Energy content and methanogenic potential of forage plant species from Alpine swards

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Introduction

Grassland areas in the mountainous region of the Alps provide an important feed resource for ruminants that complements lowland livestock systems during the summer period. Although studies on the utilization of alpine swards as feed resources for ruminants have been repeatedly conducted (Estermann et al., 2001; Leiber et al., 2006), more information is needed regarding the nutritional value of individual alpine plant species as well as their methanogenic potential when being digested and fermented by the ruminal microflora. Therefore, the objectives of this study were to determine the nutritional values, especially energy contents, of typical and abundant alpine forage plants (according to Dietl, 1998) from different functional groups, and to test their methanogenic potential when incubated in an *in vitro* rumen fermentation system.

Materials and Methods

In early July 2009, samples of 18 forage plant species were collected from three different Alpine sites (upper part of the Misox valley, in Sufers, Rheinwald, and at the ETH Alp Weissenstein at altitudes of 800, 1400 and 1800-2300 m above sea level, respectively) of Canton of Grisons, South-Eastern Switzerland. This included two grasses, 11 herbs and four tree leaves or flowers. After collection, all plant samples were oven dried at 60 ^{o}C for 24 h and ground to pass a 1-mm sieve. Prior to incubation, the plants were determined for their cell wall constituents (Van Soest et al., 1991) and phenolic fractions (Makkar, 2003). The plant samples then were incubated *in vitro* using the Hohenheim gas test as described by Soliva and Hess (2007). Approximately 200 mg dry matter (DM) of each plant was incubated with 30 ml of ruminal fluid/buffer mixture (1:2; v/v) for 24 h at a constant temperature of 39°C. Each plant was incubated in four replicates, represented by two incubation units per experimental run. Variables measured after incubation were total gas production and methane (CH_4) concentration (analyzed by gas chromatography, Hewlett Packard model 5890 Series II, Avondale, PA, USA) following the procedure of Soliva and Hess (2007). Net energy for lactation (NEL) of each plant was calculated using an equation from Menke and

Steingass (1988). Data was subjected to analysis of variance using the GLM procedure of SAS version 9.2. As the basis for multiple comparisons among means, the minimum significant difference (MSD) was generated from Tukey's test. Pearson correlation coefficients between variables and their significance were computed by the CORR procedure of SAS.

Results and Discussion

Although it is considered as a weed, *Capsella bursa-pastoris* had the highest NEL content (6.8 MJ/kg DM) among the plants investigated. Other plants that possessed NEL higher than 6.0 MJ/kg DM were *Crepis aurea*, *Alchemilla xanthochlora*, and *Sambucus nigra* flowers and leaves, with the values of 6.7, 6.4, 6.4 and 6.0 MJ/kg DM, respectively. On the contrary, very low NEL contents were observed in *Castanea sativa* and *Nardus stricta*, i.e. 3.0 and 3.8 MJ/kg DM, respectively. This is probably a reason why *N. stricta* is avoided by domestic grazers (Fischer and Wipf, 2002).

Incubation of *Castanea sativa* produced gas with an extremely low CH_4 content of only 7 ml/l total gas. This result confirmed the methane mitigating potential of chestnut extract as shown elsewhere (Bhatta et al., 2009) although the magnitude of the effect was different. Other plants producing relatively few CH_4 in relation to total gas were *A. xanthochlora* and *S. nigra* (flowers and leaves) with values of around 130 to 140 ml/l.

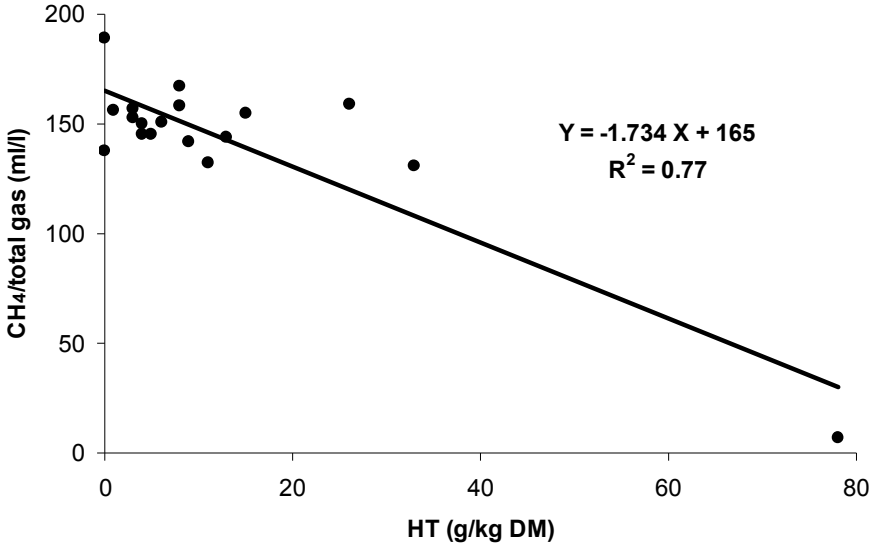

Figure 1: Relationship between hydrolysable tannins (HT) in the Alpine plants investigated and CH_4/total gas.

Among the phenolic fractions, total phenols (TP), total tannins (TT) and hydrolysable tannins (HT) had negative correlations to CH_4/total gas ($P < 0.001$), with HT having the strongest relationship

(Figure 1). No significant relationships were found between non-tannin phenols (NTP) or condensed tannins (CT) and CH_4/total gas. This was also the case with the chemical constituents other than the phenolic fractions. Negative correlations were observed for TT and HT in relation to total gas production and NEL ($P < 0.05$). Another constituent found to be negatively correlated with NEL was neutral detergent fiber ($P < 0.05$).

Conclusion

Some forage plants from the Alps possessed high NEL contents, especially *C. bursa-pastoris*, *C. aurea*, *A. xanthochlora* and *S. nigra* flowers and leaves. The *in vitro* ruminal methanogenic potential of the Alpine plants was found to vary less than expected and, in general, appeared to be quite substantial. Vegetation types containing *N. stricta* as main grass species appear to be unfavorable for ruminant nutrition not only in terms of energy content but also regarding its methanogenic potential. *C. sativa*, being the most effective methane inhibitor, had the poorest ruminal fermentation rates, but may have a potential when ingested in limited dietary proportions. The mitigation potential towards ruminal methane production seems to be determined mostly by the HT.

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