BRIEF COMMUNICATION: Milk production, feeding behaviour and rumen fermentation of dairy cows supplemented with winter brassica crops

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Abstract

This study evaluated feeding behaviour, dry matter intake (DMI), rumen fermentation and milk production responses of lactating dairy cows supplemented with kale or swedes. Twelve multiparous early lactation dairy cows were randomly allocated to three dietary treatments in a replicated 3 x 3 Latin square. The control diet comprised 10 kg dry matter (DM) of grass silage, 4 kg DM of grass pasture and 8.8 kg DM of concentrate; 25% of the diet was replaced with kale or swedes. Cows supplemented with kale showed a lower DMI compared to cows supplemented with swedes and the control diet; whereas swedes supplementation increased eating time. Milk production responses were not affected by winter brassica supplementation. This resulted in a greater feed conversion efficiency of cows supplemented with kale compared to that of the control diet.

Keywords: swedes; kale

Introduction

In humid temperate regions, pasture availability declines during winter. This represents a challenge for dairy farmers that produce milk all year around, as they need an even supply of feed. Winter brassica crops (e.g. swedes and kale) may be a sound alternative due to their high DM yield and digestibility (Westwood & Mulcock 2013). However, a greater digestibility does not necessarily ensure higher animal performance. This might be due to the presence of secondary compounds such as S-methyl-cysteine sulphoxide and glucosinolates (Barry 2013), or physical limitations of dry matter intake and altered fermentation in the rumen (Lambert et al. 1987). Furthermore, the low neutral detergent fibre (< 300 g kg^{-1}) and high DM digestibility (> 800 g kg^{-1} DM) of brassica forages may result in reduced rumen pH and altered volatile fatty acids (VFA) production (Keogh et al. 2009a). Swedes are rich in soluble sugars, with greater concentrations of glucose and fructose compared with kale, which have shown to increase *in vitro* butyrate and propionate concentrations compared to kale (Benavides 2016). However, *in vitro* experiments do not account for animal and environmental effects, differ from real rumen conditions and do not allow to measure DMI, production responses and nutrient utilisation. Thus, *in vivo* studies are required to confirm the potential of these crops as a forage source.

Therefore, the aim of this study was to determine dry matter intake, ingestive behaviour, rumen fermentation and milk production responses of lactating dairy cows supplemented with kale or swedes.

Materials and methods

The feeding trial was carried at the Austral Agriculture Research Station, Valdivia, Chile (39°47’16,30” S, 73°13’59,48” W), from May to July 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 (530 kg liveweight, 30±4 kg milk day^{-1} and 60±11 days in milk) were randomly allocated to three dietary treatments in a replicated 3 x 3 Latin square design balanced for residual effects with three consecutive 21-day periods (14 days of adaptation to the diet and seven days of experimental measurements).

The control diet was composed of (DM basis) 10.0 kg of grass silage, 4.0 kg of fresh and chopped ryegrass and 8.8 kg of concentrate. The other treatments replaced 25% of the diet (all ingredients were removed at the same proportion) with swedes or kale. All feeds were weighed and offered individually for each cow. Swedes were harvested manually and offered as whole plant, whereas kale was harvested and offered chopped. The weights of all feeds offered to and refused by individual cows were recorded for three days during the experimental week to determine dry matter intake (DMI) and, metabolisable energy (ME) and N concentration of feeds and refusals were determined to calculate ME and N intake.

Cows were milked at 05:00 and 15:00 h and milk production was recorded with a flow sensor (MM27BC DeLaval). Representative milk samples were collected in the morning and afternoon milkings on three days of the experimental weeks for fat, protein and milk urea analyses by infrared spectrophotometer. Spot urine samples were collected on one day of the experimental periods through vulva stimulation every 3 hours and a composite sample was obtained for each cow to estimate microbial protein synthesis based on purine derivatives (Chen & Ørskov 2003) by HPLC. Rumen fluid was harvested by stomach tube once before and 6 h after brassica feeding for determination of VFA (Sun et al. 2011) and ammonia (NH_3-N) (Weatherburn

1967) concentrations. Feeding behaviour was visually and continuously recorded by trained operators two days during the experimental week. Cows were kept all the time in their individual tie-stalls (except during milkings). Every 10 min, it was noted whether each cow was eating, ruminating or doing other activities. Cows in a head-down position in the trough, were considered as being eating. Time under an activity was calculated by summation of all 10-min intervals of each activity.

Data were analysed using the mixed-model procedure of SAS v 9.4 (SAS Institute 2006) to account for random effects of square, period within square, cow within square and, the fixed effect of dietary treatment. Data for DMI, milk production and composition and microbial protein synthesis were summarized by day. Data for VFA and NH_3-N were analysed with the same model but including sampling time as a repeated measure. Statistically significant differences ($P \leq 0.05$) among least-square means were tested using the PDIFF command, incorporating the Tukey test.

Results and discussion

Milk production and composition did not differ among dietary treatments (P>0.05), whereas ME and DM intake were higher for cows fed the control diet and swedes treatment (Table 1). This is in agreement with the results reported by Keogh et al. (2009b) who found no differences in milk production responses of cows supplemented with kale or swedes. Cows supplemented with kale ate less brassica compared to those supplemented with swedes. The lower DMI in cows supplemented with kale compared with the control and swedes treatment resulted in a greater feed conversion efficiency compared to that of the control diet.

Cows supplemented with swedes spent more time eating, whereas the control dietary treatment resulted in a higher ruminating time and, kale supplementation resulted in more time doing other activities. The longer eating time of cows supplemented with swedes might be due to bulkiness and physical structure of roots (Lambert et al. 1987).

Despite a higher N intake for the control treatment, N retained in milk, milk urea concentration and microbial protein synthesis did not differ among dietary treatments. This may result in greater faecal N excretion with the control diet, due to its higher rumen undegradable protein concentration.

Table 1 Dry matter intake, milk production and concentration and nitrogen utilisation of cows supplemented with kale or swedes

	Control	Swede	Kale	SEM	p-value
DMI (kg DM day^{-1})	20.9[a]	20.3[a]	19.5[b]	0.31	0.003
Brassica intake (kg DM day^{-1})	-	4.3	2.8	0.22	0.002
Metabolisable Energy (MJ day^{-1})	255[a]	250[a]	236[b]	4.01	<0.001
Milk yield (kg)	30.3	30.7	30.1	0.95	0.642
Milk fat (g kg^{-1})	41.9	41.5	40.4	1.20	0.411
Milk Protein (g kg^{-1})	32.0	32.1	31.9	0.50	0.505
Feed conversion efficiency	1.45[b]	1.52[ab]	1.55[a]	0.05	0.031
Eating (min day^{-1})	301[b]	439[a]	327[b]	15	<0.001
Ruminating (min day^{-1})	477[a]	368[b]	377[b]	23	<0.001
Other activities (min day^{-1})	482[b]	453[b]	556[a]	16	<0.001
N intake (g day^{-1})	627[a]	595[b]	601[b]	9.9	0.006
N in milk (g day^{-1})	154	157	153	4.3	0.403
Milk urea (mg dl^{-1})	259	267	275	16.4	0.607
Microbial protein (g day^{-1})	1304	1325	1287	102	0.938

Total VFA concentration tended to be greater for cows supplemented with kale (P = 0.076). The interactions between diets and time of sampling showed that after kale supplementation acetate increased and propionate declined (Table 2), while swedes supplementation increased the relative proportion of acetate and butyrate, which is in accordance with the higher sugar concentrations of swedes (Benavides 2016). Before brassica supplementation, NH_3-N concentrations in the rumen were higher for cows fed the control diet and and, six hours after supplementation NH_3-N

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

	Before brassica supplementation			6 h after brassica supplementation				
	Control	Swede	Kale	Control	Swede	Kale	SEM	p-value
tVFA (mM)	95.0	100.3	102.4	94.0	91.8	102.3	3.5	0.444
Acetate (mmol mol^{-1})	62.1[d]	63.0[cd]	64.3[bc]	67.7[a]	64.6[b]	68.0[a]	0.31	<0.001
Propionate	20.5[a]	19.8[c]	18.6[ab]	18.1[c]	19.1[bc]	16.8[d]	0.26	0.005
Butyrate	13.0[b]	12.9[b]	12.8[b]	11.4[c]	13.8[a]	12.5[b]	0.16	<0.001
mVFA	4.4	4.2	4.3	2.9	2.6	2.7	0.09	0.746
A:P	3.03[d]	3.19[cd]	3.45[c]	3.77[b]	3.40[c]	4.06[a]	0.06	<0.001
NH_3-N	12.3[a]	9.8[b]	10.3[b]	6.0[d]	7.6[c]	10.2[b]	0.51	<0.001

tVFA, total volatile fatty acids; mVFA, minor volatile fatty acids (isobutyrate + isovalerate + valerate + caproate); A:P, acetate to propionate ratio was reduced with the control and swedes treatments. This might be due to a greater energy supply in the rumen with the control and swedes treatments compared with cows supplemented with kale.

Milk production responses were not affected by winter brassica supplementation. However, mechanisms to maintain milk production were different. Swedes supplementation increased the time spent eating and maintained DMI with a greater relative proportion of butyrate, whereas kale supplementation reduced DMI but tended to increase VFA concentrations in the rumen.

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