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BRIEF COMMUNICATION

Effects of diet on udder function and regression in Holstein-Friesian cattle

S.R. DAVIS, V.C. FARR, M.J AULDIST [1] AND E. S. KOLVER [1]

AgResearch and [1]Dairying Research Corporation, Ruakura Research Centre, Private Bag 3123, Hamilton.

The rate of decline in milk yield after peak lactation is about 10% per month, for cows in New Zealand grazing pasture diets, and less than 4% per month in concentrate-fed animals in northern hemisphere environments. Much of the decline in milk yield after peak lactation is associated with a similar proportional loss of secretory cells from the udder and, once lost, these cells cannot be replaced until the dry period before the next lactation. Thus, we have found (unpublished data) that from peak lactation (October) to late-lactation in New Zealand, there was a loss of over 50% of mammary DNA. Such a loss was also reflected in changes in udder volume (Davis *et al.*, 1985) and also in changes in milk storage capacity in the udder (Davis *et al.*, 1987).

Differences in lactational persistency between concentrate and pasture-fed animals suggest that nutrition exerts a long-term effect on milk production through maintenance of mammary secretory cell structures, as well as function. In the present experiment, our hypothesis was that cows fed concentrate diets would maintain milk production better than cows fed pasture over the summer months and that this would be reflected in the functional udder capacity (FUC). FUC is a measure of mammary cell numbers and is highly correlated with milk production (Davis *et al.*, 1987). Further work attempted to correlate changes in FUC with concentrations of blood hormones sensitive to diet.

Measurements were made on 48 Holstein-Friesian heifers sourced from overseas (OS) or NZ genetics. Heifers were fed total mixed rations (TMR) or were lightly stocked, grazing pasture (full experimental details are given in Kolver *et al.*, 2000). FUC was measured at peak (12 weeks), mid- (26 weeks), and late-lactation (35 weeks), as described in Davis & Hughson, 1988 and Davis *et al.*, 1998). Measurements required that animals not be milked for 24-28h to achieve maximum udder fill, followed by three milkings. Before the first milking heifers were injected with 4 mg adrenaline via a jugular vein to block milk ejection and permit measurement of cisternal milk –the volume of milk contained within the milk storage area of the udder. After 30-45 min, the animals were milked again and then injected with oxytocin (10 mIU) via a tail vein and remilked to empty the udder of milk This latter volume (milkings 2 and 3 combined) was termed the alveolar fraction; that associated with the secretory alveoli. The total milk contained in the udder was deemed to be the functional udder capacity (defined as the contained milk volume when milk secretion was zero following a period of milk accumulation).

Blood samples were taken immediately after morning milking on the day before each FUC measurement and on a single, separate occasion midway between the first and second FUC measurements. Plasma and serum were harvested and stored at -20˚C. Insulin was assayed by enzyme immunoassay using a kit for bovine insulin (Alpco, Windham, New Hampshire, USA). Total serum thyroxine (T4) and total serum triodothyronine (T3) were assayed by solid phase radioimmunoassay (Diagnostic Products Corporation, Los Angeles, California, USA.) and prolactin by radioimmunoassay as described by (Pearson *et al.*, 1996).

Cows fed TMR showed a greater persistency of lactation (calculated as the late-lactation yield divided by yield at peak lactation) than pasture-fed animals (3.5 % loss per month relative to 9.6 % loss per month; see Kolver *et al.*, 2000). This was associated with a greater retention of FUC (Fig 1). There was a small difference in total and alveolar FUC between the NZ and OS genotypes. However, this difference was largely attributable to the 88 kg liveweight difference between the genotypes (Kolver *et al.*, 2000).

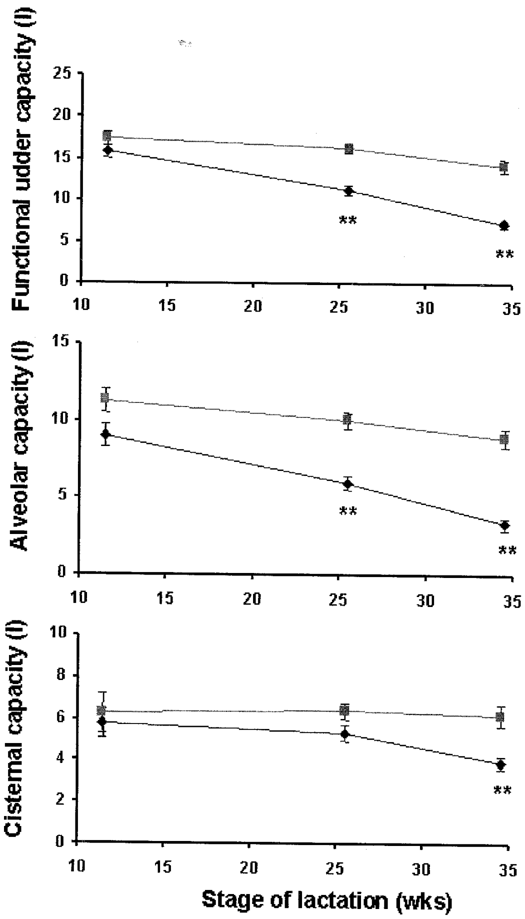
Loss of FUC following peak lactation was mostly associated with reduction in the alveolar fraction (Fig. 1). Cisternal capacity remained relatively constant throughout lactation, although a small decline was apparent in grazed animals from mid- to late-lactation (Fig. 1). Thus, loss of FUC was associated with loss of alveolar storage space and reflected loss of secretory tissue. There were no significant differences between the genotypes in the rates of loss of alveolar capacity (P>0.05) but effects of diet were significant (P<0.001).

There were no significant differences in blood concentrations of insulin between genotypes or diets. Plasma T4 concentrations were constant in grazed animals at about 50 ng/ml but increased in TMR animals in late lactation from 48 ± 2 ng/ml to 61 ± 2 ng/ml. This effect was largely due to an increase in OS animals which, on TMR, maintained a significantly higher serum T4 concentration in late lactation (67 ± 5 ng/ml; P< 0.05).

Plasma T3 concentrations were consistently higher in TMR animals at all sampling times (ave. TMR 1.84 ± 0.04 ng/ml; ave. pasture 1.38 ± 0.04 ng/ml; P< 0.01). Prolactin concentrations were similar among diets and genotypes except in February when plasma prolactin was considerably reduced in grazed animals (6.0 ± 0.7 vs 22.7 ± 1.4 ng/ml; P<0.01). Prolactin concentrations were less than 8 ng/ml in cows on both nutritional treatments at the end of lactation.

In conclusion, TMR diets maintained milk production better than did grazed pasture and this was associated with improved retention of secretory tissue in the udder. Capacity of the cisternal storage fraction remained relatively constant throughout lactation. Among hormonal correlates, T3 concentrations were enhanced by the TMR diet at all stages of lactation. The low prolactin concentrations in grazed animals in February may reflect dietary intake of endophyte-infected pasture which is known to reduce plasma prolactin concentrations (Debessai *et al.*, 1993). There was also evidence of interactions between diet and genotype in the endocrine parameters.

FIGURE 1. Changes in functional udder capacity, alveolar capacity and cisternal capacity (litres) over lactation in Friesian Holstein cows grazing pasture (◆) or fed total mixed rations (■). Significant differences are marked (✶).



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