Acta Veterinaria Hungarica 43 (1), pp. 173–177 (1995)

EFFECT OF SEVERE ENERGY RESTRICTION AND REFEEDING ON THYROID HORMONES IN BULLS

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(Received May 20, 1994)

Fifty-three Holstein-Friesian breeding bulls (944.99 ± 14.59 kg) were fasted for 4 weeks. The influence of feeding on thyroid hormones was studied by comparing a starting point with a 4-week fasting period and a refeeding period. Blood samples were taken via a jugular vein catheter at 8:00 a.m. one day before, then once every week during, and two times after the fasting period. Plasma thyroxine (T_4) and triiodothyronine (T_3) levels were determined by direct radioimmuno-assay. The concentration of T_4 and T_3 decreased during fasting. The concentration of T_3 increased after refeeding, but that of T_4 did not. These data suggest that fasting is associated with a decrease in the peripheral conversion of T_4 to T_3 and, consequently, less T_4 is converted into T_3.

Key words: Bull, fasting, refeeding, serum thyroxine, triiodothyronine

Thyroid hormones play an important role in metabolic processes. The interaction between thyroid hormones and energy intake in bulls is of interest. Previous experiments have shown a marked decrease in the plasma concentration of triiodothyronine in mammals during starvation (Pethes et al., 1985). In chickens, it is evident that feed restriction lowers the concentration of circulating triiodothyronine probably by inhibiting the activity of liver deiodinase, and also decreases the sensivity of the pituitary–thyroid axis (Bartha et al., 1989). The secretion of hormones from the thyroid gland was strongly reduced during starvation in bulls (Tveit and Almida, 1980). Tveit and Larsen (1983) reported that the secretion of hormones is nearly stopped during starvation in bull calves.

In the present experiment the influence of feeding on thyroid hormones was studied by comparing a starting point with a 4-week fasting period and a refeeding period.

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Materials and methods

Fifty-three Holstein-Friesian breeding bulls were used in the experiment. The following procedure was applied:

(1) Fasting: (1/a) on day 1, introductory phase with 10% experimental diet (see later) + 90% original (see later). (1/b) adaptation on days 2–4: 30–80% of experimental diet. (1/c) from day 5 for 4 weeks: 100% of experimental diet. (2) Refeeding: without adjustment period.

Apart from the diets the bulls were fed high-quality barley straw *ad libitum*. The experimental diet contained 3.9 MJ NEm and 216 g crude protein. This resulted in very low undernutrition. The nutrients of barley straw fed *ad libitum* did not disturb starvation.

Blood samples were taken via a jugular vein catheter at 8:00 a.m. one day before, then once every week during, and twice after the fasting period into heparinized tubes. The blood samples were cooled down immediately after collection in the laboratory they were centrifuged at 3000 rpm to harvest the plasma, which was then frozen at –20 °C. The plasma thyroxine and triiodothyronine levels were determined by direct radioimmunoassay (Pethes et al., 1978).

Results

Table 1 shows the mean T_4 and T_3 values of all the animals during the control, fasting and refeeding periods.

Table 1

Concentration of thyroxine (T_4) and triiodothyronine (T_3) in the blood serum of breeding bulls before, during and after feed restriction (ng/ml)

T_4	121.14	110.6	92.1	76.94	82.015	81.19	73.9
SEM	6.85	6.03	4.23	3.69	4.63	3.46	3.37
n	52	52	53	52	53	52	53
T_3	0.29	0.27	0.21	0.21	0.26	0.38	0.62
SEM	0.02	0.024	0.08	0.08	0.02	0.04	0.04
n	53	53	53	53	53	53	53

As shown in Table 1 and Figs 1 and 2, the concentration of T_4 and T_3 decreased during fasting and T_3 increased after refeeding. No increase in T_4 was demonstrable after refeeding as shown in Fig. 1.

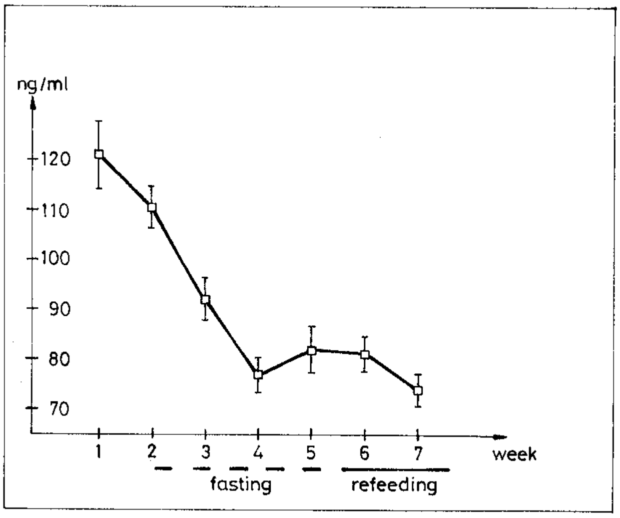

Fig. 1. Serum T_4 concentration of bulls before, during and after feed restriction

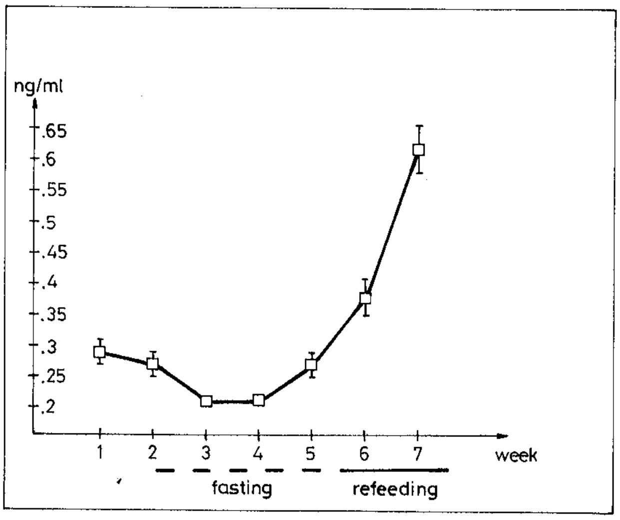

Fig. 2. Serum T_3 concentration of bulls before, during and after feed restriction

Discussion

Thyroid gland function and thyroid metabolism are under the influence of several physiological and environmental factors. Our results indicate that the concentration of T_4 and T_3 decreased during fasting. Fasting ruminants are characterized metabolically by hypoglycaemia, hyperketonaemia (Emmanuel and Kennelly, 1984) and hyperlipidaemia (DiMarco et al., 1981). The response of thyroid economy to fasting depends on several factors. It should be noted that the serum concentration of a particular iodinated compound depends not only upon its production but also upon its affinity to carrier proteins, its tissue distribution, its rate of degradation and, finally, its clearance. It is well known that humans survive prolonged fasting by using stored fat as a source of energy.The key hormones responsible for the ability to shift to fat as a source of energy are epinephrine and the thyroid hormones. More than 30% of the extrathyroidal body pool of T_3 is derived from the peripheral monodeiodination of T_4 (Sterling et al., 1970). In the centre of this mechanism stands the deiodinase enzyme that can convert thyroxine produced by the thyroid gland either to active triiodothyronine or to inactive reverse-triiodothyronine, depending on the actual needs of the organism (Silva and Larsen, 1985). The results of Kahl et al. (1984) show the presence of a very active enzymatic system responsible for the peripheral 5'-monodeiodination of T_4 to T_3 in cattle. Among a series of factors that might influence this system is the availability of energy equivalents to the cells. Therefore the response of thyroid hormone metabolism to fasting may assume the form of changes in the secretion rate of the central thyroid product (T_4 and T_3) or alteration of the peripheral deiodination of T_4 or of the utilization of T_3 on cellular level. In accordance with the findings of Blum et al. (1985), our results show that in reduced food intake the concentrations of T_4 and T_3 are reduced. Caloric deprivation in sheep also led to decreased T_3 levels and overnutrition to increased T_3 (Blum et al., 1980). During the 4-week fasting used in this experiment the concentration of T_4 decreased at a rate of 50–70%, indicating that little T_4 secretion was taking place. T_3 also decreased after fasting. As a portion of T_3 is produced in the thyroid gland, our results may suggest that the secretion of hormones from the thyroid gland is decreased during starvation. As about 70% of T_3 is known to derive from T_4 in the peripheral tissues, we can also suppose that deiodinase activity almost completely ceases after fasting. Liver deiodination activity is the first to react to energy restriction (Bartha, 1993). After a certain period of time the activity of the enzyme returns to normal. Since blood was taken one week after the beginning of restricted feeding, deiodinase activity may be assumed to have returned to the normal level.

Refeeding caused a rapid increase in T_3, but the concentration of T_4 did not change. This is contrary to results from young bulls in which refeeding caused a rapid increase in T_3 and T_4 (Tveit and Larsen, 1983). A possible explanation for this is the higher activity of deiodinase enzyme, which converts more T_4 to T_3. Consequently the concentration of T3 rose and that of T_4 remained unchanged. Blum et al. (1985) also reported that in steers the concentration of T_4 and T_3 increased within days in response to refeeding. According to Rudas and Newcomer (1987), food intake in fasted animals causes a prompt release of enteroglucagon which stimulates insulin secretion even above the fasting level. This might directly or indirectly increase the activation of thyroid hormones which then assists in raising the energy yield from the substrates available for the cells.

We can conclude from these studies that fasting decreases the serum concentration of T_4 and T_3 as it is associated with a decrease in the peripheral conversion of T_4 to T_3 and, consequently, less T_4 is converted into T_3. The concentration of T_3 increased after refeeding but there was no change in T_4 concentration.

Acknowledgements

We would like to express our gratitude Mrs. Elisabeth Kraiss for her expert technical assistance and to Mrs. Mária Nádas for her excellent help. This work was supported in part by a grant from the National Research Fund of Hungary (OTKA), no. 2429 and no. 1259.

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