

The unique properties of red clover in the diet of ruminants

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Abstract

*Grassland legumes are essential in organic ruminant livestock production due to their ability to fix atmospheric nitrogen (N), providing high yields of high feeding value without N fertilization. White clover (*Trifolium repens* L.) and red clover (*Trifolium pratense* L.) are the most important legumes of temperate grasslands with white clover as the most widely used. New research has revealed new properties of red clover that may affect animal performance and product quality significantly. Red clover containing diets have increased the production of milk and meat (compared with grasses) and the content of beneficial fatty acids in milk and meat (compared with grasses and other legumes), improved the efficiency of feed N utilization (compared with *Medicago sativa* L.), and increased the milk content of isoflavones (compared with grass and white clover). Red clover contains high levels of the enzyme polyphenol oxidase that might reduce the extent of lipolysis and proteolysis. The paper presents a review on recent results from own and others' research on the use of red clover in the diet of ruminants and the likely mechanisms by which red clover affects production and product quality.*

Introduction

Legumes are essential in organic agriculture due to their ability to fix atmospheric nitrogen (N) and thereby determine to a large extent the productivity of the system. In organic grassland livestock farming, the perennial legumes not only ensure the N input, they also provides high quality fodder. It is recognized that grassland legumes have superior feeding value with higher intake and animal production than grasses (Frame et al., 1998). White clover (*Trifolium repens* L.), lucerne (*Medicago sativa* L.), and red clover (*Trifolium pratense* L.) are the most widely cultivated grassland legumes with the white clover as the most important in Europe. In recent years, the interest for red clover has increased, partly because red clover possesses unique properties that may affect animal performance and product quality. In this paper, some recent published research with red clover and its effect on animal performance and animal products (milk and meat) is reviewed.

Animal performance

Early experiments with red clover silage fed to beef and dairy cows demonstrated higher feed intake and performance (growth rate, milk yield) than pure grass silage (Thomas et al., 1981; Thomas et al., 1985). These results have been confirmed in more recent experiments with dairy cows (Dewhurst et al., 2003b; Vanhatalo et al., 2006), and Fraser et al. (2004) observed higher growth rate in lamb grazing red clover

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than on perennial ryegrass (*Lolium perenne* L.). Others have found only small differences or that differences between red clover and grasses depended on seasonal growth conditions (Bertilsson and Murphy, 2003; van Dorland et al., 2006). The positive effect of red clover relative to grass has been explained by higher voluntary intake at similar digestibility. Higher voluntary intake is ascribed to higher concentration of cell contents in red clover than in grasses resulting in faster rates of particle breakdown in the rumen and more rapid clearance of particles from the rumen (Frame et al., 1998).

More recently, red clover has been compared with other legumes. Red clover silage has often proved to be superior to lucerne silage in relation to milk yield relative to feed intake (Broderick et al., 2001; Dewhurst et al., 2003b; Hoffman et al., 1997), and lamb grazing red clover had higher live weight gain than those grazing lucerne (Fraser et al., 2004). Broderick et al. (2001) estimated from animal performance data that the net energy of lactation was 18 % greater in red clover than lucerne. Red and white clover are to a large extent equivalent in usable energy and protein supply, as only minor differences in feed intake and milk yield have been observed when compared (Bertilsson and Murphy, 2003; Dewhurst et al., 2003b; Steinshamn and Thuen, 2008; van Dorland et al., 2006).

Red clover containing diets have increased ruminal non-ammonia N flow in terms of increased flows of microbial and dietary N entering the small intestine when compared with grass silage (Dewhurst et al., 2003a; Vanhatalo et al., 2006) and with lucerne. Consequently, higher apparent N conversion from feed N to product N is often observed on red clover than on grasses or lucerne (Broderick et al., 2001; Vanhatalo et al., 2006). However, due to high N content improved N efficiency relative to grasses or other legumes are not consistent (Bertilsson and Murphy, 2003; van Dorland et al., 2006). This inconsistency warrants further research.

Product quality

Only small and inconsistent effect of red clover has been reported on the milk content of fat, protein and lactose. However, red clover seems to have a pronounced effect on the milk and meat fatty acids composition. Red clover containing diets has increased the product content of polyunsaturated fatty acids, particularly of the beneficial alpha-linolenic acid (C18:3n-3), both when compared with grasses and other legumes (Table 1, Al Mabruk et al., 2004; Dewhurst et al., 2003b; Fraser et al., 2004; Steinshamn and Thuen, 2008; Vanhatalo et al., 2007). The inclusion of red clover in the diet of dairy cows is likely an important explanation for the often observed higher content of nutritional desirable fatty acids in organic than in conventional produced milk (Butler et al., 2008; Ellis et al., 2006).

Another striking feature with red clover is the high content of phytoestrogens of the isoflavone group. In a dairy cow experiment with organic managed cows, Steinshamn et al. (2008) found that milk content of biochanin A (1.86 vs. 0.37 µg/l), equol (318 vs. 75 µg/l), and formononetin (6.5 vs. 2.7 µg/l) were several times higher on red clover than on white clover containing silage diets. Phytoestrogens, and particularly equol, may have beneficial health effect, and increased content in milk may be important when health benefits of milk are studied.

Tab. 1: Milk content of alfa-linolenic acid (% of total milk fatty acids) of dairy cows fed either grass, white clover (WC) or red clover (RC) silages

Reference	Grass	WC	RC	Grass vs clover	WC vs RC
Al-Mabruk et al. 2003	0.47		0.93	***	
Dewhurst et al. 2003b	0.40	0.96	1.28	***	***
Vanhatalo et al. 2007	0.39		1.11	***	
Van Dorland et al. 2008	0.90	1.14	1.04	(*)	ns
Steinshamn and Thuen 2008		0.73	0.87		***

(*) significant for P<0.10

*** significant for P<0.001

Plant mechanism explaining the red clover effect

Red clover contains high levels of both the enzyme polyphenol oxidase (PPO) and its substrate *o*-diphenol. PPO convert phenols to quinones, which bind with proteins and reduces proteolysis and lipolysis in silo and in rumen (Albrecht and Muck, 1991; Lee et al., 2007; Sullivan and Hatfield, 2006). Proteolysis and lipolysis are catalyzed by the enzymes protease and lipase. These enzymes are proteins, and the quinones formed after harvesting binds to the enzymes and partly denaturalize them. The result is that more of the original plant protein remains intact after ensiling and rumen passage, explaining higher conversion of feed N into meat or milk N on red clover than on other forages. Likewise, reduced lipolysis results in reduced rumen biohydrogenation of fatty acids. Consequently, a higher proportion of the unsaturated fatty acids in the ingested feed passes the rumen to the intestine for absorption. Thus, a higher transfer rate of C18:3n-3 from feed to milk is observed on red clover diets (Dewhurst et al. 2003b; Steinshamn and Thuen, 2008).

Conclusions

Red clover has superior feeding value and higher ruminant performances (higher milk yield and growth rate) are often obtained when compared with grasses and lucerne. Red clover contains high amounts of polyphenol oxidase (PPO) and its phenolic substrate. High PPO activity reduces proteolysis and lipolysis, which is the likely mechanism for improved conversion of feed N into product N and to higher transfer of polyunsaturated fatty acids from feed to product. Red clover also contains high amounts of isoflavonoids, which is reflected in milk from dairy cows fed red clover containing diets.

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