

Clustering forage types according to their feed nutritive value

Villalba D., Molina E., Álvarez-Rodríguez J.

in

Casasús I. (ed.), Lombardi G. (ed.).

Mountain pastures and livestock farming facing uncertainty: environmental, technical and socio-economic challenges

Zaragoza : CIHEAM

Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 116

2016

pages 123-126

Article available on line / Article disponible en ligne à l'adresse :

<http://om.ciheam.org/article.php?IDPDF=00007431>

To cite this article / Pour citer cet article

Villalba D., Molina E., Álvarez-Rodríguez J. **Clustering forage types according to their feed nutritive value.** In : Casasús I. (ed.), Lombardi G. (ed.). *Mountain pastures and livestock farming facing uncertainty: environmental, technical and socio-economic challenges*. Zaragoza : CIHEAM, 2016. p. 123-126 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 116)



<http://www.ciheam.org/>
<http://om.ciheam.org/>

Clustering forage types according to their feed nutritive value

D. Villalba, E. Molina and J. Alvarez-Rodríguez

Departament de Ciència Animal, Universitat de Lleida. Av. Rovira Roure, 191, 25198 Lleida (Spain)

Abstract. The aim of the study was to evaluate the nutritive value of forages produced in the Spanish Pyrenees and whether they may fulfil nutrient requirements of growing beef calves. Forages produced at mountain farms (16) were sampled and classified as grassland forage (fresh, $n = 17$; hay, $n = 35$; silage, $n = 29$) or other fibre sources (cereal straw and hulls, $n = 14$). Samples were analysed for dry matter, crude protein (CP), ash, neutral and acid-detergent fibre (NDF and ADF). A cluster analysis was performed to group the forages into homogenous categories according to these variables. The lowest quality group (relative forage value, RFV = 75.8 ± 3.4) was mainly represented by hays (45% of the total), while the best quality group (RFV = 148.6 ± 3.7) consisted mainly of pasture silages (60.7% of the total). Forage diets for fattening calves were designed with the three groups, but they differed widely. In case of the poorest forage group (CP $6.6 \pm 0.6\%$, RFV 75.8 ± 3.4) it was not possible to design a diet including 60% forage due to its low nutritive value. The best quality forages (CP 17.1 ± 0.7) met the estimated energy (UFV) requirements but they failed to meet protein requirements (PDIE) of growing-finishing beef calves with high growth potential. In this Pyrenean area, only around one third of the roughages used may allow meeting energy and protein requirements of growing-finishing beef cattle under a forage-based strategy.

Keywords. Grassland – Protein – Fibre – Beef – Productive performance.

Regroupement des types de fourrages en fonction de leur valeur nutritive

Résumé. Le but de l'étude était d'évaluer la valeur nutritive des fourrages produits dans les Pyrénées espagnoles et d'examiner s'ils peuvent satisfaire les besoins nutritionnels des veaux de boucherie. Des fourrages produits en fermes de montagne (16) ont été échantillonnés et classés comme fourrages de prairies (frais, $n = 17$; foin, $n = 35$; ensilage, $n = 29$) ou autres sources de fibres (paille et enveloppes de céréales, $n = 14$). Les échantillons ont été analysés pour : matière sèche, matières azotées (CP), cendres, fibre neutre et fibre acido-détergente (NDF et ADF). Une analyse de cluster a été réalisée pour grouper les fourrages en catégories homogènes selon ces variables. Le groupe à moins bonne qualité (valeur relative du fourrage, RFV = $75,8 \pm 3,4$) est principalement représenté par les foin (45% du total), tandis que le meilleur groupe (RFV = $148,6 \pm 3,7$) se composait notamment d'ensilages de pâtures (60,7% du total). Des régimes fourragers pour l'engraissement ont été conçus avec les trois groupes, mais ils diffèrent largement. Dans le cas des fourrages le plus pauvres (CP $6,6 \pm 0,6\%$), il n'a pas été possible de concevoir un régime alimentaire contenant 60% de fourrage en raison de sa faible valeur nutritive. Les meilleurs fourrages (CP $17,1 \pm 0,7\%$) répondaient aux besoins en énergie estimée (UFV), mais ils ont échoué à satisfaire les besoins en protéines (PDIE) des veaux de boucherie à potentiel de croissance élevé. Dans cette zone des Pyrénées, seulement un tiers environ des fourrages utilisés peut satisfaire les besoins énergétiques et protéiques des bovins de boucherie dans une stratégie basée sur fourrage.

Mots-clés. Pâturage – Azote – Fibre – Bovin à viande – Performances de production.

I – Introduction

Mountain livestock farms at the Pyrenees have used traditionally conserved forages from permanent grasslands. Hays and silages have been commonly used to feed adults animals during winter period whereas young animals were fattened indoors using high concentrate diets, usually at lowland. Growing beef cattle (< 12 months of age) in the Catalanian Pyrenees and its surround-

ing area (Lleida, Barcelona and Girona provinces) accounts for 22.5% of the total census in Spain. In addition, beef cattle managed under organic production systems in this area has increased evenly and cattle intended for beef nowadays represents around 20% of the organic beef sector in Spain (MAGRAMA, 2016).

To meet the organic production regulations, calves must be fed at least 60% of their diet as roughage, but when they have concentrate and forage offered both ad libitum they prefer eating concentrate (Casasús *et al.*, 2011). The nutritive value of forages should be tailored to animal requirements so that a reduction of concentrate supplementation and thereby feeding costs could be achieved. Therefore, there is increasing interest in feeding finishing cattle at mountain livestock farms by means of on-farm conserved forages. The aim of the study was to evaluate the nutritive value of forages produced in the Spanish Pyrenees and whether they may fulfil nutrient requirements of growing and finishing beef calves.

II – Materials and methods

1. Roughage sampling

A total of 95 roughages (2 kg approximately, on a fresh matter basis) were sampled in spring, summer and autumn from 16 mountain farms from the east-southern Pyrenees between years 2008 and 2015. The roughages were normally provided ad libitum to adult cattle and/or they were supplemented with concentrate ad libitum to growing and finishing cattle. The roughages were classed as grassland forage (fresh, $n = 17$, $29.8 \pm 17.9\%$ dry matter (DM); hay, $n = 35$, $88.9 \pm 8.9\%$ DM; silage, $n = 29$, $46.8 \pm 19.8\%$ DM) or other fibre sources (cereal straw and hulls, $n = 14$, $89.3 \pm 4.9\%$ DM) according to FEDNA (2004). Fresh samples were collected by clipping with an electric mower all plant material above 2 cm of ground level in two $1\text{m} \times 0.25\text{m}$ quadrats per paddock. Sampling was done before the animal started to graze the paddock. The grassland forage was mainly formed of plants belonging to the *Molinio-Arrhenatheretea* phytosociological class.

2. Chemical analyses

Fresh and silage samples were dried at 60°C until constant weight and mill-ground (1 mm screen). All the roughages were analysed in duplicate for ash (A, incineration at 550°C), ether extract (EE, Soxhlet method), crude fibre (CF, Weende method) and protein (CP, nitrogen $\times 6.25$, Kjeldahl method) contents and corrected for DM content (102°C for 24 h). Neutral-detergent fibre (NDF) and acid-detergent fibre (ADF) analyses were carried out with an Ankom²⁰⁰ fibre analyser (Ankom technology, Macedon NY, USA) and their results were corrected for ash-free content. The relative forage value (RFV) was estimated based on fibre analyses by means of the formula: $\text{RFV} = [(88.9 - (0.779 \times \text{ADF}(\%))) \times (120 / \text{NDF}(\%))] / 1.29$. Roughage quality is considered excellent if $\text{RFV} > 151$, first quality if $\text{RFV} 125\text{-}150$, and very low quality if $\text{RFV} < 75$ (FEDNA, 2004).

3. Statistical analyses

A cluster analysis was performed to group the forages into homogenous categories according to these variables. Firstly, the variables defining chemical quality of roughages were simplified into two principal components that were used to calculate Euclidean distances between observations. Based on this distance a k-means clustering method with three groups has been performed. The proc CLUSTER (SAS v9.4, Cary, NC) was used to perform the clustering analysis. Secondly, the data were analysed with a general linear model by considering the cluster obtained in the earlier analysis as a fixed factor. Multiple comparisons were performed by the t-Student test. The level of significance was set at 0.05.

III – Results and discussion

The two principal components explained 70% of the variability. The first component was related positively with CP and ash, whereas it was negatively related with NDF and ADF. The second component was related basically with DM. The clusters generated were clearly segregating by the first principal component.

A high variability in chemical composition was detected (coefficient of variation around 45% for CP, and around 34% for NDF and ADF), being the clusters related to feed CP and fibres. The lowest quality group (RFV = 75.8 ± 3.4) was mainly represented by hays (45% of the total) and roughage sources as cereal straw and bran (39%), while the best quality group (RFV = 148.6 ± 3.7) consisted mainly of pasture silages (60.7% of the total) and fresh pastures (32%). The intermediate forage quality group was made of pasture hays (55.9% of the total). The RFV results, which are based on fibre components, were in line with CP and ether extract values, but they were not in agreement with the ash contents, whose values were opposite to the RFV of the samples. Probably, the origin of most of the samples in this group may contain remaining soil particles that increased their mineral content.

The identified groups differed consistently among them in their nutritive value parameters (Table 1). The three groups were considered significantly different for CP, ash, NDF and ADF values. However, the high and intermediate quality groups did not differ in ether extract and crude fibre values. Hence, these last chemical parameters may be avoided in routine analyses to determine the nutritive value of roughages.

Table 1. Chemical composition of the roughages according to the different clusters obtained (g/100 of dry matter; least square means \pm standard error)

	1-High quality	2-Low quality	3-Medium quality
n	28	33	34
Crude protein	17.09 ± 0.65^a	6.64 ± 0.60^c	11.97 ± 0.59^b
Ash	15.68 ± 0.61^a	7.10 ± 0.56^c	8.86 ± 0.56^b
Ether extract	3.23 ± 0.53^a	1.58 ± 0.56^b	2.11 ± 0.63^{ab}
Crude fibre	27.89 ± 1.30^b	39.64 ± 1.55^a	29.49 ± 1.55^b
Neutral-detergent fibre	43.75 ± 1.33^c	70.14 ± 1.22^a	52.95 ± 1.21^b
Acid-detergent fibre	27.05 ± 0.92^c	41.97 ± 0.85^a	34.59 ± 0.83^b
Relative forage value (RFV)	148.63 ± 3.65^a	75.77 ± 3.36^c	110.47 ± 3.3^b

Within each row, different letter denotes statistical differences ($P < 0.05$) among clusters.

The different roughages groups differed widely in their ability to meet energy and protein requirements of beef calves (INRA, 2007) having different growth potential and managed under 60:40 forage to concentrate ratio (Table 2). Energy content in terms of net energy for meat production (UFV) was 0.92, 0.47 and 0.52 for cluster groups 1, 2 and 3 respectively. Forages should contain UFV > 0.9 to be considered very ingestible (Baumont *et al.*, 2009). It is noteworthy that the most limiting factor of diets including low quality group roughages was its high filling value (high fibre content) exceeding the voluntary intake capacity to support nutrient requirements. Only the best quality forages met the energy requirements of beef calves both in growing (250 kg of live-weight) and finishing (450 kg of live-weight) periods, regardless of the growth potential of the animals. Concerning protein requirements, they may be nearly met with high and intermediate quality groups if the calves have low growth rate. However, if calves have high growth potential (>1.2 kg/day), supplying a 60:40 forage to concentrate diet by means of these roughages would result in a deficiency in true protein absorbable in the small intestine because rumen fermentable energy (organic mat-

ter) would be limiting microbial protein synthesis in the rumen (PDIE), both in high and intermediate quality groups. A minimum of 13% of forage CP is required to avoid a deficiency in dietary protein (balance between PDIN and PDIE in the rumen) (Baumont *et al.*, 2009). This could be achieved by advancing the harvest date of pasture hays (late spring to early summer) or by improving the botanical diversity of pastures through reseeded with perennial legumes. Consequently, the use of good quality forages may improve the meat quality of beef (Blanco *et al.*, 2011).

Table 2. Adjustment of energy and protein requirements in the different clusters when supplying roughages to growing (250 kg of live-weight) and finishing (450 kg of live-weight) calves under a 60:40 forage to concentrate ratio

	1-High quality					2-Low quality				3-Medium quality			
	ADG [†]	FU ^{††}	UFV ^{†††}	PDIN ^{†††}	PDIE ^{†††}	FU	UFV	PDIN	PDIE	FU	UFV	PDIN	PDIE
250 kg	1	y	110%	100%	90%	n	76%	114%	90%	y	74%	127%	93%
	1.2	y	103%	104%	90%	n	81%	114%	90%	y	67%	90%	84%
	1.4	y	96%	94%	81%	n	83%	114%	90%	y	63%	90%	76%
	1	y	107%	118%	103%	n	66%	90%	82%	y	72%	118%	97%
450 kg	1.2	y	103%	106%	92%	n	64%	90%	74%	y	68%	90%	88%
	1.4	y	97%	97%	84%	n	60%	85%	67%	y	64%	90%	80%

[†] ADG= expected average daily gain (kg/day).

^{††} Adjustment of diets to the voluntary intake capacity (FU; fill units): yes(y) or no (n).

^{†††} Percentage of energy (UFV, %), and protein requirements (PDIN and PDIE, %) met. The concentrate used for simulations contained 1.02 UFV and 13.7% of CP.

IV – Conclusions

In this Pyrenean area, the best quality roughages sources consisted mainly of on-farm harvested pasture silages. Only around one third of the roughages may allow meeting energy and protein requirements of growing-finishing beef calves fed forage-based diets, suggesting the need of tailoring certain farming practices to improve the nutritive value of forages.

Acknowledgments

This study was funded by grants to encourage applied research concerning organic food production (Generalitat de Catalunya, AGE2011-006 and 53-05014-2015).

References

- Baumont R., Aufrère J. and Meschy F., 2009. La valeur alimentaire des fourrages: rôle des pratiques de culture, de récolte et de conservation. *Fourrages*, 198, 153-173.
- Blanco M., Casasús I., Ripoll G., Sauerwein H. and Joy M., 2011. Grazing lucerne as fattening management for young bulls: technical and economic performance, and diet authentication. *Animal*, 5, 113-122.
- Casasús I., Albertí P., Joy M., Ripoll G. and Blanco M., 2011. Influencia del nivel de suplementación sobre las características de la canal y de la carne de terneros de raza Parda de Montaña cebados en pastoreo. *XIV Jornadas sobre Producción Animal de AIDA*, Tomo I, 61-63.
- FEDNA, 2004. *Tablas FEDNA de valor nutritivo de Forrajes y Subproductos fibrosos húmedos*. (Eds. S Calsamiglia, A Ferret, A Bach). Fundación Española para el Desarrollo de la Nutrición Animal. Madrid, Spain.
- INRA, 2007. *Alimentation des bovins, ovins et caprins. Besoins des animaux – valeurs des aliments*. Quae éditions.
- MAGRAMA, 2016. *Anuario de Estadística Agraria 2014 y Estadísticas Agricultura Ecológica 2013*. Ed. Ministerio de Agricultura, Alimentación y Medio Ambiente. Madrid, Spain.