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Effects of chromium picolinate on milk production and plasma insulin concentration in dairy cows

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ABSTRACT

Chromium picolinate (CrPic) is a biologically active molecule in which chromium is chelated to an isomer of niacin. It is claimed to reduce plasma cholesterol levels in humans, pigs and hens and to have beneficial effects on muscle and fat composition of humans, pigs and lambs. The metabolic responses recorded in lambs were similar to those observed in cows of high genetic merit for milk production, suggesting that CrPic may increase milk yields by altering aspects of glucose and insulin metabolism. The trial reported in this paper investigated the effect of supplementation with CrPic on milk yields and plasma insulin concentration in multiparous Friesian dairy cows grazing pasture. Preliminary measurements of milk yield and composition were made during a pre-treatment period of 1 week in 59 mixed-age dairy cows before separation into four treatment groups balanced for previous milksolids yield, live weight and condition. Beginning at peak lactation, groups received 0, 5, 20, or 100 mg CrPic/day administered once daily by oral drenching. Milk yields were measured and samples taken at weekly intervals for compositional analyses (fat, protein and lactose %). Blood samples were taken from the jugular at weekly intervals for insulin analysis. Chromium Picolinate had no effect on milk yield or composition. Plasma insulin concentrations did not differ between treatment groups.

Keywords: lactating dairy cows; chromium picolinate; milk yield; milk composition; insulin.

INTRODUCTION

Chromium picolinate (CrPic) is a biologically active molecule in which chromium is chelated to an isomer of nicotinic acid (niacin) that has properties similar to the naturally-occurring "glucose tolerance factor" (GTF)(Mertz, 1976), which is required for proper binding of insulin to its receptor (Evans *et al.*, 1973). In humans, CrPic is claimed to reduce plasma cholesterol levels and cardiovascular risk and to increase muscle growth in exercising individuals (Evans 1989). In growing pigs, CrPic increased carcass muscle percentage and decreased fat percentage (Page *et al.*, 1991a) and serum cholesterol concentration (Page *et al.*, 1991b). CrPic reduced serum cholesterol and increased egg production in laying hens (Page *et al.*, 1991c).

There are few reports of the effect of CrPic in ruminants. In calves, increased growth rate and decreased morbidity resulted from treatment with CrPic (Mowat *et al.*, 1992) and with a high-chromium yeast source (Moonsie-Shageer & Mowat, 1993). In New Zealand trials with growing lambs, CrPic tended to increase liveweight gain, while increasing carcass muscle and decreasing fat. Although these differences were not significant, the lambs did exhibit significant changes in insulin and glucose responses to glucose tolerance tests (Bray, 1992). Although the effect of supplementation with CrPic had not been studied in lactating animals, the metabolic responses recorded in lambs were similar to those observed in cows of high genetic merit for milk production (Xing *et al.*, 1993). Plasma insulin concentrations immediately following intravenous glucose challenge were significantly greater in high-breeding-index heifers than in low-breeding-index heifers. Thus, due to its claimed effects on glucose tolerance and tissue sensitivity to insulin, it is thought that supplementation with CrPic may increase milk yields in dairy cows. This experiment examined the effect of daily drenching with CrPic, at a range

of doses, on milk yield and composition, and on plasma insulin concentration in dairy cows.

MATERIALS AND METHODS

Animals

The trial was carried out on a group of 60 mixed-age (mean 4.3 years) Friesian dairy cows that calved in the spring and were grazed at pasture throughout the study. Preliminary measurements of condition score, milk yield and composition were made during a pre-treatment period of 2 weeks from 28 October. At the beginning of the treatment period, cows were divided into four treatment groups, balanced as much as possible for previous milksolids yield, production index (PI), live weight and condition score. One cow was diagnosed with mastitis and dropped from the trial.

Treatments

Groups were orally drenched daily for six weeks with the following doses of chromium picolinate (CrPic) in 20 ml of paraffin (pharmaceutical white oil "Whiterex 307" Mobil Oil, Wellington): Control (paraffin only; n=15), CrPic5 (5 mg, n=15), CrPic20 (20 mg; n=14), and CrPic100 (100 mg; n=15).

Sampling & measurements

Milk yields were measured and samples taken at weekly intervals for compositional analyses. Milk samples were analysed for fat, protein and lactose content using a Milkoscan 104 A/B (A/S N. Foss Electric, Denmark). The instrument was calibrated according to the manufacturer's recommendations for normal bovine milk using samples provided by the Dairy Research Institute, Palmerston North, New Zealand. Blood samples were taken via jugular venipuncture into heparinised vacutainers at weekly intervals after milking. Plasma was harvested and stored

at -20 °C until analysed for insulin.

The insulin assay was a heterologous double-antibody competitive binding radioimmunoassay based upon the method of Hales & Randle (1963). Details of the assay have been described previously (Flux *et al.*, 1984). The antisera, guinea pig anti-insulin and sheep anti-guinea pig g-globulin, were used at working dilutions of 1:25,000 and 1:40, respectively. All samples reported were assayed in a single assay. The performance details of the assay were: sensitivity 2 ng/l; intra-assay CV 11.2% (the mean CV of five reference samples with a concentration range of 13-232 ng/l).

Statistical analyses

Multivariate (repeated measures) analysis of variance was used to analyse all time-series data. Insulin data were log transformed and all milk composition data were arc sine transformed to achieve homogeneity of variance for statistical analyses. Where appropriate, pre-treatment values were used as a covariate and the model included live weight, production index, and age. Data were analysed using the computer statistical package REG (Gilmour, 1990). The test for an effect of treatment on any parameter over time was the interaction of treatment group with time.

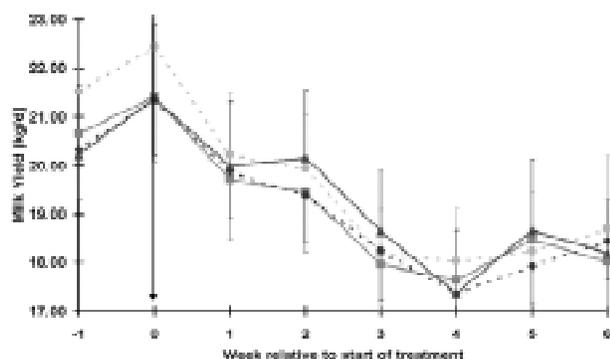
The Massey University Animal Ethics Committee approved this work. The sponsors of this research (Nufarm) were licensed by the Animal Remedies Board (License No. AO 6943) to test CrPic in 45 cows. There were no restrictions on the milk or animal products entering the food chain.

RESULTS

Milk yield

The data for milk yield during the preliminary and trial periods are presented in Figure 1. Analysis of pre-treatment data (weeks 0-1) indicated that milk yield differed significantly ($P<0.001$) between groups before treatment started, so it was necessary to include the pre-treatment milk yields in the statistical model as covariates. However, after treatment commenced (weeks 1-6), groups treated with CrPic did not differ significantly from the control group in milk yield (Figure 1). Analysis of variance revealed that live weight, production index (PI) and age all significantly ($P<0.001$) affected milk yield, so these factors were retained

FIGURE 1. Mean \pm S.E.M. daily milk yields of groups of cows drenched daily, from peak lactation (indicated by arrow), with excipient (n=15; —■—) or chromium picolinate at 5 (n=15; ---●---), 20 (n=14; —▲—) or 100 (n=15; ---◆---) mg/d



in the model. The start of treatments was well synchronised with the time of the peak in herd milk yields (11 November). Milk yield increased in all groups during the pre-treatment period and then declined steadily ($P<0.001$) in all four groups from the beginning of treatments, but there was no difference in the rate of decline between groups.

Milk composition

Analysis of pre-treatment data revealed no differences between groups in milk fat, protein or lactose yields. Milk fat yield was significantly ($P<0.001$) affected by cow age, condition score and PI and these factors were retained in the model for analysis of milk fat yield. Protein yield and lactose yield were both significantly ($P<0.001$) affected by cow age, live weight and PI and these factors were retained in the model for analysis of protein and lactose yields. Milk fat, protein and lactose yields declined ($P<0.001$) but did not differ between groups during the treatment period (Figure 2).

FIGURE 2. Mean \pm S.E.M. daily milk fat (top panel), protein (middle panel), and lactose (bottom panel) yields of groups of cows drenched daily, from peak lactation (indicated by arrow), with excipient (n=15; —■—) or chromium picolinate at 5 (n=15; ---●---), 20 (n=14; —▲—) or 100 (n=15; ---◆---) mg/d

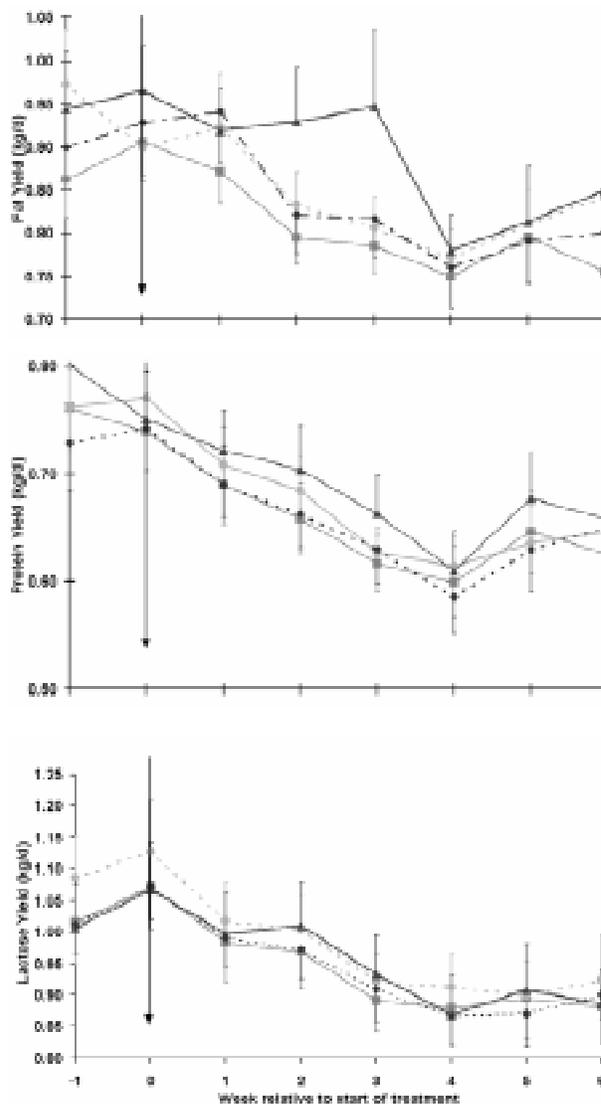


FIGURE 3. Mean \pm S.E.M. live weight (kg) of groups of cows drenched daily, from peak lactation (indicated by arrow), with excipient (n=15; —■—) or chromium picolinate at 5 (n=15; ---●---), 20 (n=14; —▲—) or 100 (n=15; ---◆---) mg/d

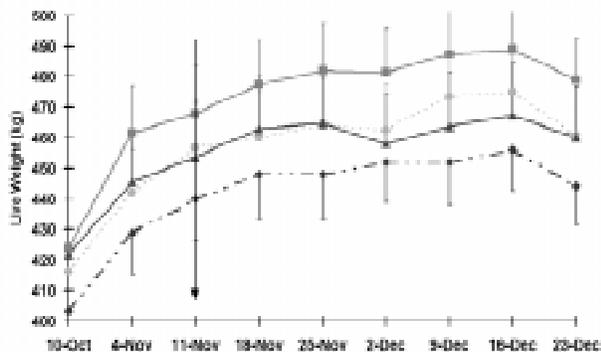
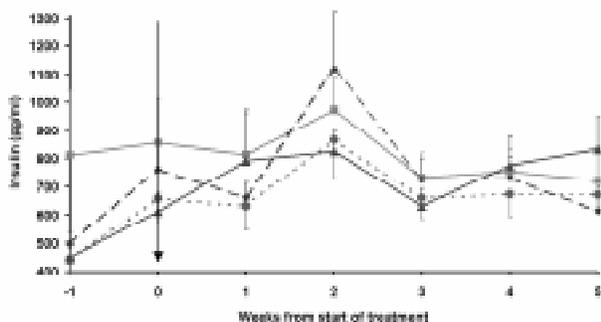


FIGURE 4. Mean \pm S.E.M. plasma insulin concentrations of groups of cows drenched daily, from peak lactation (indicated by arrow), with excipient (n=15; —■—) or chromium picolinate at 5 (n=15; ---●---), 20 (n=14; —▲—) or 100 (n=15; ---◆---) mg/d



Live weight

Despite the attempts to balance groups for live weight and other factors, groups differed ($P < 0.001$) in mean live weight when treatment commenced. Hence, live weight at the start of treatment was used in the model as a covariate for analysis of treatment effects. Age, condition score and PI were also retained in the model. Live weight increased during the pre-treatment period and continued to increase ($P < 0.001$) in all groups after commencement of treatments, but did not differ significantly between groups (Figure 4).

Insulin

Pre-treatment condition score of the cows had a significant ($P < 0.05$) effect on plasma insulin concentrations, so this factor remained in the model. Insulin concentrations (Figure 4) changed ($P < 0.001$) with time during the five weeks from commencement of CrPic treatment, but there were no significant differences between groups during that period.

DISCUSSION

CrPic was administered at a range of doses, commencing at the time of peak herd milk yield in an attempt to reduce the rate of decline in milk yields. If CrPic were to have any commercial use in increasing milk production, this seemed

the most likely time for its practical utilisation. Hormone-mediated partitioning of nutrients is responsible for meeting the increased energy demand of lactating cows (Sartin *et al.*, 1985). Differences in glucose metabolism, mediated by differences in insulin, growth hormone and glucagon, provide the metabolic environment for higher milk yields and provide a potential mechanism for manipulating lactation. Moreover, differences were reported between selection lines of dairy cattle in concentrations of blood glucose and insulin (Mackenzie *et al.*, 1988; Xing *et al.*, 1993). More recently, insulin-nutrient supply manipulation (using a hyperinsulinaemic euglycaemic clamp) has been used in concentrate-fed dairy cows to increase milk protein yield (McGuire *et al.*, 1995; Griinari *et al.*, 1997; Mackle *et al.*, 1999). Chromium may affect glucose metabolism by enhancing glucose tolerance and insulin sensitivity, leading to improved regulation of plasma glucose concentrations, and hence, increased milk yields (Back *et al.*, 1999).

However, treatment with CrPic had no significant effects on milk yield, milk composition (fat protein and lactose yields), live weight or plasma insulin concentrations during the six-week treatment period of this study. These results are supported by results published since the trial reported here was carried out (in 1993). In young steers and heifers, plasma glucose, insulin and non-esterified fatty acids (NEFA) were not affected by CrPic, although plasma cholesterol was lowered (Bunting *et al.*, 1994). Chromium supplementation (9.3 g/cow/d chromium yeast infused into the abomasum) in lactating, housed, pasture-fed New Zealand Jersey cows for six weeks during early lactation (6–12 weeks postpartum) had no effect on milk yield, plasma NEFA and 3-hydroxybutyrate concentrations. In addition, a hyperinsulinaemic euglycaemic clamp revealed no effect of chromium treatment (Back *et al.*, 1999). In contrast, North American studies, in which primiparous dairy cattle were supplemented with chromium for longer periods (16 weeks) in early lactation, have shown significant increases in milk yields and decreased concentrations of cortisol and 3-hydroxybutyrate in blood (Burton, 1995; Yang *et al.*, 1996). The earlier application and extended duration of treatment, the parity of the heifers, genotype, body condition and energy status may all be contributory sources of differences between those trials and the one reported here. Another potential source of variation between trials is that different forms of chromium supplement have differing biological activity: chromium bound to nicotinate is claimed to have a greater physiological activity than chromium picolinate or yeast-bound chromium (Mertz, 1976; Cooper, *et al.*, 1984; Bland *et al.*, 1986).

CONCLUSIONS

Research on human and animal species has shown that dietary chromium supplementation is beneficial in stressful situations such as ageing, disease and pregnancy, and some studies have shown alterations in lean or fat deposition with chromium picolinate supplementation. However, there are many instances in which there were no practically useful production responses obtained. This is likely due to differences in species, age, type of chromium supplement and the aspect of metabolism or production considered.

Nevertheless, this study indicates that chromium picolinate supplementation for six weeks does not affect productive parameters in pasture-fed lactating cows and supports the one other similar New Zealand study (reported by Back *et al.*, 1999).

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