BRIEF COMMUNICATION: Milk production responses and rumen fermentation of dairy cows supplemented with summer brassica crops

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Abstract

This study evaluated the dry matter intake (DMI), rumen fermentation and milk production responses of lactating dairy cows supplemented summer brassicas. Twelve multiparous lactating dairy cows were randomly allocated to three dietary treatments in a replicated 3 x 3 Latin square design. The control diet was composed of 16.2 kg DM of grass silage and 4.5 kg DM of concentrate; 25% of the diet was replaced by rape or turnip. Cows supplemented with summer brassicas showed a lower DMI (P<0.001) compared to the control diet, however milk yield was not affected, resulting in a greater feed conversion efficiency (1.35 for turnip and rape v/s 1.27 for the control diet). Rape supplementation significantly increased microbial protein (P=0.002). VFA concentration and the relative proportion of propionate were increased with turnips, whereas rape increased the acetate:propionate ratio. Mid-lactating dairy cows fed with brassicas are able to maintain production despite the reduced intake, probably due to improved rumen fermentation and therefore nutrient utilisation.

Keywords: turnips; rape

Introduction

Brassica crops are used to supply feed in times of seasonal shortage, or when pasture quality is low. It has been observed that brassica forages can improve animal performance (Moate et al. 1998) and reduce the environmental impact due to a lower methane production (Sun et al. 2016) compared to ruminants grazing pasture diets. However, in some cases productive responses are lower than expected. This might be due to the presence of secondary compounds (Barry 2013), physical limitations of DM intake and altered fermentation in the rumen (Lambert et al. 1987). Whereas studies have examined the effects of brassica forages on sheep metabolism and performance, there is less information about brassica forages on rumen metabolism of the dairy cow (Barry 2013; Keogh et al. 2009). Therefore, the aim of this study was to determine dry matter intake, rumen fermentation and milk production responses of lactating dairy cows supplemented with turnips or rape.

Materials and methods

The experiment was carried out between January and March 2017. All experimental procedures were approved by the Universidad Austral Institutional Animal Care and Use Committee. Cows were housed in tiestalls with rubber bedding and *ad-libitum* water access.

Twelve multiparous lactating dairy cows (22.7±0.67 kg milk day^{-1}, 534±7.5 kg liveweight and 155±6.6 days in milk) were randomly allocated to the three dietary treatments in a replicated 3 x 3 Latin square with three 21-day periods (14 days of adaptation to the diet and 7 days of evaluation).

The control diet was composed of 16.2 kg DM of grass silage (DM: 360 g kg^{-1}; CP: 177 g kg^{-1}; NDF: 418 g kg^{-1}; ADF: 272 g kg^{-1}; lipids: 45 g kg^{-1}; ashes: 95 g kg^{-1}; ME: 11.8 MJ kg^{-1} DM) and 4.5 kg DM of concentrate (DM: 882 g kg^{-1}; CP: 318 g kg^{-1}; NDF: 226 g kg^{-1}; ADF: 94 g kg^{-1}; lipids: 26 g kg^{-1}; ashes: 59 g kg^{-1}; ME: 13.2 MJ kg^{-1} DM). The other two dietary treatments replaced 25% of the diet with rape (leaf:stem ratio: 65:35; DM: 117 g kg^{-1}; CP: 174 g kg^{-1}; NDF: 217 g kg^{-1}; ADF: 155 g kg^{-1}; lipids: 18 g kg^{-1}; ashes: 133 g kg^{-1}; ME: 12.5 MJ kg^{-1} DM) or turnips (leaf:root ratio: 40:60; DM: 95 g kg^{-1}; CP: 145 g kg^{-1}; NDF: 191 g kg^{-1}; ADF: 139 g kg^{-1}; lipids: 10 g kg^{-1}; ashes: 99 g kg^{-1}; ME: 13.2 MJ kg^{-1} DM). The weights of all feeds offered to, and refused by, individual cows were recorded for three days during the last week of each period to determine DMI.

Cows were milked at 05:00 and 15:00 h and milk yield was recorded daily with a flow sensor during the experimental periods. Cows were weighed twice per day after each milking. Representative milk samples were collected three times in the last week of the experimental period for fat, protein, lactose and milk urea analyses by infrared spectrophotometer (Foss 4300 Milko-scan, Foss Electric, Denmark). Spot urine samples were collected by vulva stimulation every three hours once a day during the experimental period, to estimate rumen microbial protein based on purine derivatives (Chen & Ørskov 2003) by HPLC. Rumen fluid was harvested by stomach tube before and six hours after brassica feeding. A 10-mL sample was filtered, drawn off, mixed with 2 mL of 50% (wt/vol) TCA, and stored at −20°C pending determination of VFA (Sun et al. 2011) and NH_3-N (Weatherburn 1967) concentrations. For the whole experiment pH was measured by wireless telemetric bolus.

Data were analysed using the mixed-model procedure of SAS (SAS Institute 2006) to account for effects of square, period within square, cow within square, and treatment. The dietary treatment was considered a fixed effect; square, period within square, and cow within square were considered random effects. Data for DMI, milk yield, milk composition and microbial protein were summarized by day. Data for VFA, ammonia and pH were analysed with the same model but including sampling time or hour as a repeated measure. Statistically significant differences ($P \leq 0.05$) between least-square means were tested using the PDIFF command, incorporating the Tukey test for pairwise comparison of treatment means.

Results and discussion

Cows supplemented with either turnips or rape showed a lower DMI ($P<0.001$) compared to those on the control diet (Table 1), basically because they ate 3.1 and 3.3 kg DM (for rape and turnips, respectively) from the 5 kg DM of brassica that were offered. Similarly, Moate et al. (1998) reported a reduction in DMI when lactating dairy cows where supplemented with turnips. This may be attributed to the high water content of brassicas which results in physical limitations that affect DMI (Stefanski et al. 2010). Despite the lower DMI, milk production and composition were not affected by brassica supplementation ($P>0.05$). This resulted in a greater feed conversion efficiency for cows supplemented with turnips or rape compared to the control diet.

Nitrogen intake, milk N, urea in blood and milk were not affected by brassica supplementation ($P>0.05$). Nevertheless, rape supplementation significantly increased microbial protein ($P=0.002$; Table 1).

Significant interactions among diet and time of sampling were observed for total VFA (tVFA), the relative proportion of VFAs and N-NH_3 concentrations ($P<0.05$). Total VFA concentration and butyrate proportion of tVFA were similar among diets prior to brassica supplementation, however after six hours cows supplemented with turnips showed greater values. Acetate relative proportion of tVFA was similar among diets before brassica supplementation, whereas after six hours it was greater for cows supplemented with rape. Meanwhile propionate proportion of tVFA was lower for cows fed turnips prior to brassica feeding, but lowest for cows fed rape after supplementation. The relative proportion of minor VFA (sum of caproate, valerate, iso-valerate and iso-butyrate) and NH_3-N concentration were similar among diets prior to supplementation, but after supplementation a significant reduction was observed with either rape or turnip supplementation. Finally, acetate:propionate ratio was only increased with rape supplementation. Mean daily pH was lower (6.23) for cows supplemented with turnips compared to the control and rape diets (6.32 and 6.30, respectively) and pH remained below 6.2 for 143 and 110 more minutes compared to control and rape diets.

Sun et al. (2016) indicated that feeding brassica might improve rumen fermentation and therefore, nutrient utilisation and efficiency. This is in agreement with the greater tVFA concentrations observed and microbial protein for turnip and rape supplementation, respectively, resulting in higher feed conversion efficiency.

Table 1 Dry matter intake, milk yield, milk fat and protein concentration and, nitrogen utilisation of cows supplemented with turnip or rape

	Control	Turnip	Rape	SEM	P
DMI (kg DM day^{-1})	19.00^{a}	17.88^{b}	18.02^{b}	0.46	0.0001
Brassica intake (kg MS day^{-1})	-	3.27	3.09	0.19	0.090
Milk yield (kg day^{-1})	24.2	24.1	24.3	0.78	0.936
Fat (g kg^{-1})	42.8	42.8	44.1	1.40	0.538
Crude protein (g kg^{-1})	33.1	34.2	33.6	0.80	0.320
MY:DMI	1.27^{b}	1.35^{a}	1.35^{a}	0.04	0.015
N intake (g day^{-1})	228.3	242.5	240.0	8.88	0.499
N in milk (g day^{-1})	51.0	52.7	52.0	1.49	0.308
Blood urea (mmol l^{-1})	5.22	5.78	5.49	0.29	0.245
Milk urea (mg l^{-1})	307	273	291	15.6	0.228
Microbial protein (g day^{-1})	1181^{b}	1448^{ab}	1739^{a}	93.6	0.002

DMI, Dry matter intake; MY:DMI, feed conversion efficiency (kg milk/dry matter intake)

Table 2 Interaction between diet and sampling time on VFA and NH_3-N concentrations of cows supplemented with turnip or rape

	Before feeding			After feeding				
	Control	Turnip	Rape	Control	Turnip	Rape	SEM	p-value
tVFA	100.0^{ab}	101.2^{a}	98.7^{ab}	83.3^{c}	97.1^{ab}	85.3^{bc}	3.19	0.014
C2	648^{b}	652^{b}	644^{b}	663^{b}	661^{b}	686^{a}	4.80	0.004
C3	189^{a}	176^{b}	181^{ab}	177^{ab}	180^{ab}	160^{c}	3.30	0.001
C4	116^{b}	127^{ab}	127^{ab}	119^{b}	135^{a}	127^{ab}	3.20	0.045
mVFA	46^{a}	45^{ab}	48^{a}	40^{b}	25^{c}	27^{c}	1.30	<.0001
C2:C3	3.44^{b}	3.71^{b}	3.57^{b}	3.77^{b}	3.71^{b}	4.30^{a}	0.09	0.0002
NH_3-N	10.08^{ab}	8.31^{b}	11.03^{a}	7.44^{b}	2.73^{c}	3.75^{c}	0.55	0.0005

tVFA, total volatile fatty acids (mM); C2, acetate (mmol mol^{-1}); C3, propionate (mmol mol^{-1}); C4, butyrate (mmol mol^{-1}); mVFA, minor volatile fatty acids (isobutyrate + isovalerate + valerate + caproate) (mmol mol^{-1}); C2:C3, acetate:propionate ratio; NH3-N, ammonia nitrogen (mmol mol^{-1})

These results indicate that cows fed with brassica are able to maintain production despite the reduced intake, probably due to improved rumen fermentation and therefore nutrient utilisation.

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