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Effect of energy restriction and dietary protein level during the re-alimentation period on feed efficiency in double-muscled Belgian Blue cows

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ABSTRACT

Two experiments were conducted to determine the effect of an energy restriction (80% (ER) *vs.* 100% (CON) of total energy requirements; 140 d: P1) followed by a re-alimentation (*ad libitum* intake; 70 d; P2) on feed intake, body weight (BW) change, and feed efficiency in double-muscled Belgian Blue cows. Regression analysis based on feed intake and BW change during P1 was used to deduce energy requirements for maintenance by setting BW change to zero. The diet consisted of maize silage and 0.5 kg mineral–vitamin premix in experiment 1, where dietary crude protein (CP) concentration was constant (105 g/kg dry matter (DM)) during the whole experiment. A similar diet was fed during the restriction period in experiment 2 with 97 g CP/kg DM. Extra soybean meal and urea were fed to all cows during the re-alimentation period of experiment 2, resulting in 198 g CP/kg DM. Both experiments showed that BW loss of ER cows during P1 was not compensated during P2, so that BW gain of ER cows during the entire experiment remained lower compared to CON cows ($P<0.05$). Similar results were obtained for feed intake. Feed conversion ratio was not different between treatments during P2, but it tended to be worse for ER cows *vs.* CON cows for the entire experiment ($P<0.10$). Extra dietary crude protein during P2 in experiment 2 did not modify the effect of treatment on animal performance compared to experiment 1. Therefore, feeding double-muscled Belgian Blue cows below their energy requirements for maintenance, and growth in case of first and second-calf cows should be strongly discouraged. Metabolisable and net energy requirements for maintenance were estimated at 0.586 MJ and 0.338 MJ/kg $BW^{0.75}$, respectively.

1. Introduction

Forage quantity may decrease in autumn and low-quality feeds are often fed to beef cows during winter, which may lead to a temporary undernutrition. It has been assumed that beef cows can efficiently mobilise body tissue reserves when their nutrient requirements are not met. Body tissue reserves are restored during periods with an abundant feed supply, as prevails early in the grazing period (Petit et al., 1992). Previous experiments showed that an energy level of 80% of the requirements for maintenance in double-muscled Belgian Blue (DMBB) cows during a 140-d indoor period, followed by a re-alimentation on pasture, did not adversely affect overall animal performance (Fiems et al., 2009). Freetly and Nienaber (1998) showed that mature MARC III composite beef cows fed subsequently at 65% and 135% of the intake of cows with a fixed feed intake, and a similar total mean

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nutrient intake (100%), used nutrients more efficiently. On the other hand, experiments with growing steers, subjected to a period of feed restriction (Hays et al., 1995), showed an enhanced BW (body weight) gain due to an increased concentration of dietary protein during the initial phase of the re-alimentation period compared to lower dietary protein concentrations. DMBB cows are markedly leaner than cows of most other breeds, so that mobilisation and restoration of body tissue reserves may be different due to low adipose tissue reserves. Furthermore, DMBB cows have shown to mobilise protein during a restriction period (Fiems et al., 2007), so that extra protein may be required to compensate the BW loss. Vermorel et al. (1976) reported a detrimental effect on feed efficiency when feed was restricted up to 75% of ad lib intake in double-muscled Charolais bulls. However, cows may differ from growing bulls because of their advanced development, whereas growth retardation due to a feed restriction in growing bulls takes place earlier in life.

Another aspect of energy efficiency is the energy expenditure for maintenance. It may be affected by the low body fat compartment and the large muscle mass in double-muscled animals. Adipose tissue contributes little to the metabolic rate, while lean tissue is much more metabolically active, resulting in higher maintenance requirements (Ferrell and Jenkins, 1985). However, double-muscled animals are characterised by a higher frequency of fast glycolytic muscle fibres (Fiems, 2012). These fibres have a lower protein turnover than slow oxidative fibres, with a lower net energy cost for protein remodelling (Bergen, 2008), which would suggest a lower maintenance requirement.

The aim of the present experiments was to investigate the effect of a feed restriction on feed efficiency during a subsequent re-alimentation period as well as during the combined periods. The two experiments differed by the protein supply during the re-alimentation phase and by the housing of the animals. Furthermore, the energy cost for weight equilibrium (*i.e.* maintenance) was estimated from these experiments. Energy requirements for maintenance can be defined as the amount of energy intake resulting in no loss or gain of body energy reserves (Ferrell and Jenkins, 1984; DiCostanzo et al., 1990).

2. Material and methods

2.1. Animals and housing

Two separate experiments, lasting 210 d each and involving 12 and 28 different non-pregnant dry DMBB cows, respectively, were conducted during 2006 (Exp. 1) and 2008 and 2009 (Exp. 2, $N=18$ and 10, respectively). Experiments started 81.4 ± 64.2 (Exp. 1) and 116.5 ± 82.6 (Exp. 2) days after parturition, respectively. Cows did not nurse their calves in experiment 1, whereas only 6 cows were suckled in experiment 2. For these cows, calf weaning occurred at 91.7 ± 12.0 d prior to the start of the experiment. Cows were grazing on pasture in similar conditions without supplementation before the start of both experiments. They were further used for breeding at the end of the experiments, unless they were finished for slaughter for reasons of a lack of pregnancy within 5 months postpartum at the onset of the experiments, or perimetrial adhesions as a consequence of caesarean section. Initial age and BW amounted to (mean ± SD) 1153 ± 476 and 1444 ± 509 d, and 590 ± 101 and 656 ± 97 kg, respectively. Within each experiment cows were divided into two similar treatment groups based on initial BW, age, body condition and parity. The effect of a similar energy restriction on feed intake and efficiency was investigated in the two experiments, but with a different protein supply during the re-alimentation period. For both experiments, two energy levels were studied during the first phase (P1, restriction period; 140 d): 100% (Control, CON) and 80% (Energy Restriction, ER) of total requirements for maintenance increased with a supply for growth in first and second-calf cows, applied for dairy cattle (CVB, 1998). An energy restriction of 20% below the requirements was chosen, because a more severe restriction of DMBB cows increased calf mortality (Fiems et al., 2009). Protein requirements (CVB, 1998) were always fulfilled. Cows were fed *ad libitum* during P2 (re-alimentation period, 70 d). A constant dietary crude protein (CP) concentration was fed in experiment 1 (105 g/kg dry matter (DM)), whereas dietary CP increased from 97 g during P1 to 198 g/kg DM during P2 in experiment 2. In experiment 1, an appropriate amount of maize silage, supplemented with 0.5 kg/d of a vitamin-mineral premix was fed during P1 to realise the proposed energy restriction. During P2 maize silage was fed *ad libitum*. Urea was individually fed during both periods, and top-dressed over the maize silage. The daily amount was calculated so that dietary rumen degradable protein balance (OEB; Tamminga et al., 1994) was close to 0 g/d. In experiment 2 the diet fed during P1 was similar to the diet fed in experiment 1. Extra soybean meal and urea were supplied during P2 to increase dietary protein to 84 g truly absorbed protein in the small intestine (DVE; Tamminga et al., 1994) and 60 g OEB/kg DM, corresponding to the protein values in grass in spring. Maize silage, soybean meal and urea were mixed in a mixer wagon. Furthermore, confinement was also different, with tie stalls in experiment 1, whereas cows were only kept in tie stalls during P1, and individually housed in pens of 3.5×2.5 m^2 during P2 in experiment 2. Wood shavings and straw were used as bedding materials during P1 and P2, respectively, in both experiments. Cows were weighed at 5-week intervals. They were weighed on two subsequent days at the start and the end of the experiment and at days 139 and 140. Body condition score (BCS) was determined at the start and the end of each sub-period as described by Agabriel et al. (1986). Drinking water was always freely available in both experiments.

The use of a different dietary protein level in the two experiments was based on the following considerations. A similar diet was fed at a fixed intake level or at a variable intake level in experiments of Freetly and Nienaber (1998), so that the total amount of nutrients offered during the entire experiment was the same for each treatment. Our experiment 1 was different from that of Freetly and Nienaber (1998), because cows were fed *ad libitum* during the re-alimentation period. The abundant feed supply during the re-alimentation period, as prevails early in the grazing period, is a requisite to restore body reserves after a period with feed restriction. However, cows grazing a green lush pasture are consuming a feed with higher protein values (higher DVE and OEB-values)