Digestion characteristics of forages, including perennial ryegrass at different stages of maturity, and supplementary feeding for dairy cows grazing pasture

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Abstract

This thesis defines digestion kinetics for perennial ryegrass (*Lolium perenne* L.), which is the main component of diets fed to dairy cows in New Zealand. Chemical composition and digestion kinetics were measured in fresh minced ryegrass as it matured and leaf, stem and inflorescence of several grass species. *In sacco* and *in vitro* incubations were used to define rates of degradation and nutrient release. Two short-term grazing trials were used to evaluate contrasting silages as supplements for cows fed restricted amounts of summer pasture. The minced preparation of ryegrass resulted in a similar distribution of dry matter (DM) between particle size fraction and rumen digesta from cows fed pasture. Mincing released 0.46 – 0.80 of crude protein into the soluble fraction, with highest proportions for mature grasses which had low CP concentrations (about 8 g CP/100 g DM). In contrast, the majority of fibre remained in the insoluble fraction but rates of degradation (k) approximately halved as grass matured. *In vitro* yield of VFA was similar for immature and mature minced ryegrass (after 12 hours VFA was equivalent to about 30% of DM), even though ammonia concentration declined to very low values for stem and mature grass. This suggests the rapid initial microbial growth was able to sustain a high level of DM degradation to VFA with mature grass. The summer pasture used for silage supplementation was of uncharacteristically good quality so the expected contrasts between maize, pasture, sulla (*Hedysarum coronarium*), lotus (*Lotus corniculatus*) and sulla/maize silage mixtures were less than expected. Milk responses to lotus silage supplements were greater than other silages (e.g.: 290 g milksolids from 54 MJ ME by lotus versus 110 g milksolids from about 50 MJ ME supplied by other silages). Pasture substitution was low (0.06 – 0.33). The Cornell Net Carbohydrate and Protein System (CNCPS) was chosen for evaluation of cow trial data because it uses feed degradation parameters as input variables to estimate nutrient supply. Model prediction of milk yield matched observed values when cows maintained liveweight. Milk yield was underestimated at low intakes and overestimated at high intakes because no allowance is made for nutrient partitioning between milk production and liveweight change.

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What does PhD mean?

A PhD means inspiration, commitment, responsibility, education, teamwork and fun as well (not writing this thesis though!).

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Abbreviations

AA: Amino acids.

AAC: Australian Agriculture Council.

ADF: Acid detergent fibre.

ADL: Acid detergent lignin.

ADFIN: Acid detergent fibre insoluble nitrogen (the N present in ADF).

BW: Body weight (kg).

^{o}C: Degree centigrade.

CP: Crude protein, being total N x 6.25 (or x 6.38 for milk).

CPI: Crude protein intake.

CS: Condition score.

CV: Coefficient of variation.

DE: Digestible energy. GE of the feed minus the GE of the corresponding faeces.

DIP: Degradable intake protein (%CP).

DM: Dry matter.

DMD: Dry matter digestibility.

DMI: Dry matter intake.

DOMI: Digestible organic matter intake.

g: Grams.

GE: Gross energy. Synonymous with heat of combustion.

h: Hour(s).

ha: Hectare.

INRA: Institut National de la Recherche Agronomique.

in sacco: In bag.

in vitro: In glass.

in vivo: In animal.

k_i (subscript): The net efficiency of use by the animal of ME (i.e., NE/ME) for energy maintenance (k_m), for NE gain in growth and fattening (k_g), as milk produced (k_L) and pregnancy (k_{pr}).

kg: Kilograms.

LIC: Livestock Improvement Corporation.

LW: Live weight.

LWC: Live weight change.

LWG: Live weight gain.

MCP: Microbial crude protein.

ME: Metabolisable energy.

MEI: Metabolisable energy intake.

ME_m: The ME required by the animal for maintenance, or the maintenance (support) metabolism.

mg: Milligram (10^{-3}g).

mL: Millilitres.

mm: Millimetres.

MP: Metabolisable protein.

MS: Milk solids (milk fat + milk protein).

MSE: Mean square error.

NAN: Non-ammonia nitrogen (total N in digesta minus ammonia-N).

NDF: Neutral detergent fibre.

NDFIN: Neutral detergent fibre insoluble nitrogen (the N present in NDF).

NE: Net energy. The NE value of a feed (MJ/kg DM) varies with the purpose for which its ME is used because of differences between the k_m, k_g and k_L values for that feed.

NFC: non-fibrous carbohydrates (calculated by difference: 100 – CP – lipid – NDF – ash).

ng: Nanogram (10^{-9}g).

NIRS: Near infrared reflectance spectroscopy.

NPN: Non-protein nitrogen.

NSC: Non-structural carbohydrates.

NV: Nutritive value.

NZ: New Zealand.

OM: Organic matter.

OMD: Organic matter digestibility.

OMI: Organic matter intake.

pH: Whole number referring to the number of hydrogen ions present in a solution. Negative logarithm of the hydrogen ion concentration.

RDP: Rumen degraded protein; that part of the CPI which is fermented and may be used by the microbial population in the rumen, yielding MCP (synonymous of DIP).

RUD: Rumen undegraded protein.

SE: Standard error.

SR: Substitution rate (kg pasture/kg supplement) = (Pasture DMI in control (unsupplemented) group – pasture DMI in supplemented group)/supplement DMI.

STDEV: Standard deviation.

TMR: Total mixed ration.

UDP: Undegradable dietary protein (synonymous of RUD).

µg: Microgram (10^{-6}g).

µL: Microliter (10^{-6}L).

VFA: Volatile fatty acids.

Forage common and scientific names

Birdsfoot trefoil, lotus	*Lotus corniculatus*
Browntop:	*Agrostia capillaris*
Chicory:	*Cichorium intybus*
Foxtail:	*Alopecurus arundinaceus*
Italian ryegrass:	*Lolium multiflorum*
Kentucky bluegrass:	*Poa pratensis L.*
Kikuyu:	*Pennisetum clandestinum*
Lotus major:	*Lotus penduculatus*
Lucerne, alfalfa:	*Medicago sativa*
Maize, corn:	*Zea maize*
Meadow bromegrass:	*Bromus biebersteinii* Roem & Schreb.
Orchardgrass or cocksfoot:	*Dactylis glomerata* L.
Paspalum:	*Paspalum dilatatum*
Red clover:	*Trifolium pratense*
Phalaris, reed canarygrass:	*Phalaris arundinacea* L.
Ryegrass (perennial):	*Lolium perenne* L.
Smooth brome grass:	*Bromus inermis* L.
Sulla:	*Hedysarum coronarium*
Tall fescue:	*Festuca arundinacea* Schreb.
Timothy:	*Phleum pratense*
Yorkshire fog:	*Holcus lanatus*
White clover:	*Trifolium repens*