EFFECT OF PROCESSING ON THE NUTRITIVE VALUE OF EIGHT CROP RESIDUES AND TWO FOREST GRASSES IN GOATS AND SHEEP

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Summary

Eight crop residues: 1, sorghum (*Sorghum bicolor*) straw, 2, maize (*Zea mays*) straw, 3, cotton (*Gossypium* Sp.) straw, 4, sunflower (*Helianthus* Sp.) straw, 5, cotton (*Gossypium* Sp.) seed hulls, 6, groundnut (*Archais hypogaea*) hulls, 7, maize (*Zea mays*) cobs, 8, sugarcane (*Saccharum officinarum*) bagasse and two forest grasses 9, *Heteropogan contortus* dry grass and 10, *Sehima nervosum* dry grass were subjected to three physical processing 1, chopping (2-3 cm) 2, grinding (8 mm sieve) and 3, pelleting (10 mm die holes). The processed material was fed *ad lib.* along with 250 g of concentrate mixture per head per day to 6 adult local goats and 16 adult Nellore rams in ten digestion experiments and finally assessed the nutritive value of the processed roughages by difference method. Grinding increased bulk density by 32.4 (cotton seed hulls, CSH) to 88.1% (*Sehima* dry grass) while pelleting of ground material increased bulk density by 53.9 (maize cobs) to 235.8% (maize straw). The average particle size ranged from 584.1/$^{\mu}$ (sorghum straw) to 1467/$^{\mu}$ (CSH). Modulus of uniformity ranged from 2 : 5 : 3 (sorghum straw) to 7 : 2 : 1 (CSH) while modulus of fineness ranged from 3.4 (sorghum straw) to 5.4 (CSH). Molasses absorbability was highest with cotton seed hulls and least with maize cobs. Pelleting increased DM intake of the residues except cotton seed hulls compared to grinding. Grinding of chopped material/unprocessed material increased DM intake on sorghum straw and cotton seed hulls. Sheep consumed more DM compared to goats on all the residues except sorghum and sunflower straws. Pelleting increased nutritive value of all the residues compared to grinding and chopping. However, no difference was observed in the nutritive value due to grinding and chopping. Goats performed better compared to sheep in utilizing the fibrous residues.

(**Key Words**: Crop Residues, Forest Grasses, Goat, Sheep, Chopping, Grinding, Pelleting)

Introduction

Huge quantities of crop residues, more than 250 million tonnes (Reddy, 1990) are being produced annually in India as a renewable resources but these materials are not being efficiently utilized in view of fibrous nature and poor nutritional quality. Due to severe shortage of feedstuffs for the livestock, the ways of exploring increased use of these materials is of considerable importance. The nutritive value of these roughages can be improved by physical processing methods like chopping, grinding and pelleting which increases the surface area, density of roughages and expose the lignocellulosic fractions for easy access to enzymatic digestion. Increased use of crop residues is one of the important strategies to be pursued for accelerated meat production from small ruminants. Hence, an attempt has been made to study the effect of physical processing on physical characters and nutritive value of eight crop residues, and two forest dry grasses in goats and sheep.

Materials and Methods

Eight crop residues: 1, sorghum (*Sorghum bicolor*) straw, 2, maize (*Zea mays*) straw, 3, cotton (*Gossypium* Sp.) straw, 4, sunflower (*Helianthus* Sp.) straw, 5, cotton (*Gossypium* Sp.) seed hulls, 6, groundnut (*Archis hypogaea*) hulls, 7, maize (*Zea mays*) cobs, 8, sugarcane (*Saccharum Officinarum*) bagasse and two forest dry grasses 9, *Heteropogan contortus* and 10, *Sehima nervosum* were procured locally. Sorghum straw,

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Received May 8, 1991
Accepted January 29, 1992

maize straw, *Heteropogan* grass and *Sehima* grass were subjected to three processing methods 1, chopping (2-3 cm), 2, grinding (8 mm) and steam pelleting (8-10 mm die holes) while the remaining crop residues were subjected to grinding and pelleting. The processed materials were tested for physical characters like molasses absorbability, bulk density, modulus of uniformity, modulus of fineness (ASAE, 1970) and average particle size (Headley and Pfost, 1970). Each of these processed materials and unprocessed cotton seed hulls were fed *ad lib.* along/with 250 g concentrate mixture (48.5 maize, 48.5 groundnut cake, 2 mineral mixture and 1 salt) per head per day in digestion experiments to six adult local male goats and six adult Nellore rams. Ten digestion experiments were conducted on goats and sheep using ten feedstuffs. All the experimental animals were dewormed and kept in individual metabolism cages with feeding and watering arrangements. Fresh clean water was made available all the time. After a 30-day preliminary period a 7-day collection was made. The feed, faeces and urine samples were analysed using the methods of AOAC (1980). Fibre fractions were estimated by the methods of Goering and Van Soest (1970). Statistical analysis of the data were carried out in accordance with Snedecor and Cochran (1968). The nutritive value of the processed roughages was calculated by differnce method.

Results and Discussion

The physical characters of crop residues as affected by different processing methods are presented in table 1. The bulk density of chopped/unprocessed material increased by grinding and further increased by pelleting. The increased bulk density on grinding was due to decreased particle size and further increase on pelleting was due to compaction in the pelleting process. Grinding increased the bulk density of chopped/unprocessed material by 32.4 (CSH) to 88.1% (Sehima grass). Pelleting of ground material increased the bulk density by 53.9 (maize cobs) to 235.8% (maize straw). These differences in bulk density among the residues may be attributed to differences in particle size, shape, fibre character and compactness of molecules.

The average particle size ranged from 584.1 (sorghum straw) to 1467/μ (CSH). The modulus of uniformity (indicative of distribution of particles in coarse, medium and fine mesh screens respectively) ranged from 2 : 5 : 3 for sorghum straw to 7 : 2 : 1 for cotton seed hulls while modulus of fineness (indicative of coarseness of the particles) ranged from 3.4 (sorghum straw) to 5.4 (CSH). These results indicate that the fibre

TABLE 1. PHYSICAL CHARACTERS OF CROP RESIDUES

Characters	Sorghum straw	Maize straw	Cotton straw	Sunflower straw	Heteropogan grass	Sehima grass	Cotton seed hulls	Ground nut hulls	Maize cobs	Sugarcane bagasse
Bulk density (kg/m³)										
Chopped	81.5	59.3	—	—	47.4	44.4	148.0[1]	104.0[1]	148.0[1]	55.6[1]
Ground[2]	133.3	102.6	129.6	166.7	87.5	83.5	196.0	185.0	233.3	100.0
Pelleted	333.4	344.5	311.1	319.1	213.9	207.2	356.0	331.0	359.1	243.7
Particle size (μ)	581.1	659.2	891.3	971.7	1052.3	1079.7	1467.0	851.0	1148.0	625.2
Modulus of uniformity[2]	2:5:3	3:5:2	5:3:2	3:5:2	3:4:3	3:4:3	7:2:1	4:4:2	6:2:2	2:6:2
Modulus of fineness[2]	3.4	3.7	4.4	3.8	3.7	3.6	5.4	4.2	5.0	3.6
Molasses absorbability	40.0	52.5	37.3	34.1	33.4	32.7	55.0	30.0	28.0	41.1
Pelletability	very low	very low	low	low	low	low	good	low	very low	low

[1] Unprocessed
[2] Ground in a hammer mill (40 HP) through 8 mm sieve.

TABLE 2. CHEMICAL COMPOSITION OF EXPERIMENTAL FEEDS (% DMB)

Residues	Type of processing	CP	CF	EE	NFE	TA	NDF	ADF	Hemi-cellulose	Cellulose	Lignin
Sorghum	Chopped/ground	4.6	38.4	1.3	46.2	9.5	76.6	47.5	29.1	37.6	8.4
straw	Pellet	4.6	38.3	1.1	46.7	9.3	77.5	47.9	29.6	38.7	8.8
Maize	Chopped/ground	6.9	37.8	1.3	45.1	9.0	76.7	47.5	29.2	38.3	8.9
straw	Pellet	6.8	37.7	1.2	45.9	8.4	77.7	48.0	29.7	38.7	9.1
Cotton	Ground	4.2	42.7	1.7	46.5	5.0	60.8	46.5	14.3	39.3	6.2
straw	Pellet	4.2	39.6	1.4	49.2	5.6	60.9	46.6	14.3	39.7	6.3
Sunflower	Ground	6.3	39.4	1.1	39.7	13.4	54.5	40.4	14.0	32.3	6.2
straw	Pellet	6.4	38.7	0.9	42.1	12.0	54.8	41.0	13.8	33.3	6.8
Heteropogan	Chopped/ground	3.7	34.1	1.7	54.4	9.1	70.9	45.7	25.1	33.8	6.7
grass	Pellet	3.5	29.8	1.5	55.4	9.8	68.1	44.9	23.2	32.1	6.0
Sehima	Chopped/ground	3.5	32.9	2.0	53.8	7.9	74.2	53.4	20.8	32.3	17.2
grass	Pellet	3.7	29.9	1.6	57.3	7.6	72.2	51.1	20.2	30.1	16.7
Cotton seed	Unprocessed/ground	4.8	39.6	1.0	51.3	3.3	89.4	64.2	25.2	44.9	18.9
hulls	Pellet	4.6	36.8	1.0	53.7	3.9	86.1	61.9	24.3	42.7	17.1
Groundnut	Ground	6.1	60.9	0.6	21.9	11.4	77.4	65.4	11.8	31.1	31.0
hulls	Pellet	6.1	60.4	0.7	21.0	11.9	77.3	66.0	11.3	31.2	31.2
Maize	Ground	3.7	30.1	0.6	53.2	12.4	79.9	39.7	40.2	31.1	5.1
cobs	Pellet	3.7	29.7	0.6	53.1	12.8	79.6	40.1	39.4	31.3	5.2
Sugarcane	Ground	3.4	41.9	1.0	48.8	5.0	70.1	44.3	25.8	40.3	3.3
bagasse	Pellet	3.4	40.1	1.2	49.0	6.3	70.4	44.5	25.9	40.7	3.5
Concentrate mixture	Mash	26.4	3.5	6.0	52.7	11.3	18.3	8.8	9.5	4.9	1.1

from sorghum was much brittle and less resistant and yielded more particles of uniform size compared to other materials. Cotton seed hulls recorded highest particle size and more coarse particles and this may be due to the presence of lint attached to the hulls.

Molasses absorbability was highest with cotton seed hulls and least with maize cobs. The differences can be attributed to the shape of the particles and compactness of molecules. Presence of lint on cotton seed hulls has helped for increased molasses absorbability. The particles of maize cobs were compact, smooth and heavy like solid grits compared to other roughages and this might have resulted in low molasses absorbability. The molasses absorbability which ranged from 28.0 (maize cobs) to 55.0% (CSH) indicate that 100 kg of these ground materials can absorb 28.0 to 55.0 kg of molasses.

Pelletability (indicative of smooth and proper pelleting without creating problems during processing) was good with cotton seed hulls. Pelleting was very low with sorghum straw, maize straw and maize cobs compared to other re-

TABLE 3. EFFECT OF PROCESSING ON DMI AND DIGESTIBILITY OF FIBRE FRACTIONS IN GOATS AND SHEEP

Crop residue	Processing	DMI (% B. wt.)	NDF (%)	ADF (%)	Hemi-cellulose (%)	Cellulose (%)	Lignin (%)
Sorghum straw	Chopping	2.8^{c}	49.9^{d}	49.6^{d}	50.5^{d}	52.1^{e}	17.0^{c}
	Grinding	3.1^{d}	47.6^{c}	47.3^{d}	48.8^{d}	48.0^{d}	17.2^{c}
	Pelleting	3.9^{e}	56.2^{c}	55.7^{e}	56.8^{e}	56.2^{f}	17.9^{d}
Maize straw	Chopping	3.1^{a}	54.9^{e}	55.4^{e}	54.2^{d}	56.4^{e}	17.2^{d}
	Grinding	3.1^{a}	51.9^{d}	51.7^{d}	52.0^{d}	51.0^{d}	17.6^{d}
	Pelleting	3.5^{b}	58.7^{f}	59.2^{f}	58.0^{e}	58.3^{e}	18.7^{e}
Cotton straw	Grinding	3.1^{a}	43.3	40.1	52.8	52.8	21.5
	Pelleting	3.7^{b}	41.2	41.7	39.2	49.9	19.4
Sunflower straw	Grinding	3.2^{a}	45.1	43.6	49.4	42.9	23.7
	Pelleting	3.5^{b}	46.8	45.6	44.0	46.9	21.6
Heteropogan grass	Chopping	3.0^{d}	48.0	45.9^{a}	51.8^{a}	64.8	12.2
	Grinding	3.1^{d}	49.8	47.5^{ab}	53.7^{ab}	66.3	12.2
	Pelleting	4.0^{e}	53.4	51.5^{b}	58.0^{b}	65.0	12.8
Sehima grass	Chopping	2.7^{d}	45.9^{d}	44.3^{d}	49.8^{d}	51.6	12.0
	Grinding	2.8^{d}	45.5^{d}	44.1^{d}	48.8^{d}	51.3	12.2
	Pelleting	3.3^{e}	42.4^{e}	50.7^{e}	57.3^{e}	57.6	12.7
Cotton seed hulls	Unprocessed	4.3^{a}	52.3	50.2^{a}	57.2	63.4	18.2
	Grinding	4.6^{b}	51.7	50.1	55.5	62.8	18.6
	Pelleting	4.6^{b}	56.2	53.9^{b}	61.8	62.2	19.0
Groundnut hulls	Grinding	3.1	14.3	13.2	19.6	22.4	3.1
	Pelleting	4.2	19.2	17.6	27.7	27.3	4.7
Maize cobs	Grinding	3.0	45.5	43.3	47.7	51.9	9.6
	Pelleting	4.0	51.0	48.7	53.4	57.6	9.0
Sugarcane bagasse	Grinding	2.1^{a}	44.8^{a}	42.8^{a}	48.1	44.8^{d}	15.3^{d}
	Pelleting	2.3	42.3^{b}	39.7^{b}	46.6	48.6^{e}	13.6^{e}

^{abc} Values with different superscripts itemwise differ significantly ($p < 0.05$).
^{def} Values with different superscripts itemwise differ significantly ($p < 0.01$).

sidues. This may be due to light, fibrous and coarse nature of the straw particles and more compact and hard grit like nature of maize cobs particles. The knowledge of physical characteristics of these crop residues is helpful in commercial processing and feed compounding.

The chemical composition of different processed roughages (table 2) indicate that they were poor in crude protein, rich in crude fibre. Groundnut hulls were having highest crude fibre (60.9%), lignin (31%) and least nitrogen-free extract (21%) compared to other materials. Lignin content was moderate in *Sehima* dry grass (17.2%) and cotton seed hulls (18.9%) and least in sugarcane bagasse (3.3%).

Voluntary feed intake (table 3) was highest (4.5% B.Wt.) on cotton seed hulls and leaset on sugarcane bagasse (2.2% B.Wt.) among goats and sheep indicating that cotton seed hulls were highly palatable and bagasse was least palatable compared to other residues. Increased DM intake of pelleted rations on all the residues indicate that steam pelleting process improved palatability of these residues compared to ground and chopped forms. Sheep consumed more DM (table 4) compared to goats on all the residues except sorghum and sunflower straw.

Pelleting increased the digestibility of neutral detergent fibre (NDF) in sorghum straw, maize straw, *Sehima* grass ($p < 0.01$) and sugarcane bagasse ($p < 0.05$); acid detergent fibre (ADF) in sorghum straw, maize straw, *Sehima* grass ($p < 0.01$) *Heteropogan* grass, cotton seed hulls and sugarcane bagasse ($p < 0.05$); hemicellulose

TABLE 4. EFFECT OF SPECIES DIFFERENCE ON DMI AND DIGESTIBILITY OF FIBRE FRACTIONS OF CROP RESIDUES

Crop residue	Species	DMI (% B. wt.)	NDF (%)	ADF (%)	Hemi-cellulose (%)	Cellulose (%)	Lignin (%)
Sorghum straw	Goats	3.4^b	52.6^d	52.8^d	52.2	51.2	17.5^b
	Sheep	3.1^a	49.9^c	48.9^c	51.9	52.9	17.2^a
Maize straw	Goats	3.1^d	55.3	55.9	54.5	54.2^b	18.0
	Sheep	3.4^c	55.0	55.1	55.0	56.3^a	17.7
Cotton straw	Goats	3.1	43.0	41.8	45.8	52.9	20.9
	Sheep	3.6	41.5	40.0	46.1	49.8	20.0
Sunflower straw	Goats	3.5^b	46.3	44.7	52.4	44.1	16.2^b
	Sheep	3.2^a	45.1	43.6	49.4	42.9	23.7^a
Heteropogan grass	Goats	3.2	50.3	48.3	54.6	65.4	12.4
	Sheep	3.5	50.5	48.2	54.4	66.0	12.4
Sehima grass	Goats	2.9	48.5	46.8	53.1	52.8	12.1
	Sheep	3.0	47.4	46.0	50.8	54.2	12.8
Cotton seed hulls	Goats	4.0^d	57.2^d	54.4^d	63.8	67.0	19.0
	Sheep	4.8^c	50.9^c	49.4^c	54.4	62.2	18.2
Groundnut hulls	Goats	3.3	16.2	14.7	23.6	25.5	3.7
	Sheep	4.0	17.3	16.1	23.6	24.2	4.1
Maize cobs	Goats	3.4	50.1	47.8	52.4	55.9	9.6
	Sheep	3.6	46.4	44.2	48.6	53.5	9.0
Sugarcane bagasse	Goats	2.1^b	44.3	41.2	49.4	43.3	14.7
	Sheep	2.4^a	42.8	41.3	45.4	42.1	14.3

[ab] Values with different superscripts itemwise differ significantly ($p < 0.05$)
[cd] Values with different superscripts itemwise differ significantly ($p < 0.01$).

in sorghum straw, maize straw, *Sehima* grass ($p < 0.01$), cotton straw and *Heteropogan* grass ($p < 0.05$), cellulose and lignin digestibilities in sorghum straw, maize straw and sugarcane bagasse ($p < 0.01$). Sorghum straw and maize straw recorded higher ($p < 0.01$) NDF and ADF digestibilities and lower ($p < 0.01$) lignin digestibility on chopped ration compared to ground. Goats recorded higher digestibilities of NDF and ADF in sorghum straw and cotton seed hulls ($p < 0.05$) and lignin in sunflower straw compared to sheep. Devendra (1978, 1979a and 1979b) has reported efficient utilization of fibrous residues by goats.

The data of the nutritive value of the residues obtained by difference method (talbe 5) indicate an increased trend of digestible protein (DP) and TDN values due to pelleting on all the residues though these values were statistically significant ($p < 0.05$) only in the case of *Heteropogan* and *Sehima* grasses. The higher nutritive value on pelleted rations may be attributed to higher digestibilities of the nutrients on these rations. Goats recorded higher DP and TDN values on all the residues except maize straw indicating that goats were superior to sheep in utilizing the nutrients from these roughages. The DP value was lowest on cotton seed hulls and sugarcane bagasse (1.4%) and highest on maize straw (3.3%) while the TDN values was least on groundnut hulls (22.5%) and highest on cotton seed hulls (53.5%) compared to other residues.

These results indicate that pelleting increased the nutritive value of these poor quality roughages compared to grinding and chopping. In order to utilize fibrous crop residues in the rations of small ruminants, they have to be subjected to at least a minimum processing like chopping/grinding. Sheep were superior in DM intake and goats were superior in utilization of nutrients from

TABLE 5. EFFECT OF PROCESSING ON THE NUTRITIVE VALUE OF FIBROUS RESIDUES AMONG GOATS AND SHEEP

Crop residues		Chopping	Grinding	Pelleting
Sorghum straw	DP	1.3	0.8	2.6
	TDN	43.8	43.6	52.6
Maize straw	DP	3.2	2.4	4.3
	TDN	49.4	48.0	54.0
Cotton straw	DP	–	2.3	2.7
	TDN	–	51.5	49.3
Sunflower straw	DP	–	2.2	2.4
	TDN		43.9	47.3
Heteropogan grass	DP	1.6	1.6	2.0
	TDN	47.0[a]	48.1[ab]	51.8[b]
Sehima grass	DP	1.3	1.5	2.0
	TDN	51.2[a]	50.1[a]	56.3[b]
Cotton seed hulls	DP	1.2	1.3	1.6
	TDN	52.5	52.6	55.4
Groundnut hulls	DP	–	2.8	3.2
	TDN	–	18.7	26.2
Maize cobs	DP	–	1.8	1.8
	TDN	–	42.9	48.3
Sugarcane bagasse	DP		1.1	1.6
	TDN	–	50.8	49.2

[abc] Values with different superscripts row wise differ significantly ($p < 0.05$).

TABLE 6. EFFECT OF SPECIES DIFFERENCES ON THE NUTRITIVE VALUE OF FIBROUS CROP RESIDUES

Residue		Goats	Sheep
Sorghum straw	DP	1.3	2.4
	TDN	48.1	45.1
Maize straw	DP	3.1	3.4
	TDN	50.1	50.9
Cotton straw	DP	2.5	2.4
	TDN	50.9	49.9
Sunflower straw	DP	2.4	2.2
	TDN*	47.7	43.6
Heteropogan grass	DP	1.8	1.6
	TDN	50.5	48.7
Sehima grass	DP	1.6	1.6
	TDN*	55.4	50.6
Cotton seed hulls	DP	1.4	1.2
	TDN	56.9	50.1
Groundnut hulls	DP	3.0	3.0
	TDN	23.3	21.6
Maize cobs	DP	1.9	1.7
	TDN	47.0	44.2
Sugarcane bagasse	DP**	1.7	1.0
	TDN**	57.6	42.4

* $p < 0.05$, ** $p < 0.01$.

fibrous residues. The nutrients from cotton seed hulls were better utilized and those of groundnut hulls were least utilized by both the species of animals.

Acknowledgements

The authors will like to thank the International Development Research Centre (IDRC) of Canada for the support of the project in the Development of Economic Feeding Systems for goats and sheep from which these results were derived.

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