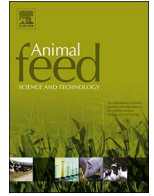




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Including chicory or plantain in a perennial ryegrass/white clover-based diet of dairy cattle in late lactation: Feed intake, milk production and rumen digestion

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ABSTRACT

In temperate grass-based dairy cattle grazing systems, summer dry conditions can reduce feed availability and quality, and limit milk production. This study reports the effects of including high nutritive value, drought tolerant forbs, chicory (*Cichorium intybus* L.) and plantain (*Plantago lanceolata* L.), in a grass-based diet of dairy cattle on intake, milk production and digestion. Forty-two mixed aged cattle in late lactation were randomly allocated to one of five dietary treatments in late summer: perennial ryegrass/white clover (PRG) or ryegrass/white clover (ryegrass) with either chicory (CHI) or plantain (PLA) comprising either 20 or 40% of the daily dry matter intake (DMI). Each treatment group included three cattle with a permanent rumen fistula. The experiment was conducted in an indoor feeding facility to allow individual intakes to be determined and comprised of two independent measurement weeks (Week I and Week II). Over the two measurement weeks, milk production and DMI were similar across diets and there were only minor differences in milk composition. Different effects of including chicory or plantain in the diet were observed, however, between measurement weeks. In Week I, DMI of cattle offered chicory or plantain (forbs) was 10% less than cattle offered PRG (14.7 vs. 16.4 kg dry matter (DM)/cow/d, $p = 0.039$) but milk yield (12.3 ± 0.53 kg/cow/d) and milk component (fat + protein) yield (1.01 ± 0.05 kg/cow/d) were similar across diets. In Week II, DMI was similar (14.2 kg DM/cow/d), but cattle offered forbs produced 19% more milk and 17% more milk component yield than those offered PRG. The decrease in DMI and milk production from Week I to II on the PRG treatment was accompanied by a decline in the estimated nutritive value of the ryegrass in the diets. *In sacco* incubations of fresh forages showed slower rates of DM degradation of ryegrass, relative to chicory or plantain (0.11 vs. 0.22 and 0.19%/h respectively; $p < 0.001$). Total rumen volatile fatty acid concentration and molar proportions measured in 6-hourly spot samplings was similar across diets. Rumen ammonia (NH₃) and urine nitrogen (N) concentrations, however, were reduced by up to 37 and 38% in cattle where forb was included in the diet, with greater reductions observed with increasing percentage of forb in the diet ($p < 0.01$). This

Abbreviations: A, soluble fraction in an *in vitro* digestibility study; ANCOVA, analysis of covariance; ANOVA, analysis of variance; B, degradable insoluble fraction in an *in vitro* digestibility study; CHI, chicory; DIM, days in milk; DOMD, digestibility of the organic matter in the DM; DM, dry matter; DMI, dry matter intake; k, fractional degradation rate in an *in vitro* digestibility study; P, potentially degradable fraction in an *in vitro* digestibility study; PRG, perennial ryegrass; PLA, plantain; REML, restricted maximum likelihood; ME, metabolisable energy; MS, milk solids; NSC, non-structural carbohydrates; OM, organic matter; OMD, organic matter digestibility; VFA, volatile fatty acids

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study suggests that chicory and plantain are suitable species to include in the diet of cattle grazing temperate grass-based swards to maintain or improve milk production in summer. Furthermore, the reductions in rumen NH₃ and urine N observed, indicate potential environmental benefits could be gained from feeding forbs.

1. Introduction

Dairy farming in temperate zones such as southern Australia and New Zealand is largely based on the rotational grazing of perennial ryegrass (*Lolium perenne* L.) swards sown with white clover (*Trifolium repens* L.). The prevalence of this sward type is due to the species' tolerance to grazing and because it typically generates large yields of good quality feed annually (Kemp et al., 2000). A limitation of dairy systems based on grazing ryegrass-based swards, however, is the decline in sward productivity and nutritive quality during summer and autumn due to climate and reproductive development of the plant (McKenzie et al., 2000; Roche et al., 2009). This can lead to reduced feed supply on-farm and reduced milk production (Clark et al., 1996). Consequently, farmers have looked to alternative sward species that have potential to yield greater amounts of good quality feed as compared with ryegrass based-swards in summer and autumn. Two forbs, chicory (*Cichorium intybus* L.) and plantain (*Plantago lanceolata* L.), have become increasingly utilised due to their superior herbage yield and nutritive value compared with ryegrass in summer (Fraser et al., 1988; Moorhead and Piggot, 2009; Minneé et al., 2013). Studies of the milk production response to inclusion of forbs in the diet have not been unanimous. Waugh et al. (1998) reported a greater milk fat + protein response from cattle grazing chicory and ryegrass in autumn than from cattle grazing ryegrass only (0.93 vs. 0.87 kg/kg DM eaten; $P < 0.001$); and cattle grazing a chicory/white clover sward produced more milk (18.8 vs. 9.8 l/cow/day) and consumed nearly twice as much DM than cattle grazing temperate grass-based swards in Australia in summer (Chapman et al., 2008). Recently, Pembleton et al. (2016) reported improved milk yield from cattle grazing a mixed sward of ryegrass/clover/plantain compared with cattle grazing ryegrass in early lactation; and Hutton et al. (2011) reported benefits of diets containing plantain and chicory for milk production in grazing ewes. The authors of these studies attributed the improved lactation performance to both improved diet quality of the chicory/grass diet and greater apparent DMI. Muir et al. (2014, 2015) however, reported no increase in DMI or milk production from cattle grazing monocultures of chicory and a mixed sward of chicory and ryegrass compared with cattle grazing ryegrass monocultures in spring or summer in South West Victoria, Australia. Therefore, there is a need to better understand the milk production response of cattle fed diets including forbs, how varying the percentage of forb in the diet influences this, and for intake to be more precisely measured through controlled feeding.

Milk production can also be limited by feed DMI. One of the mechanisms that controls feed intake is rumen fill (Allen, 2014). Unirrigated swards of ryegrass in summer often contain more poor-quality dead and stem material, and greater DM and fibre than at other times of the year (Holmes et al., 2007). This material is bulky and slowly digested (Chaves et al., 2006), so is retained in the rumen for a long time, maintaining rumen fill and can then reduce feed DMI (John and Ulyatt, 1987) to a point where metabolisable energy (ME) intake limits milk production (Waghorn et al., 2007). Chicory and plantain are lower in DM (Minneé et al., 2013) and are more rapidly digested than ryegrass (Burke et al., 2000). Thus, including these forbs in the diet could facilitate more rapid rumen clearance allowing for greater DMI, and result in greater milk production compared to cattle offered a solely ryegrass-based diet.

The hypothesis tested in this study was that dairy cattle offered chicory or plantain with ryegrass would have greater DMI and milk production than cattle offered ryegrass alone. A secondary objective was to investigate the ruminal digestion of forbs.

2. Materials and methods

An indoor feeding experiment with 42 animals was conducted to enable individual cow feed intake to be determined. The experimental design comprised five dietary treatments: a control group of six cattle fed ryegrass/white clover only (PRG) and four groups of nine cattle for which either chicory (CHI) or plantain (PLA) were included to replace some of the ryegrass/white clover. Where forbs were included in the diet, it was at either 20 or 40% of the total daily DM offered, creating a 2 × 2 factorial arrangement of forb species (chicory or plantain) and level of inclusion.

The 22-d experiment was conducted at DairyNZ's Lye Farm property, near Hamilton, New Zealand (37°76'S, 175°36'E) from 15 February to 8 March 2011. Cattle were housed indoors in a well-ventilated indoor feeding facility configured to allow individual intakes to be determined (American Calan, USA). The first four days served as a period for adaptation to the facility (although cattle had been trained to feed in the facility previously), during which all cattle were offered a common diet of ryegrass/white clover herbage. Dietary treatments were imposed from d 5, then measurements conducted over two 6-d experimental measurement weeks (Week I: d 9–14 and Week II: d 17–22). On d 15–16, cattle were grazed outdoors on ryegrass/clover swards in their treatment groups and offered cut chicory or plantain according to their allocated treatment. This served as a rest period to prevent lameness that can affect cattle accustomed to pastoral grazing that are brought indoors.

Animal ethics approval for this experiment was granted by the Ruakura Animal Ethics Committee, application No.: 12251 (Hamilton, New Zealand).

2.1. Forages

Swards of chicory (cv. Choice) and plantain (cv. Tonic) were established in October 2010 at DairyNZ's Scott Farm approximately

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