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Metabolic homeostasis in postpartum dairy cows hampered by fatty livers

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ACCUMULATION of triacylglycerol (TAG) in the liver is a frequent occurrence in postpartum dairy cows (Jorritsma and others 2001). It has been related to decreased fertility and may cause clinical diseases in lactating and non-lactating cows and heifers (Gerlof and Herdt 1984, Andrews and others 1991, Wentink and others 1992, Jorritsma and others 2000). There are many biochemical changes that are related to or contribute to TAG accumulation in the liver, such as lowered activities of key enzymes in gluconeogenesis and lowered basal lipolytic rates (Rukkwamsuk and others 1998, 1999). However, studies on the pathogenesis of subclinical fatty liver in dairy cows have not detected lower plasma glucose and insulin concentrations (Van den Top and others 1996, Rukkwamsuk and others 1998) and the effects of the metabolic changes on, for example, fertility are not fully understood. The aim of this study was to assess the relationship between liver TAG and metabolic homeostasis.

Fifteen pregnant, multiparous Holstein-Friesian cows were included in the study, which started at six weeks before the expected calving date. All animals had free access to tap water and were individually fed the same total mixed ration throughout the experiment. The two feeding regimens differed only in the amount of feed offered, with the objective of challenging the metabolic adaptation of the cows in early lactation. Six cows were fed according to standard recommendations (CVB 2000), whereas nine cows were fed ad libitum during the dry period, fasted for eight hours immediately after parturition and fed a restricted diet for the next five days.

Blood was collected from a jugular vein in each cow five times a day (7.00, 10.00, 12.00, 22.00 and 24.00) during the first 21 days of lactation. Additionally, a liver biopsy was taken to estimate the amount of TAG produced in week 2 of lactation, using methods previously described by Van den Top and others (1995). Liver TAG content was calculated in mg/g wet liver tissue. All blood analyses were performed using commercially available kits (CX5; Beckman Instruments, NEFA C; Instruchemie BV, Coat-a-Count; TKIN). Liver biopsies were analysed as described by Van den Top and others (1995) using a commercial kit (337-A; Sigma Chemical). The mean and 95 per cent range of concentrations of plasma glucose, non-esterified fatty acids (NEFAs) and insulin during the first 21 days postpartum were compared with the level of TAG in the liver using linear models. Data were checked for normality before analysis.

None of the cows had any serious clinical problem during the study period. Mean (sd) concentrations during the first 21 days after parturition were 2·69 (0·45) mmol/litre for

TABLE 1: Relationships between the mean concentrations of glucose, non-esterified fatty acids (NEFAs) and insulin during the first 21 days of lactation with the level of triacylglycerol (TAG) in the second week of lactation using linear models

	β	P	R^2
Mean glucose (mmol/litre)	−190	0·01	0·41
Mean NEFAs (mmol/litre)	213	<0·001	0·70
Mean insulin (μU/ml)	2·71	0·89	0·001

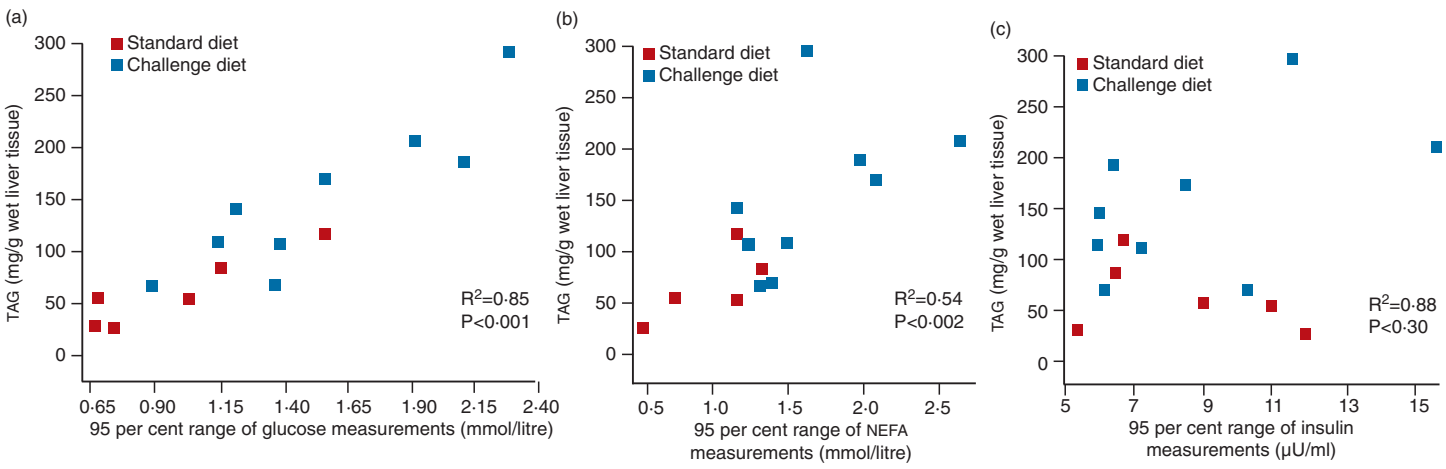

FIG 1: Relationship between the amount of triacylglycerol (TAG) in the liver two weeks after parturition and the 95 per cent range of the (a) glucose, (b) non-esterified fatty acids (NEFAs) and (c) insulin measurements for that cow during the first 21 days postpartum

glucose, 0·76 (0·48) mmol/litre for NEFAs and 2·89 (2·51) μU/ml for insulin. Treatment effects were detected for the mean concentration of NEFAs (P=0·0003), the 95 per cent range of glucose (P=0·01) and the 95 per cent range of NEFAs (P=0·004). There was no association between the 95 per cent range of glucose and the 95 per cent range of insulin (R^2=0·26, P=0·55). The relationships between the liver TAG content and plasma concentrations of glucose, NEFAs and insulin are shown in Table 1 and Fig 1.

The results of this study indicate that lower mean plasma glucose and higher mean plasma NEFA concentrations were closely related to the amount of TAG in the liver (R^2=0·41 and 0·70, respectively). Moreover, cows with higher TAG levels were characterised by increased variation in the concentrations of glucose and NEFAs. In contrast, neither the mean nor the 95 per cent range of concentrations of insulin were associated with the liver TAG level. Fluctuations in glucose concentrations were not likely to be caused by fluctuations in insulin concentrations. Consequently, it could be concluded that cows with increased levels of TAG in the liver would be less capable of maintaining concentrations of glucose and NEFAs within a small margin.

The present study also showed that insulin loses its regulatory control on the glucose concentration and the accumulation of TAG in the liver of the early lactating cow. These findings might be used to explain increased susceptibility to metabolic diseases and reduced fertility in cows during negative energy balance; for example, adverse metabolic conditions may affect folliculogenesis (Britt 1992). Further research is needed to examine whether the observed conditions have these effects.

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