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THE NUTRITIVE VALUE OF FOUR ARABLE FARM BY-PRODUCTS COMMONLY FED TO DAIRY CATTLE BY SMALL SCALE FARMERS IN KENYA
II. THE UTILIZATION OF NUTRIENTS BY WETHER SHEEP

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Intake and utilization of nutrients by wether sheep fed on four arable by-products were investigated in in vivo trials conducted at the National Agricultural Research Station, Kitale. The trials were carried out in a completely randomized block design.
Mean daily DM and OM intakes were significantly different ($P < 0.05$) between by-products. All the by-products except sugarcane stalks were readily accepted by the sheep. Daily OM intakes of maize stalks, maize cobs, sugarcane stalks and sugarcane tops we e 60.4, 31.3, 22.1 and 48.4 g per kg $W^{0.75}$, respectively.
ME intake varied form 2.2 to 10.0 MJ/day, with sugarcane stalks and maize cobs providing less than the calculated requirement. Daily mean liveweight changes (measured over 24 days) in the sheep fed on the maize stalks, maize cobs, sugarcane stalks and sugarcane tops were +350, -110, -510 and -10 g, respectively.
DMD of maize stalks (63.8%), maize cobs (60.1%) and sugarcane stalks (60.8%) were not significantly different ($P > 0.05$) but were higher ($P < 0.05$) than DMD of sugarcane tops (54.3%). Similar findings were obtained for their respective OMD.
Voluntary DM and OM intakes of the by-products could not be predicted from their respective digestibility values. However, liveweight changes did vary in relation to the ME content of the by-products.

Key Words: By-products, sheep, digestibility, intake, liveweight change

A viable livestock enterprise requires sufficient feed of the right quality to be available throughout the year. This presents a problem during the dry season in tropical conditions. It was suggested by Chudleigh (1974), Kevelenge (1975) and Stotz (1977) that in Kenya large quantitites of various arable by-products are present on farms during the dry season and could provide a solution to seasonal availability of pastures. Kevelenge et al (1982) reported laboratory studies on four arable by-products -maize stalks, maize cobs, sugarcane stalks and sugarcane tops. The trial showed that the by-products would be a potential source of energy for ruminants. However, the high lignin content could have a deleterious effect on voluntary intake and digestibility.

Workers in other countries have reported relatively high intakes of maize stalks (Ranjan and Kariyar 1969) and ground maize cobs (Hill et al 1953) and sugarcane tops (Ferreiro and Preston 1977a), with lower intakes of sugarcane stalks (Preston 1975).

These observations from other countries require resting under Kenyan conditions and thus a feeding trial with wether sheep was initiated to ascertain the nutritive values of the four arable by-products.

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Materials and Methods

The trial was conducted at the National Agricultural Research Station, Kitale, Kenya. The station is situated at 1° 01' N and 35° 00' E at an altitude of 1890 m.

The experimental diets were green maize stalks, maize cobs, sugarcane stalks and sugarcane tops. The chemical composition of the by-products is summarized in Table 1.

Table 1:
Average composition of the by-products

Item	Experimental feeds			
	Maize stalks	Maize cobs	Sugarcane stalks	Sugarcane tops
Dry matter as fed, %	84.4	72.2	27.1	87.4
Composition of dry matter (100% DM basis), %				
Organic matter	91.9	98.7	97.8	90.4
Crude protein	8.5	2.0	2.4	4.7
Crude fibre	25.0	32.8	20.2	32.2
Ether extract	2.0	0.9	1.6	2.0
N F E	56.4	63.0	73.6	51.5
Gross energy KJ/g	18.0	18.4	16.3	15.9
Digestible energy KJ/g	11.7	10.0	9.6	8.4

Animals and treatments: Twenty Romney Marsh wethers were used in the experiments. The wethers were one to two years old with liveweight ranging from 30.4 to 45.5 kg.

The were four treatments: Maize stlaks, maize cobs, sugarcane stalks and sugarcane tops. Maize cobs were mixed with hay in the ratio of 60:40. The digestibility of the maize cob meal was determined by feeding with the Chloris gayana hay. The quality and digestibility of the hay were 90.6%, 63.2% and 12.0% dry matter, dry matter digestibility and crude protein, respectively. Initially 600g maize cobs were mixed with 400 g hay and fed to the sheep. Each diet was either increased or decreased by 10% refusal. Data analysis was computed by indirect digestibility formula (Crampton and Harris 1969).

Procedures and Measurements: The experiments were conducted in a completely randomized block design. The animals were kept in individual metabolism cages. The cages were locally made, based on the specifications of Hobbs et al (1950) and Horn et al (1954). Modifications were made to the cages by fitting them with rectangular aluminium troughs for separate urine collection.

All sheep were weighed on the first and last day of the feeding trial after they had been starved over night on each occasion. The twenty wether sheep were divided into 4 groups after they had been balanced for age and weight.

Two replicate experiments were conducted for each treatment. There was a preliminary period of 10 days and an experimental period of 14 days in each trial. The sheep were fed twice daily, at 9:00 and 18:00 hours. Each animal was initially fed a total of 1000 g of each by-products. The amounts were increased or decreased according to the appetite of the animals, making sure there was a 10 percent refusal. A comprehensive salt mixture and clean water were provided ad libitum.

Total collection of faeces was made twice daily at 18:00 and 09:00 hr on the following day using faecal collection bags. A 10 percent subsample was obtained from total collected faeces of each sheep. The faecal sub-samples were weighed and dried at 65°C for 48 hr in forced draught ovens. After drying, the sub-samples were weighed again and bulked separately for each sheep. At the end of the experiment, the dry faeces were milled in a Christy and Norris hammer mill (0.8 mm mesh size) and stored in airtight plastic bags ready for laboratory analyses.

Total urine collection in stoppered bottles containing 0.23 g of Mercury bichloride, 2 drops of toluene and 6.2 mls concentrated sulphuric acid was done daily. A 10 percent urine sample from each sheep was bulked and deep frozen for gross energy determination.

The sheep were drenched against parasitism before the trial since the presence of parasites has been shown to depress intake in sheep (Donelly et al 1974).

Analytical procedure: Chemical analyses for dry matter, crude fibre, ether extracts, total ash and nitrogen free-extractives were carried out conventional methods according to A O A C (1975). Nitrogen determination was done by the semi-micro Kjeldahl analysis, according to Markham(1942).

Determination of the gross energy of the by-products, faeces and urine was done by Adiabatic Bomb Calorimetry. Metabolizable energy was estimated by adjusting digestible energy for losses in urine and fermentation gases. Gaseous products of digestion was calculated as 8.0% of the gross energy intake (Maynard and Loosli, 1969; MacDonald et al 1978).

Statistical analyses: Analyses of variance and F-test were done according to standard procedures by Snedecor and Cochran (1967), Goulden (1956) and Steel and Torrie (1960). Means were compared using Duncan's New Multiple Range Test (Steel and Torrie 1960). Regressions and correlations were tested by a t-test (Steel and Torrie 1960; Snedecor and Cochran 1967).

Results

Feed intake and performance by wether sheep are shown in Table 2. The results show that daily dry matter (DM) intake was significantly different ($P < 0.05$) between by-products. Maize stalks had the highest($P < 0.05$) and sugarcane stalks the lowest DM intake. A similar trend was observed in the intake of organic matter of the by-products. All feeds except sugarcane stalks were readily accepted by the wether sheep.

Table 2:

Average dry matter and organic matter intakes and performance of wether sheep fed on arable by-products[1]

Item	Experimental diets				S E of treatment mean and significance level
	Maize stalks	Maize cobs	Sugar-cane stalks	Sugar-cane tops	
Mean liveweight, kg	38.2	43.9	31.5	42.6	
Daily gain/loss weight, kg	$+0.35^{a}$	-0.11^{b}	-0.51^{b}	-0.01^{c}	$\pm 0.04^{***}$
Dry matter intake, g/day	1007.5^{a}	553.1^{b}	299.5^{c}	864.3^{d}	$\pm 30.7^{***}$
DM intake/kg $W^{0.75}$/ day, g	65.7^{a}	32.6^{b}	22.5^{c}	52.7^{d}	$\pm 2.1^{***}$
OM intake, g/day	926.9^{a}	531.4^{b}	293.3^{c}	794.8^{d}	$\pm 26.8^{***}$
OM intake, g/ Kg $W^{0.75}$/day	60.4^{a}	31.3^{b}	22.1^{c}	48.4^{d}	1.8^{***}

*** $P < 0.005$

[1] Means represent data from 10 wether sheep

[a,b,c,d] Means in the same row with different superscripts were significantly different ($P < 0.05$)

Those sheep fed on maize stalks gained weight significantly($P < 0.05$) whereas those on maize cobs, sugarcane stalks and sugarcane tops lost weight. However, liveweight losses in sheep which received maize cobs and sugarcane stalks were not different ($P > 0.05$) but were more ($P < 0.05$) than that observed in sugarcane tops.

Dry matter and organic matter digestibility of maize stalks, maize cobs and sugarcane stalks in Table 3 were not different ($P > 0.05$)but were higher ($P < 0.05$) than that of sugarcane tops.

Crude protein digestibility (CPD) in maize stalks was superior ($P < 0.05$) to the rest of the by-products. The CPD of sugarcane stalks was lowest of all, with large negative coefficient.

The intake of digestible nutrients expressed per kilogram metabolic body weight (Table 3) was highest for maize stalks, followed by sugarcane tops, maize cobs and sugarcane stalks, respectively, with each difference being significant ($P < 0.05$). Intake of metabolizable energy showed a similar significant trent.

Table 3:

Average apparent digestibility coefficients of the by-products and daily intake of nutrients by wether sheep[1]

Item	Experimental Diets				SE of treatment Mean and significance level
	Maize stalks	Maize cobs	Sugarcane stalks	Sugarcane tops	
<u>Apparent digestibility</u>					
Dry matter	63.8^{a}	60.1^{a}	60.8^{a}	54.3^{b}	$\pm$ 1.1 ***
Organic matter	63.8^{a}	60.6^{a}	62.9^{a}	56.2^{b}	$\pm$ 1.1 ***
Crude protein	52.4^{a}	37.3^{c}	-25.1^{b}	37.7^{c}	$\pm$ 3.3 ***
Crude fibre	62.3^{a}	69.8^{b}	35.3^{c}	56.5^{b}	$\pm$ 1.6 ***
N F E	66.1^{a}	57.8^{b}	73.0^{c}	56.6^{b}	$\pm$ 1.2 ***
Gross energy	63.9^{a}	54.8^{b}	58.7^{b}	52.4^{b}	$\pm$ 1.7 ***
<u>Nutrient intake</u>					
Digestible OM, g/day	585.0^{a}	329.3^{b}	183.9^{c}	447.5^{d}	$\pm$ 17.6***
Digestible energy, M J/day	11.8^{a}	5.0^{b}	2.9^{c}	7.4^{d}	$\pm$ 0.37***
Metabolizable energy, M J/day	10.0^{a}	4.3^{b}	2.2^{c}	6.0^{d}	$\pm$ 0.32***

*** P <0.005 [1] Means represent data from 10 sheep

a, b, c, d, Means in the same row with different superscripts were significantly different ($P < 0.05$)

Discussion

Voluntary intake of any feed is an important factor in determining the quality of feeds (Brody 1945; Milford and Minson 1966). In these studies, voluntary intake measurement was a better criterion than digestibility for assessing nutritive value of the by-products.

The intake of maize stalks was found to be equivalent to that of any other green fodder like napier grass *Pennisetum purpureum*. Milford and Minson (1965a) and Milford and Haydock (1965b) found 7.0% CP to be the critical value below which intake declines significantly- The CP content of the maize stalks was 8.5% and that of the other by-products was less than 7.0%. Hence it is possible that crude protein content of the by-products was one of the factors that controlled the observed intakes.

Other factors could also have contributed to the observed low feed intakes. These are indications by Halley and Dougall (1962) that crude fibre plays a role in intake control. However, in the present experiment, crude fibre content could not explain the observed variations in intake.

The contents of the reticulo-rumen exert a direct effect on voluntary intake of dry matter, whereby there exists an inverse relationship between voluntary intake and reticulo-rumen contents (Campling and Balch 1961 ; Campling et al 1961). All the by-products studied could have exerted a filling effect in the reticulo-rumen, due to their bulkiness, thus inducing a depressing effect on intake. Large moisture contents of diets inhibit intake (Perry et al 1975) and the observed low intakes by sheep fed on sugarcane stalks could have been caused by their higher moisture content (sugarcane stalks was fed at 27.1% DM).

Intake is inversely related to retention time (Campling and Freer, 1962 ; Campling et al 1962 ; Freer et al 1962; Freer and Campling 1963) hence the intake of maize stalks and sugarcane tops could have been associated with shorter mean retention time due to their highleaf to stem ratio. Different plant fractions are eaten in different proportions. Laredo and Minson (1973) found a higher intake of leaf than stem due to shorter retention time of leaf DM in the reticulo-rumen. These observations confirm findings by Kevelenge et al (1982). The rate of in vitro dry matter and organic matter disappearance as measured by in vitro digestibility technique for each of the four by-products studied confirmed the observed intakes in this trial.

Maize stalks in this trial gave higher ($P < 0.05$) DMD values than those found by Dysli and and Bressani (1969); Ranjan and Kariyar (1969). These differences in the DMD of maize stalks could have been caused by variations brought about by age of the fodder, environmental temperatures, soil factors and changes in cell contents (Deinum and Dirven 1971; Deinum 1976). Regressions could not establish any significant relationship between dry matter intake, organic matter intake and their respective in vivo DMD and OMD. This indicated that the DM intake and OM intake could not be predicted accurately, hence the observed variations in the intakes of the by-products could not on this basic be explained fully by variation in in vivo apparent digestibility. Generalisation about intake being accounted for by differences in DMD alone cannot be undertaken in tropical grasses due to observed large varietal differences in intake (Minson 1971

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