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Prediction of nutrient digestibility and energy concentrations in fresh grass using nutrient composition

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ABSTRACT

Improved nutrient utilization efficiency is strongly related to enhanced economic performance and reduced environmental footprint of dairy farms. Pasture-based systems are widely used for dairy production in certain areas of the world, but prediction equations of fresh grass nutritive value (nutrient digestibility and energy concentrations) are limited. Equations to predict digestible energy (DE) and metabolizable energy (ME) used for grazing cattle have been either developed with cattle fed conserved forage and concentrate diets or sheep fed previously frozen grass, and the majority of them require measurements less commonly available to producers, such as nutrient digestibility. The aim of the present study was therefore to develop prediction equations more suitable to grazing cattle for nutrient digestibility and energy concentrations, which are routinely available at farm level by using grass nutrient contents as predictors. A study with 33 nonpregnant, nonlactating cows fed solely fresh-cut grass at maintenance energy level for 50 wk was carried out over 3 consecutive grazing seasons. Freshly harvested grass of 3 cuts (primary growth and first and second regrowth), 9 fertilizer input levels, and contrasting stage of maturity (3 to 9 wk after harvest) was used, thus ensuring a wide representation of nutritional quality. As a result, a large variation existed in digestibility of dry matter (0.642–0.900) and digestible organic matter in dry matter (0.636–0.851) and in concentrations of DE (11.8–16.7 MJ/kg of dry matter) and ME (9.0–14.1 MJ/kg of dry matter). Nutrient digestibilities and DE and ME concentrations were negatively related to grass neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents but positively related to nitrogen (N), gross energy, and ether extract (EE) contents. For each predicted variable (nutrient digestibilities or energy concentrations), different combinations of predictors (grass chemical composition) were found to be significant and increase the explained variation. For example, relatively higher R^2 values were found for prediction of N digestibility using N and EE as predictors; gross-energy digestibility using EE, NDF, ADF, and ash; NDF, ADF, and organic matter digestibilities using N, water-soluble carbohydrates, EE, and NDF; digestible organic matter in dry matter using water-soluble carbohydrates, EE, NDF, and ADF; DE concentration using gross energy, EE, NDF, ADF, and ash; and ME concentration using N, EE, ADF, and ash. Equations presented may allow a relatively quick and easy prediction of grass quality and, hence, better grazing utilization on commercial and research farms, where nutrient composition falls within the range assessed in the current study.

Key words: grass, digestibility, energy, prediction, maintenance feeding

INTRODUCTION

Livestock production relying on pasture has traditionally been the common practice in certain areas of the world such as parts of the UK, Ireland, and New Zealand (Waghorn and Clark, 2004; Hopkins and Wilkins, 2006; Ferris, 2007). Permanent and temperate grasslands have been increased by 45 and 40%, respectively, between 1900 and 2000 in the UK (Hopkins and Wilkins, 2006), whereas nowadays they account for 95% of total UK agricultural land (Ferris, 2007). Perennial ryegrass shows a multifunctional importance by (1) reducing production costs when grazed in situ, compared with feeding conserved forage and concentrates indoors, in cool and moist areas suitable for long grazing seasons; (2) being appropriate to be offered as grazing sward, fresh cut, or preserved forage; and (3) sustaining rural landscape and wildlife habitats (Ferris,

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2007). Fresh grass may supply more than half of the energy and protein requirements in ruminants, thus sustaining a moderate level of production, and some production systems totally rely on grassland (Waghorn and Clark, 2004; Hopkins and Wilkins, 2006; Ferris, 2007).

Advances in the fast-moving dairy industry, related to improvements on animal productivity and health, reduction of environmental footprint as well as dairy management and social changes, require in-depth and accurate knowledge of feed nutritive value to maintain economic sustainability of dairy farms. For example, improvement of cow productivity over the last 25 yr, as a result of genetic selection over higher milk yields, increased nutrient requirements, thus making it challenging to meet demands of high-yielding cows in grazing systems (Waghorn and Clark, 2004; Ferris, 2007; Phuong et al., 2013). In addition, reduced digestibility of certain nutrients, such as nitrogen (N), by grazing ruminants raises environmental concerns because of the increased outputs of nitrogenous compounds, such as ammonia, nitrous oxide, nitric oxide, di-N, and nitrate (Dijkstra et al., 2013). Productivity and environmental issues therefore necessitate the development of optimum feeding efficiency practices in pasture-based systems; in this effort, predicting as precisely as possible nutrient digestibility and energy concentrations of fresh grass is of eminent importance.

Digestibility of silage-based diets has been extensively investigated, and meta-analyses of existing data have in detail reported factors affecting digestibility of mixed-ration silage-based diets (Huhtanen et al., 2009; Nousiainen et al., 2009). Other authors have published prediction equations for nutrient digestibility in silages, using chemical-composition and fermentation parameters as predictors (Nousiainen et al., 2003; Yan and Agnew, 2004). However, work is limited on the prediction of fresh-grass nutrient digestibility and energy concentrations (Morgan and Stakelum, 1987; Givens et al., 1989, 1990a,b), and the equations used for mixed-ration silage-based diets may not be suitable for grazing animals. Dietary ME is a fundamental unit to assess feeding value of forages and is used to ration dairy cattle (Waghorn and Clark, 2004; Yan and Agnew, 2004). However, experiments assessing nutrient digestibility (in metabolism units) and energy outputs (in calorimetric chambers) are laborious and expensive and consequently impractical for estimating ME of fresh grass at the commercial level (Yan and Agnew, 2004). Development of prediction equations for ME and nutrient digestibility by using routinely and less-costly obtained data at farm level, such as grass chemical composition, would be a valuable tool in developing sustainable grazing and feeding strategies.

The recent renewed interest in pasture-based systems and the limited availability of equations more suitable to grazing cattle, coupled with changes in animal requirements and grass quality over the last decades (Hopkins and Wilkins, 2006; Ferris, 2007), necessitates the development of more up-to-date relations for nutrient digestibility and ME content. The aim of the present study was therefore to (1) investigate relationships between both nutrient digestibility and energy concentrations and grass chemical-composition parameters in nonpregnant, nonlactating cows fed fresh grass at maintenance energy level, and (2) develop prediction equations for nutrient digestibility and energy concentrations, using grass chemical-composition variables as predictors.

MATERIALS AND METHODS

The present study was performed under the regulations of the Department of Health, Social Services, and Public Safety of Northern Ireland, in line with the Animal (Scientific Procedures) Act 1986 (Home Office, 1986).

Experimental Design

The present study shows results (n = 464) of a series of digestibility measurements performed over 50 wk, distributed in 3 consecutive grazing seasons (2007, 2008, 2009) and included 33 nonpregnant, nonlactating dairy cows fed solely fresh-cut grass at maintenance energy level. All experiments were carried out in the ruminant digestibility facilities of Agri-Food and Biosciences Institute, Hillsborough, UK, which are designed for accurate recording of feed intake and feces and urine outputs. Trials were designed to investigate relationships of nutrient composition and digestibility, using a wide range of fresh-cut-grass quality from a range of perennial ryegrass swards of contrasting management practices known to strongly affect chemical composition, such as harvest date, fertilizer input, and maturity stage.

Swards were initially trimmed throughout at a residual height of 4 cm at (1) early and mid April of 2008 (n = 2) and 2009 (n = 2) for the primary-growth swards, (2) late May of 2007 (n = 1) and early June 2008 (n = 2) for the first-regrowth swards, and (3) mid August of 2007 (n = 1) and early and mid August 2008 (n = 2) for the second-regrowth swards. All swards were then allowed to grow for 2 to 3 wk (at an average height of 15 cm) before being harvested daily at 1300 h for a 7-wk period for each sward from early growth to late maturity and offered to cows at a maintenance energy level.