 1, which gives a schematic representation of the various energy measurement and how they are related to nutritional factors.

Feed evaluation systems to assess the energy value of a feed can be based on DE (TDN system), ME (ARC, 1980) or sometimes NE (NRC, 1984). Energy is digested in the rumen, in the small intestine (energy containing proteins) and in the large intestine and absorbed from the gastro-intestinal tract. However, a part of the energy not recovered in faeces will not be available at tissue level due to losses as methane and in urine. Energy available at tissue level can only partly be used for metabolism. Energy losses are inevitable and determined by digestive and metabolic processes. In this paper various factors will be presented that are responsible for the low nutritive quality of straws.

Gross energy

The gross energy (GE) of carbohydrates (CH_2O) is 4.3 Kcal/g, of protein 5.6 Kcal/g and of fat is 9.2 Kcal/g. Since straws do not vary much with regard to fat and protein contents, the average GE is almost similar for all straws (see Table 2). Rye grass has a slightly higher GE content on DM basis than straws. But the DE, ME, NE_m and NE_g values are much higher in grass than in straws, because of factors that reduce the availability of energy from straw for the animal.

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Digestible energy

A classification of roughages as proposed by Ellis *et al.* (1988) is given in Table 3. The OMD of straws, which is highly related to the energy digestibility, is generally varying from 40 to 55% (Mangat Ram, 1989; Singh and Gupta, 1990; Mohini and Gupta, 1990) and should be classified as low.

The NDF and lignin contents for wheat and paddy straw is shown in Table 4. Both straws should be classified as low quality roughages based on their NDF content.

On the whole, NDF, lignin and silica content of straw are negatively correlated with digestibility (see Table 5). Between and within straws there is however a considerable variation in the effect of lignin on digestibility. For straw from 22 rice varieties grown in Sri Lanka no significant correlation was observed between *in vitro* cell-wall digestibility and lignin content of cell walls (Oosting, unpublished results).

Table 1 Energy definitions in relation to nutritional factors.

Energy definition	Abbreviation	Nutritional factors
1. Gross Energy	GE	Feed composition: - fat (9.2 Kcal/g) - protein (5.6 Kcal/g) - carbohydrates (4.3 Kcal/g)
2. Digestible Energy GE - faecal energy	DE	Feed composition: - cellwall concentration and - composition - nitrogen concentration Metabolic faecal energy losses Intake level
3. Metabolizable energy DE - urinary energy - faecal energy	ME	Excretion of energy urine Production of methanogenic volatile fatty acids in the rumen
4. Net energy ME - heat losses; NE_m = net energy for maintenance NE_g = net energy for growth	NE	Utilization of absorbed nutrients Heat losses due to chewing, rumination and digestion - increased heat losses with increased ME intake or lower quality of feed. NE_m higher than NE_g

Table 2 Energy contents of straws (Mcal/kg DM).

Straws/ grasses	GE (Mcal/mg DM)	DE	ME	NE_m	NE_g
Wheat straw	4.3	1.8	1.48	0.64	0.11
Rice straw	4.0	1.8	1.48	0.65	0.09
Barley straw	3.9	1.8	1.45	0.60	0.08
Bermuda straw	4.4	2.7	2.17	1.31	0.74
Rye grass	4.6	3.0	2.46	1.57	0.97

Source: NRC (1984).

Table 3 Gradation of roughages based on nutritional characteristics.

Type	NDF (%) in OM	Lignin (%) in NDF	OMD (%)	DMI
High	<45	<5	70	90
Medium	45-65	5-10	55-70	70-90
Low	65-80	10-15	45-55	50-70
Poor	80	15	<45	<45

Source: Ellis et al. (1988).

Table 4 Fibre and lignin content in crop residues.

	NDF	ADF	Lignin	Reference
Wheat straw	75.23	50.84	9.60	Walli et al. (1987)
	79.43	58.43	11.90	Kundu and Mudgal (1985)
	82.06	63.94	12.27	Singh and Gupta (1990)
	78.13	55.33	15.00	Franzidas and Porteous (1981)
Paddy straw	64.97	49.03	9.17	Yadav and Yadav (1988)
	79.74	59.27	5.79	Rao et al. (1987)
	66.24	50.83	10.00	Franzidas and Porteous (1981)

Table 5 Correlation coefficients between in IVDMD and some components of feeds.

X_1	X_2	$r(X_1, X_2)$
IVDMD	NDF	-0.44^{*}
	Lignin	-0.71^{**}
	Silica	-0.48^{*}
	OMD	$+0.79^{**}$

Source: Roxas et al. (1984)
* $P < 0.05$; ** $P < 0.01$

Table 6 CP contents in straw and ammonia N concentration inrumen fluid

Straw	CP (%) (N*6.25)	Ammonia (mg/l)	Reference
Wheat straw	3.86	63	Verdonk et al. (1989)
	4.36	46	Mangat Ram (1989)
	3.98	49	Singh and Gupta (1990)
	3.48	39	Srinivas (1991)
Paddy straw	2.5-9.37	-	Doyle et al. (1986)
	5.69	-	Yadav and Yadav (1989)
	4.56	-	Mohini and Gupta (1990)
	6.86	88	Sharif (1984)

The relation between DE and availability of straw nitrogen and minerals

Cereal straws are a poor source of CP (see Table 6), due to a low concentration and a low availability of CP for rumen microbes. The degradability of cell wall associated N in rice straws after 48 hours of incubation in rumen fluid was 48.5% (Oosting, unpublished data). Rumen N availability from straws for microbial digestion may be limited as shown by Oosting *et al.* (1989), although *in vivo* supplementation of straws with a N source does not always result in an increased rumen digestibility (Ørskov and Grubb, 1978).

Metabolizable energy

The ME content of straws is low as compared with most grasses. ARC (1980) stated that 20% of DE is lost as energy in urine and methane independent of the quality of the feed. Total losses of DE in methane and urinary energy of rations based on wheat straw and ammoniated wheat straw fed to cattle and sheep were 18-29% (Oosting *et al.*, unpublished). This indicates, that straws do not differ from other feeds with regard to total losses in methane and urinary energy.

However, during the fermentation of straws, the proportion of acetate is higher and the proportion of propionate lower than in grasses (see Table 7). The methanogenic volatile fatty acids (acetate and butyrate), of wheat and paddy straw diet varies from 80-88% whereas it is about 70% in case of grass. Thus energy losses in the form of methane could be theoretically higher in straws than in better quality feeds.

Net energy

The efficiency of utilization of ME for NE (expressed as k value) decreases with the feed quality. The k value for maintenance does not differ much between feeds (ARC, 1980). Above maintenance higher efficiencies can be expected for better quality feeds than for lower.

Low quality feeds require more grinding energy than better quality feeds as shown in Table 8 (Doyle, 1983). He reported that grinding energy was much higher for untreated wheat straw than for the same straw treated with 5% sodium hydroxide. The higher heat loss observed with low quality feeds in comparison to better feeds could probably partly be explained by an extra heat production associated with chewing and mastication.

Dry matter intake (DMI)

The dry matter intake of an animal is an important parameter in determination of the energy intake. DMI is low when animals are fed straw alone as further elaborated by Prasad *et al.* (1993 a,b) (see Table 9). Comparison of the intake data in Table 9 with the classification of roughages as given in Table 3 shows that straws should be classified as poor/low, with regard to intake.

Table 7 Total Volatile Fatty Acids (VFA), molar percentage and methanogenic percentage of VFA on straw diets.

Straw	VFA molar proportion (%)			
	Acetate	Propionate	Butyrate	Methanogenic
Paddy straw[1]	79.0	15.4	4.2	84.4
Wheat straw[2]	71.0	16.0	13.0	84.0
Grasses	60.0	30.0	10.0	70.0

[1] Sharif (1984); [2] Srinivas (1991).

Table 8 Dry matter intake and grinding energy required for milling of rice straw

Straws	DMI (g/kg$^{0.75}$/day	Power consumption (J/g DM)
Rice straw untreated	28-38	150
Rice straw treated with 5% NaOH	64	74
Rice straw soaked in 5% NaOH	71	89

Source: Doyle (1983)

Table 9 Dry matter intake when fed straws.

Straw	Intake		Reference
	kg/100 kg	BWg/W$^{0.75}$/kg	
Wheat straw	1.27	48.77	Mangat Ram (1989)
Wheat straw	1.40	55.51	Singh and Gupta (1990)
Wheat straw	-	43.00	Thiago et al. (1979)
Oat	-	51.00	Thiago et al. (1979)
Paddy straw	1.61	64.13	Mohini and Gupta (1990)

Source : Prasad et al, 1993a,b

CONCLUSIONS

Straws form a potential source of feed energy, particularly for ruminants. But many factors cause energy in straws to not be as available as in grasses. The energy in straws and grasses can be expressed in different ways, i.e. Gross -, Digestible -, Metabolizable - and Net Energy.

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