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Grape marc and maize cobs in heavy lamb diets

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Summary — The effect of the introduction into mixed diets of grape marc (GM) or maize cobs (MC) in partial or total substitution for lucerne hay was evaluated in 2 experiments with heavy Bergamasca lambs. The diets were pelleted and contained 40% (DM basis) concentrate and 60% hay and/or by product: GM_0, GM_{30} and GM_{60} in the first experiment and MC_0, MC_{30} and MC_{60} in the second. For each diet, the voluntary intake and live weight gain were measured with 3 lambs, initially 2 months old, over a period of 50 d. Digestibility was measured by intake/excretion balance in 4 4-month-old lambs. The digestibility of the dry matter (DM), organic matter (OM), gross energy (GE), crude protein (CP) and NDF in diets GM_0, GM_{30} and GM_{60} decreased ($P < 0.05$) with the increasing percentage of grape marc. Generally smaller and non-significant differences were observed in the second experiment, but in diets MC_{30} and MC_{60} the digestibility of GE was lower ($P < 0.05$) than in MC_0. In both trials there was a modest non-significant negative digestive interaction between the hay and the by-product. The maximum DM intake was recorded in diets containing both lucerne and the by-products: 147 g/$LW^{0.75}$ for the GM_{30} diet and 139 g/$LW^{0.75}$ for the MC_{30} diet. The GM_{60} diet produced a lower daily gain than the GM_0 diet (–98 g/d), while GM_{30} had an intermediate gain. In the MC diets the best result was obtained with the MC_{30} diet (70 g/d higher than MC_0).

grape marc / maize cob / heavy lamb / digestibility / voluntary intake / daily gain

Résumé — Marc de raisin et rafles de maïs dans les rations pour agneaux lourds. *L'utilisation digestive, l'ingestibilité et le rendement pour la croissance de rations mixtes à base des sous-produits marc de raisin (GM) et rafles de maïs (MC), en substitution totale ou partielle du foin de luzerne, ont été évalués au cours de 2 expériences sur des agneaux de race Bergamasca. Les rations étaient broyées et agglomérées et contenaient 40% de la MS sous forme d'aliments concentrés dosant 25% de MAT (maïs 35,5%, orge 20,0%, farine de soja 39,0%, minéraux et vitamines 5,5%) et 60% de foin et/ou de sous-produit. Dans le 1^er^ essai, nous avons étudié le marc de raisin avec 3 régimes : foin seul (GM_0), moitié foin et moitié marc de raisin (GM_{30}) et marc de raisin seul (GM_{60}). Nous avons fait de même avec les rafles de maïs dans le 2^e^ essai : MC_0, MC_{30} et MC_{60} (tableau I). La digestibilité a été mesurée sur 24 agneaux âgés de 4 mois, 4 pour chaque régime, l'ingestion volontaire et la croissance pondérale sur 18 agneaux de 2 mois, 3 pour chaque régime, pendant une période de 50 jours. La digestibilité de la MS, de la MO, de la MAT, du NDF et de l'EB des rations GM_0, GM_{30} et GM_{60} a diminué (P < 0,05) avec l'augmentation des marcs de raisin dans la ration. Avec les rations MC_{30} et MC_{60}, la digestibilité de l'EB a été inférieure (P < 0,05) à celui de MC_0 Une modeste et négative interaction digestive a été observée dans les 2 essais entre le foin et les sous-*

produits. En considérant conjointement les observations des 2 essais, le pourcentage de NDF digéré est en corrélation négative (r = –0,96) avec le degré de lignification ; les constituants cellulaires solubles sont digérés en proportion constante (digestibilité évaluée 82%, P < 0,01), indépendamment de la formulation des rations. L'ingestibilité de la MS a été élevée pour toutes les rations ; en particulier, la valeur maximale a été relevée avec le régime contenant soit de la luzerne, soit des sous-produits : 147 g/PV^{0,75} pour le régime GM_{30} et 139 g/PV^{0,75} pour le régime MC_{30}. Celle-ci a été favorisée par le broyage et l'agglomération (tableaux V et VI). Une ingestion d'EB faible a été remarquée seulement avec la ration GM_{60} (P < 0,05). Dans les autres cas, la concentration faible de l'ED dans les régimes avec les sous-produits a été compensée par une consommation plus élevée. Par suite, l'ingestion quotidienne d'ED pour les régimes GM_0 et GM_{30}, d'autre part, et les régimes MC_0, MC_{30} et MC_{60}, d'autre part, n'a pas été différente de façon significative. Le régime GM_{60} a produit une croissance journalière plus basse comparé au régime GM_0 (–98 g/j), tandis que le GM_{30} a permis une croissance intermédiaire. Avec les régimes MC, les meilleurs résultats ont été obtenus avec le MC_{30} (70 g/j plus élevés par rapport au MC_0).

marc de raisin / rafles de mais / agneau / digestibilité / ingestibilité / croissance

INTRODUCTION

Fibrous and poor quality agricultural and processing industry by-products need to be offered with higher quality forages or concentrates to balance their deficiencies in animal diets. The efficiency of the introduction of by-products into the diet in place of more traditional feedstuffs depends on the nutritional characteristics of the by-products, and may cause interactions at various levels.

Particular attention has been given to interactions between fibrous feeds and concentrates in terms of intake and digestibility.

In the former case, the interaction is manifested as a depression in forage intake caused by a substitution mechanism (Blaxter *et al,* 1961; Berge and Dulphy, 1985; Jarrige, 1988a). In the latter, the addition of concentrates to the diet results in lowered digestibility of the fibrous components due to modifications in the composition and efficiency of the microflora (Mould, 1988; Mould *et al,* 1983; Berge and Dulphy, 1991). These phenomena are defined as associative effects.

It is sometimes also possible to identify a type of interaction between the fibrous components in a diet if these components are sufficiently different in chemical and physical terms. Phenomena of this type have been reported for combinations of poor quality forages and lucerne (Paterson *et al,* 1981; Soofi *et al,* 1982; Hunt and Paterson, 1983; Brandt and Klopfenstein 1986a, b, c).

The study reported here, which is part of a wider research project on the nutritive value of ruminant rations, studied the effects in terms of digestibility, voluntary intake, live weight gain and possible interactions, of the introduction of various levels of the by-products grape marc and maize cobs into diets for heavy lambs. Lucerne hay was used as reference feed.

MATERIAL AND METHODS

Diets

The trial was conducted in 2 distinct cycles. In each experiment, 3 pelleted diets were used, composed in each case of 40% compound feed together with either lucerne hay (diet identified by the subscript "0"), one by-product (subscript "60") or equal parts of hay and by-product (subscript "30"). In the first experiment, dried grape marc (GM) was used and in the second milled maize cobs (MC) (table I). The concentrate based on maize, barley and extracted soyabean meal was formulated to provide, in each diet, a crude protein concentration of not less than 13.5% on a dry matter basis.

Chemical composition

Samples of the feeds, concentrates and diets were analysed for dry matter (DM), crude protein (CP), ether extract (EE) and fibre fractions – NDF, ADF, ADL – (Goering and Van Soest, 1970). The cell content (CC) was calculated from 100-NDF, the endocellular carbohydrates (EC) from CC-CP-EE-(ash–acid insoluble ash). Gross energy (GE) was determined by adiabatic bomb calorimetry.

Digestibility

The digestibility of each diet was calculated by direct weighing of food offered and faeces excreted by 4 heavy Bergamasca lambs aged 4 months and with an average liveweight (LW) of 45 kg. An average intake level of 102 g/kg $LW^{0.75}$ was adopted, ≈ 80% of the value recorded during the last days of the voluntary intake trial.

The digestibility coefficients (d) of DM, OM, CP, EE, CC, NDF and GE were determined.

The relationship between dNDF and the degree of lignification (L) expressed as ADL/NDF (Van Soest, 1983) and between the amount of digested CC and CC content in DM was calculated.

Voluntary intake and live weight gain

The voluntary intake of the experimental diets and the live weight gain (LWG) of the lambs was measured over a 50-d period in 18 Bergamasca lambs (3 per diet), initially 60 d old and kept in individual pens after weaning at 40 d. The animals were weighed (2 weighings on 2 consecutive days) at the beginning (LWi) and end (LWf) of the experimental period. The data were expressed in g/d, with the voluntary intake also in g/kg $LW^{0.75}$, with LW = (LWi + LWf)/2. In order to assess the combined effects of metabolic control and stomach fill on appetite, voluntary intake was related to dietary digestible energy (DE).

The feeding level (FL) was calculated as the ratio of daily intake of digestible organic matter (DOM) expressed in g/kg $LW^{0.75}$ and the daily maintenance requirements of lambs, *ie* 26 g DOM/kg $LW^{0.75}$ (Tissier and Theriez, 1978).

Table I. Diet composition.

Diets		*Components (%)*		
1st experiment (grape marc)	*2nd experiment (maize cobs)*	*Concentrate **	*Lucerne hay*	*By-products*
GM_{60}	MC_{60}	40	0	60
GM_{30}	MC_{30}	40	30	30
GM_0	MC_0	40	60	0

* Concentrate (on a DM basis): maize 35.5%, barley 20.0%, soybean meal 39.0%, mineral and vitamin supplement 5.5%.

Statistical analysis

The parameters measured in each experiment were analysed separately by monofactorial design (diet) at 3 levels. The significance of the 2 orthogonal contrasts was tested: a) the effect of the complete substitution of the lucerne by the by-product (GM_0 *vs* GM_{60} and MC_0 *vs* MC_{60}) ; b) the effect of the interaction between the diets with only 1 bulky component (GM_{30} *vs* [GM_0 + GM_{60}]/2 and MC_{30} *vs* [MC_0 + MC_{60}]/2, expression of the possible non-additive effects between the mixed diets. As the proportion of concentrate in the diets was constant, the interactions could be attributed to the forage components.

RESULTS

Chemical composition and digestibility

The chemical compositions of the dietary ingredients – hay, by-products and concentrates – are reported in table II. The hays used in the 2 years had the typical composition of poor quality first-cut lucerne hays.

The grape marc had a good protein level, an NDF content comparable to that of the hay and high ADF and lignin concentrations due to the presence of an appreciable quantity of pips.

The maize cobs had very low nitrogen and ether extract levels, but were rich in structural carbohydrates, relatively lightly lignified.

The EC content was higher in GM than in MC; referred to CC, it represented respectively 38.4% and 60.9%.

Table II also shows the chemical composition of the diets, which do not differ from that expected from the proportions of the individual constituents.

In particular, the diets in the 1st experiment had very similar concentrations of CC and CP and a progressive increase in ADL with the increasing fraction of marc.

Table II. Chemical composition (%DM) and GE (Mcal/kg DM) of ingredients and diets.

	CP	*EE*	*ASH*	*NDF*	*ADF*	*ADL*	*CC*	*EC*	*GE*
Ingredient:									
Grape marc (GM)	14.9	5.1	9.0	64.6	56.2	29.5	35.4	13.6	4.95
Maize cobs (MC)	4.6	0.6	3.0	84.4	41.8	6.8	15.6	9.5	4.41
Lucerne hay, 1st experiment	13.3	1.4	12.7	60.6	43.4	8.5	39.4	16.4	4.21
Lucerne hay, 2nd experiment	13.5	1.9	10.3	59.3	43.1	9.8	40.7	18.2	4.41
Concentrate, 1st experiment	25.0	3.0	9.0	12.1	5.3	0.9	87.9	51.8	4.30
Concentrate, 2nd experiment	26.7	2.5	8.8	12.4	5.4	0.9	87.6	50.6	4.28
Diets, 1st experiment:									
GM_0	17.8	1.9	11.9	43.5	27.6	4.9	56.5	27.9	4.25
GM_{30}	18.5	3.5	10.1	44.4	32.0	12.8	55.6	26.8	4.47
GM_{60}	18.5	4.7	9.8	44.9	35.6	18.1	55.1	26.5	4.60
Diets, 2nd experiment:									
MC_0	18.1	2.2	9.7	40.4	28.1	5.6	59.6	32.5	4.42
MC_{30}	15.9	2.1	8.2	48.0	25.0	4.0	52.0	26.9	4.43
MC_{60}	13.5	1.5	6.3	53.6	25.0	3.3	46.4	26.7	4.40

On the other hand, in the diets in the 2nd experiment, the concentrations of CC and CP diminished with the increasing proportion of by-product. The same trend was observed for lignin.

The digestibility coefficients of the diets in the 1st experiment based on lucerne hay and/or grape marc are reported in table III. The values for dietary DM, OM, GE, CP and NDF decreased ($P < 0.05$) with increasing marc percentage; the CC digestibility remained constant. Those of diet GM_{30} were intermediate between those of diets GM_{60} and GM_0, but were slightly displaced towards the lower values, leading to a slightly negative non-significant interaction.

Smaller differences were obtained between the digestibility coefficients for the diets in the 2nd experiment based on hay and/or maize cobs (table IV). It is worth mentioning the good dNDF (54.6%) in diet MC_{60}, which was 4.6 percentage points higher than that recorded for diet MC_0. The dEE was high, particularly in the diets containing the corn cobs, which had the lowest percentage of this chemical component. However, the values were affected by analytical error leading to a degree of overestimation, as an important fraction of the faecal fatty acids are present as Mg and Ca soaps which are insoluble in ether (Van Soest, 1983). The dE of the diets containing the maize by-product was significantly lower ($P < 0.05$) than in the diet containing only lucerne and concentrate.

As in the 1st experiment, a modest non-significant, generally negative, interaction was observed between the diets.

Figure 1 shows the effect of the degree of lignification on NDF digestibility from all the 24 intake/excretion ratios assessed in the 2 experiments. It can be seen how the progressive substitution of lucerne hay by the more heavily lignified grape marc or by the slightly lignified maize cobs resulted in the first case in a reduction of NDF digestibility, in the second in an improvement. Overall, the dietary ADL/NDF ratio explained 92% of the variability observed in NDF digestibility.

The amount of digested CC increased with increasing concentration in DM (fig 2). The regression coefficient, which is an estimate of the true digestibility coefficient for CC, was 0.82.

Table III. Digestibility coefficients (%), 1st experiment.

	Diets			*Interaction*	*SEM* *
	GM_0	*GM_{30}*	*GM_{60}*		
DM	63.5^a	54.4^b	48.2^c	−1.4	2.24
OM	64.6^a	55.3^b	47.6^c	−0.8	2.22
CP	67.5^a	56.4^b	49.3^c	−2.0	2.92
EE	77.4	76.8	79.2	−1.5	5.23
CC	74.3	72.0	72.6	−1.4	2.66
NDF	49.6^a	32.3^b	18.2^c	−1.6	3.10
GE	62.5^a	54.5^b	49.7^c	−1.7	2.26

* SEM: pooled standard error of the mean; on the same row: ^{a,b,c} $P < 0.05$; GM: grape marc.

Table IV. Digestibility coefficients (%), 2nd experiment.

	Diets			*Interaction*	*SEM* *
	MC_0	*MC_{30}*	*MC_{60}*		
DM	64.6	62.0	62.8	−1.7	2.30
OM	66.3	63.4	63.7	−1.7	2.13
CP	71.7	68.9	70.2	−2.1	2.33
EE	77.5^b	84.0^a	85.7^a	2.4	2.78
CC	74.4	71.7	72.2	−1.6	2.23
NDF	50.0	51.4	54.6	−1.0	3.07
GE	66.0^a	60.2^b	58.7^b	−2.2	2.44

* SEM: pooled standard error of the mean; on the same row: ^{a,b,c} $P < 0.05$; MC: maize cobs.

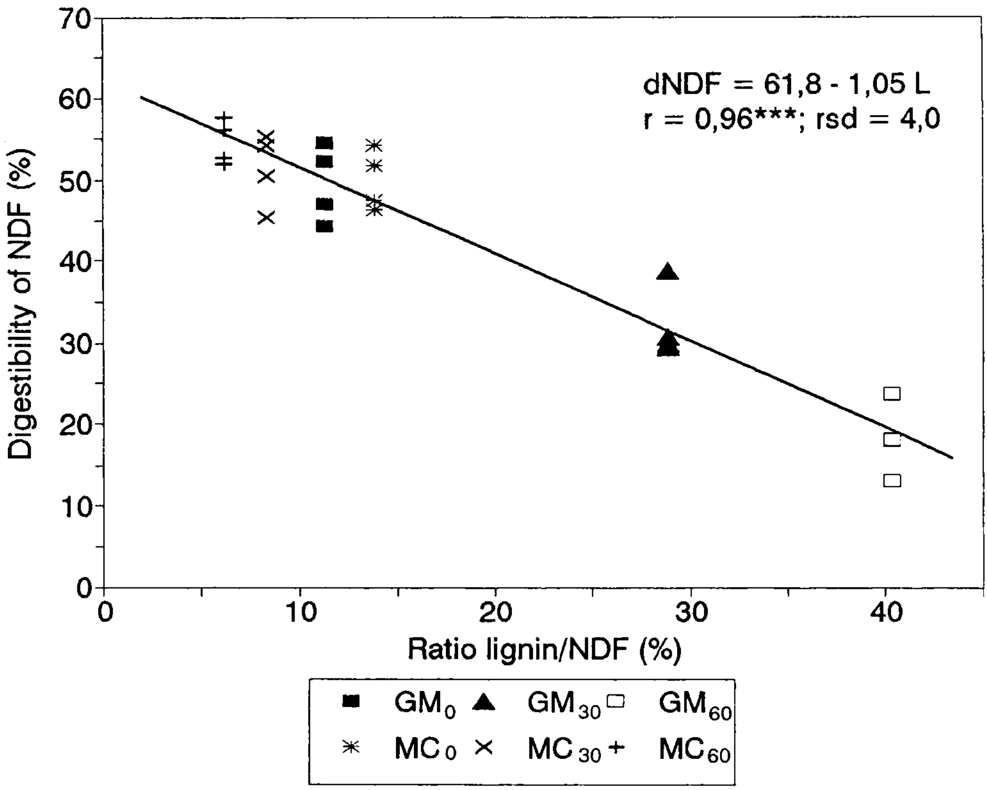

Fig 1. Digestibility of NDF (dNDF) in relation to the degree of lignification (L = lignin/NDF %).

Figure 3 shows the quantity of digested OM, its separate components and digested energy per kg DM. The substitution of lucerne hay by grape marc led to a decrease in digested OM and in the ratio between the cell wall and cell content nutrients. In the case of maize cobs, the amount of digested OM remained almost constant, whilst the digested NDF/digested CC ratio increased with increasing rates of MC in the diet. However, in each case, the use of grape marc or maize cobs resulted in a reduction in the quantity of apparently digested energy and protein.

Voluntary intake

The voluntary intake of the diets is reported in tables V and VI. In both experiments, DM intake was higher in the diets containing by-products in the place of lucerne. In terms of metabolic live weight, intake was ≈ 7% higher with the GM_{60} diet and 8% with the MC_{60} diet. The maximum intake was recorded with diets containing both lucerne and the by-product: GM_{30} was 14% higher than GM_0 and MC_{30} 19% higher than MC_0. These DM intakes allowed the lambs fed the GM_{30} and MC_{30} diets to

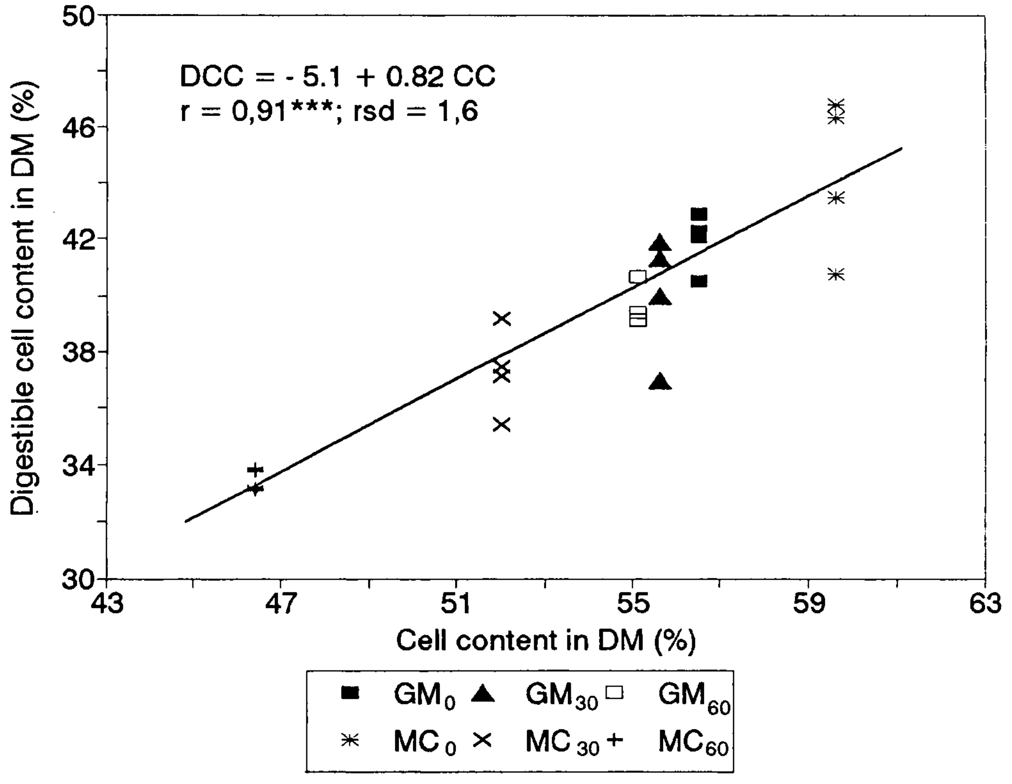

Fig 2. Digestible cell content (DCC) in relation to cell content (CC) in DM.

Table V. Voluntary intake, 1st experiment.

	Diets			*Interaction*	*SEM*[1]
	GM_0	*GM_{30}*	*GM_{60}*		
Live weight (kg)	35.8	33.5	30.3		
DM intake					
g/d	1 890	2 050	1 790	203	192.1
g/kg $LW^{0.75}$	129^b	147^a	138^{ab}	13*	6.2
Feeding level	2.83^a	2.81^a	2.29^b	0.50	0.11
DE intake					
Mcal/d	5.03^a	4.94^a	4.05^b	0.40	0.448
Kcal/kg $LW^{0.75}$	343^a	355^a	313^b	26*	14.6
NDF intake					
g/d	824	909	805	94	85.8
g/kg $LW^{0.75}$	56^b	65^a	62^a	6*	2.8

[1] SEM: pooled standard error of the mean; on the same row: a,b,* $P < 0.05$; GM grape marc.

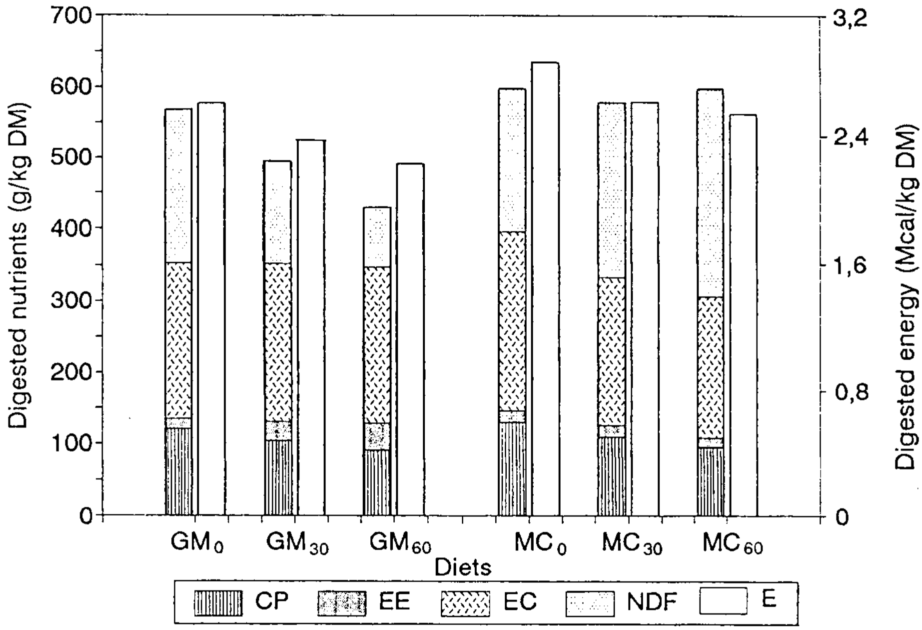

Fig 3. Content of digested nutrients and energy in DM.

Table VI. Voluntary intake, 2nd experiment.

	Diets			Interaction	SEM[1]
	MC_0	*MC_{30}*	*MC_{60}*		
Live weight (kg)	28.5	30.0	28.9		
DM intake					
g/d	1 450^b	1 770^a	1 570^{ab}	270*	140.2
g/kg $LW^{0.75}$	117^b	139^a	126^{ab}	17*	10.3
Feeding level	2.70	3.11	2.90	0.62	0.24
DE intake					
Mcal/d	4.21	4.73	4.05	0.60	63.2
Kcal/kg $LW^{0.75}$	342	371	327	36	4.5
NDF intake					
g/d	583^b	851^a	840^a	139*	0.393
g/kg $LW^{0.75}$	47^b	67^a	68^a	9*	29.3

[1] SEM: pooled standard error of the mean; on the same row: ^{a,b,*} $P < 0.05$; MC: maize cobs.

reach the same FL and consume similar quantities of DE as those receiving the GM_0 and MC_0 diets.

The NDF intake, which was not significantly different between GM_{30} and GM_{60} or MC_{30} and MC_{60}, was lowest for the rations without by-products (GM_0 and MC_0).

Figure 4 shows the relation between DM intake and dietary energy density. DM intake tended to decrease with increasing DE content. However, the diets with both fibrous feeds, *ie* hay and a by-product (GM_{30} and MC_{30}), differed from this, confirming the effect of positive dietary interactions on intake.

Live weight gain and feed conversion

The GM_{60} diet (table VII) produced a lower ($P < 0.05$) daily gain than the GM_0 diet (–98 g/d). The mixed diet (GM_{30}) showed an intermediate gain which was not significantly different from a linear combination of the other 2 diets. Considering the high intake levels for the diets containing the grape marc, their introduction in partial or total substitution for lucerne hay caused a reduction in the food conversion ratio (in terms of DM) in comparison with the GM_0 diet. The increase in the food conversion ratio was particularly high for the GM_{30} diet.

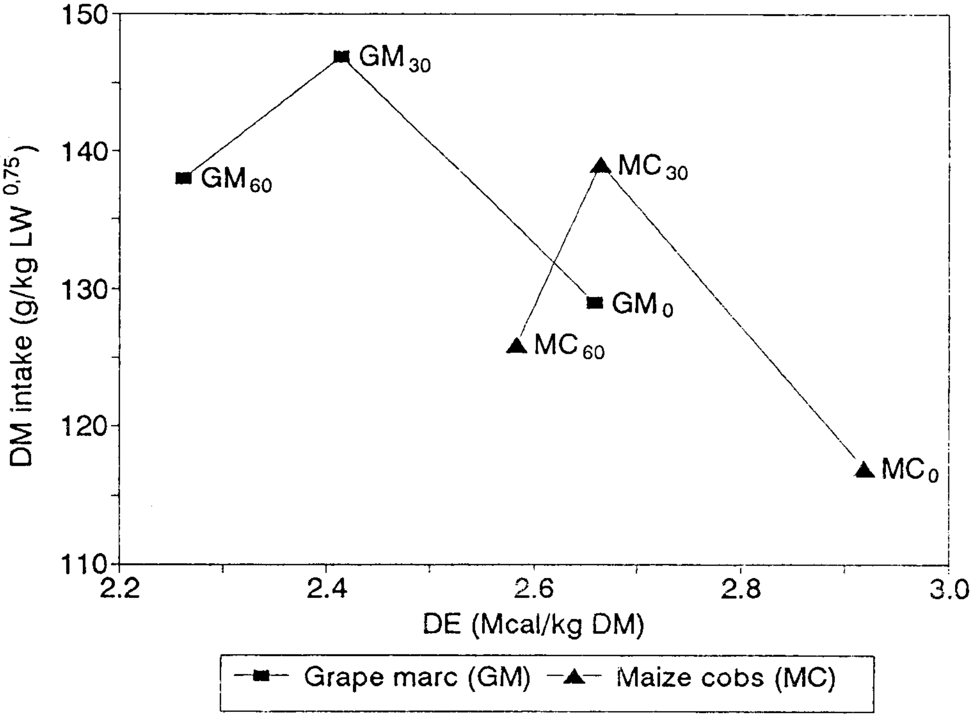

Fig 4. Intake of DM (g per kg metabolic weight) in relation to digested energy in DM.

Table VII. Live weight gain and feed conversion, 1st experiment.

	Diets			Interaction	SEM *
	GM_0	GM_{30}	GM_{60}		
Initial live weight (kg)	26.3	25.1	22.9		
Live weight gain (g/d)	414[a]	353[ab]	316[b]	12	34.2
Feed conversion	4.6	5.9	5.7	0.8	0.78

* SEM: pooled standard error of the mean; on the same row: [a,b] $P < 0.05$; GM: grape marc.

Table VIII. Live weight gain and feed conversion, 1st experiment.

	Diets			Interaction	SEM *
	MC_0	MC_{30}	MC_{60}		
Initial live weight (kg)	21.9	21.7	21.7		
Live weight gain (g/d)	264	335	287	60	43.6
Feed conversion	5.5	5.3	5.5	–0.2	0.46

* SEM: pooled standard error of the mean; MC: maize cobs.

In contrast to the observations recorded with the grape marc, the complete substitution of lucerne hay by maize cobs (table VIII) did not cause any significant variations in growth rates or feed conversion ratio in comparison with those measured in the MC_0 diet. The best productivity results were obtained with the MC_{30} diet which combined the lucerne and maize cobs. The LWG recorded with MC_{30} was 71 g/d higher than MC_0, a value at the limit of significance ($P = 0.093$).

DISCUSSION

Chemical composition and digestibility

The chemical composition of the grape marc and the maize cobs was within the range reported in the literature in general texts and tables (Andrieu *et al*, 1988; Piccioni, 1989; Alibes and Tisserand, 1990; Preston, 1990) and in specific works (Morgan and Trinder, 1980; Aguilera, 1987; Settineri *et al*, 1987).

The substitution of lucerne hay by the by-products had differing effects on cell-wall digestibility: with the grape marc dNDF fell, whilst with the maize cobs there was a tendency towards an increase in this parameter. These results, as may be seen in figure 1, can largely be explained by the degree of lignification of the fibre in the different forages used. Similarly, Kinser *et al* (1988) who offered lambs pelleted diets containing from 25% to 39% DM maize cobs as the only roughage source, observed a good digestibility of dietary NDF which increased from 35 to

55% with the increasing proportion of by-product.

In both trials, the apparent digestibility for the cell contents was not affected by dietary composition but seemed to undergo a decrease which was probably linked to the physical form of the diet. In fact, the true digestibility of the cell soluble fraction (82%, fig 2), whilst within the range of data found by Van Soest (1983), fell towards the bottom of the range. The pelletting of the diets could have altered the balance between rate of digestion and rate of passage of the cell-soluble fraction in favour of the latter.

Following these digestive processes, the introduction of the by-products in partial or total substitution for lucerne hay caused a progressive and considerable reduction in the quantity of OM digested only for grape marc. For maize cobs diets, the reduction of cell content was compensated by an increased amount of digested NDF. However, even for the maize cobs, the differing energy values of the digested nutrients resulted in a small but significant reduction in the quantity of energy digested (fig 3).

Other authors have also reported the poor digestibility of grape marc. After examining the bibliographic data available, Larwence *et al* (1985) calculated an average DOM of 31 ± 8%. The high variability is due amongst other reasons to the changing composition of the by-product, determined at the factory by the technological procedures of juice extraction, treatment of residues and conservation technique.

This low digestibility is not only due to the high lignin concentration but also to the high tannin content (3–7% DM; Aguilera, 1987; Larwence, 1991) the presence of which is widely reported to have a negative effect on digestibility (Mitjavila, 1979; Baroccio and Pace, 1984; Larwence *et al,* 1984; Settineri *et al,* 1987). As shown by Larwence and Yahiaoui (1983), grape marc crude protein is practically insoluble (2%) and only slightly fermentable (9%), due to bonding with the tannins and the ADF.

In mixed diets based on by-products and lucerne hay, various researchers have reported positive (Brandt and Klopfenstein 1986a,b,c) or negative (Soofi *et al,* 1982) digestive interactions depending on the availability of DOM and N in the by-products.

In all the experimental diets, including GM_{60} and MC_{60}, the composition and quantity of concentrate assured a level of degradable protein sufficient to satisfy the N requirements of the rumen microflora, displacing in favour of PDIN the PDIN/PDIE balance which in both by-products was biased towards PDIE (Andrieu *et al,* 1988). Similarly, the supply of fermentable carbohydrates was assured by the starch from cereal grain. Under these conditions, considering the low rate of fermentation of the by-product fibrous components and the short rumen retention time of the pelletted food, any positive digestive interaction of the lucerne with the by-product would not have time to be expressed.

Voluntary intake

The number of lambs available for the measurement of intake for each diet was not high, but was sufficient to determine a minimum significant difference ($P < 0.05$) of 8% with respect to the general mean in the 1st experiment and 16% in the 2nd.

The high voluntary intakes observed in both trials, as well as presumably being linked to the breed of sheep, were probably influenced by the physical form of the diets. It is known that milling and pelleting result in a reduction in the dimensions of the feed particles and a collapse in the structure of their plant cell walls, causing an increase in diet density which increases intake (Jarrige *et al,* 1978; Van Soest, 1983).

The effect of pelleting and chop length is important in sheep due to receptors on the reticulum walls which are particularly sensitive to the stretching of the stomachs after meals (NRC, 1987). The observations on intake for these ruminants, summarised by the ARC (1980) and the NRC (1987), demonstrate how the action of physical factors on feed intake is reduced by pelleting, following which voluntary intake appears to diminish with increasing dietary energy density.

In this way, the high intakes recorded even with 60% by-product can be accepted as reasonable.

The interactions recorded with diets GM_{30} and MC_{30} demonstrate the good intake characteristics of the mixes of forage components.

Live weight gain and feed conversion

The productive performance of the lambs is the result of the feed intake and the capacity of the diet to supply a balance of the nutrients required for growth. Therefore, analysis of the weight gain is a further element for the evaluation of the nutritive value of the diets which integrates, in terms of metabolic utilisation, all the information on the digestive utilisation of the nutrients in the diets. The reduction in LWG and the worsening FC following the substitution of lucerne by grape marc confirms the poor nutritional quality of the by-product, already demonstrated by the low digestibility of the GM_{60} diet. However, the efficiency of utilisation of the digestible energy for growth in diets GM_{60} and GM_0 was not significantly different.

The use of maize cobs in total substitution for lucerne did not reduce the LWG or modify food conversion efficiency. The greatest gain with the mixed diet appears to have been principally dependent on food intake. Comparable results have been reported by Paterson *et al* (1981) with diets based on maize cobs offered to growing steers.

CONCLUSION

The trials have shown how heavy lambs are able to satisfactorily utilize both grape marc and maize cobs when these are incorporated in balanced diets and to obtain acceptable live weight gains.

However, for grape marc the nutritional analysis and the results from the growth trial suggest that it is a feed which could only be introduced in diets in limited quantities if efficiency is not to be prejudiced. In contrast, the maize cobs gave good results even at a 60% inclusion rate.

In general, the pelleted diets containing the by-products compensated partly for their lower digestibility by higher intakes, favoured, in the formulations containing hay, by positive interactions.

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