Fatty acid composition of forage herb species

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Abstract

The use of alternative forage species in grasslands for intensive livestock production is receiving renewed attention. Data on fatty acid composition of herbs are scarce, so four herbs (*Plantago lanceolata*, *Achillea millefolium*, *Cichorium intybus*, *Pastinaca sativa*) and one grass species (timothy, *Phleum pratense*) were sown in a cutting trial. The chemical composition and concentration of fatty acids (FA) of individual species were determined during the growing season. Concentrations of crude protein and FA were generally higher in the herbs than in timothy. *C. intybus* had the highest nutritive value and FA concentrations. FA concentrations were generally lower in June after a heavy cut than in May and August.

Keywords: Forage herbs, fatty acid methyl esters, seasonal variation, C18:3, timothy

Introduction

In recent years, much effort has been made to elucidate the fatty acid (FA) profile of forage plants in relation to meat and milk quality with regard to potential health aspects. Most studies on the FA composition of individual species were carried out with common grasses (Dewhurst *et al.*, 2001; Elgersma *et al.*, 2003) and some legume species. Data on alternative forage species are scarce. Clapham *et al.* (2005) compared traditional and novel forage species grown under greenhouse conditions and observed significant differences in the FA profile of grass and herb species. The proportion of C18:3 was lower and more variable in herbs than in grasses. Increased concentrations of polyunsaturated FA in milk from higher altitudes could be related to a higher percentage of herbs (Collomb *et al.*, 2002). However, to our knowledge, no data are available on the FA profile of individual herb species grown in a sward. Therefore, a cutting trial was set up with four herb species and timothy. The chemical composition and concentrations of FA of these species were determined during three cuts during the growing season to quantify seasonal variation.

Material and methods

The trial was established on a clay soil in 2003 in Wageningen, The Netherlands (51°58'N and 5°39'E, 7 m a.s.l.). Plots of 1.5 by 8 m were sown in triplicate in a randomized block design with four entries: monocultures of ribwort (*Plantago lanceolata*), yarrow (*Achillea millefolium*), chicory (*Cichorium intybus*) and a mixture of parsnip (*Pastinaca sativa*) and timothy (*Phleum pratense*).
The trial had been established in 2003 and was cut 4 to 5 times annually during 2004-2006. Results for 2007 are presented here only. In 2007, a summer drought occurred and, as the plots were not irrigated, they were only cut three times (with a Haldrup forage harvester) i.e., 14 May, 18 June and 27 August (Table 1). The trial was N fertilised with ammonium nitrate: 30 kg ha^{-1} in March and 20 kg ha^{-1} after every cut; P and K were applied according to

requirements. Samples of about 125 g of the harvested material were taken directly after cutting in 2007 and hand-separated into sown species and weeds, to obtain pure species samples for analyses. Samples were immediately stored in a freezer (−20 °C), freeze-dried and stored. Samples were ground to pass a 1-mm sieve. FA analysis was performed at Aarhus University in Foulum, Denmark. Lipids were extracted according to the HCl-Bligh and Dyer extraction with a mixture of water, methanol and chloroform and esterified to form methyl esters (FAME) which were quantified by gas chromatography with C17 as internal standard (Jensen, 2008).

Table 1. Content in DM (g kg^{-1}) of ash, crude protein (CP), neutral detergent fibre (NDF), individual and total fatty acids (TFA) of grass and herb species over three cuts in 2007.

Harvest date	DM content (g kg^{-1})	Ash	CP	NDF	C16:0	C18:2	C18:3	TFA
Phleum pratense								
14/05/2007	182	52	102	396	2.68	3.46	10.49	18.28
18/06/2007	199	63	65	539	1.93	2.38	5.92	11.48
27/08/2007	215	71	103	361	2.48	3.58	10.57	18.10
Plantago lanceolata								
14/05/2007	145	102	115	174	3.20	3.57	12.86	20.84
18/06/2007	155	100	87	295	2.41	3.03	7.56	14.07
27/08/2007	206	115	108	237	3.29	4.13	11.71	20.77
Cichorium intybus								
14/05/2007	108	127	123	169	6.06	6.15	18.59	32.63
18/06/2007	121	141	101	171	5.23	5.55	15.63	28.03
27/08/2007	144	152	110	174	4.70	5.33	13.96	25.60
Achillea millefolium								
14/05/2007	156	108	139	174	3.98	6.25	13.96	25.92
18/06/2007	169	102	87	284	3.37	5.18	8.45	18.56
27/08/2007	220	151	115	209	3.43	5.27	9.65	19.97
Pastinaca sativa								
14/05/2007	134	101	86	171	4.16	8.89	8.00	24.95
18/06/2007	153	110	88	286	3.75	8.78	4.30	20.48
27/08/2007	191	147	119	163	4.20	9.13	7.19	20.02
Mean	167	109	103	257	3.64	5.13	10.88	21.52
SEM	5	6	3	28	0.221	0.279	0.712	1.30
Significances								
Species (S)	***	***	**	***	***	***	***	**
Harvest (H)	***	***	***	**	NS	NS	**	*
S x H	**	**	***	*	NS	NS	NS	NS

*** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$; NS, non significant; SEM, standard error of the mean.

Results and discussion

Herbage chemical composition, and total and individual FAME concentrations were characteristic to species (Table 1); particularly the three major FA, C18:3, C18:2 and C16:0, were highly affected by the plant material ($P < 0.001$). Timothy differed from the herbs in terms of having particularly low levels of total FA (TFA), C18:3, C18:2 and C16:0. Besides expected differences between the grass and the herbs, a further distinction could be made among the individual herb species studied. Chicory was highest in TFA and C18:3 concentrations, which is in accordance with the results of Clapham *et al.* (2005). Ribwort and yarrow were similar in terms of FAME levels. Parsnip had fibre and protein levels that were comparable to chicory, but a unique FA profile with very low concentrations of C18:3 (27% of TFA) and high concentrations of C18:2 (39% of TFA).

The cutting date affected the concentration of C18:3 ($P < 0.01$) and TFA ($P < 0.05$): all species had lower values in mid-June (after a heavy cut) than in mid-May or in late August. In other studies with grass species, cutting date was a central factor in determining FA concentration in fresh forage (Dewhurst *et al.*, 2001; Elgersma *et al.*, 2003), and particularly high FA concentrations were found in autumn at low temperatures (Witkowska *et al.*, 2008). In our study, no autumn cut was taken due to poor growth.

Conclusions

Herbs were superior to timothy in crude protein and FA concentrations; the latter differed considerably among herb species. Chicory contained the highest concentration of total FA and C18:3, and was also superior to other herb species in terms of nutritional composition. Parsnip had a distinctive FA profile, with a particularly low proportion of C18:3.

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