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## Incorporating turnips into the pasture diet of lactating dairy cows

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### ABSTRACT

Turnips have become a popular forage crop in New Zealand and Australia for supplementing dairy cows grazing pasture during the summer and autumn. However, it is unclear what combination of turnips and summer pasture best meets the dietary requirements of lactating dairy cows. New information was therefore gathered on the digestibility of turnips fed in conjunction with summer pasture and this was used in the ration balancing model, SPARTAN, to determine the optimum combination of turnips and summer pasture for a 'large' dairy cow (500 kg, 17 l/d) during mid-to late-lactation.

Twelve wethers (n = 3/group) were used to determine the *in vivo* digestibility of four diets with a summer pasture (P):turnip (T) dry matter (DM) ratio of: 100P:0T, 75P:25T, 50P:50T and 0P:100T. The DM digestibilities of the diets, fed at 1.0 kg DM/d, were 65, 71, 81 and 89 %, respectively. As the portion of turnips in the diet increased so too did the dry matter intake (0.64, 0.78, 0.77 and 0.93 kg DM/d, respectively). Relative to pasture, turnip was low in fibre and crude protein but high in available carbohydrate. The optimum portion of turnips, on a DM basis, when fed in conjunction with summer pasture was 21% of the dietary intake. For the average New Zealand dairy cow, this equates to 3-5 kg turnip DM/d. A 100% turnip diet would not meet cow requirements because of the low fibre and protein content of turnips, but a 100% pasture diet could, providing it was reasonable of quality (ca. 65% DMD and at least 17% crude protein) and available in sufficient quantity not to restrict cow intake.

**Keywords:** turnips; summer pasture; dairy cows; ration balance.

### INTRODUCTION

Many seasonal supply dairy farms in New Zealand experience a feed deficit during the summer and autumn (Gray and Lockhart, 1996). In order to extend lactation into the autumn months and meet the feed herd's requirements, supplementary feeds and forage crops are sometimes used to make up for the shortfall in pasture supply. In recent years turnips have become popular as a high yielding and high quality crop for this purpose (Clark, 1995). Turnip yields of 10-12 t DM/ha should be achievable in all dairying regions of New Zealand (Clark, 1995), but actual yields and milk production by cows supplemented with turnips have, in many cases, been poor (Clark *et al.*, 1996; Exton *et al.*, 1996; Thomson, 1997).

Penno *et al.* (1996) described the nutritional composition of the bulb and leaf portions of the turnip plant and provided recommendations on feeding turnips to dairy cows. However, there is very limited other information on the nutritional composition of turnips, especially for the recently introduced and improved varieties grown under New Zealand conditions. This paper reports on the nutritional properties of Barkant turnip and the use of this information to balance the diet of lactating cows on various combinations of summer pasture and turnip.

### MATERIALS AND METHODS

#### *In vivo* digestibility trial and feed analysis

Four diets, each offered at maintenance (ca. 1.0 kg DM/d) were fed to groups (n=3) of two year old Romney

x Dorset wethers. The wethers, whose mean ( $\pm$ sd) live weight was 44 $\pm$ 2 kg, were randomly allocated to metabolism crates and fed at 0830 and 1700 h diets of: 100% summer pasture, T1 (control); 25% turnips and 75% summer pasture (T2); 50% turnips and 50% summer pasture (T3); or 100% turnip (T4). The pasture was harvested each afternoon from a dairy pasture of 2700 kg DM/ha using a Strautman wagon. The composition of the sward was 83% grasses, 15% clover and 2% weeds. December-sown Barkant turnips were collected prior to each morning feeding. The *in vivo* digestibility of the diets were determined over a 5 day collection period following a 7 day adaption period.

The oven dried turnip and summer pasture samples were ground to 2 mm and submitted for a full NIRs (NIRS 6500, Perstop and Merryland, USA) feed analysis (Ulyatt *et al.*, 1995). Readings for the turnip material were checked against wet chemistry determinations (Corson, D. pers. comm.).

#### Ration balance

Data from the NIRs analysis and *in vivo* digestibility trial were used to specify the composition of pasture and turnip in SPARTAN, a computerised feed ration balancing model (Department of Animal Science, Michigan State University). SPARTAN has a user-friendly format, is being used by consultants in New Zealand and allows local data to be used. Diets, which can incorporate one or more feeds, were formulated for a 500 kg cow in her second lactation producing 17 l milk/d at day 180 of lactation, and

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at condition score 4.3. Her milk composition was 4.0% fat and 3.5% protein. The DMI of 16 kg DM/d was provided in the same diet ratios as for the digestibility trial (i.e. 100P, 75P:25T, 50P:50T and 100T). In addition, the optimum DM combination for the two feeds was derived and the effect of changes in summer pasture quality on diet balance was evaluated. An effective NDF of 75 and 65% for pasture and turnip, respectively, was assumed. The calculated M/D values for turnip and pasture were reduced to 13.2 and 9.4 MJME/kg DM, respectively, for the ration balance exercise to reflect the probable increase in particle size and slower passage rate in the dairy cow compared to sheep (MacDonald *et al.*, 1996).

## RESULTS

### *In vivo* digestibility

The calculated *in vivo* dry matter digestibility (DMD) for the four diets are presented in Table 1. The DMD of pasture (65%) was substantially less than that of a 100% turnip diet (89%). The daily DMI of sheep increased with the proportion of turnip (x) in the diet ( $y_{\text{DMI}} = 0.66 + 0.003x$ ,  $r^2 = 0.4$ ), as did the diet DMD ( $y_{\text{DMD}} = 65.1 + 0.25x$ ;  $r^2 = 0.9$ ). The derived DOMD values were 58.9% for summer pasture and 86.3% for turnip. The corresponding energy densities were 9.4 and 13.8 MJME/kg DM, respectively.

The NIRs values for summer pasture and turnip used in the digestibility study are shown in Table 2. Turnip had a lower crude protein, fibre and available carbohydrate level than pasture, but a higher ash content. The *in vitro* estimate of pasture DMD (derived from the ADF analysis) was higher than the *in vivo* value (Table 2).

### Ration balance

Diet components for the mid-lactation cow for different combinations of pasture: turnip are presented in Table 3. The cow's energy needs could be met by all the pasture turnip combinations, however, a pure turnip diet would not fulfil the cow's needs for crude protein or fibre. Neither Ca nor P requirements would be met from the pasture or pasture:turnip combinations, indicating that some form of mineral supplementation may be required if the diets were fed over a long period of time. The optimum pasture:turnip DM mix to meet the milk production target

**TABLE 2:** Nutritional composition of summer pasture and turnip as measured by NIRs.

Nutritional Component	Summer pasture	Turnip
Dry Matter %	18.4	12.2
Organic Matter (% of DM)	86.3	83.3
Crude protein (% of DM)	24.3	10.3
<i>In vitro</i> digestibility <sup>1</sup> (DMD%)	72.9	N/D <sup>2</sup>
Fibre - ADF (% of DM)	27.2	23.9
- NDF (% of DM)	41.0	23.0
Available Carbohydrate (SSS) <sup>3</sup> (% of DM)	5.0	23.7
Ash (% of DM)	13.3	17.4

<sup>1</sup> Calculated from ADF analysis.

<sup>2</sup> Not determined.

<sup>3</sup> Dissoluble sugars and starch.

was 79:21.

The nutrient composition of diets containing 25% turnip and different pasture types, relative to cow requirements, are outlined in Table 4. With the exception of Ca and P, for some diets, the different pasture types plus turnips would meet cow requirements.

## DISCUSSION

Turnips are highly digestible and stimulated intake. The high DMD of a 100% turnip diet (89%) was similar to the findings of Taylor *et al.* (1978) who found the *in vivo* DMD of turnips to be 86%. Penno *et al.* (1996) reported an *in vitro* OMD of 82% for turnip (ca. 11.8 MJME/kg DM; Geenty & Rattray, 1987). The DMD of the summer pasture (65%) in the present experiment was lower than the findings of Taylor *et al.* (72%) and Penno *et al.* (79% OMD), but was similar to the 66.5% reported by Ulyatt and Waghorn (1993). Differences in the DMD of summer pasture are most likely to relate to variations in sward clover and green leaf content.

Lambert *et al.* (1987) believed that the intake of brassicas is stimulated by their higher digestibility. Feeds with a high NDF content take longer to digest (Russel, 1967; MacDonald *et al.*, 1996) and because turnips, and brassicas in general, have a very low NDF content (Table 2) they are possibly digested more rapidly than summer pasture.

**TABLE 1:** Dry matter intake and dry matter digestibility (mean  $\pm$  sd) of four pasture (P):turnip (T) combinations. Calculated DOMD and M/D are also shown.

Diet	P:T <sup>1</sup>	Feed <sup>2</sup> (g/d)	DMI <sup>3</sup> (g/d)	DMD <sup>4</sup> (g/kg)	DOMD <sup>5</sup> (g/kg)	M/D <sup>6</sup> (MJME/kg)	OM <sup>7</sup> (g/kg)
T1	100:0	900 $\pm$ 0.02	640 $\pm$ 0.14	650 $\pm$ 0.03	589	9.4	863
T2	75:25	965 $\pm$ 0	780 $\pm$ 0.07	710 $\pm$ 0.02	648	10.4	855
T3	50:50	920 $\pm$ 0	770 $\pm$ 0.09	810 $\pm$ 0.02	746	11.9	848
T4	0:100	970 $\pm$ 0.09	930 $\pm$ 0.14	890 $\pm$ 0.02	863	13.8	833

<sup>1</sup> P:T ratio of pasture to turnips in the diet.

<sup>2</sup> Feed, feed offered.

<sup>3</sup> DMI, dry matter intake.

<sup>4</sup> DMD, dry matter digestibility.

<sup>5</sup> DOMD = (0.98 DMD - 4.8) (Geenty and Rattray, 1987).

<sup>6</sup> M/D = 0.16 DOMD (Geenty and Rattray, 1987).

<sup>7</sup> OM, organic matter in the feed.

**TABLE 3:** Predicted nutrient supply from pasture (P):turnip (T) diet dry matter (DM) combinations relative to the requirements of a 500 kg cow producing 17 l/day at day 180 of lactation.

Diet	As fed (kgs)	DMI (kg)	NEL <sup>1</sup> (Mcal/d)	CP <sup>2</sup> (kg/d)	NDF <sup>3</sup> (kg/d)	ADF <sup>4</sup> (kg/d)	Ca (%DM)	P (%DM)
100P	64	16	22.08	2.4	8.8	5.0	0.23	0.27
75P:25T	88	16	24.04	2.2	7.5	4.7	0.32	0.27
50P:50T	112	16	26.00	2.0	6.2	4.4	0.41	0.27
100T	160	16	29.92	1.6	3.7	3.8	0.59	0.26
REQ		15.17	21.31	2.0	4.6	2.4	0.54	0.35

<sup>1</sup> NEL = net energy required for lactation (Mcal x 6.5 = MJME).

<sup>2</sup> CP = crude protein.

<sup>3</sup> NDF = acid detergent fibre.

<sup>4</sup> ADF = neutral detergent fibre.

**TABLE 4:** Nutrient adequacy of mixed diets containing turnip (25 % DMI) and either mature pasture, leafy pasture or immature pasture (75 % DMI) for a 500 kg cow producing 17 l/day at day 180 of lactation. (See Table 3 for explanation of abbreviations).

Diet	As fed (kgs)	DMI (kg)	NEL (Mcal/d)	CP (kg/d)	NDF (kg/d)	ADF (kg/d)	Ca (%DM)	P (%DM)
Immature pasture	100	16	29.68	3.8	5.9	3.8	0.55	0.39
Mature pasture	88	16	24.04	2.2	7.5	4.7	0.32	0.27
Leafy pasture	90	16	27.76	3.1	6.7	4.2	0.43	0.35
REQ	15.17	21.31	2.0	4.6	2.4	0.54	0.35	10

The DM content of the November-sown turnips at 14% was greater than the 8-9% reported by Penno *et al.* (1996). This probably related to their greater maturity at harvest (late March versus February for Penno *et al.*, 1996). Turnip maturity is also likely to explain the difference in NDF value (23 vs. 30%) between the current study and Penno *et al.* (1996). Both the calculated M/D value and the NIRs available carbohydrate reading confirm turnips as a good energy source and an effective complement to summer pasture (Moller & Wilson 1993).

The effective NDF assumed for the SPARTAN analysis for this study was 70% for summer pasture and 65% for turnips. The effective NDF of turnips has not been reported, while that of pasture has been estimated to be as low as 40-50% (Kolver *et al.*, 1994). The values assumed for effective NDF are very important when attempting to balance a diet. SPARTAN balances first on fibre content and then on energy content. This study indicates the effective NDF content of summer pasture and turnips must be greater than 65% if the diets specified in Table 3 are to balance, and this may be a contributing factor to the poorer than expected performance of milking cows on mixed turnip:pasture diets (Thomson, 1997). Further research is required to determine the effective fibre content of the two feeds.

In practical terms, the ration balance suggests a farmer should provide about one fifth of the daily DMI for high producing mid-lactation cows from turnips, providing pasture quality (McFerran, 1997) and availability is good. Depending on the relative availability of pasture and turnips, the proportion of turnip could be increased to improve cow production or condition, or spare pasture for

use later in the season. However, increasing the proportion of turnip in the diet to more than 50% would increase the risk of tainted milk (Keen, 1993), and may result in cows not receiving their daily requirement of crude protein or NDF. Feed costs would also rise compared to an all pasture diet (ca. 7 c/kgDM for turnip vs. 3-5 c/kgDM for pasture (McFerran, 1997)). Penno *et al.* (1996) similarly suggested that a moderate allowance of 4-5 kgDM/d to cows grazing restricted amounts of pasture will result in a good milk production response and little pasture substitution. They warned that offering higher allowances of turnips may not increase cow performance.

## CONCLUSION

It is concluded from the *in vivo* digestibility study and the use of the SPARTAN nutrition model that the feeding of turnips, in conjunction with summer pasture, would better meet the nutritional requirements of dairy cows during mid-to late-lactation than a pasture-only diet, if pasture quality and availability is low. Turnips are a good energy source, but are lower in protein and fibre than summer pasture. The addition of turnip to a diet may stimulate DMI and farmers seeking to spare pasture through the use of turnips may not transfer as much pasture as expected. This study suggests summer pasture can support the nutritional requirements of dairy cows but this is contingent upon effective pasture control being achieved earlier in the season and sufficient rainfall being received to maintain pasture growth and quality into February. The results also highlight the importance of feed quality in determining whether the dietary requirements of dairy

cows can be met and, in this respect, feed quality measurement and the principles of ration balancing have a role in feed management on New Zealand dairy farms.

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