Alpine grasslands: relations among botanical and chemical variables affecting animal product quality

Renna M., Ravetto Enri s., Probo M., Lussiana C., Malfatto V., Battaglini L.M., Lonati M., Lombardi G.

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 117-121

Alpine grasslands: relations among botanical and chemical variables affecting animal product quality

M. Renna, S. Ravetto Enri, M. Probo, C. Lussiana, V. Malfatto, L.M. Battaglini, M. Lonati and G. Lombardi

DISAFA, University of Torino, Largo P. Braccini 2 – 10095, Grugliasco (TO) (Italy)

Abstract. In alpine farms, forage composition is considered as the most important factor influencing the quality of grazing ruminant productions. This study aimed at analysing the complex relationships existing among botanical composition, chemical composition and some plant community variables of different alpine grassland communities. Thirty-nine vegetation surveys were carried out within some of the most common alpine grassland communities in the western Italian Alps. The botanical composition was determined, and mean values of Landolt's ecological indicators, biodiversity indices, phenological stage, and pastoral values (PV) were computed. Representative samples of grass were collected and analysed for dry matter (DM), crude protein (CP), fibre, and fatty acid (FA) composition. The relationships among the considered variables were assessed computing Pearson's correlation coefficients and performing a canonical correspondence analysis (CCA). A hierarchical cluster analysis identified two main grassland ecological groups: (i) mesophilic grasslands (MG), including *Poa pratensis*, *Lolium perenne* and *Festuca nigrescens* types; and (ii) dry grasslands (DG), including *Bromus erectus*, *Brachypodium rupestre* and *Helianthemum nummularium* types. Independent sample *t*-tests showed that MG and DG were comparable (P > 0.05) in terms of phenology, biodiversity indices and proportion of botanical families. The CCA clearly separated MG and DG along the first axis (32.1% of explained variance): MG species were associated with higher CP, total FA, a-linolenic, linoleic and palmitic acids contents, while DG species were associated with higher DM, fibre and oleic acid contents. Interestingly, the PV (a synthetic vegetation index) was strictly linked with the plant concentration of a-linolenic acid. These findings highlight that ruminants grazing on MG can benefit from forage of higher palatability, nutritive value and concentration of precursors for the synthesis of beneficial FA (e.g., rumenic acid and omega-3 fatty acids) in dairy and meat products.

Keywords. Canonical correspondence analysis – Forage quality – Grazing ruminants – Fatty acids.

Prairies alpines: relations entre variables botaniques et chimiques qui influencent la qualité des produits animaux

Résumé. *Dans les fermes d'alpage, la composition des fourrages est considérée comme le plus important des facteurs qui influencent la qualité de la production des ruminants au pâturage. Cette étude visait à analyser les relations complexes qui existent entre la composition botanique, la composition chimique et certaines caractéristiques des communautés végétales de différentes prairies alpines. Trente-neuf relevés de végétation ont été effectués dans certaines des communautés végétales les plus courantes dans les prairies alpines de l'ouest des Alpes italiennes. La composition botanique a été déterminée, et les valeurs moyennes des indicateurs écologiques de Landolt, des indices de biodiversité, du stade phénologique et des valeurs pastorales (VP) ont été calculées. Des échantillons représentatifs d'herbe ont été recueillis pour les analyses de la matière sèche (MS), de la protéine brute (PB), des parois et de la composition en acides gras (AG). Les relations entre les variables considérées ont été évaluées au moyen des coefficients de corrélation de Pearson et d'une analyse canonique des correspondances (ACC). L'analyse des données botaniques par classification hiérarchique a permis d'identifier deux principaux groupes écologiques: (i) les prairies mésophiles (PM), incluant les typologies à* Poa pratensis, Lolium perenne *et* Festuca nigrescens; *et (ii) les prairies sèches (PS), incluant les typologies à* Bromus erectus, Brachypodium rupestre *et* Helianthemum nummularium. *Les t-tests ont montré que PM et PS étaient comparables (P > 0,05) en termes de phénologie, d'indices de biodiversité et de proportion des familles botaniques. L'ACC sépare clairement PM et PS le long du premier axe (32,1% de la variance expliquée): les espèces PM ont été associées avec les plus hautes teneurs* *de PB, AG totaux, acides alpha-linolénique, linoléique et palmitique, tandis que les espèces PS ont été associées avec les plus hautes teneurs de MS, parois et acide oléique. Il est intéressant de noter que la VP (un indice de végétation synthétique) est strictement liée à la concentration d'acide alpha-linolénique détectée dans le fourrage. Ces résultats mettent en évidence que les ruminants qui pâturent sur des prairies PM peuvent bénéficier de fourrage caractérisé par une palatabilité élevée, une meilleur valeur nutritive et une plus haute concentration des précurseurs pour la synthèse des AG bénéfiques (par exemple, l'acide ruménique et les acides gras oméga-3) que l'on retrouve dans les produits laitiers et la viande.*

Mots-clés. *Analyse canonique des correspondances – Qualité des fourrages – Ruminants au pâturage – Acides gras.*

I – Introduction

Herbaceous species vary in their contents of proximate constituents and fatty acids (FA) (Bovolenta *et al*., 2008). As a consequence, grasslands with different botanical composition can significantly affect the chemical and sensory properties of ruminant derived food products (Lourenço *et al*., 2009). Considering various grassland types typical of alpine European communities, this work was planned to study the relationships existing among the botanical, ecological and chemical variables of grasslands potentially affecting dairy and meat quality.

II – Materials and methods

Different grasslands were chosen in the Piedmont region, within an altitude range from 250 to 2000 m a.s.l. Thirty-nine vegetation surveys were carried out from September 2013 to September 2014. The grasslands were characterized in terms of botanical composition, phenological stage of plants, Landolt's ecological indicators, plant biodiversity, and forage pastoral value (PV), according to the procedures described in Lambertin (1990) and Orlandi *et al*. (2016). During each vegetation survey, representative grass samples were harvested, split into two aliquots and frozen at -80°C until analysed. The first aliquot was dried and ground, and then used for the determination of dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), and acid detergent fibre (ADF). The second aliquot was freeze-dried and analysed for the FA composition. The proximate and FA compositions were expressed as g/100 g DM. The followed analytical procedures are reported in Renna *et al*. (2012).

Pearson correlations were performed among the botanical, chemical and plant community variables (IBM SPSS 22). A hierarchical cluster analysis was used to classify vegetation surveys into homogeneous vegetation types and ecological groups (Clustan Graphics 5.27). The relationships existing between chemical (main matrix) and botanical (second matrix) data were also assessed with a canonical correspondence analysis (CCA), where plant community variables were included in a supplementary matrix (PAST 3.08). Independent sample Student's t-tests were then used to evaluate differences in the botanical composition, chemical composition and plant community variables between the two main grassland ecological groups identified by the cluster analysis (IBM SPSS 22).

III – Results and discussion

The total fatty acid (TFA) content as well as the concentrations of palmitic (C16:0), linoleic (C18:2 n6) and a-linolenic (C18:3 n3) acids were negatively correlated with DM and fibre and positively correlated with the CP content of the grass samples; an opposite trend was observed for oleic (C18:1 n9) acid (Table 1). The concentration of C18:3 n3 was positively correlated with the relative abundance of *Fabaceae* and negatively correlated with *Poaceae*. The obtained results confirm known relationships among various chemical variables and phenology in plants (Nelson and

Moser, 1994; Glasser *et al*., 2013). Interestingly, the PV (a synthetic vegetation index) was significantly and positively (C16:0, C18:3 n3) or negatively (DM, NDF, ADF) correlated with some of the considered chemical parameters.

Table 1. Dataset variability (mean ± SD) and most significant Pearson's correlation coefficients among botanical, chemical and plant community variables (n = 39)

Mean ± SD	DM: 29.6 ± 10.51 g/100 g; CP: 12.0 ± 2.83 g/100 g DM; NDF: 52.3 ± 7.43 g/100 g DM; ADF: 32.8 ± 5.37 g/100 g DM; C16:0: 0.30 ± 0.057 g/100 g DM; C18:0: 0.04 ± 0.013 g/100 g DM; C18:1n9: 0.09 ± 0.049 g/100 g DM; C18:2n6: 0.32 ± 0.093 g/100 g DM; C18:3n3: 0.81 ± 0.358 g/100 g DM; TFA: 1.66 ± 0.480 g/100 g DM; PV: 34.5 ± 12.54; F: 2.4 ± 0.34; N: 2.9 ± 0.48; R: 3.2 ± 0.28; Phenology: 312 ± 214.5; Poaceae: 51.4 ± 13.44 % of relative abundance; Fabaceae: 10.7 ± 5.50 % of relative abundance
DM	CP (-0.78***), NDF (0.70***), ADF (0.81***), C16:0 (-0.65***), C18:1 n9 (0.57***), C18:2 n6 (-0.43**), C18:3 n3 (-0.79***), TFA (-0.71***), PV (-0.40*), Phenology (0.33*), F (-0.51**), R (0.64***), N (-0.63***), *Poaceae* (0.34*)
CP	NDF (-0.77***), ADF (-0.84***), C16:0 (0.81***), C18:1 n9 (-0.46**), C18:2 n6 (0.45**), C18:3 n3 (0.79***), TFA (0.76***), Phenology (-0.33*), F (0.40*), R (-0.54***), N (0.55***)
NDF	ADF (0.80***), C16:0 (-0.81***), C18:2 n6 (-0.48**), C18:3 n3 (-0.81***), TFA (-0.82***), PV (-0.35*), F (-0.45**), R (0.50***), N (-0.47**), *Fabaceae* (-0.54***), *Poaceae* (0.36*)
ADF	C16:0 (-0.69***), C18:1 n9 (0.55***), C18:2 n6 (-0.35*), C18:3 n3 (-0.78***), TFA (-0.70***), PV (-0.46**), F (-0.51***), R (0.63***), N (-0.66***), *Fabaceae* (-0.38*)
C16:0	C18:0 (0.38*), C18:2 n6 (0.75***), C18:3 n3 (0.79***), TFA (0.90***), PV (0.34*), F (0.46**), R (-0.49**), N (0.53***)
C18:0	C18:1 n9 (0.60***), C18:2 n6 (0.44**)
C18:1 n9	C18:3 n3 (-0.41**), Phenology (0.40*), R (0.44**), N (-0.35*)
C18:2 n6	C18:3 n3 (0.56***), TFA (0.77***), *Poaceae* (-0.36*)
C18:3 n3	TFA (0.95***), PV (0.36*), F (0.44**), R (-0.56***), N (0.50***), *Fabaceae* (0.42**), *Poaceae* (-0.34*)
TFA	F (0.40*), R (-0.49***), N (0.45**), *Fabaceae* (0.36*), *Poaceae* (-0.37*)

F: Landolt's soil moisture; R: Landolt's soil reaction; N: Landolt's nutrient supply.
*** $P \leq 0.001$; ** $P \leq 0.01$; * $P \leq 0.05$.

The cluster analysis (data not shown) identified two main ecological groups: i) mesophilic grasslands (MG), including *Poa pratensis*, *Lolium perenne* and *Festuca nigrescens* types and ii) dry grasslands (DG), including *Bromus erectus*, *Brachypodium rupestre* and *Helianthemum nummularium* types (Cavallero *et al*., 2007). In the CCA, the first and second axis explained 53.1% of total variance and MG and DG were well separated along the first axis (Fig. 1). The CCA confirmed the results obtained with the Pearson's correlation analysis. The *t*-tests showed that MG and DG were comparable (P > 0.05) for phenology, biodiversity and proportion of botanical families. However, MG species were associated with higher CP, TFA, C16:0, C18:2 n6 and C18:3 n3 contents, while DG species were associated with higher DM, fibre and C18:1 n9 contents (Table 2).

IV – Conclusions

Ruminants grazing on MG can benefit from forage of higher palatability, nutritive value and concentration of precursors (e.g., C18:3 n3) for the synthesis of beneficial FA (e.g., rumenic acid and omega-3 FA) in dairy and meat products. MG are related to higher soil moisture content and more intensive management; it is therefore recommended to maintain the agro-pastoral practices that have promoted the affirmation of those grasslands in order to obtain animal products richer in nutraceutical compounds. Further research is needed to evaluate if significant differences can be also found among different grassland types belonging to the MG group.

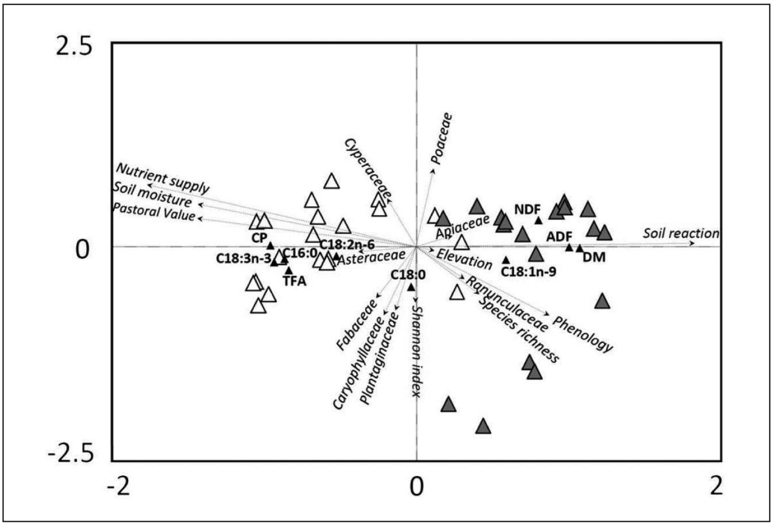

Fig. 1. Canonical correspondence analysis ordination biplot. White triangles: mesophilic grasslands; grey triangles: dry grasslands.

Table 2. Differences in terms of chemical and plant community variables between mesophilic and dry grasslands

	MG	DG	s.e.m.	P		MG	DG	s.e.m.	P
DM, g/100 g	22.3	38.1	1.68	***	C16:0, g/100 g DM	0.33	0.27	0.01	***
CP, g/100 g DM	13.6	10.2	0.45	***	C18:1 n9, g/100 g DM	0.07	0.12	0.00	**
NDF, g/100 g DM	48.9	56.3	1.19	***	C18:2 n6, g/100 g DM	0.34	0.28	0.01	*
ADF, g/100 g DM	29.5	36.6	0.86	***	C18:3 n3, g/100 g DM	0.98	0.60	0.06	***
Landolt's Soil moisture (F)	2.6	2.2	0.05	***	TFA, g/100 g DM	1.88	1.41	0.08	**
Landolt's Nutrient supply (N)	3.3	2.6	0.08	***	PV	40.0	27.9	2.01	**
Landolt's Soil reaction (R)	3.0	3.5	0.05	***					

Variables which did not significantly differ between ecological groups (i.e., Poaceae, Asteraceae, Fabaceae, Cyperaceae, Apiaceae, Plantaginaceae, Other forbs, Stearic acid, Phenology, Species richness, Shannon diversity index) are not displayed in the table.

*** P ≤ 0.001; ** P ≤ 0.01; * P ≤ 0.05.

Acknowledgments

Funded by Piedmont Region–RDP 2007–2013 Measure 124.1-Health Check.

References

Bovolenta S., Spanghero M., Dovier S., Orlandi D. and Clementel F., 2008. Chemical composition and net energy content of alpine pasture species during the grazing season. *Animal Feed Science and Technology,* 146, 178-191.

Cavallero A., Aceto P., Gorlier A., Lombardi G., Lonati M., Martinasso B. and Tagliatori C., 2007. *I tipi pastorali delle Alpi piemontesi: vegetazione e gestione dei pascoli delle Alpi occidentali*. Alberto Perdisa Ed., Bologna, Italy, 467 pp.

Glasser F., Doreau M., Maxin G. and Baumont R., 2013. Fat and fatty acid content and composition of forages: A meta-analysis. *Animal Feed Science and Technology,* 185, 19-34.

Lambertin M., 1990. *Calcul de la charge d'un alpage par un approche phyto-écologique: synthèse de deux années d'exploitation par des vaches laitières.* Aosta, Italy: Institut Agricole Régional.

Lourenço M., Moloney A.P. and Fievez V., 2009. Botanically diverse forages: implications for ruminant product composition and quality. *Pastagens e Forragens,* 30, 119-137.

Nelson C.J. and Moser L.E., 1994. Plant factors affecting forage quality. In: *Forage quality, evaluation, and utilization* (Fahey GC Ed.), pp. 115-154. ISBN 0-89118-119-9.

Orlandi S., Probo M., Sitzia T., Trentanovi G., Garbarino M., Lombardi G. and Lonati M., 2016. Environmental and land use determinants of grassland patch diversity in the western and eastern Alps under agro-pastoral abandonment. *Biodiversity and Conservation,* 25: 275-293.

Renna M., Lussiana C., Cornale P., Fortina R. and Mimosi A., 2012. Changes in goat milk fatty acids during abrupt transition from indoor to pasture diet. *Small Ruminant Research,* 108, 12-21.