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in

Baumont R. (ed.), Carrère P. (ed.), Jouven M. (ed.), Lombardi G. (ed.), López-Francos A. (ed.), Martin B. (ed.), Peeters A. (ed.), Porqueddu C. (ed.).
Forage resources and ecosystem services provided by Mountain and Mediterranean grasslands and rangelands

Zaragoza : CIHEAM / INRA / FAO / VetAgro Sup Clermont-Ferrand / Montpellier SupAgro
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 109

2014
pages 87-90

Dairy cattle on Norwegian alpine rangelands – grazing preferences and milk quality

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Abstract. The results from the study 'Effects of vegetation and grazing preferences on the quality of alpine dairy products' will be presented. The main objective of the project was to investigate the connections between alpine rangeland vegetation, landscape use and grazing preferences of free ranging dairy cattle and the milk quality with regard to fatty acid composition and content of various secondary plant metabolites. Two herds in two different geographical summer farming areas were studied during three grazing seasons (2007-2009). Area use and grazing preferences were studied by using high frequency GPS data in combination with detailed vegetation mapping, field studies of animal behaviour, microhistological analysis of faeces, analyses of rangeland vegetation composition and records of grazed plant species. The results showed that when available, the dairy cattle preferred open areas with a vegetation rich in species, dominated by grass and herb species. Different plant groups influenced the chemical composition of the milk differently. The study concludes that milk from alpine rangelands differ from "normal" summer and winter milk in Norway by having a healthier fatty acid composition and a higher content of various secondary plant metabolites, which may be a potential for development of labelled products. Also, preventing regrowth of alpine rangelands seems to be important, not only to maintain high biodiversity but also to secure good product quality.

Keywords. Alpine rangelands – Biodiversity – Grazing preferences – Milk quality – GPS.

Des vaches laitières sur les pâturages alpins norvégiens – préférences au pâturage et qualité du lait

Résumé. *Les résultats présentés concernent une étude sur «les effets de la végétation et des préférences au pâturage sur la qualité des produits laitiers alpins». L`objectif était d'examiner la relation entre les pâturages alpins, l`utilisation des parcelles, les préférences alimentaires des bovins et la qualité du lait, concernant sa composition en acide gras et en métabolites végétaux secondaires. Deux troupeaux dans deux régions de pâturage estival différentes ont été étudiés pendent trois saisons (2007-2009). L'utilisation des parcelles et les préférences alimentaires ont été étudiées par un suivi GPS haute fréquence en combinaison avec une analyse détaillée de la végétation, des études du comportement animal sur le terrain, des analyses micro histologiques des fèces, des analyses de la composition des plantes et un suivi des plantes broutées. Les résultats montrent que les bovins laitiers préfèrent, si possible, les espaces ouverts et une végétation riche, dominée par les graminées et les herbes. Les différents types de végétation influencent la composition chimique du lait. L'étude conclut que le lait des pâturages alpins est différent du lait 'normal' estival et hivernal en Norvège, ayant une composition en acides gras plus saine et un contenu plus élevé en métabolites végétaux secondaires, offrant ainsi un potentiel de développement de produits labellisés. Il semble important de préserver les pâturages alpins du reboisement pour maintenir une grande biodiversité et garantir la qualité des produits.*

Mots-clés. *Pâturages alpins – Biodiversité – Préférences de pâturage – Qualité du lait – GPS.*

I – Introduction

Agriculture is still one of the most important businesses for settlement in alpine regions in Norway. In such areas, the traditional production system for milk production was summer farming on alpine rangelands. However, agricultural practices changed during the last century and milk production in alpine areas decreased considerably. In Norway, about 1200 mountainous summer farms are still in use. The grazing animals at these summer farms maintain landscape qualities, grazing resources and high biodiversity, which are important common goods and a contribution to local resource exploitation. If these traditional and extensive production systems shall survive, however, it is necessary to bring in a new economy, which makes it possible to compete with bulk products from intensive production systems. One strategy, which has proved to help alpine farmers in e.g. France and Italy, is diversification of dairy products, based on scientific evidence, which may give products from extensive product systems in alpine regions a better price in the market (Lombardi *et al.,* 2008). Milk from species rich pastures in alpine regions often exhibits a healthier fatty acid composition than milk produced on species poor pastures and pastures in the lowlands (Collomb *et al.,* 2002a). There is still generally little knowledge about the quality of Norwegian alpine milk products and how this quality is related to the grazing preferences of free ranging cattle and species composition of the grazing plants. The main objectives in this study was thus to investigate: 1. Area use, grazing patterns and grazing preferences of free ranging dairy cattle in two alpine rangelands; 2. Fatty acid composition and the content of various antioxidants and terpenes in the milk from the dairy cattle in the study areas; 3. Possible connections between alpine rangelands, grazed plants groups and milk quality.

II – Materials and methods

1. Study sites and herds

The study sites were two summer farms situated in two different alpine regions in south-central Norway, Valdres and Hallingdal, with dairy cattle grazing alpine ranges. The sites are referred to as site 1 (in Valdres) and 2 (in Hallingdal). Site 1 (60°57´N; 8°49´E) is situated approximately 910 m a.s.l., in the northern boreal vegetation zone. Site 2 (60°32´N; 8°11´E) is located approximately 1040 m a.s.l. in the transition between the northern boreal and low alpine vegetation zone. The animals in both herds are of the breed Norwegian Red. At site 1, the herd consisted of 12-14 dairy cows and 7-9 heifers while the herd at site 2 consisted of 18-20 dairy cows and 1-3 heifers. The herds grazed on alpine rangeland 9-11 hours per day, after the morning milking and until they returned to the milking barn in the afternoon. After the afternoon milking, the cattle were let out in fenced cultivated pastures at the summer farms where they spent the night resting and grazing until the morning milking. Supplemental feeding consisted of 4-6 kg grain based concentrates per cow per day at both sites.

2. GPS collars, field studies and vegetation maps

Global positioning system (GPS) units were utilised for tracking the grazing cattle. Five dairy cows in the herds wore collars with GPS units while they were out grazing between morning and afternoon milking, during two study periods (in July and August) in 2007-2009. The GPS units were logging the geographical position and time every 5 seconds. The data from all days were integrated in a Geographical Information System (GIS); thus, the movement of the cows could be analysed and presented on maps. In 2008, parallel field studies of animal behaviour were done during the periods when the cattle wore GPS collars. By using parameters derived from the GPS data alone, models of behaviour were developed and validated by observation data, and the GPS data could finally be classified into walking, grazing and resting. Vegetation maps, based on aerial photo interpretation and field work, were made from both study areas. Digital aerial near-

infrared colour photos (CIR) with a pixel resolution of 0.20 m x 0.20 m on ground level were used for interpretation. Natural and semi-natural vegetation types available for grazing were interpreted according to a classification system based on Sickel *et al.* (2004). The vegetation maps were used together with GPS data in GIS analysis.

3. Milk sampling procedures and analysis

In all study years (2007-2009), milk samples (morning milk) were taken from 9-10 cows in each herd, once in July and once in August at both study sites for analysis of fatty acid composition, carotenoids, vitamin E and terpenes. Analysis of tocopherol and carotenoids were performed at a commercial laboratory using HPLC with fluorescence and diode array detectors, respectively. Methylated fatty acids were analysed at the same laboratory using GC with flame ionization detector. Terpenes were sampled using a head space method and subsequently analysed using GC-MS at the University of Copenhagen, Department of Food Science.

4. Diet variables

Faeces samples were collected and prepared for microhistological analyses following the procedures of Garcia-Gonzalez (1984). A set of individual diet variables was made from the results of the microhistological analyses of faeces samples taken from the GPS cows. The species and plant families detected were grouped in five functional groups: woody species, grasses, sedges, herbs and Pteridophytes, and the proportions of grazed plant groups were calculated. The faeces samples were taken day 1-5 in the week, and the milk samples were taken on day 7 in the same week. Grazed plant species were also recorded by plot analysis on grazed patches. A grazed patch was defined as a patch where a cow was observed grazing continuously for 1 minute or more. Five grazed patches from each locality within a vegetation type were marked with wooden sticks and analysed by putting down a frame sized 0.5 m x 0.5 m around the stick. All species within the plot were recorded and scored with respect to whether they were grazed on or not. The proportions of grazed plant groups (woody species, grasses, sedges, herbs and Pteridophytes) within each grazed vegetation type were calculated. For every GPS cow, a set of diet variables were calculated by multiplying the proportions of grazed plant groups within the vegetation type with the proportion of time spent grazing in the vegetation type the week before milk sampling, summing up for all grazed vegetation types and calculating the overall proportions of eaten plant groups from that week.

5. Statistical analysis

For the analysis used to develop GPS models, the data were stored in a PostGIS 1.5 enabled PostgreSQL 9.1.8 database. To do the analyses, the dataset were pulled into R 2.14.1. The scripts used in the analyses are available at http://github.com/sickel/cowplot at commit f4353c8. To investigate potential relationships between diet and the chemical composition of the milk, generalised linear mixed modelling was performed using the milk data as response variables and different measures of cow diet as explanatory variables. The analyses were performed in R.

III – Results and discussion

It was possible to classify grazing behaviour correctly from the high frequency GPS data with as much as 92 percent accuracy. Grazing was the main activity and the cows preferred to graze in open areas with a vegetation rich in species, dominated by grass and herb species. Previous studies have shown that cattle select grasslands for grazing (Sickel *et al.*, 2004) probably due to a combination of high plant density and nutrient content (Dumont *et al.,* 2007). The study also reveals that to maintain the biodiversity and grazing value of these semi-natural species rich habi-

tats it may be necessary to supply grazing with clearing of bushes and trees. Furthermore, the analytical results which characterize the milk from summer farms in this project, and which can be said to give rise to unique milk products are low contents of the unfavourable fatty acids C14:0 and C16:0, high levels of the favourable fatty acids C18:3 n-6 and CLA, a low ratio omega-6:omega-3 and a relatively high number of terpenes. These findings are in accordance with Martin *et al.* (2005). The results of the statistical modelling indicate that the different plant groups on the rangelands were significantly related to specific chemical components in the milk. The omega 3 fatty acid C18:3 and β-carotene were both positively related to herbs. This is in accordance with the studies of Collomb *et al.* (2002b) who found that PUFAs were positively correlated with herb species from the families *Asteraceae, Apiaceae, Rosaceae* and *Fabaceae*. Our results corroborate these findings as some of the most frequently eaten herb species at our study sites also belonged to three of these families. The levels of C18:2 n-6 decreased with increasing levels of woody species, grasses and sedges in the diet. Woody species and sedges occur with higher proportions in the diet at site 1 where C18:2 n-6 was found to occur with lower levels than at site 2 where herbs have higher proportions in the diet. As Collomb *et al.* (2002b) found herbs to be positively correlated with PUFAs this might also explain this negative relation of C18:2 n-6 with other plant groups. The ratio omega-6:omega-3 decreased as the intake of grass increased in the diet. This may be explained by decreasing levels of C18:2 n-6 with increased levels of grasses in the diet as discussed above. Lot of grass in the diet may also imply grazing on open grass and herb rich field layer, which also lead to a higher intake of herbs. Herbs increase the levels of C18:3 n-3 as discussed above. A low ratio omega-6:omega-3 may thus be explained by either less C18:2 n-6 or more C18:3 n-6, or a combination of both. Oleic acid, C18:1 c9, was positively related to woody species and Pteridophytes and the saturated fatty acid C14:0 was on the contrary negatively related to these variables. It is difficult to say whether there is a direct influence of woody species and Pteridophytes on the levels of these fatty acids in the milk or if there are underlying factors e.g. energy shortage, which are the real explanations of these observed relationships.

Acknowledgments

This study was part of a project financed by the Research Council of Norway.

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