# Application

Dairy cows grazing pasture containing plantain produce milk with a greater concentration of human-beneficial unsaturated fatty acids.

# Introduction

Including plantain (*Plantago lanceolata* L.) in pastures offers the opportunity to reduce N loss to the environment from dairy cows, by reducing the concentration and excretion of N in cows’ urine, while improving milk production (Minnée et al., 2020). However, only a few studies have reported the effect of plantain inclusion on milk quality parameters, such as fatty acids (Mangwe et al., 2020), and no study has reported the effect on milk mineral concentrations. Milk from cows grazing pasture is an important source of unsaturated fatty acids and minerals for human consumption (Cimmino et al., 2023). Thus, there is a requirement to quantify the concentrations of individual fatty acids and minerals in milk from cows grazing pasture containing plantain. It was hypothesised that plantains’ inclusion in grazed pasture for dairy cows would result in milk being produced with greater concentrations of poly-unsaturated fatty acids, with no difference in the milk mineral profile.

# Materials and methods

This study was conducted at UCD Lyons Farm. A randomized complete block design was implemented using 26 Holstein × Friesian spring-calving dairy cows (*Bos taurus*). Cows were blocked based on parity and randomly assigned to one of two treatments (n = 13). The pasture treatments offered were 1) perennial ryegrass and white clover (**GC**) and 2) perennial ryegrass, white clover, and plantain (**GCP**). Cows grazed their pasture treatment from day four post-partum. The experiment consisted of two measurement days conducted during early lactation on the 19th of April and late lactation on the 20th of September 2023. Cows were on average 61 ± 12 (early lactation) and 214 ± 16 (late lactation) days in milk on each measurement day.

All cows were offered on average 16.3 ± 2.59 kg DM pasture plus 5.75 kg DM concentrate feed per day in early lactation and 17.6 ± 2.03 kg DM pasture plus 2.66 kg DM concentrate feed per day in late lactation, respectively. Pasture dry matter intake was determined through herbage disappearance (n = 6) (Nguyen et al., 2024). Cows were milked at 0800 and 1530 h and offered half of their daily concentrate feed allocation at each milking. Individual milk samples (100 ml) were obtained from successive a.m. and p.m. milkings and pooled in proportion to the respective yields. The concentrations of fatty acids were determined using gas chromatography with Flame Ionisation Detection. The concentrations of calcium, magnesium, phosphorous, potassium, and sodium were determined through inductively coupled plasma atomic emission spectroscopy.

Data was analyzed for each stage of lactation using the PROC MIXED procedure of SAS® Studio (version 3.81). The model included the fixed effect of treatment, block, and their interaction. The cow was included as a random effect.

# Results

In early lactation, perennial ryegrass and plantain comprised 46 and 47 % (DM basis) of GCP pasture, whereas perennial ryegrass dominated (93%) the GC pasture. In late lactation, perennial ryegrass (44%) and plantain (37%) dominated the GCP pasture and perennial ryegrass was still present in the greatest proportion in the GC pasture (72%). The nutritive value of the pastures is presented in Table 1.

**Table 1**. Mineral and fatty acid concentrations of the experimental pastures and concentrate on each measurement day.

|  |  |
| --- | --- |
|  | **Period** |
|  | **Early lactation** | **Late lactation** |
| Treatment1 | **GC** | **GCP** | **Concentrate** | **GC** | **GCP** | **Concentrate** |
| Minerals (g/kg DM) |  |  |  |  |  |
| Calcium | 8.03 | 17.7 | 6.78 | 7.55 | 15.8 | 10.8 |
| Magnesium | 1.72 | 1.54 | 5.21 | 0.98 | 1.04 | 11.3 |
| Phosphorous | 5.42 | 5.69 | 5.38 | 3.03 | 3.52 | 6.16 |
| Potassium | 30.5 | 27.2 | 9.02 | 23.7 | 22.4 | 8.51 |
| Sodium | 0.85 | 1.77 | 5.92 | 1.14 | 1.75 | 8.95 |
| Fatty acids (g/kg DM) |  |  |  |  |  |
| Saturated | 6.9 | 5.0 | 2.4 | 4.1 | 3.3 | 3.6 |
| Mono-unsaturated | 1.2 | 2.1 | 2.3 | - | - | 3.3 |
| Poly-unsaturated | 15.6 | 11.5 | 1.5 | 13.0 | 10.7 | 2.9 |
| Omega-3 | 11.9 | 8.5 | - | 10.9 | 8.6 | - |
| Omega-6 | 3.7 | 3.0 | 1.4 | 2.0 | 2.0 | 2.7 |
| Fatty acids (g/100 g fat) |  |  |  |  |  |
| C18:2 cis-9, 12 | 14.8 | 15.2 | 22.0 | 11.0 | 13.3 | 26.3 |
| C18:3 cis-9, 12, 15 | 47.8 | 43.5 | 1.25 | 58.9 | 57.2 | 1.18 |
| ΣOmega-3 | 47.8 | 43.5 | 1.76 | 58.9 | 57.2 | 1.73 |
| ΣOmega-6 | 14.8 | 15.2 | 22.4 | 11.0 | 13.3 | 26.7 |
| Omega-6:Omega-3 | 0.31 | 0.35 | 12.7 | 0.19 | 0.23 | 15.4 |

1 Treatment, GC = Perennial ryegrass and white clover pasture; GCP = Perennial ryegrass, white clover, and plantain pasture.

Cows grazing GCP had a greater concentration of C18:3 cis-9, 12, 15 in milk on both measurement days (Table 2). The calcium, magnesium, and phosphorous concentrations were lower in milk from cows grazing GCP in late lactation.

|  |  |
| --- | --- |
|  | **Period** |
|  | **Early lactation** | **Late lactation** |
| Treatment1 | **GC** | **GCP** | SEM | *P*-value | **GC** | **GCP** | SEM | *P*-value |
| Dry matter intake (kg/day) |  |  |  |  |  |  |  |  |
| Pasture | 13.6 | 15.0 | 0.68 | 0.04 | 14.6 | 16.9 | 0.63 | <0.01 |
| Concentrate | 5.75 | 5.75 | - | - | 2.66 | 2.66 | - | - |
| Total | 19.3 | 20.8 | 0.68 | 0.04 | 17.2 | 19.5 | 0.63 | <0.01 |
| Milk yield (kg/day) | 31.6 | 31.8 | 0.98 | 0.86 | 18.7 | 21.0 | 0.62 | 0.02 |
| Milk fat (%) | 4.05 | 3.73 | 0.108 | <0.05 | 5.23 | 4.68 | 0.121 | <0.01 |
| Milk fat (kg/day) | 1.27 | 1.19 | 0.049 | 0.28 | 0.97 | 0.98 | 0.036 | 0.81 |
| Milk minerals (mg/kg) |  |  |  |  |  |  |  |
| Calcium | 1174 | 1192 | 32.9 | 0.70 | 1274 | 1149 | 27.0 | <0.01 |
| Magnesium | 100 | 101 | 3.6 | 0.84 | 125 | 116 | 2.3 | 0.01 |
| Phosphorous | 1048 | 997 | 23.7 | 0.14 | 1043 | 982 | 21.7 | 0.06 |
| Potassium | 1567 | 1564 | 37.2 | 0.95 | 1475 | 1445 | 31.8 | 0.52 |
| Sodium | 294 | 299 | 8.6 | 0.68 | 341 | 336 | 14.3 | 0.81 |
| Milk fatty acids (g/100g) |  |  |  |  |  |  |  |
| Saturated  | 2.39 | 2.34 | 0.161 | 0.84 | 2.49 | 2.69 | 0.146 | 0.36 |
| Mono-unsaturated | 0.78 | 0.76 | 0.069 | 0.82 | 0.81 | 0.81 | 0.041 | 0.98 |
| Poly-unsaturated | 0.12 | 0.15 | 0.009 | 0.03 | 0.13 | 0.13 | 0.008 | 0.80 |
| Trans | 0.19 | 0.17 | 0.015 | 0.20 | 0.16 | 0.18 | 0.012 | 0.32 |
| Milk fatty acids (g/100g fat) |  |  |  |  |  |  |  |
| C18:1 trans-FA | 4.18 | 4.12 | 0.362 | 0.90 | 3.49 | 4.15 | 0.226 | <0.05 |
| C18:2 cis - 9, 12 | 1.70 | 1.98 | 0.235 | 0.41 | 1.75 | 1.79 | 0.131 | 0.85 |
| C18:3 cis - 9, 12, 15 | 0.82 | 1.14 | 0.107 | <0.05 | 0.80 | 1.18 | 0.085 | <0.01 |
| ΣOmega-3 | 0.86 | 1.18 | 0.117 | 0.06 | 0.80 | 1.18 | 0.085 | <0.01 |
| ΣOmega-6 | 1.74 | 2.03 | 0.236 | 0.39 | 1.75 | 1.79 | 0.131 | 0.85 |
| Omega-6:Omega-3 | 2.01 | 1.85 | 0.110 | 0.31 | 1.99 | 1.52 | 0.101 | <0.01 |

**Table 2**. The effect of treatment on milk yield, milk mineral, and milk fatty acid concentrations on each measurement day.

1 Treatment, GC = Perennial ryegrass and white clover pasture; GCP = Perennial ryegrass, white clover, and plantain pasture.

# Conclusion

Including plantain in perennial ryegrass and white clover pasture for spring-calving dairy cows results in a greater concentration of human-beneficial poly-unsaturated fatty acids, namely C18:3 cis-9, 12, 15, in milk fat, through a greater transfer efficiency of poly-unsaturated fatty acids from feed to milk. No negative effect on the individual milk mineral profile was recorded from plantain inclusion in pasture.

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# References

Cimmino, F., Catapano, A., Petrella, L., Villano, I., Tudisco, R. & Cavaliere, G. 2023. Role of Milk Micronutrients in Human Health. Front Biosci (Landmark Ed), 28(2):41.

Mangwe, M., Bryant, R., Beck, M., Fleming, A. & Gregorini, P. 2020. Grazed chicory, plantain or ryegrass–white clover alters milk yield and fatty acid composition of late-lactating dairy cows. Animal Production Science, 60(1):107-113.

Minnée, E. M. K., Leach, C. M. T. & Dalley, D. E. 2020. Substituting a pasture-based diet with plantain (Plantago lanceolata) reduces nitrogen excreted in urine from dairy cows in late lactation. Livestock Science, 239.

Nguyen, T. T., Navarrete, S., Horne, D., Donaghy, D. & Kemp, P. 2024. Milk production and nitrogen excretion of grazed dairy cows in response to plantain (Plantago lanceolata) content and lactation season. Animal Bioscience.