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Characterization and utilization of rice, legume and rape straws

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SUMMARY - Legume (9 species), rice (3 varieties) and rape straws were given to 6-8 rams in metabolic cages, together with several levels of energy and protein supplementation. Three of the legume straws and all three rice straws were also studied in rumen cannulated sheep. Determinations of chemical composition (ash, CP, NDF, ADF, ADL, some minerals), organic matter digestibility (OMD), metabolizable energy (ME) and voluntary intake of the feeds were made; rumen degradability of organic matter was also assessed with the nylon bag technique. Legume straws had 4.2-10.6% CP, 58.0-82.4% NDF. Rice and rape straws had approximately 4% CP, 77% NDF. OMD varied between 43.5% and 55.3% in legume straws, between 47.0% and 51.9% in rice straws. Rape straw OMD was about 40%. Voluntary intakes varied between 48 g and 77 g per kg $LW^{0.75}$ in legume straws, were around 50 g per kg $LW^{0.75}$ in rice straws and 30 g per kg $LW^{0.75}$ in rape straw. Organic matter degradability was highest, 68.5%, in rice straw (cv. Ringo), lowest in horse bean straw, 53.9%.

Key words: Legume straws, rice straws, rape straw, chemical composition, nutritive value, degradability, ruminants.

RESUME *- "Caractérisation et utilisation des pailles de riz, de légumineuses et de colza". Des pailles de légumineuses (9 espèces), de riz (3 variétés) et de colza ont été distribuées à 6-8 moutons logés dans des cages de métabolisme, incorporées dans des régimes à différents niveaux d'énergie et de supplémentation azotée. 3 des 9 pailles de légumineuses et des 3 pailles de riz ont été étudiées sur des moutons canulés au niveau du rumen. La composition chimique (cendres, PB, NDF, ADF, ADL, et quelques minéraux), la digestibilité de la matière organique (DMO), l'énergie métabolizable (EM), l'ingestion spontanée d'aliment a été contrôlée et la dégradabilité de la MO dans le rumen a été mesurée par la technique des sachets de nylon. Les pailles de légumineuses ont dosé 4,2-10,6% de PB et 58,0-82,4% de NDF. Les pailles de riz et de colza ont dosé 4% de PB et 77% de NDF environ. Le DMO des pailles de légumineuses a changé de 43,5% à 55,3% et celui des pailles de riz de 47,0% à 51,9%. Le DMO des pailles de colza a été de 40%. L'ingéré a été de 48-77 g per kg* $P^{0,75}$*, de 50 g per kg* $P^{0,75}$ *et de 30 g per kg* $P^{0,75}$ *avec les pailles de légumineuses, de riz et de colza, respectivement. La paille de riz (cv. Ringo) a été la plus dégradable dans le rumen, avec une dégradabilité de 68,5%, par contre la paille de féverole a été la moins dégradable avec une valeur de 53,9%.*

Mots-clés : *Pailles de légumineuses, pailles de riz, pailles de colza, composition chimique, valeur nutritive, dégradabilité, ruminants.*

Introduction

High levels of fibrous feeds, particularly straws, are common in ruminant diets in extensive Mediterranean production systems (Coombe, 1981). During the colder 3-4 months of the year (November-February), when grass is scarce, cereal straws are frequently used to complement it. On the other hand, legume straws are usually left in the place where the grains were threshed, where animals can go during the summer months (June-September). Because it is hard to collect, rice straw also tends to stay in the field, where animals shall be allowed to go during the autumn (October-December). While cereal straws are given to cattle, sheep and goats, legume straws are usually reserved for sheep and goats and rice straws reserved for cattle.

In the context of this study it is of fundamental importance that the real meaning of straw be understood. The general definition of straw, as being the aerial part of the mature plant minus its grains, is mostly true for cereals, rice included (Andrieu and Demarquilly, 1987). Legumes easily lose their leaves, and so legume straws are basically constituted by stems – a fact which logically tends to lower their nutritive value (Abreu *et al.*, in press).

The aim of this work, which was supported by contract No. 8001-CT91-0307 was to study: (i) the composition and the nutritive value of a broad range of straws – rice (3), legume (9) and rape (1) straws – when used as the basic feed of sheep diets with different energy densities; and (ii) the degradation rate of such straws in the rumen of cannulated rams.

Material and methods

Feeds

The intake and the nutritive value of nine legume straws, three rice straws and rape straw were studied: 1 - chickpea (*Cicer arietinum* L.) var. Ch K283; 2 - common vetch (*Vicia sativa* L.) cv. Do Caia; 3 - hairy vetch (*Vicia villosa* Roth.) cv. Amoreira; 4 - horse bean (*Vicia faba* L. var. minor) cv. Beja; 5 - lentil (*Lens culinaris* Miedicus) cv. L 214; 6 - pea (*Pisum sativum* L.) cv. Gp 950; 7 - purple vetch (*Vicia benghalensis* L.) cv. Fontainhas; 8 - rape (*Brassica napus* L.); 9 - white lupin (*Lupinus albus* L.) cv. Estoril; 10 - yellow lupin (*Lupinus luteus* L.) cv. Cardiga; and 11, 12 and 13 - rice (*Oryza sativa* L.) cvs Koral, Ringo and Venaria.

Some of the straws were also studied in associated to several grains (barley or peas), mimicking diets used in sheep feeding in Southern Portugal during parts of the year when forages are scarce. Four diets of this kind were studied: (i) chickpea straw + pea grain; (ii) chickpea straw + barley grain; (iii) horse bean straw + barley grain; and (iv) lentil straw + barley grain.

Legume and rape straws were produced from 1992 to 1995 either at Tapada da Ajuda, in Lisbon, or at the National Plant Breeding Station (ENMP), in Elvas. Rice straws were produced in 1994 and 1995 in the Sado valley, near Setúbal. Straws were chopped to 5-8 mm, grains broken in a mill with 5 mm round holes.

Every value described for legume, rape and rice straws (mineral values excepted) is the average of 4 observations (2 places x 2 times).

Animals and diets

In vivo *studies*

Trials were done with adult merino sheep of 55 kg average liveweight and average body score 3-3.5, in metabolic cages. Animals were fed in two identical meals, at 08:30 and 16:30, and had access to mineral supplements in all diets.

Straws were given *ad libitum* (so as to allow for a 10-15% leftover), supplemented with 150 g of protein-rich grain. Groups of 8 rams were used for intake studies, of 6 rams for digestibility studies.

Diets were also studied in *ad libitum* regimes (10-15% leftovers) in which grains (cereals or peas) were added at increasing levels. The same number of animals was used as in straw trials. The grains used had been previously studied by giving them in restricted quantities (600 g d^{-1}), together with barley straw (200 g d^{-1}), to groups of 4 rams (details about these previous studies can be found in Abreu and Bruno-Soares, 1992).

All the trials started with a 15-day adaptation period, followed by a 10-day period of data collection.

In sacco *studies*

In these studies three rumen-cannulated rams in metabolic cages were used. Rams had an average liveweight of 58 kg, and each one received 700 g of oats-vetch hay [9% crude protein (CP) and 44% acid detergent fibre (ADF) in dry matter (DM)] and 300 g of concentrate meal (33% CP and 20% ADF in DM) in two identical meals, at 08:30 and 16:30.

In these trials we studied three legume straws, namely common vetch, hairy vetch and horse bean, and also three straws from different rice varieties. Replicates, one per straw, were ground in a

2.5 mm hole mill, and about 2.5 g of each put in a 12 cm x 7-cm bag. One bag was used per animal and incubation time. Straws were incubated twice per incubation time.

A maximum of twelve bags per animal were introduced into rumens after the 08:30 meal, and periodically removed for analysis: after 3, 6, 16, 24, 48, 72 and 120 hours in legume straw samples, and 3, 6, 16, 24, 48, 72, 96, 120 and 140 hours in rice straw samples. Once removed bags were mechanically washed for 30 min at 30°C, then dried at 65°C for 24 hours. The contents of two bags withdrawn at the same incubation time were pooled to measure organic matter (OM). Washing losses of OM were measured according to Hovell *et al.* (1986).

Sample preparation

To obtain samples of feeds, leftovers and faeces, each data collection period was divided in two 5-day subperiods. The leftovers of each animal were mixed so as to obtain samples for each of the two subperiods, which were then analysed for dry matter and ash. Identical procedures were applied to the faeces, but in this case only 1/5 of the faeces, approximately, was collected daily. As to feeds, daily samples were taken each day, mixed for each subperiod, and analysed for DM and ash.

Chemical composition

Samples of feeds, faeces and leftovers were dried at 60-65°C during 24 hours, then milled with a 1 mm screen. Dry matter was then determined by drying at 100-105°C during 4 hours, and ash determined by complete incineration at 550°C.

Samples of each feed (two per period) were subject to additional analyses: CP (6.25 x Kjeldahl N), crude fibre (CF) (according to AOAC, 1980), neutral detergent fibre (NDF), ADF and acid detergent lignin (ADL), according to Robertson and van Soest (1981). Mineral composition was assessed according to analytical methods used at LQARS (1988). After ashing for 4 hours at 550°C in an oven, ashes were dissolved in chloridric acid. Calcium (Ca), magnesium (Mg), manganese (Mn) and zinc (Zn) were determined by atomic absorption spectrophotometry, phosphorus (P) was determined colorimetrically (ammonium vanadomolibdate), sulphur (S) was determined turbidimetrically.

Intake, digestibility and energy value

Intakes were determined daily for each ram. Organic matter apparent digestibility (OMD) was calculated from the daily quantities of feed, leftovers and faeces, and the corresponding 5-day ash percentages for each ram. To calculate the digestibility of straws the indirect method (Lloyd *et al.*, 1978) was used. Digestible energies were calculated by determining the energies of feeds, leftovers and faeces in a bomb calorimeter (Parr 1261). Metabolizable energy was calculated with the equation of Vermorel *et al.* (1987).

Degradability

Organic matter degradability was assessed by the nylon bag technique (Ørskov *et al.*, 1980), using bags of 42 μm pore size. The corresponding kinetics in the rumen were described according to the model $p = a + b\ (1 - e^{-ct})$ (Ørskov and McDonald, 1979), where a, b, and c are constants defining the degradation characteristics of the sample and t is the incubation time. Regression coefficients were calculated by Genstat (version 5.1).

Statistics

Data on chemical composition were subject to Anova I, data on OM digestibility, intake and degradability to Anova II testing. The Duncan test (Duncan, 1955) was used in all cases to compare averages.

Results and discussion

Straws

Chemical composition

The chemical composition of rice, rape and legume straws are shown in Tables 1 and 2. Some points are worth stressing: (i) the higher CP (*ca.* 10%) and lower NDF (*ca.* 60%) of vetches and peas; (ii) the very low CP (*ca.* 5%) and the very high ADL (14.2%) of chickpea; (iii) the very low CP (4.7%) of rape straw, the high NDF of lupins (*ca.* 80%); and (iv) the low ADL of peas (8.3%). Similar values were mentioned by Sundstøl (1988) for vetch and lentil straws, Jarrige (1988) for horse bean and pea straws, and Hadjipanayiotou *et al.* (1985) for chickpea and horse bean straws.

Table 1. Chemical composition (% DM) of rice, legume and rape straws (averages ± SD)[†]

Straws	Ash	CP	CF	NDF	ADF	ADL
Chickpea	4.7[a] ±0.84	5.0[ab] ±0.66	50.6[de] ±1.5	75.5[cde] ±2.2	57.9[e] ±2.4	14.2[g] ±1.2
Common vetch	8.8[cd] ±3.1	8.3[d] ±0.93	34.4[a] ±1.5	59.9[a] ±2.4	43.0[ab] ±2.9	10.1[bc] ±0.42
Hairy vetch	7.7[bc] ±0.34	10.1[f] ±0.89	35.4[a] ±1.4	61.9[a] ±1.3	47.9[cd] ±2.7	10.6[cd] ±3.0
Horse bean	7.6[bc] ±2.3	6.6[c] ±1.7	46.7[d] ±8.9	72.3[c] ±7.0	55.4[e] ±7.2	11.6[cdef] ±2.3
Lentil	7.0[b] ±2.1	8.6[de] ±1.3	41.8[c] ±3.4	72.7[cd] ±10.4	51.2[d] ±6.2	12.8[efg] ±2.0
Pea	10.1[de] ±1.8	9.7[ef] ±2.0	34.2[a] ±4.0	58.0[a] ±3.8	40.0[a] ±2.9	8.3[b] ±0.53
Purple vetch	8.7[e] ±0.44	10.6[f] ±1.0	41.0[bc] ±3.1	67.1[b] ±0.23	48.5[cd] ±1.5	13.4[fg] ±0.86
Rape	9.7[de] ±0.36	4.2[a] ±0.22	51.3[def] ±0.98	77.0[de] ±1.2	62.3[f] ±1.8	10.8[cde] ±0.54
White lupin	4.1[a] ±0.41	5.9[bc] ±1.3	55.3[f] ±0.88	82.4[f] ±0.57	63.8[f] ±2.0	12.6[defg] ±0.41
Yellow lupin	4.7[a] ±0.27	6.7[a] ±0.92	49.9[ef] ±1.2	77.6[e] ±0.78	58.3[d] ±1.4	9.9[bc] ±0.74
Rice cv. Koral	13.1[f] ±0.35	4.0[a] ±0.15	37.2[ab] ±0.66	76.1[cde] ±0.55	46.3[bc] ±0.95	4.8[a] ±0.10
Rice cv. Ringo	16.3[g] ±0.50	4.0[a] ±0.40	37.2[a] ±0.65	77.3[e] ±0.60	47.2[d] ±1.7	4.7[a] ±0.20
Rice cv. Venaria	12.1[f] ±1.3	4.1[a] ±0.06	38.7[abc] ±0.35	77.1[de] ±0.15	50.1[cd] ±1.1	5.2[a] ±0.10

[†]DM: dry matter; SD: standard deviation; CP: crude protein; CF: crude fibre; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin
[a,b,c,d,e,f,g]Values in the same columns with the same letter do not differ significantly (P = 0.05)

Rice straws had the highest ash (12-16%) and the lowest CP (*ca.* 4%) and ADL (*ca.* 5%) of all straws. Higher values for CP (*ca.* 5.8%) and lower values for cell wall fractions (*ca.* 71%, 43% and 4% for NDF, ADF and ADL, respectively) were reported by Ibrahim *et al.* (1989).

Table 2. Mineral composition (% DM) of rice, legume and rape straws

Straws	Ca (%)	P (%)	Mg (%)	S (%)	Mn (mg 100 g^{-1})	Zn (mg 100 g^{-1})
Chickpea	0.92	0.12	0.27	0.10	1.00	0.55
Common vetch	1.30	0.22	0.30	0.12	3.40	1.70
Hairy vetch	1.20	0.20	0.26	0.18	7.40	3.50
Horse bean	1.00	0.15	0.19	0.04	2.40	3.90
Lentil	1.50	0.19	0.25	0.09	1.80	1.60
Pea	1.10	0.12	0.47	0.15	4.30	2.40
Purple vetch	1.10	0.14	0.32	0.18	5.80	2.50
Rape	0.90	0.10	0.26	0.54	3.00	0.70
White lupin	0.43	0.10	0.18	0.13	12.30	1.00
Yellow lupin	0.66	0.12	0.17	0.14	10.40	3.40
Rice cv. Koral	0.44	0.10	0.11	0.10	3.30	1.70
Rice cv. Ringo	0.46	0.11	0.16	0.12	5.40	4.40
Rice cv. Venaria	0.31	0.11	0.26	0.13	5.00	3.70

As to mineral composition, vetches, horse beans, peas and lentils had higher levels of calcium (1.0-1.5%), vetches and lentils higher levels of phosphorus (*ca.* 0.20%). Other points worth mentioning were the lower levels of Ca, P and Mg in lupins, and the lower levels of S (0.04%) in horse beans. On the other hand, lupins are particularly rich in Mn (10-12 mg 100 g^{-1}). Similar values for calcium and phosphorus composition of legume straws were reported in Alibés and Tisserand (1990).

The composition of cereal straws, reported by several authors (Jarrige, 1988; Sundstøl, 1988; Dias-da-Silva and Guedes, 1990), in agreement with our own data (Abreu *et al.*, in press), seems to vary less than the legume straws here studied. As a rule, cereal straws have lower average CP and ADL, and higher average NDF, than legume straws (Fig. 1).

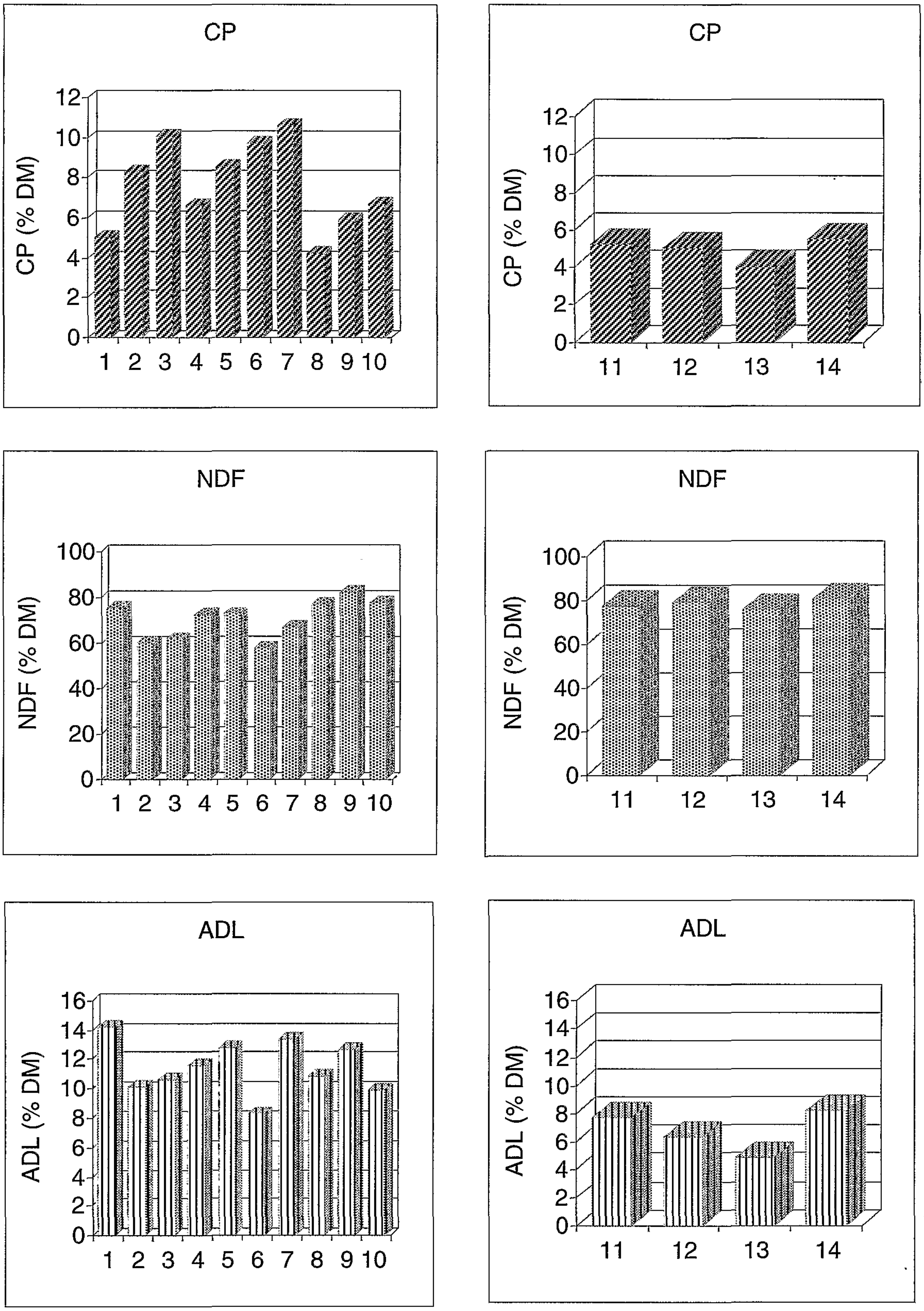
Digestibility and nutritive value

The OMD and the ME of rice, rape and legume straws are described in Table 3.

Since differences among animals were not statistically significant ($F_{[5;46]} = 0.434$; $P > 0.05$), differences in digestibility were related to differences among straws.

Pea straw had the higher (55.3%), rape straw the lower (49.1%) digestibility. Rape straw, furthermore, caused digestive disturbances such as obstipation and abdominal contractions, as well as a reduction of intake.

The legume straws here studied had, as an average, a digestibility of 47.5%, which is practically similar to the average value of 47.3% we found when studying cereal straws (Abreu *et al.*, in press). The digestibilities of the former were, however, more variable than the digestibilities of the latter (Fig. 2) – just as happened with their chemical compositions, that were generally more variable in legume than in cereal straws. The greater range of digestibilities in legume straws may be due to the level and composition of their cell walls. ADF by itself explains ($r = -0.80$; $P \leq 0.001$) about 64% of this variability in our case. Rice straws were somewhat more digestible (51.6%) than other cereal straws. Ibrahim *et al.* (1989) found *in vitro* digestible organic matter (DOM) values of rice straws from 32.7% to 53.4%.



1 to 7 and 9 to 10 – legume; 8 – rape; 11 – barley; 12 – maize; 13 – rice; 14 – wheat

Fig. 1. Crude protein (CP), neutral detergent fibre (NDF) and acid detergent lignin (ADL) of legume, rape and cereal straws.

Table 3. Organic matter digestibility (OMD) (%), metabolizable energy (ME) (MJ kg DM^{-1}) and dry matter intake (g per kg $LW^{0.75\dagger}$) of rice, legume and rape straws

Straws	OMD	ME	Intake
Chickpea	45.1[be] ±2.5	6.1	57[cd] ±4.3
Common vetch	50.0[de] ±1.5	6.6	73[fg] ±2.6
Hairy vetch	49.6[de] ±1.8	6.6	71[fg] ±4.4
Horse bean	48.3[cde] ±3.7	6.2	61[de] ±1.3
Lentil	46.6[bcd] ±3.4	6.2	70f[g] ±8.9
Pea	55.3[f] ±2.9	7.1	77[g] ±8.5
Purple vetch	46.0[bcd] ±1.5	6.0	67[ef] ±7.4
Rape	40.1[a] ±4.6	5.0	30[a] ±4.5
White lupin	43.5[ab] ±2.5	5.8	52[bc] ±3.4
Yellow lupin	50.0[de] ±4.0	6.6	48[b] ±2.5
Rice cv. Koral	51.6[ef] ±1.5	6.3	51[bc] ±5.7
Rice cv. Ringo	51.9[ef] ±3.0	6.0	48[b] ±4.8
Rice cv. Venaria	47.0[bcd] ±2.6	5.7	50[bc] ±8.0

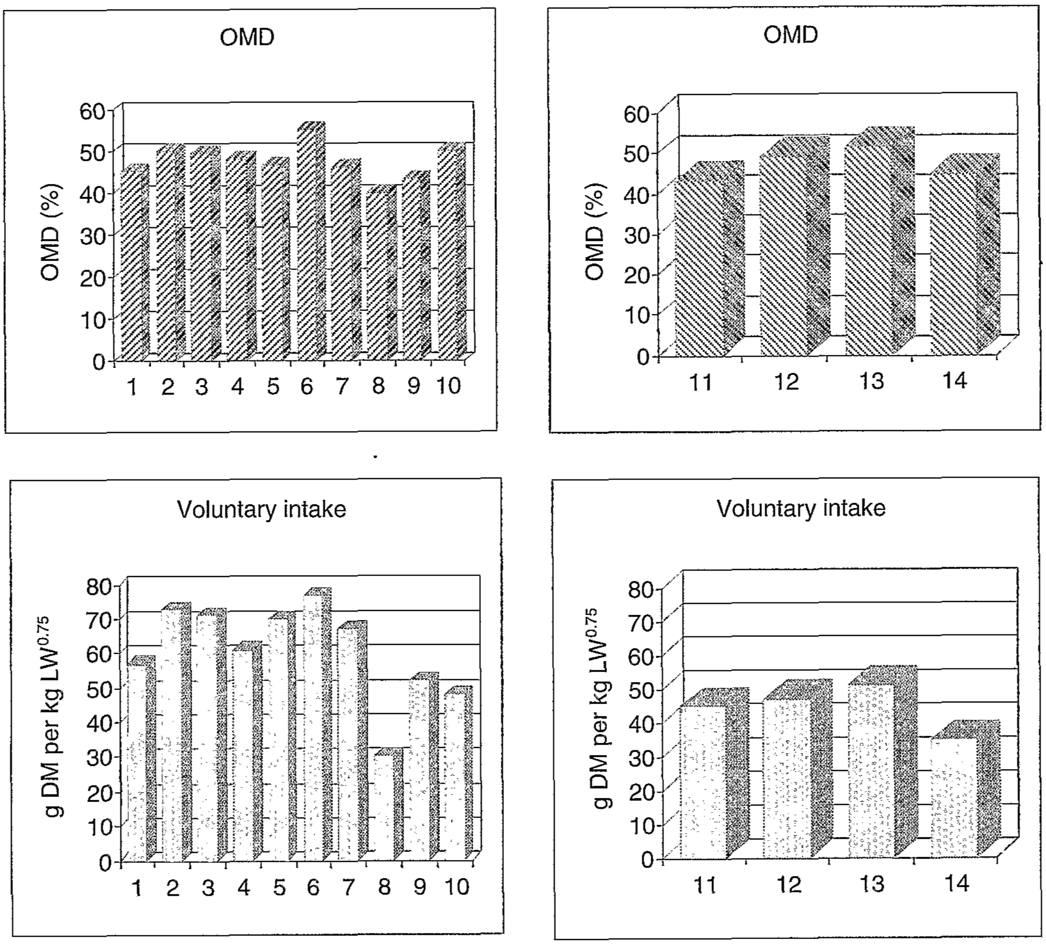
[†]LW: liveweight
[a,b,c,d,e,f,g]Values in the same columns with the same letter do not differ significantly (P = 0.05)

Differences in the digestibility of straws may be due, among other factors, to different stem: leaf ratios (Bhargava *et al.*, 1988), level of weeds (Sundstøl, 1988), soil and climate conditions and variety (Dias-da-Silva and Guedes, 1990).

As might be expected the ME of straws parallels their OMD ($r = 0.94$; $P \leq 0.001$), with a slight discrepancy in the case of rice straw (Fig. 3), probably due to its high level of ash. The same effect of a high level of ash on OMD was reported by Bruno-Soares (1996) in legume leaves.

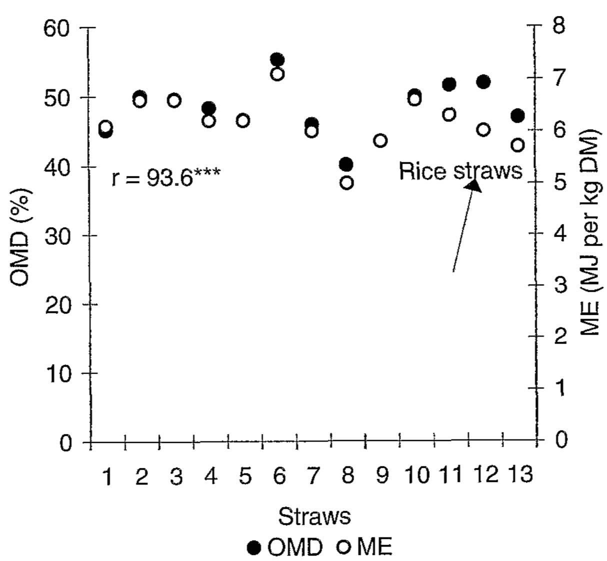
The nutritional balance of straws (from a rumen standpoint) was analysed by looking in each case at the following ratios: N/DOM (ideally 26), P/DOM (ideally 5), and S/DOM (ideally 1.8). The ideal ratios just quoted are the ones proposed by ARC (1980).

Rape, chickpea and white lupin straws, as well as the cereal straws, had N/DOM ratios of half the recommended value. Straws from purple vetch, hairy vetch and pea had higher N/DOM ratios. The ratio P/DOM was low in all cases (< 5) while the ratio S/DOM was always high (> 1.8) except in the case of horse bean straw (S/DOM = 0.9). Rape straw had a particularly high S/DOM ratio (14.9). The high S/DOM ratios were mainly due to high levels of sulphur (0.04% in horse bean straw, 0.54% in rape straw).



1 to 7 and 9 to 10 – legume; 8 – rape; 11 – barley; 12 – maize; 13 – rice; 14 – wheat

Fig. 2. Organic matter digestibility (OMD) and voluntary intake of legume, rape and cereal straws.



1 to 7 and 9 to 10 – legume straws; 8 – rape straw; 10 to 13 – rice straws

Fig. 3. Organic matter digestibility (OMD) and metabolizable energy (ME) of rice, legume and rape straws.

Potential intake

Intakes of rice, rape and legume straws are presented in Table 3.

Since differences among animals were not statistically significant ($F_{[5;46]}$ = 1.12; P > 0.05), differences in intake reflected differences among straws.

Among the seconds, vetch, lentil and pea straws are notable for their high intakes (*ca.* 70 g per kg $LW^{0.75}$), rape straw for its very low intake (30 g per kg $LW^{0.75}$). These intakes may be a reflection of differing cell wall contents – NDF content (r = -0.81; P ≤ 0.001) explains by itself about 66% of variability in intake. The influence of NDF on intake was stressed by several authors, including van Soest (1982) and von Keyserlingk and Mathison (1989). On the other hand rice straws always have intakes (51 g per kg $LW^{0.75}$) greater than the other cereal straws. As a rule legume straws have higher intakes than cereal straws (Abreu *et al.*, in press), a fact that may be related to a quicker particle size reduction during their digestion (Michalet-Doreau and Cerneau, 1991; Bruno-Soares, 1996).

Degradability

Degradability values of rice and legume straws are presented in Table 4, where degradation parameters and washing losses are also reported. The degradation rate and the soluble fraction are always lower in rice than in legume straws. Washing losses are also lower in rice straws (Fig. 4). Nevertheless, the potentially degradable fraction (b) is always higher in rice than in legume straws (in average, 53.3% vs. 40.8%).

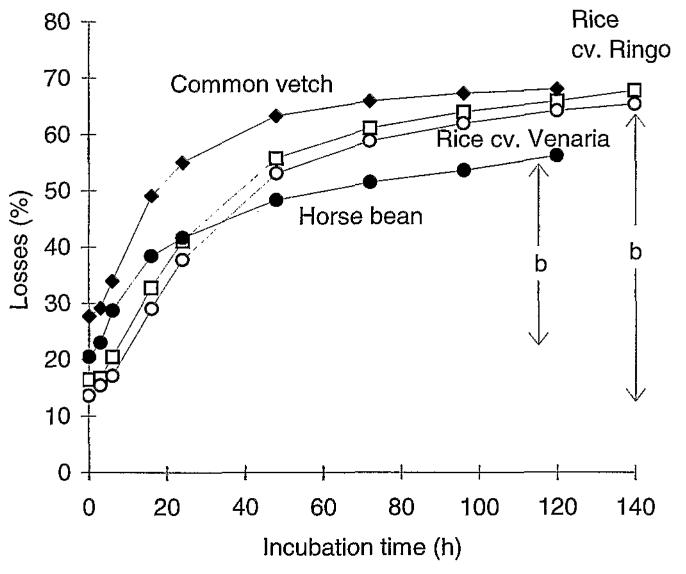
Table 4. Degradation parameters (a, b, c)[†], organic matter degradability (a + b) and organic matter washing losses of rice and legume straws (% in DM)

Straws	a (%)	b (%)	c (% h^{-1})	RSD[††]	a + b (%)	Washing losses (%)
Rice cv. Koral	16.3[c]	49.7[d]	0.028[b]	1.1	66.0[c]	17.6[b]
Rice cv. Ringo	13.7[b]	54.8[e]	0.028[b]	1.3	68.5[c]	16.4[b]
Rice cv. Venaria	11.3[a]	55.3[e]	0.026[a]	1.0	66.6[c]	13.6[a]
Common vetch	23.1[e]	44.6[c]	0.049[c]	0.92	67.7[c]	27.7[e]
Hairy vetch	19.6[d]	40.7[b]	0.069[d]	0.81	60.3[b]	24.0[d]
Horse bean	16.8[c]	37.1[a]	0.048[c]	1.9	53.9[a]	20.4[c]

[†]Constants of Ørskov and McDonald (1979) model (a: soluble fraction; b: potential degradable fraction; c: degradation rate of b fraction)
[††]RSD: residual standard deviation
[a,b,c,d,e]Values in the same columns with the same letter do not differ significantly (P = 0.05)

The organic matter degradability of rice straws varied between 66.0% (cv. Koral) and 68.5% (cv. Ringo), of legume straws between 53.9% (horse bean) and 67.7% (common vetch). Our values for rice straw rumen degradability are in agreement with data of other authors (Ørskov and Reid, 1987; Adebowale *et al.*, 1989; Ariel and Werner, 1989) on the degradability of cereal straws.

An analysis of the relationship between degradability and chemical composition showed correlations between the soluble fraction (a) and CP (r = 0.88; P ≤ 0.05), the potentially degradable fraction and NDF (r = 0.87; P ≤ 0.05) or ADL (r = -0.92; P ≤ 0.001), and the degradation rate and the NDF (r = -0.99; P ≤ 0.001). Our results confirm other authors (Cross *et al.*, 1974; Mertens, 1993) observations that the level and composition of the walls have a strong influence on the degradability of straws.



b – Potentially degradable fraction

Fig. 4. Organic matter losses in rumen of rice and legume straws, during incubation time.

Diets

Values for the OMD, ME, intake and feeding level of the diets tested are reported in Table 5.

Table 5. Organic matter digestibility (OMD) (%), metabolizable energy (ME) (MJ kg DM^{-1}), intake (g per kg $LW^{0.75}$) and feeding level of the diets

	OMD	ME	Intake	Feeding level
Chickpea straw + Pea grain				
70% chickpea + 30% pea grain	57.0	8.0	83	1.7
45% chickpea + 55% pea grain	68.5	10.0	99	2.5
Chickpea straw + Barley grain				
80% chickpea + 20% barley grain	50.1	6.3	65	1.2
70% chickpea + 30% barley grain	52.7	7.7	82	1.6
60% chickpea + 40% barley grain	55.5	7.8	90	1.8
Horse bean straw + Barley grain				
80% horse bean + 20% barley grain	54.0	7.1	70	1.4
70% horse bean + 30% barley grain	56.3	7.5	86	1.7
60% horse bean + 40% barley grain	57.0	7.2	89	1.8
Lentil straw + Barley grain				
85% lentil + 15% barley grain	51.4	7.0	80	1.5
75% lentil + 25% barley grain	54.3	7.1	86	1.7
65% lentil + 35% barley grain	56.6	7.5	92	1.9

The diet chickpea + pea caused a 3.6% reduction in the digestibility of straw OM, irrespective of the level of grain (30% and 50%); with 30% of grain there was a slight increase in straw intake (1.1 g per kg $LW^{0.75}$), while 50% of grain strongly reduced it (12.5 g per kg $LW^{0.75}$). The addition of 30% of grain to the diet thus strongly increased the intake of energy, which almost doubled.

The diets chickpea straw + barley grain, horse bean straw + barley grain and lentil straw + barley grain all caused a reduction of straw digestibility, a reduction which amounted to 5 points with 40% grain in the diet. In our case the effect of high levels of grain (Y) on the digestibility (X) of the straws may be expressed by the equation $Y = 1.55 - 0.16X$ ($R^2 = 78.8\%$; $P \leq 0.001$). Straw intakes, however, were not so much affected by the grain.

Conclusions

Almost all straws studied, vetch and pea straws being exceptions, had very low nitrogen levels. All straws had high NDF values, all legume straws high ADL values.

As a rule the straws of this study were not low in sulphur, horse bean straw being the only exception to this. On the other hand their phosphorus levels were always limiting for the activity of the rumen microflora.

Intakes of rice straw were intermediate relative to the range of legume straw intakes. Particularly low levels of intake of some straws, such as rape straw, may reflect the presence of toxic or antinutritional substances in such straws, while particularly high intakes of others may be due to a faster degradation in the rumen.

Digestibility and energy value of all straws studied were, as might be expected, low; but one could detect significant differences among straws.

The depressing effect of cereal grain on straw OM digestibility, and the stimulating effect of legume grains on straw intake, were confirmed.

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