Feeding concentrate formulated with native Irish feed ingredients and a low crude protein content to grazing dairy cows has no effect on milk production or milk composition

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Key words: grazing; concentrate crude protein; native-feed ingredients; milk production; milk composition

Abstract

Improving nitrogen use efficiency (NUE) and feeding native feed ingredients offers potential to improve the environmental sustainability of dairy production. However, improving NUE is a key challenge in grass-based systems due to high crude protein (CP) levels in grass and low nitrogen retention by dairy cows. In addition, concentrate feed typically contains imported feed ingredients which contribute to increased carbon footprint. Therefore, the objective of this study was to investigate the effect of concentrate CP level and ingredient source on milk production and composition. Forty-two mixed-parity Holstein-Friesian cows were blocked on parity and balanced on days in milk (DIM), milk production, BCS and Economic Breeding Index (EBI; n=14). Cows grazed full time and were offered a basal diet of perennial ryegrass pasture (average 17 kg DM/cow/day) and fed one of three concentrate supplements at varying levels according to DIM during the main grazing season (153 days). The concentrate treatments (T) were: T1) 14% CP concentrate formulated with non-native ingredients, T2) 12% CP concentrate formulated with non-native ingredients or T3) 12% CP concentrate formulated with native ingredients. Reducing the CP level or formulating with native feed ingredients did not alter milk or milk solids yield (T1: 25.7 kg/day, 2.11 kg/day; T2: 25.3 kg/day, 2.06 kg/day; T3: 24.9 kg/day, 2.01 kg/day respectively). Similarly, no effect of treatment was observed for milk fat or protein percentage (T1: 4.40 %, 3.66 %; T2: 4.44 %, 3.64 %; T3: 4.37 %, 3.66 %, respectively). The results of this study highlight that the sustainability of grass-based dairy may be improved by using a low concentrate CP content (12%) in addition to offering concentrate feed based on native feed ingredients which can result in similar performance to that of dairy cows offered a 14% CP concentrate or a concentrate based on imported ingredients respectively.

Introduction

Agriculture is coming under increasing pressure to reduce its effect on the environment and to increase the sustainability of ruminant production through reducing greenhouse gas (GHG) emissions and pollutant loss to water (EPA, 2022). In temperate climates of the world, such as Ireland, the main forage for dairy cows is grazed pasture which offers many advantages in terms of being a low-cost high-quality feed (Finneran et al., 2010). However, as pasture is a high in crude protein (CP), grazing cows contribute to high nutrient loss through low nitrogen use efficiency (NUE; Casey and Holden, 2005). The nitrogen retention by dairy cows is low typically ranging from 12 to 25% depending on stage of lactation (Whelan, et al., 2012; Reid et al., 2015; Mckay et al., 2019)). In times when pasture is in short supply or to increase milk output, concentrate supplementation is required (Bargo et al., 2003). Imported ingredients such as soya and maize are common ingredients used in concentrate feeds however, these ingredients contribute negatively to the sustainability of the system through increased carbon footprint (Brunschwig et al., 1996). When grazed pasture is the sole feed fed to dairy cows this limits dietary manipulation to increase NUE. However, where concentrate supplementation is offered at pasture this presents an opportunity to alter the protein content of the concentrate. Doran et al. (2022) supplemented grazing dairy cows at pasture with an 18% or a 14% CP concentrate feed during the main grazing season and reported no effect of reducing the CP level to 14% on milk production or milk composition. Therefore, the objective of this study was to investigate the effect of a lower CP concentrate level and ingredient source on milk production and composition.

Methods

Forty-two mixed-parity Holstein-Friesian cows were selected from the spring-calving dairy herd at University College Dublin Lyons Farm. The concentrate treatments (T) offered were: **T1**) 14% CP concentrate formulated with non-native ingredients, **T2**) 12% CP concentrate formulated with non-native ingredients or **T3**) 12% CP concentrate formulated with native ingredients (Table 1). Cows were allocated at random to their treatment (n=14) after being blocked on parity and balanced on days in milk (DIM; 72.4 ± 16.4), milk production and BCS (3 ±0.20) before the experiment began. The treatments were offered for the duration of the main grazing season (153 days, 8th May to 8th October 2021). During this period cows grazed full time and were offered a basal diet of perennial ryegrass (*Lolium perenne*) pasture (average 17 kg DM/cow/day) and fed one of the three concentrate supplements at varying levels according to DIM. Concentrate supplementation was offered in the milking parlour twice daily with levels ranging from 7.4 kg of DM/cow per day at the beginning of the study, eventually decreasing to 3.0 kg DM/cow per day at the end of the study as DIM increased and energy requirements decreased. Cows were milked twice daily at 0700 h and 1500 h. Milk output was recorded and milk sampling was facilitated using the Weighall milk metering and sampling system (Dairymaster, Causeway, Causeway, Ireland). Milk samples for each individual cow were collected and analysed on a weekly basis and on the same occasion for milk composition parameters. Test day milk fat, total protein, fat + protein yield and somatic cell count (SCC) were then determined in a commercial milk laboratory as reported by Doran et al. (2022). Data was analysed using PROC MIXED in SAS 9.4 (SAS Institute Inc., Cary, NC, USA, 2002). The model included tests for the fixed effects of treatment, week, parity, body weight at the start of the trial, month of calving and their interactions. Repeated measures (week) and a post-hoc Tukey adjustment when comparing all treatment groups were also included in the model.

Table 1: Ingredient composition of concentrate supplementation offered (% inclusion)

	14% CP Non-native[1]	**12% CP Non-native[2]**	**12% CP Native[3]**
Rolled oats	-	-	32
Rolled barley	22.7	22.7	33.7
Ground maize	22.5	22.5	-
Rolled beans	-	-	18
Maize distillers grains	7.5	7.5	-
Unmolassed beet pulp	12.2	12.1	-
Soya hulls	13.1	18.8	-
Soyabean meal 48	10.7	5.1	-
Pollard (wheat feed)	-	-	5
Molasses	4.5	4.5	4.5
Fat added	1.5	1.5	1.5
Acid buff	1	1	1
Limestone	0.8	0.8	0.8
Milling salt	0.9	0.9	0.9
Mono dicalcium phosphate	0.8	0.8	0.8
Cal Mag	0.75	0.75	0.75
Trace element /additive pack	1.05	1.05	1.05

[1] 14% CP concentrate formulated with non-native ingredients
[2] 12% CP concentrate formulated with non-native ingredients
[3] 12% CP concentrate formulated with native ingredient

Results and Discussion

The objective of this study was to investigate the effect of a lower CP concentrate level and ingredient source on milk production and composition. As reported in Table 2 reducing the CP level or formulating with native feed ingredients did not alter milk, milk solids yield or fat or protein percentage. Therefore, offering cows a concentrate feed formulated to 12% CP was sufficient to support levels of milk yield and composition similar to that of cows offered 14% CP during the main grazing season. In agreement, Mulligan et al. (2004) compared the effect of offering a low to high range of CP (90 to 240g CP/kg DM) levels in concentrate supplementation to grazing dairy cows and observed no effect of the lower level on milk yield or composition. This supports the hypothesis that the high levels of CP in grazed grass, typically 18.5% (Kopp et al., 2019), is sufficient to support production requirements during the main grazing season.

Direct substitution of imported feed ingredients (maize, soya) for native feed ingredients such as oats, barley and beans in a pelleted feed was also capable of supporting production requirements of dairy cows during the main grazing season. To the best of the authors knowledge this is the first study to investigate the use of fully native Irish ingredients in the formulation of concentrate feed. Mckay et al. (2019a) investigated the effect of the type of cereal (barley vs maize) used in concentrate feed for grazing dairy cows over a 9-week period. The study observed that cows offered a barley-based concentrate had increased milk and milk solids yield in comparison to a maize based concentrate suggesting the potential for increased use of home-grown feeds such as barley to be used instead of imported maize. A follow up study investigated the potential for the use of oats in concentrate feed and observed that grazing dairy cows offered a barley or oat-based concentrate feed produced the same amount of milk yield and milk solids (Mckay et al., 2019b) which also supported the hypothesis for the use of fully native concentrate feeds. With regard to the source of protein, Tufarelli et al. (2012) reported that feeding field beans as the protein source in concentrate feed to dairy cows as a supplement to hay supported lactation performance similar to cows fed a traditional soya bean containing concentrate.

Table 2: The effect of feeding strategy on milk production and milk composition

	Treatment			
	T1: 14% CP [1]	**12% CP Non-native [2]**	**12% CP Native[3]**	**P-Value**
Milk yield (kg)	25.7 ±1.1	25.3 ±1.0	24.9 ±1.0	*P*=0.85
Fat (%)	4.4 ±0.12	4.44 ±0.12	4.37 ±0.12	*P*=0.91
Protein (%)	3.66 ±0.05	3.64 ±0.05	3.66 ±0.05	*P*=0.94
F+P (kg)	2.11 ±0.07	2.06 ±0.07	2.01 ±0.17	*P*=0.59
SCC ($\times 10^3$ cells/ ml)	46.6 ±7.1	48.3 ±7.1	60.9 ±7.0	*P*=0.30

[1] 14% CP concentrate formulated with non-native ingredients
[2] 12% CP concentrate formulated with non-native ingredients
[3] 12% CP concentrate formulated with native ingredient

Conclusions and/or Implications

The results of this study highlight the potential role of natively sourced concentrate feed with a lower concentrate CP content (12%) in grass-based dairy. Such a feeding strategy can result in similar performance to that of dairy cows offered a 14% CP concentrate or a concentrate based on imported ingredients respectively. Theses feeding strategies may contribute towards achieving the emissions targets to increase environmental sustainability of Irish pasture-based milk production systems by reducing the nitrogen lost from dairy systems, increasing NUE and reducing the carbon footprint.

Acknowledgements

The authors wish to acknowledge and thank Dairy Research Ireland for funding this research project. The authors also would like to acknowledge the contribution made by the IFA grain committee in support of this research. Additionally, the authors acknowledge the contributions of the laboratory and farm staff and students at University College Dublin Lyons Farm.

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