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In vitro prediction of whole ration digestibility

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Summary

In vitro digestibility measures allow to predict the *in vivo* digestibility of roughage organic matter with a better accuracy than the proximate chemical analysis. In the present study a comparison was made using mixed diets fed to lactating dairy goats at various levels of intake and proportions of concentrates. Moreover, two kinds of concentrate feeds varying by their proportion of cell-wall constituents were studied. The *in vitro* digestibility technique applied to feedstuffs taken separately or combined in the same proportions as those of the ingested diet allowed to predict the *in vivo* digestibility of the whole diet with a higher accuracy than that of the proximate chemical analysis.

Introduction

Digestibility of the organic matter is the most important factor of the energy value of feedstuffs. However, the most fitted criterion liable to predict digestibility and consequently the energy value of feedstuffs is the crude fibre content. Since a long time, experimental data have shown the limitations of this predictor (NORMAN, 1935) and research has therefore been undertaken resulting in the development of several methods such as the *two stage in vitro digestibility method* suggested by TILLEY and TERRY (1963).

Experimental results showed that this technique, applied in a well defined manner (BAUMGARDT and OH, 1964), might predict forage digestibility more accurately than chemical methods (OH, BAUMGARDT and SCHOLL, 1966; DEINUM and VAN SOEST, 1969; VAN DER KOELEN and VAN ES, 1973; AERTS *et al.*, 1977).

But the two stage *in vitro* technique has not been applied to mixed rations very often. A few experimental data obtained with such rations seem to show that the *in vivo* digestibility can be well estimated by this *in vitro* method (KUMENO,

DEHORITY and JOHNSON, 1967; KLETT, 1967; NIK-KHAH and TRIBE, 1977). Only mixed rations provide enough energy to lactating females according to their high needs. The present study was carried out in order to determine the ability of the *in vitro* rumen fermentation method to predict the *in vivo* digestibility of mixed rations. Diets with widely varying hay to concentrate ratios were fed to goats with various levels of intake and milk yields.

Material and methods

A. — In vivo *trial*

The *in vivo* trial was performed on two groups of three goats housed in the metabolism crates described by GIGER and HERVIEU (1980). It lasted nine weeks and was divided into three periods of three weeks each. For every period, digestibility measures were undertaken at the second and third week during five consecutive days. A constant and restricted level of lucerne hay was fed (1 150 g D. M. /d) and the concentrates were offered according to milk yield (170 to 1 250 g D. M. /d). The quantities of concentrates fed are given in table 1.

TABLEAU 1

Quantities of concentrates fed to the goats (g D.M. /d)
Quantités d'aliments concentrés distribués aux chèvres (g M.S. /j)

Period \ Group	I	II	III
I	710	980	1 250
II	440	710	980
III	170	440	710

TABLEAU 2

Composition of the experimental concentrates
Composition des aliments concentrés expérimentaux

Riche en énergie *High in energy: H*		Pauvre en énergie *Low in energy: L*	
Pulpe de betterave (*Sugar beet pulp*)	44,0 %	Son de blé (*Wheat bran*)	62,0 %
Maïs grain (*Maize*)	17,8 %	T. de coprah (*Coconut meal*)	13,2 %
Graines de lupin (*Lupine*)	6,5 %	T. de soja (*Soybeanmeal 44*)	10,3 %
Tourteau de soja (*Soybeanmeal 44*)	21,7 %	Luzerne déshydratée (*Dehydrated lucerne meal*)	4,5 %
Mélasse (*Molasses*)	7,0 %	Mélasse (*Molasses*)	7,0 %
CMV (*Vitamin-mineral mixture*)	3,0 %	CMV (*Vitamin-mineral mixture*)	3,0 %

The two groups of animals were given two different concentrates. The concentrates were formulated by linear programming. The results of the proximate chemical analysis were the same for both, but the net energy value for lactation expressed in milk feed unit (I.N.R.A., 1978) was maximized for the first concentrate (concentrate H : high), minimized for the second one (concentrate L : low). The composition of the concentrates is given in table 2.

The cell-wall composition of these concentrates determined according to the VAN SOEST method (GOERING and VAN SOEST, 1970) modified by Sylvie GIGER *et al.* (1979*a*) for semi-automatic use of concentrates was very different, whereas the crude fibre content (AFNOR, 1977) was almost the same (see table 3).

TABLEAU 3

Fibre composition of the feedstuffs offered
Composition membranaire des différents aliments

% DM (% *MS*)	Concentrate L « low » *Aliment P.* « *Pauvre* »	Concentrate H « high » *Aliment R.* « *riche* »	Hay *Foin*
Crude fibre (*Cellulose brute*)	10.0	11.5	32.4
Neutral Detergent Fibre (*NDF*)	37.8	31.5	47.8
Acid Detergent Fibre (*ADF*)	14.2	14.8	35.2
« Hémicelluloses » (*NDF-ADF*)	23.6	16.7	12.6
Cellulose	10.5	13.5	27.2
Lignin (*Lignine*)	3.7	1.3	8.0

B. — In vitro *trial*

The *in vitro* digestibility was estimated by means of the technique of TILLEY and TERRY (1963) modified by ALEXANDER and Mc GOWAN (1966). Two methods were used.

1. *Method 1*

The *in vitro* digestibility of samples of the two dietary components (hay and concentrates) was measured and the estimation of the *in vitro* digestibility of the ration was calculated for each of the six weeks of *in vivo* digestibility measurements according to quantities of hay and concentrates actually eaten by the goats.

2. *Method 2*

The *in vitro* digestibility of the ration was evaluated as a whole: each sample was a mixture of hay and concentrates in the same proportion as in the rations fed to the animals. Such a sample was prepared for each goat and for each experimental week.

Results and Discussion

In the present trial, the *in vivo* dry matter (D.M.D.) and organic matter (O.M.D.) digestibility were negatively correlated with the crude fibre content (C.F.).

$$D.M.D. = 82.6 - 0.70\ C.F. \qquad (r = -0.64,\ n = 36)$$
$$O.M.D. = 84.9 - 0.70\ C.F. \qquad (r = -0.62,\ n = 36)$$

Large differences due to the diets (fig. 1) were observed; they might be explained by the very different cell-wall constituents in the two experimental concentrates (table 3). For one and the same crude fibre content, a difference of five points in the *in vivo* organic matter digestibility of the whole diet appeared between the two types of rations (fig. 1).

The equations correlating the *in vivo* digestibility of the dry matter and the organic matter with the *in vitro* digestibility of the dry matter were the following with the first method.

$$D.M.D. = 0.715\ IVD_1 + 16.6 \qquad (r = 0.93,\ n = 36)$$
$$O.M.D. = 0.749\ IVD_1 + 16.4 \qquad (r = 0.93,\ n = 36)\ \text{(fig. 2)}$$

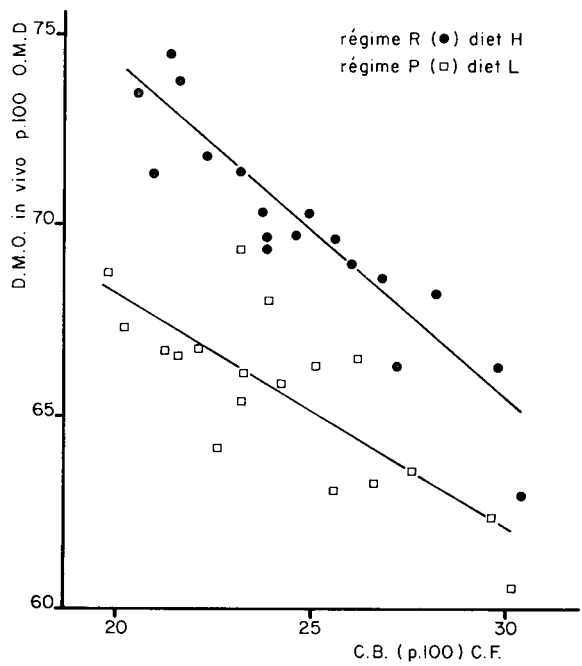

FIG. 1. — *Relations entre la digestibilité de la matière organique (D.M.O.) et le taux de cellulose brute de la ration totale (C.B.)*

Relations between « in vivo » organic matter digestibility (O.M.D.) and the crude fiber content of the whole ration (C.F.)

$$y = 84.9 - 0.70\ x \qquad (r = -0.62,\ n = 36)$$

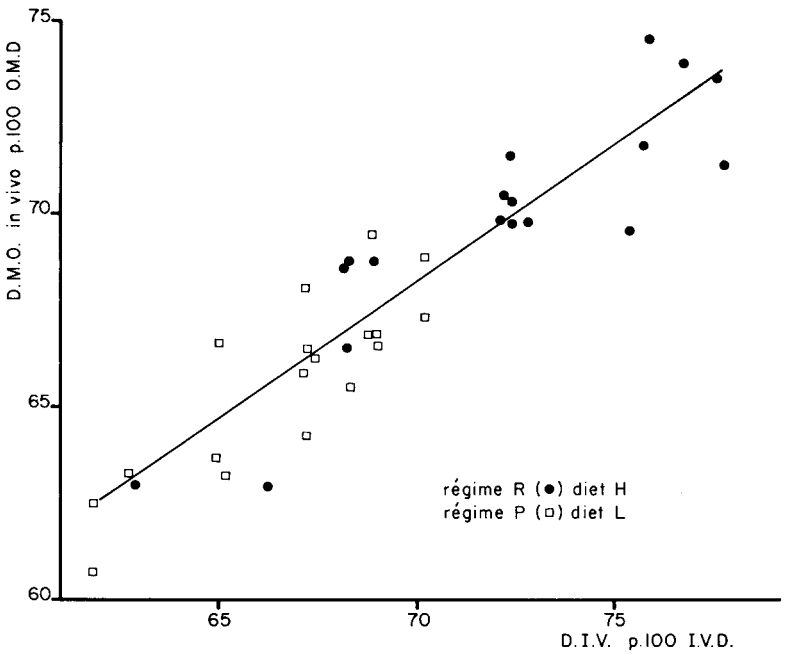

FIG. 2. — *Relations entre la digestibilité de la matière organique (D.M.O.) et la digestibilité « in vitro » de la matière sèche (D.I.V.)*

Relations between : « in vivo » organic matter digestibility (O.M.D.) and « in vitro » dry matter digestibility (I.V.D.)

$$y = 0.749\,x + 16.4 \qquad (r = 0.93,\ n = 36)$$

and with the second method :

$$\text{D.M.D.} = 0.674\ \text{IVD}_2 + 18.8 \qquad (r = 0.94,\ n = 36)$$
$$\text{O.M.D.} = 0.688\ \text{IVD}_2 + 20.0 \qquad (r = 0.91,\ n = 36)$$

The correlation coefficients between the *in vivo* and the *in vitro* digestibilities resulting from both methods were highly significant. These values were similar to those of TILLEY and TERRY (1963) and OH, BAUMGART and SCHOLL (1966), using forages only and better than those obtained by CLARK (1975) for mixtures of forages and cereals. They were more satisfactory than the crude fibre estimation and seemed not to be affected by the large differences in the cell-wall constituents.

The accurate estimation of the *in vivo* digestibility by means of the *in vitro* method could be explained by the absence of associative digestibility and a lack of effect on digestibility in connection with an increase in the level of intake as reported elsewhere (GIGER *et al.*, 1979*b*). In fact, the variation in the level of intake was not very large (less than two times). A greater variation might have led to another result. The absence of a digestive interaction with the variation in the proportion of concentrates in the ration (10 to 50 p. 100), might perhaps be explained by their low starch content (10 to 15 p. 100 dry matter) (KANE, JACOBSON and DAMEWOOD, 1959) and by the restricted level of hay given.

The slightly lower accuracy of the second method for predicting the digestibility *in vivo* may due to a problem arising from sampling of mixed rations.

The values recorded with the two methods were highly correlated ($r = 0.92$, $n = 36$), but the data obtained with the « whole ration » method were generally higher than those with the « separate components » method, particularly in the case of the most digestible rations. These differences might be due to the reduction of the *in vitro* digestibility value by a possible deficiency of degradable nitrogen in the rumen liquor (ALEXANDER and Mc GOWAN, 1966), or other growth factors which might be supplied by lucerne hay with the «reconstituted diets ».

Conclusion

The *in vitro* digestibility method is of real interest for predicting the *in vivo* digestibility of ruminant mixed rations with a variable proportion of concentrates. It is much more accurate than the crude fibre content value, particularly with mixed rations which differ by their cell-wall composition although their crude fibre content, is the same.

Further studies would be required to check the ability of the *in vitro* measurement to satisfactorily predict the feeding value of rations rich in starch and tending to induce large associative digestibility effects.

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Résumé

Prévision in vitro *de la digestibilité de la ration complète*

La mesure de la digestibilité *in vitro* permet de prévoir la digestibilité *in vivo* de la matière organique des fourrages avec une précision supérieure à celle obtenue à partir des résultats de l'analyse chimique classique. Dans la présente étude, la comparaison est effectuée pour des rations complètes distribuées à des chèvres en lactation, correspondant à des niveaux d'ingestion, et des proportions d'aliments concentrés variables. En outre, deux types de composition pariétale des aliments concentrés ont été étudiés. La digestibilité *in vitro*, effectuée à partir des aliments pris séparément ou associés dans les proportions de la ration ingérée, permet de prédire avec une bien meilleure précision la digestibilité *in vivo* de la matière organique de l'ensemble de la ration que l'analyse chimique classique.

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