

INDIVIDUAL ANIMAL VARIATION AND EFFECT OF DIET ON PLASMA CONCENTRATION OF INSULIN-LIKE GROWTH FACTOR-1 (IGF-1) IN LACTATING PASTURE-FED HOLSTEIN-FRIESIAN COWS

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SUMMARY

Thirty-two lactating Holstein-Friesian dairy cows, 4 to 5 weeks postpartum were randomly assigned to four dietary sub-groups and fed diets varying in two levels of dry matter (DM) and metabolisable energy (ME) for 5 weeks. The four diets consisted of pasture, hay and pelleted cereal grain. Blood samples were taken from cows to evaluate changes in circulating IGF-1 concentration. Dietary treatment significantly ($P < 0.001$) influenced plasma IGF-1 concentration with cows on high-ME diets having greater IGF-1 concentration at week 5 than cows on the low-ME diets. In contrast, DM intake had less effect ($P = 0.08$) on plasma concentration of IGF-1. Day-to-day variation in mean plasma concentration of IGF-1 from an intensive 14-day daily sampling was low in all the dietary sub-groups. Within-cow day-to-day variation was less compared to that among cows within the same dietary group. There was high repeatability in day-to-day concentration of IGF-1 in individual cows. Intraclass correlation coefficients, a measure of the proportion of the total variance that was due to between cow variance, were high ($P < 0.001$) within each dietary sub-group ranging from $0.56 (\pm 0.14 \text{ standard error (se)})$ to $0.88 (\pm 0.06 \text{ se})$ and the combined (pooled) value for the four sub-groups was $0.77 (\pm 0.05 \text{ se})$.

Keywords: IGF-1, dairy cows, lactation, intraclass correlation, heritability

INTRODUCTION

The insulin-like growth factors (IGF) comprising of IGF-1 and IGF-2 are single chain, ubiquitously expressed polypeptides important in the regulation of cell growth, cell differentiation and maintenance of differentiated cell function (Jones and Clemmons 1995; Cohick 1998). Nutrient intake and energy balance have been found to regulate circulating levels of IGF-1 in high genetic merit dairy cattle fed total mixed ration under feedlot conditions in European and North American studies (Lucy *et al.* 1992; Cohick 1998; Beam and Butler 1999; Taylor *et al.* 2000). There are no systematic or comparable studies in Victorian dairy herds in Australia where the production system is mainly pasture-based, with strategic feeding of grain supplements to complement pasture intake of cows in early lactation. Furthermore, most published information on changes in circulating IGF-1 due to nutrient status have relied mainly on data from weekly blood concentrations. Information on day-to-day variation in concentration of IGF-1 in the blood is lacking. The objectives of this study were to evaluate the effect of four diets comprising two levels of dry matter (DM) and metabolisable energy (ME) intake on plasma concentration of IGF-1, and to determine the day-to-day variation in circulating IGF-1 concentration as well as assessing individual cow variability in relation to these changes in pasture-fed Holstein-Friesian dairy cows in early lactation.

MATERIALS AND METHODS

Animals and IGF-1 measurement. Thirty-two Holstein-Friesian cows, 4 to 5 weeks postpartum were randomly assigned to four dietary sub-groups. The cows in the four groups received daily rations comprising high (H) or low (L) dry matter (DM) or metabolisable energy (ME) (LL: 16.6 kg DM and 174 MJ ME; HL: 17.3 kg DM and 181 MJ ME; LH: 15.4 kg DM and 183.1 MJ ME; HH: 17.9 and 213.3 MJ ME, where the first letter designates DM and the second, ME) for 5 weeks. The diets consisted of pasture, hay and pelleted cereal grain. Blood samples were taken weekly from a coccygeal vein at 07:00 h after morning milking during the 5-week study. Each sample was centrifuged at 3000 rpm for 15 mins at 4°C. Plasma was collected and stored at -20°C until assayed for IGF-1. In addition, samples were collected daily between week 3 and week 5 to provide information on day-to-day variation in IGF-1. Plasma concentrations of IGF-1 were measured using the DSL-10-2800 Active™ non-extraction IGF-1 Enzyme-linked Immunosorbent Assay (ELISA; Diagnostic Systems Laboratories, Inc, Webster, Texas, USA). The ELISA was validated against an IGF-1 radioimmunoassay after acid gel chromatography (HPLC) dissociation and extraction of IGFs from IGFBPs (Owens *et al.* 1994).

Statistical analysis. The effects DM and ME on plasma concentrations of IGF-1, milk yield, bodyweight and body condition score and interaction between DM and ME at week 5 were analysed using GLM procedure in SPSS v. 9.0 (SPSS 1999). Data for week 0 was used as covariate. The model used was $Y = DM + ME + DM*ME + Covariate$ at week 0, where Y = variable at week 5. The interaction was included in the model when it had a probability of <0.1 . Intraclass correlations (ICC, Snedecor and Cochran 1980), being the proportion of the total variance that is due to the between cow variance were used to assess the day-to-day variation in plasma concentrations of IGF-1 of cows within each dietary sub-group.

RESULTS AND DISCUSSION

Dietary effect on plasma concentration of IGF-1. Figure 1 shows the effect of diet on the mean plasma concentration of IGF-1 at week 5. Dietary treatment influenced IGF-1 concentration with cows on the high-ME diets (LH and HH sub-groups) having higher (79.3 vs 41.4 ng/mL; $P < 0.001$) concentrations than cows on the low-ME diets (LL and HL sub-groups). DM intake had less effect ($P = 0.08$) on the mean plasma concentrations of IGF-1 in plasma at week 5 and there was no interaction between DM and ME at this time. The model had an adjusted R^2 of 0.65. The greater influence of ME on circulating IGF-1 levels than DM is consistent with earlier research indicating high plasma concentrations of IGF-I in dairy cows (Lucy *et al.* 1992) and heifers (Armstrong *et al.* 2001) offered high energy diets compared to counterparts on low energy diets. Nutritional status involving energy and protein intake relative to requirements partially controls the synthesis and secretion of IGF-1 (Thissen *et al.* 1994). High energy diets will be expected to improve the energy balance status of cows and increase circulating IGF-1 levels. Data presented here corroborates this theory, with cows receiving high-ME (HH and LH groups; Fig. 1) exhibiting the greatest increases in plasma IGF-1 concentrations.

Day-to-day variation in plasma concentration of IGF-1. The mean plasma concentration of IGF-1 obtained from a 14-day daily sampling remained relatively constant within the four dietary sub-groups (Fig. 2). Within-cow day-to-day variation was less compared to that among cows within the

same dietary sub-group. Repeatability was high in day-to-day plasma concentration of IGF-1 in individual animals and cows exhibited consistently high, medium or low plasma concentration. An example of this high repeatability demonstrated by individual cows with the highest and the lowest plasma concentration of IGF-1 in the HH and LL sub-groups is illustrated in Figure 3.

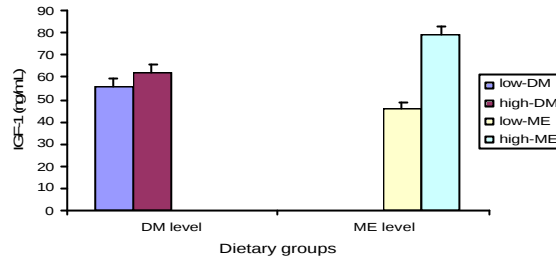


Figure 1. Effect of dry matter (DM) and metabolisable energy (ME) intake on plasma concentrations of IGF-1 at week 5. Values are LS -means $\pm$ se.

Intraclass correlations were high for the four dietary sub-groups ranging from 0.56 ± 0.14 to 0.88 ± 0.06 . The coefficient for the four groups combined (pooled ICC based on the deviations from each group mean) was 0.77 ± 0.05 . The high repeatability with respect to day-to-day variation in plasma IGF-1 concentration in individual cows may be genetic as evidence exist for genetic variation in circulating levels of IGF-1 (Rosen *et al.* 1998; Herd *et al.* 2002). IGF-1 concentration in blood is moderately heritable in cattle, and heritability estimates of 0.35, and 0.31 to 0.59 have been reported for dairy (Grochowska *et al.* 2001) and beef cattle (Johnston *et al.* 2002) respectively. Another possible reason for the low fluctuation in IGF-1 concentrations in an individual cow relates to its relatively long half-life in the blood as a result of binding with specific binding proteins in the blood (Coverly and Baxter 1997).

The relatively constant daily concentration of IGF-1 may have major implications for experimental designs in studies investigating the effect of nutritional status or energy balance on IGF-1 changes. Weekly sampling may be adequate to characterise IGF-1 changes. The above results suggest that plasma concentration of IGF-I may be heritable after taking into account factors such as stage of lactation and dietary influences. Variations in circulating IGF-1 concentration may be a sensitive monitor of dietary changes and energy balance in pasture-fed lactating dairy cows.

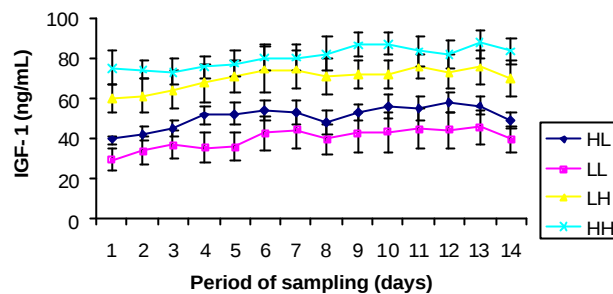


Figure 2. Mean daily plasma IGF-1 concentrations for dietary sub-groups. Values are means $\pm$ se.

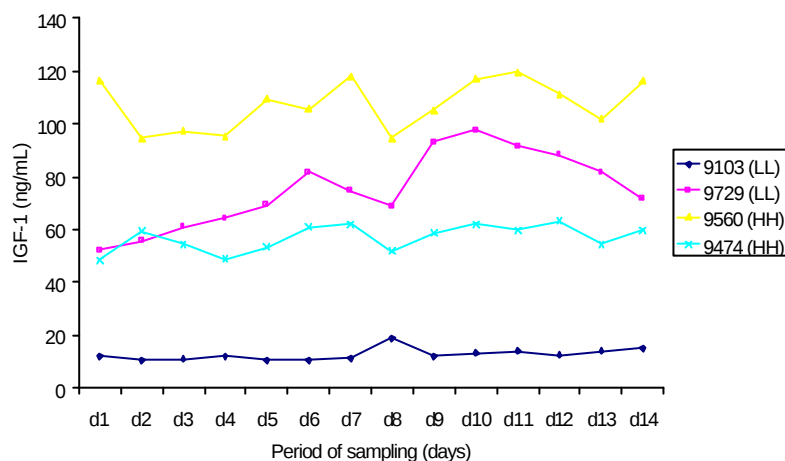


Figure 3. Profiles of individual cows in the HH and LL dietary sub-groups with the highest and lowest plasma concentration of IGF-1.

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