Changes in vitamin and fatty acid contents in grass-red clover herbage after cutting

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Abstract

Fresh herbage is an important natural source of protein, fibre, fatty acids (FA) and vitamins in ruminant diets and it is desirable for farmers that they minimise losses. Thus the concentrations of vitamins and FA in herbages during the growing season as well as their fate after cutting are of interest. A study was conducted in Denmark in which a red clover (*Trifolium pratense*) – perennial ryegrass (*Lolium perenne*) sward was mown eight times during the crop growing season. Swaths were subjected to three wilting strategies, and sampled at six time intervals after cutting. Dry matter content and concentrations of α-tocopherol, β-carotene and FA were determined. Fatty acid and α-tocopherol concentrations were highest in October, followed by May, and lowest in summer. Total FA and vitamin concentrations showed a significant overall decline from freshly cut to 29 h-wilted forage. Weather conditions and swath management practices had significant effects on the drying rate of cut forage. The magnitude and rates of decline of concentrations of vitamins and FA during the wilting process were not affected by swath management or herbage drying rates. Choice of harvest date and wilting duration could be used as management tools to optimise concentrations of vitamins and FA in forage.

Keywords: α-tocopherol, β-carotene, α-linolenic acid, drying rate, fatty acids, seasonal pattern

Introduction

As N is a major limiting factor for plant growth, inclusion of legumes in grasslands contributes to sustainable intensification, as symbiotically fixed N_2 may replace fertilizer-N. Red clover (*Trifolium pratense*) is an important forage legume and perennial ryegrass (*Lolium perenne*) a major grass species. Livestock products are an important source of fat-soluble vitamins. Tocopherols and carotenoids can be transferred from feed into milk and the fatty acid (FA) profile of feed has a direct impact on the FA profile of animal products. Fresh herbage is an important natural source of protein, fibre, FA and vitamins in ruminant diets. It is desirable to optimise contents of valuable compounds in grazing animals' diets, and for zero grazing systems and conserved forage, to minimise losses after cutting. Thus the contents of vitamins and FA during the growing season, as well as their fate after cutting, were studied in perennial ryegrass-red clover herbage. Although synthetic vitamins are cheap and widely used in livestock production, there is interest in naturally occurring vitamins, particularly in organic farming systems and thus, for physiological and economic reasons, it is desirable to keep vitamin levels in conserved forages close to the initial levels in the fresh crop. Post-harvest treatments can affect FA contents in grass (e.g. Witkowska *et al.,* 2009). Following cutting, pre-wilting of herbage prior to ensiling is a widely used swath management practice. Detrimental effects of prolonged wilting and field drying on the concentrations of FA and vitamins have been reported in grass and legume species (Müller *et al.*, 2007). The aim of this experiment was to study the effects of harvest date and swath management on changes in concentrations of vitamins and FA in a gradually wilted grass-red clover mixture, in relation to wilting duration, weather conditions and herbage drying rate. We hypothesised that during wilting, concentrations of vitamins and FA would decline, and that the rate of decline would be related to herbage drying rate.

Materials and methods

A study was conducted in Denmark in which a red clover-perennial ryegrass sward was mown on eight occasions (early May until mid-October 2009). Swaths were subjected to three wilting strategies, i.e. 'narrow' (50% area cover), 'broad' (full field cover) and 'broad' swaths tedded 2 h after cutting, and sampled on six occasions (0, 3, 5, 10, 24 and 29 h after cutting). Weather parameters were measured hourly by a weather station ca. 200 m from the experimental area. of Dry matter (DM) content and concentrations of α-tocopherol, β-carotene and FA were determined as described in Elgersma *et al.* (2013). Change in DM content was calculated for each interval between two sampling times. Changes with time were evaluated with a model (ProcMixed) that included fixed effects of swath treatment, harvest date and sampling time and their two-way interactions. Across harvest dates, air temperature at cutting (at 10:00 h) ranged from 7.3 to 22.6 °C. In May, September and October, the grass was in a vegetative stage and predominantly leafy. Grass stems mainly occurred at the flowering stage in June (harvests 2 and 3). Red clover was at the flowering stage and was most stemmy in mid-summer (late July-August, harvests 4-6).

Results

In freshly cut herbage (t=1), significant effects of harvest date occurred for concentrations of vitamins, FA and DM. Fatty acid and α-tocopherol concentrations were highest in harvest 8 (October) followed by harvest 1 (May). Averaged across harvest dates and swath managements, vitamins and FA concentrations declined during wilting from sampling time t=1 to t=6, whereas DM concentration increased from 140 to 320 g kg^{-1} (Table 1). Average drying rates across the five time intervals were 0.7, 1.7 and 2.0 g 100 g DM^{-1} h^{-1} in narrow, broad and broad tedded swaths, respectively, but there was large variation in crop drying rates among the eight harvest dates in each swath type. After 19 h, in narrow swaths DM contents were lowest and ranged from 138 (harvest 1) to 324 g kg^{-1} (harvest 5) but in broad swaths, only in harvests 1, 6 and 8 the final DM content was below 320 g kg^{-1}. The highest DM contents were found in harvests 2 and 7 in broad swaths and particularly in broad tedded swaths (519 g kg^{-1} in harvest 3 and 643 g kg^{-1} in harvest 5). Despite interactions, the main effect of sampling time was highly significant (P<0.001). Total FA concentration showed a significant overall decline (P<0.001) from fresh to 29 h-wilted forage (2.13 to 1.87 g 100 g DM^{-1}) (Table 1). Regression analyses with the rate of change in FA concentration as dependent variable did not reveal significant explanatory variables. Swath management had no effect. During the wilting process, vitamins and particularly β-carotene concentrations were more variable than FA concentrations; during some time intervals contents increased and there were interactions between harvest date and sampling times. However, after 29 h, concentrations of α-tocopherol and β-carotene had declined on average from 29 to 27, and 44 to 31 mg kg^{-1}, respectively (Table 1). No relationships were found between the rates of change in vitamin concentrations from t=1-6 and crop drying rates or weather parameters. Swath management had no effect. Interrelations in concentrations of vitamins and FA were complex, and were different in fresh and wilted herbage. Weather conditions and swath management practices had significant effects on the drying rate of cut herbage. The magnitude and rates

Table 1. Concentrations of α-tocopherol, β-carotene, and fatty acids (FA) and dry matter (DM) content in perennial ryegrass-red clover herbage, cut at 10:00 h and sampled 0, 3, 5, 8, 24 and 29 h after cutting (t=1-6), respectively.[1,2]

	t1	t2	t3	t4	t5	t6	SEM	Significance		
	0 h	3 h	5 h	8 h	24 h	29 h		Time (T)	T×S	T×H
DM (g kg^{-1})	14 ^{a}	17 ^{b}	21 ^{c}	24 ^{d}	24 ^{d}	32 ^{e}	0.61	<0.001	<0.001	<0.001
FA (mg kg^{-1})	2.13 ^{e}	2.06 ^{d}	2.03 ^{cd}	2.00 ^{c}	1.93 ^{b}	1.87 ^{a}	0.026	<0.001	NS	NS
α-tocopherol (mg kg^{-1})	29 ^{b}	29 ^{b}	31 ^{c}	29 ^{b}	28 ^{ab}	27 ^{a}	0.7	<0.001	NS	<0.001
β-carotene (mg kg^{-1})	44 ^{c}	45 ^{c}	44 ^{c}	41 ^{c}	35 ^{b}	31 ^{a}	0.2	<0.001	NS	<0.001

[1] Average values of three swath (S) treatments and eight harvest (H) dates between 18 May and 12 October 2009; n=24. SEM = standard error of the mean.

[2] Different letters within a row indicate a significant difference at P=0.05. NS = not significant.

of decline during the wilting process were not affected by swath management or herbage drying rates (P>0.05; not shown).

Discussion

This study provided insight into changes in concentrations of vitamins and FA and their interrelations in grass-clover herbage during wilting as affected by management, herbage drying rates and season. In general, broad swaths where cut herbage covered the ground area had a faster drying rate than narrow swaths, while tedding accelerated the drying rate. In broad swaths, the drying conditions were better as the layer was thinner and had a larger surface area. Swath management had no effect changes in concentrations of vitamins and FA. Although the decline in vitamin and FA concentrations was significantly affected by wilting time, the numerical values were small and less important than differences between harvest dates. Our hypothesis that concentrations of vitamins and FA would decline during wilting was confirmed but, contrary to our expectation, the magnitude and rates of decline during the wilting process were not affected by swath management or herbage drying rates. Choice of harvest date and wilting duration could be used as management tools to optimise contents of vitamins and FA in forage. In line with Witkowska *et al.* (2008), FA contents were highest in vegetative forage grown at low temperatures. Utilization of autumn-grown grass-clover as well as early spring growth, by either grazing or feeding freshly cut grass in zero grazing systems, could be a way to enhance vitamin and FA contents in animal diets. In conclusion, the outcome of this study suggests that shortening the post-harvest wilting period would result in reduced losses of vitamins and FA in perennial ryegrass-red clover herbage, regardless of swath treatment or crop drying rate.

References

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