COMPARATIVE STUDY ON FIBRE CHARACTERISTICS OF RICE AND WHEAT STRAWS

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Summary

In this Experiment three wether male Matou goats (♂), all fitted with permanent rumen fistulae, were used to study the rumen degradabilities (incubation time 48h) of dry matter (DM), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent ligin (ADL), cellulose (CEL) and hemicellulose (HC) and their contents of wheat and rice straws were determined for the different morphological fractions and segments. The results showed that the variation of different fractions for wheat and rice straw is the true resources of their nutritive value variation and the cell wall contents of wheat and rice straw are also obviously different. The rumen degradabilities of different straw fibre are significantly different ($p < 0.01$), meanwhile the effect of straw variety is also significant ($p < 0.05$). The aim was to set up a foundation for studying the rumen degradation of the roughage resources.

(Key Words : Fibre, Rumen Degradation, Wheat, Rice, Straw)

Introduction

Crop residues are an enormous feed resources for ruminants. The digestibility of most crop residues is very low (Chesson, 1984) because of liginification of its cell wall components. In recent years the herbivores nutrition study has made new great progress, the study on feed protein nutrient requirement for herbivores is greatly improved on account of the development of the new protein rumen degradation system (Orskov and McDonald, 1979; Feng, 1984). However, the rumen degradation of straw cell wall is short of system and integrity. It is well known that the straw fibre nutrition is an important factor of the herbivores nutrition study. In this paper, the contents and rumen degradability of wheat and rice straw fibre (NDF, ADF, CEL, HC et al.) were measured and their degradation characteristics in Matou goat rumen were studied.

Materials and Methods

Experimental materials

Three rice varieties's straws of Shanyou 63 (SY63), Dyou 63 (DY63) and Xiangai 63 (XG63) from Changsha city and Taoyuan county in southern China and three wheat varieties's straw of 3039, Baofeng (BF) and Zhengying No. 1 (ZY1) from Yanjin county and Huixian city in northern China were collected during their maturation. The harvesting procedure involved in selecting 50 individual plants at random, beginning one metre from the edge of band, adjacent rows within a block were not collected. Subsequently they were packed into plastic bag then transported into laboratory. The analytical samples were made after being dried in the air. Each rice or wheat variety was collected with three replication.

Preparation of samples

All plants were separated into three morphological fractions identified as the stem (S), leaf blade (LB) and leaf sheath (LS), meanwhile the stem, leaf blade and leaf sheath of 3039 wheat variety from Yanjin and SY63 rice variety from Changsha were respectively disected into three segments designated as $S_{1\text{-}3}$ and $LB_{1\text{-}3}$ and $LB_{1\text{-}3}$ from the top to the bottom according to the plant's position of each fraction, then all samples were dried in a forced draught oven at 65℃ and ground in the laboratory mill to pass through a 1 mm sieve.

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Analytical procedure

The samples were dried in a forced draught oven at 100℃ for 5-6 hours to constant weight to determine the dry matter (DM). The neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) contents were analysed using the method of Goering and Van Soest (1972), the hemicellulose (HC) and cellulose (CEL) contents were calculated as NDF-ADF and ADF-72% acid residues, respectively.

Rumen degradability

The degradabilities of DM, NDF, ADF, ADL, HC and CEL were determined by the Nylon Bag Method (Orskov and McDonald, 1979) with three wether Matou goats fited with the permanent rumen fistulae. The goats were kept in pens with plastic slatted floors, and water was provided ad libitum.

Statistical analysis

The differences of the rumen degradability were tested by analysis of variance (Steel and Torrie, 1980).

Results

Cell wall contents of wheat and rice straw

Rice and wheat variety influenced the cell wall content of their straws as shown in table 1. Especially there were significant differences ($p < 0.05$) in the HC contents of different rice and wheat varieties, but NDF, ADF, ADL and CEL contents had no significant differences ($p > 0.05$).

The variation between rice and wheat straw was significant ($p < 0.05$), in which the NDF and HC contents of wheat straw were lower, the ADL and CEL contents were higher than those of rice straw.

TABLE 1. CELL WALL CONTENTS OF THE WHOLE PLANT AND DIFFERENT MORPHOLOGICAL FRACTIONS (% DM)

		Rice straw					Wheat straw				
		SY63	DY63	XG63	Mean	SEM	3039	BF	ZY1	Mean	SEM
NDF	Whole plant	72.6	74.4	72.3	73.1	1.1	67.1	73.0	67.2	69.1	3.4
	Stem	71.3	74.3	69.4	71.7[b]	2.5	76.2	80.9	70.1	75.7[a]	5.4
	Leaf sheath	77.3	77.5	77.5	77.4[a]	0.1	67.6	71.9	66.5	68.7[b]	2.8
	Leaf blade	68.7	68.4	70.8	69.3[b]	1.3	58.1	61.8	54.8	58.2[c]	3.5
ADF	Whole plant	53.4	56.6	50.3	53.4	3.2	53.5	56.2	55.1	54.9	1.4
	Stem	52.7	58.8	48.9	53.5[a]	5.0	63.8	68.7	61.2	64.6[a]	3.8
	Leaf sheath	56.9	51.4	58.9	55.7[a]	3.9	51.3	50.8	51.3	51.1[c]	0.3
	Leaf blade	49.1	45.6	52.3	49.0[b]	3.4	45.0	46.8	43.0	44.9[d]	1.9
ADL	Whole plant	6.3	6.6	6.0	6.3	0.3	7.4	8.4	7.9	7.9	0.5
	Stem	5.4	6.9	6.0	6.1[a]	0.8	9.5	10.1	9.7	9.8[a]	0.3
	Leaf sheath	4.9	4.8	5.5	5.1[a]	0.4	5.1	5.7	6.5	5.8[b]	0.7
	Leaf blade	7.6	7.6	7.8	7.7[a]	0.1	6.3	6.1	7.7	6.7[b]	0.9
CEL	Whole plant	39.5	42.8	34.6	39.0	4.1	41.6	44.6	43.4	43.2	1.5
	Stem	43.2	49.2	40.1	44.2[a]	4.8	52.8	58.0	50.2	53.7[a]	4.0
	Leaf sheath	41.9	45.2	37.9	41.7[a]	3.6	40.8	40.4	40.1	40.4[c]	0.4
	Leaf blade	29.5	35.2	26.1	30.4[c]	4.6	29.8	33.5	27.2	30.2[c]	3.2
HC	Whole plant	19.4	17.5	22.0	19.6	2.2	13.6	16.8	12.1	14.2	2.4
	Stem	20.5	15.4	20.5	18.8[a]	2.9	12.3	12.2	8.9	11.1[b]	1.9
	Leaf sheath	20.5	18.6	26.1	21.7[a]	3.9	16.3	21.1	11.2	16.2[a]	5.0
	Leaf blade	19.6	18.5	22.8	20.3[a]	2.2	13.1	15.1	11.8	13.3[b]	1.7

[1] Values of each fibre content in the same column with different letters differed ($p < 0.05$).
[2] SEM = Standard error of the treatment means.

As far as the different morphological fractions (stem, leaf sheath and leaf blade) of rice and wheat straw, the corresponding cell wall measurements were all showing significant differences ($p < 0.01$) (table 1). The CEL content of stem, NDF and ADF and HC contents of leaf sheath and ADL content of leaf blade were the highest among three fractions respectively for rice straw, meanwhile the NDF, ADF, ADL and CEL contents of stem and HC content of leaf sheath were the highest among three fractions respectively for wheat straw.

In general, from the top to the bottom, there were a tendency of increasing for the NDF, ADF and CEL contents of different segments from rice and wheat straw, this regularity was not clear for the ADL and HC contents of different segments (table 2).

TABLE 2. CELL WALL CONTENTS OF DIFFERENT SEGMENTS (% DM)

	SY63 rice straw								
	S_1	S_2	S_3	LS_1	LS_2	LS_3	LB_1	LB_2	LB_3
NDF	66.1	71.0	73.1	77.9	77.8	80.0	68.7	69.2	69.4
ADF	47.5	51.2	53.0	51.6	56.7	58.7	45.2	44.9	47.1
ADL	4.0	4.5	5.2	4.6	4.0	6.5	8.5	6.9	6.6
CEL	38.8	41.3	42.0	34.9	40.4	40.2	22.5	26.5	29.0
HC	18.7	19.8	20.0	26.3	21.2	21.3	23.5	24.3	22.4
	3039 wheat straw								
	S_1	S_2	S_3	LS_1	LS_2	LS_3	LB_1	LB_2	LB_3
NDF	73.0	74.1	72.2	62.0	66.3	68.2	53.1	52.8	55.2
ADF	59.4	68.1	64.3	50.1	52.4	48.6	30.0	37.2	39.0
ADL	9.1	8.7	8.5	5.5	5.7	5.6	7.8	6.1	6.5
CEL	48.1	55.7	54.1	40.6	44.1	38.8	22.4	25.8	27.2
HC	13.6	6.0	7.8	11.9	13.9	19.5	14.0	15.7	16.3

In sacco degradability

The rumen dry matter and fibre degradabilities of the whole plant from wheat straw were higher than those of rice straw ($p < 0.05$).

The fibre rumen degradabilities of wheat straw were in the order of CELD > ADFD > NDFD > ADLD > HCD, and the variations among these measurements were very significant ($p < 0.01$), and these fibre rumen degradabilities of different varieties were significant ($p < 0.05$). Similar results were observed for fibre rumen degradabilities in rice straw (table 3).

The DMD, NDFD, ADFD, ADLD and CELD values of leaf blade were higher than those of leaf sheath and stem for wheat straw ($p < 0.01$), but the variation of fibre degradability between leaf sheath and stem was not significant ($p > 0.05$). The DMD, NDFD, ADFD and CELD values of stem were significantly ($p < 0.01$) higher than those of leaf sheath and leaf blade ($p < 0.01$) for rice straw, while differences between leaf sheath and leaf blade were not significant ($p > 0.05$). However the HCD value of stem was much lower than that of leaf sheath and leaf blade ($p < 0.01$) (table 3).

The dry matter and cell wall (fibre) rumen degradabilities of different segments from rice and wheat straws had not obvious regularity from the top to the bottom, however the differences of fibre rumen degradabilities of different segments were not significant ($p < 0.05$) (table 4).

Discussion

Cell wall content

The main components of the cell wall are neutral detergent fibre, acid detergent fibre, acid detergent lignin, cellulose and hemicellulose. The data in table 1 and table 2 show the mean NDF content of the whole plant of rice straw ranging from 72 to 74%, ADF content ranging from 50 to 57%, ADL content ranging from 6 to 7%, CEL content ranging from 35% to 43% and HC content ranging from 18 to 22%. As far the whole plant of wheat straw, its mean NDF, ADF, ADL, CEL and HC content are ranging from 67 to 73%, 54 to 56%, 7 to 8%, 42 to 45% and 12 to 17%, respectively. The significant variation of varieties was also observed. In other word, cell wall

TABLE 3. RUMEN DEGRADABILITIES OF THE WHOLE PLANT AND DIFFERENT MORPHOLOGICAL FRACTIONS (INCUBATION TIME 48 HOURS)

		Rice straw					Wheat straw				
		SY63	DY63	XG63	Mean	SEM	3039	BF	ZY1	Mean	SEM
DMD	Whole plant	45.6	44.2	37.8	42.6	4.2	51.1	47.3	44.3	47.6	3.4
	Stem	46.0	52.3	44.4	47.6[a]	4.2	29.1	29.0	36.9	31.7[e]	4.5
	Leaf sheath	41.4	40.7	42.4	41.5[b]	0.8	46.1	9.9	6.8	47.6[c]	2.0
	Leaf blade	41.2	45.3	37.2	40.9[b]	4.1	60.9	68.3	60.3	63.2[a]	4.4
NDFD	Whole plant	41.0	43.5	38.1	40.9	2.7	45.9	44.7	35.9	42.2	5.5
	Stem	39.8	45.9	36.1	40.6[a]	4.9	26.6	31.1	26.9	28.2[e]	2.5
	Leaf sheath	40.1	38.2	45.7	41.3[a]	3.9	38.7	46.0	39.2	41.3[c]	4.1
	Leaf blade	38.7	45.8	36.3	40.3[a]	4.9	57.1	66.6	52.6	58.8[a]	7.1
ADFD	Whole plant	49.1	50.7	37.8	45.8	7.0	56.0	56.0	48.2	53.4	4.5
	Stem	47.9	57.4	39.3	48.2[a]	9.1	45.8	48.4	48.4	47.5[c]	1.5
	Leaf sheath	45.1	46.0	42.9	44.7[b]	1.6	52.9	56.0	59.4	56.1[b]	3.2
	Leaf blade	42.3	55.3	36.2	44.6[b]	9.8	62.4	67.8	59.6	63.3[a]	4.2
ADLD	Whole plant	27.4	13.1	25.9	22.1	7.8	14.3	26.0	5.6	15.3	10.2
	Stem	23.8	−14.8	39.7	16.2[c]	28.0	−0.7	28.7	21.4	16.5[d]	15.3
	Leaf sheath	3.5	10.7	−0.6	4.5[e]	5.7	8.9	32.3	29.7	23.6[c]	12.8
	Leaf blade	45.4	27.1	46.4	39.6[a]	10.9	43.0	58.9	49.5	50.5[a]	8.0
CELD	Whole plant	52.1	58.6	37.6	49.4	10.8	62.8	61.1	54.0	59.3	4.7
	Stem	53.6	68.8	41.2	54.5[a]	13.8	55.2	53.0	57.6	55.3[c]	2.3
	Leaf sheath	46.5	48.9	48.9	48.1[b]	1.4	64.5	61.2	57.2	61.6[b]	3.6
	Leaf blade	38.0	61.6	30.9	43.5[c]	16.1	68.9	73.0	58.3	66.7[a]	7.6
HCD	Whole plant	19.3	11.6	38.7	23.2	14.0	6.8	−23.2	4.8	−3.9	16.8
	Stem	15.4	2.0	28.4	15.3[c]	10.8	−76.0	−65.4	−166.4	−102.6[f]	55.5
	Leaf sheath	26.0	10.8	51.8	29.5[a]	20.7	−10.8	23.7	−9.8	10.3[d]	19.6
	Leaf blade	29.0	19.1	36.5	28.2[a]	8.7	37.9	62.9	24.8	41.9[a]	19.4

[1] Values of each fibre degradability in the same column with different letters differed ($p < 0.05$).
[2] SEM = Standard error of the treatment means.

content of rice straw is higher than that of wheat straw. Doyle et al. (1986) has pointed out the same effects of variety on the chemical compositions and nutritive value of rice and wheat straws.

Comparisons of the compositions of the different morphological fractions indicated that there were substantial differences between leaf blade, stem and leaf sheath for rice straw. The NDF content of leaf sheath is 6% and 8%, ADF content is 2% and 7%, HC content is 1% and 3% higher than those of leaf blade and stem. This is in agreement with Doyle's report (1990).

On the other hand, the compositions of major morphological fractions in the wheat straw were observed that the NDF content of stem is 7% and 15%, ADF content is 14% and 20%, ADL content is 4% and 3%, CEL content is 13% and 24% higher than those of leaf sheath and leaf blade, respectively. Similar results were reported in the Wales's research report (1990).

Small significances are also noted among different segments from the top to the bottom.

Rumen degradation

Nakashima and Orskov (1989) had reported the rumen degradation of straw. In the present study, the dry matter and cell wall degradabilities of wheat straw were clearly higher than those of rice straw, indicated that the fibre

TABLE 4. RUMEN DEGRADABILITY OF DIFFERENT SEGMENTS (INCUBATION TIME 48H)

	SY63 rice straw								
	S_1	S_2	S_3	LS_1	LS_2	LS_3	LB_1	LB_2	LB_3
DMD	47.4	33.5	49.2	43.3	42.7	32.3	36.4	40.9	42.4
NDFD	37.5	28.7	43.6	43.7	42.3	37.5	41.9	46.2	45.7
ADFD	44.5	33.5	45.9	42.0	45.6	40.6	37.0	44.2	39.5
ADLD	8.4	−15.7	−3.5	25.0	−4.7	34.6	15.1	16.3	20.9
CELD	47.6	38.6	54.2	37.7	50.9	44.0	42.4	53.0	46.2
HCD	19.6	16.5	37.6	47.0	33.5	28.9	51.3	49.9	58.8
	3039 wheat straw								
	S_1	S_2	S_3	LS_1	LS_2	LS_3	LB_1	LB_2	LB_3
DMD	39.7	34.1	33.0	50.2	45.8	44.4	58.6	66.7	53.3
NDFD	30.5	30.6	26.0	39.4	37.2	37.2	55.5	61.1	44.7
ADFD	46.5	51.1	45.5	53.7	53.5	50.5	57.6	65.4	54.0
ADLD	12.1	16.2	−40.3	22.0	21.1	14.5	39.8	37.9	25.5
CELD	53.5	54.9	60.1	57.1	58.3	57.1	64.8	70.8	56.3
HCD	−39.4	−20.0	−134.4	−21.1	−24.6	4.0	49.5	51.0	22.4

structure of rice straw is more complicated and more difficult to be degradated than that of wheat straw.

Wu (1986) suggested that cellulose decompositive bacteria have 25% of total bacteria in rumen and secrete considerable cellulase, so the CELD values of wheat and rice straw were the highest. Higher NDFD and ADFD values occurred in this trial, however ADL was difficult to be degraded. Because cellulose is degraded into hemicellulose in rumen at first and left in the nylon bag, the negative values occurred for HCD.

For three fractions, the lower NDF and ADF contents of stem for rice straw are, the higher DMD and cell wall degradabilities are. As far as the wheat straw, its leaf blade contains the lowest NDF, ADF, ADL and CEL contents, so the DMD and fibre degradabilities are the highest. It could be deduced that the high negative correlations exist between DMD value and NDF, ADF contents, the degradation of straw fibre is depended upon the composition of microbe and bacteria in rumen and chemical structure of straw fibre.

Conclusions

The cell wall content of wheat and rice straw is affected by the variety, morphological fraction and segment, especially the fraction not only influenced the cell wall content of straw but also influence the DMD and fibre degradabilities of straw. Wheat straw is more easily degradable than rice straw in goat rumen. The higher NDF, ADF and ADL contents are, the lower the DMD value and fibre degradabiliteis are. The variation of straw nutritive value is due to the differences of morphological fractions of straw.

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