Annual Ryegrass Pasture for Dairy Cows Receiving Total Mixed Ration

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Key words: intake; milk production; milk composition; *Lolium multiflorum*

Abstract
The inclusion of herbage in the diet of medium yielding dairy cows offered a total mixed ration (TMR) may be beneficial. This study, which involved mid lactation dairy cows, examined the effect of partial replacement of a TMR with annual temperate pasture. Treatments were *ad libitum* TMR (TMR_{100}), 75% *ad libitum* TMR + ryegrass (*Lolium multiflorum* 'Maximus') (TMR_{75}), and 50% *ad libitum* TMR + ryegrass (TMR_{50}). Twelve multiparous Holstein and F1 Jersey × Holstein cows were divided into six homogeneous groups, taking account of milk production (26.6 ± 4.5 kg/day), days in milk (128 ± 50) and body weight (546 ± 31 kg). Treatments were compared in a replicated 3×3 Latin square design, comprising three 21-day periods (measurements during final 5 days). Cows on TMR_{75} and TMR_{50} strip grazed between morning and afternoon milking (7 h/day), with a target pre- and post-grazing sward height of 24 and 12 cm, respectively. Herbage DM intake was estimated as the difference between pre- and post-grazing herbage mass. The TMR and herbage had a crude protein content of 150 and 303 g/kg DM, and a NDF content of 366 and 495 g/kg DM, respectively. Herbage DM intake increased from 4.8 kg/day in TMR_{75} to 6.7 kg/day on TMR_{50}. Total DM intake decreased from 19.4 kg/day (TMR_{100}), to 18.1 and 15.9 kg/day (TMR_{75} and TMR_{50}, respectively). Milk production, milk fat and milk protein content were similar between treatments, averaging 25.6 kg/day, 44.6 g/kg and 33.7 g/kg, respectively. The net energy for lactation (NE_L) supply was 113, 104 and 92% of NE_L requirements, for cows receiving TMR_{100}, TMR_{75} and TMR_{50}, respectively. Ryegrass pastures were able to replace up to 50% of TMR offered to mid lactation dairy cows without any adverse effects on milk production and milk composition.

Introduction
Full time grazing systems are normally unable to supply all of the energy requirements of lactating dairy cows (Kolver and Muller 1998), and often do not provide a constant supply of herbage throughout the year (Wilkinson et al. 2020). As a result, systems involving full time housing, in which cows are often offered a total mixed ration (TMR), are common. However, giving housed cows access to grazing for part of the day may improve animal welfare (Arnott et al. 2017) and reduce feeding costs (White et al. 2002). Thus the adoption of 'mixed systems' ('part housing-part grazing') may provide a tool to help maintain individual cow total DM intakes and milk production, and overall stocking density (Wales et al. 2013).

Previous studies involving dairy cows grazing annual ryegrass (*Lolium multiflorum* Lam.) swards in a subtropical region have observed that even when herbage allowance was high, herbage DM intake was lower than expected due to low pre-grazing herbage mass (Miguel et al. 2014, 2019). The low herbage mass of annual ryegrass has been explained by its low tiller density, especially during the first grazing cycles, in comparison to perennial species (Miguel et al. 2014). Thus, herbage DM intake appears to be predominantly limited by sward structure. Nevertheless, the effect of including this kind of pasture in dairy cow diets which are predominantly comprised of a TMR deserves further research.

Thus, the aim of this study was to assess the effect of including annual ryegrass pasture in the diets of TMR-fed dairy cows, on total DM intake and milk production. We hypothesized that when a TMR comprises at least 50% of *ad libitum* intake, annual ryegrass pasture would allow total DM intake and milk production to be maintained.

Methods and Study Site
The experiment was performed in Lages, SC, Brazil (50.18°W, 27.47°S; 920 m above sea level) from 19 June to 21 August 2019. During the experimental period the average temperature was 11.8°C and the total rainfall was 197 mm (3.1 mm/day). The 10-year climatic average temperature and rainfall during the months of the experiment were 13.9°C and 107 mm, respectively. Before the first grazing cycle, and after each experimental period, the experimental area was fertilized with 50 kg N/ha, supplied as urea.

Twelve multiparous Holstein and Holstein × Jersey cows were divided in six homogeneous groups, each of two cows (experimental unit), according to milk production (26.6 ± 4.55 kg/day), days-in-milk (129 ± 50.8 days) and body weight (546 ± 30.6 kg) measured during the week prior to the experiment starting. Each pair of cows were distributed within two 3 × 3 Latin squares, with each experimental period 21 days: a 16-day adaptation period and a 5-day measurement period.

The treatments comprised a TMR diet offered at 100% of *ad libitum* intake (TMR_{100}), TMR at 75% of *ad libitum* intake + access to an annual ryegrass pasture for grazing (TMR_{75}), and TMR at 50% of *ad libitum* intake + access to annual ryegrass pasture for grazing (TMR_{50}). Cows on TMR_{75} and TMR_{50} had access to pasture for 7 h/day, between morning and afternoon milking (from 08:00 h to 15:00 h), and were offered the TMR following afternoon milking. The TMR comprised corn silage (600 g/kg DM), ground corn (260 g/kg DM) and soybean meal (140 g/kg DM), and had a crude protein and neutral detergent fiber (NDF) content of 150 and 366 g/kg DM, respectively.

The pasture area (approx. 3 ha) was divided into two halves (one half for each Latin square), with one third of each half assigned to TMR_{75} and two thirds assigned to TMR_{50} (4 paddocks in total, 2 cows per paddock). Paddocks were strip grazed, with target pre- and post-grazing sward height of 24 and 12 cm, respectively (a target reduction in sward height of 50%). Fresh pasture was allocated daily, with the area allocated based on allocations during the one-week pre-experimental period. As actual pre- and post-grazing sward heights were similar to the target heights, no other adjustment was necessary. Pre- and post-grazing sward heights were measured daily using a rising plate meter (F200 model, Farmworks, Feilding, New Zealand). In addition, the plate-meter was calibrated to predict herbage mass at the start of each experimental period, pre- and post-grazing. Samples were cut at ground level using scissors from 18 × 0.1 m^2 quadrats (4 and 5 in each of the TMR_{75} and TMR_{50} paddocks, respectively) in the 'footprint' of areas where the plate meter had been used to record herbage height. Individual samples were dried in an oven for 72 h at 60°C, and equations subsequently developed to predict the actual herbage mass that had been offered during the study. The chemical composition of herbage offered was determined from samples collected on days 17 and 19 of each period, and herbage nutritive value estimated from chemical composition, as described by INRA (2007).

Cows were milked twice daily at 07:00 h and 16:00 h, and individual cow milk yields recorded. Milk samples were collected during the final 5 days of each period and each individual sample analysed for fat and protein concentrations. Daily herbage intakes for each pair of cows were estimated as the difference between the pre- and post-grazing herbage mass during the last 5 days of each period. Intakes of the mixed ration offered while cows were indoors was determined daily during the last 5 days of each period, as the difference between the quantity of ration offered and the orts.

The dependent variables were subjected to an analysis of variance using the function PROC MIXED in the software SAS (2002, version 9.4, SAS Institute, Cary, NC). The animal variables (averaged per group and period (n=18)) were analyzed considering the random effect of the animal, the fixed effect of the period and the fixed effect of the treatment. The pasture variables were averaged per paddock and period (n = 12) and analysed considering the random effect of period and the fixed effect of the treatment. Animal variables were tested using an orthogonal polynomial contrast and examined for linear and quadratic effects.

Results

Pre- and post-grazing herbage mass of annual ryegrass averaged 1804 and 906 kg DM/ha, respectively (Table 1). Pre- and post-grazing sward height were similar with both treatments and averaged 23.8 cm and 11.4 cm, respectively. Herbage offered with TMR_{75} and TMR_{50} was similar in composition, with an average crude protein, NDF and ADF content of 303, 495 and 199 g/kg DM.

Total DM intake decreased from TMR_{100} to TMR_{50} group (Table 2). There was a quadratic reduction in concentrate DM intakes, with intakes of corn silage following the same trend. Herbage DM intake increased by 1.9 kg/day from TMR_{75} to TMR_{50}, being 27 and 42% of total DM intake. For each kg of herbage DM consumed, intake of TMR with treatments TMR_{75} and TMR_{50} decreased by 1.3 and 1.6 kg DM/day, respectively. Thus, total DM intake decreased as the proportion of herbage increased. Diets TMR_{100}, TMR_{75} and TMR_{50} supplied 113%, 104% and 92% of energy requirements. However, milk production, milk fat and milk protein content did not differ between treatments, averaging 25.6 kg/day, 44.6 g/kg and 33.7 g/kg, respectively.

Table 1. Pre- and post-grazing characteristics, chemical composition and nutritive value of annual ryegrass (Lolium multiflorum 'Maximus') pastures grazed by cows on TMR_{75} and TMR_{50}

	Treatment[1]			
	TMR_{75}	TMR_{50}	SEM	*P-value*
Pre-grazing characteristics				
Herbage mass, kg DM/ha	1895	1713	11.2	0.087
Sward height, cm	25.8	23.1	1.13	0.983
Post-grazing characteristics				
Herbage mass, kg DM/ha	915	902	7.6	0.712
Sward height, cm	11.5	11.3	0.74	0.743
Chemical composition g/kg DM				
Dry matter	112	111	0.9	0.358
Organic matter	876	867	7.2	1.733
Crude protein	300	306	1.56	0.429
NDF	494	496	1.25	0.619
ADF	198	199	1.14	0.856
Nutritive Value				
OM digestibility	828	812	18.1	0.419
NE_L, Mcal/kg DM	7.03	6.90	1.38	0.617
PDIN, g/kg DM	203	201	4.9	0.772
PDIE, g/kg DM	122	119	2.8	0.626

[1]TMR_{75}, TMR offered at 75% of *ad libitum* intake + access to pasture for 7 h/d; TMR_{50}, TMR offered at 50% of *ad libitum* intake + access to pasture for 7 h/d; NE_L, Net energy for lactation; PDIN, metabolizable protein when nitrogen is limiting for microbial synthesis in the rumen (INRA 2007); PDIE, metabolizable protein when energy is limiting for microbial synthesis in the rumen (INRA 2007).

Table 2. Effect of treatment on DM intake, milk production and milk composition.

	Treatments[1]				*P*-value		
	TMR_{100}	TMR_{75}	TMR_{50}	SEM	Treatment	Linear	Quadr
DM intake, kg/day							
Corn silage	11.7	7.9	5.5	0.08	0.001	0.001	0.001
Concentrate[2]	7.8	5.3	3.4	0.05	0.001	0.001	0.001
Pasture	-	4.8	6.7	0.04	0.001	-	-
Total	19.4	18.1	15.8	0.13	0.001	0.001	0.017
NE_L supply, Mcal/day	32.6	30.3	26.5	0.23	0.001	0.001	0.024
NE_L balance, %[3]	113	104	92	2.52	0.001	0.001	0.736
Milk production, kg/day	24.8	26.7	25.2	0.87	0.273	0.712	0.120
4% FCM, kg/day[4]	26.5	27.9	26.7	0.81	0.437	0.868	0.206
Milk fat, g/kg	45.5	43.1	45.3	0.96	0.163	0.868	0.060
Milk protein, g/kg	34.2	33.8	33.1	0.63	0.489	0.240	0.879
Milk fat, g/day	1122	1157	1184	39.9	0.548	0.279	0.934
Milk protein, g/day	846	898	873	22.0	0.255	0.390	0.157

[1]TMR_{100}, TMR offered at 100% of *ad libitum* intake; TMR_{75}, TMR offered at 75% of *ad libitum* intake + access to pasture for 7 h/d; TMR_{50}, TMR offered at 50% of *ad libitum* intake + access to pasture for 7 h/d; [2] Corn ground: soybean meal 65:35; NE_L= Net energy for lactation; [3] % NE_L requirements; [4] 4% fat-corrected milk production.

Discussion [Conclusions/Implications]

The reduction in total DM intake when cows were given access to grazing is unlikely to be due to the quality of herbage offered, as the relatively low NDF and high CP content of the herbage suggests that quality was good. Indeed, Vibart et al. (2008) found that total DM intake was not reduced when TMR-fed dairy cows had access to high-quality pastures. However, a reduction in pre-grazing herbage mass was shown to reduce herbage intake (Pérez-Prieto et al. 2013), even with good quality pastures. For example, Pérez-Prieto and Delagarde (2012) demonstrated that herbage DM intake decreases linearly when pre-grazing herbage mass (calculated above ground level) decreased from 5500 to 2500 kg DM/ha. In the current study pre-grazing herbage mass averaged only 1800 kg DM ha, even though pre grazing sward heights were over 23 cm, a reflection of the low tiller density of annual ryegrass. Thus, it is likely that the reduction in total DM intake with the TMR_{75} and TMR_{50} treatments is due to sward structure restricting intakes.

Despite the reduction in total DM intake, the inclusion of herbage in the diet of TMR-fed dairy cow did not decrease milk production, and had no effect on milk composition, thus partially confirming the main hypothesis of this study. However, despite the reduction in intake with TMR_{75} (compared to TMR_{100}) this diet supplied 104% of energy required for milk production. In contrast, TMR_{50} provided 92% of energy requirements for milk production, suggesting that milk production was maintained by mobilization of body tissue reserves. Given the short-term nature of the experimental periods, it was not possible to accurately assess changes in body tissue. However, previous studies have demonstrated that cows with similar energy deficiency at mid-lactation can recovery their body condition during final third of lactation and first 4 weeks of the dry period, without any negative effect on performance and reproduction during the next lactation (Roche et al. 2006, 2017). Additionally, when the energy supply is not less than 90% of requirements, there is a reduced likelihood of metabolic disorders (Overton and Waldron 2004).

In conclusion, giving cows access to fresh pasture allowed the amount of TMR offered to by reduced by 50% with no loss in milk production. However, pasture access reduced total DMI, forcing cows into negative energy balance. The lower intakes are likely due to the low tiller density and low herbage mass of annual ryegrass.

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