Do serum IGF-I and leptin concentrations monitor growth rate and muscle composition in yearling bulls?

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Abstract

Three fattening strategies were tested in 21 autumn-born Parda de Montaña male calves from weaning (224 kg) to slaughter at 450 kg. One group of calves were concentrate-fed until slaughter (CON), another group of calves rotationally grazed in lucerne paddocks supplemented with 1.8 kg DM/d barley until slaughter (LUC), and the third group of calves had the same management as LUC calves for 3 months (Period 1) and were finished on concentrates until they reached the slaughter weight (Period 2). During Period 1, CON calves presented slightly greater weight gains than their grazing counterparts ($P < 0.10$), while during Period 2, LUC calves had the lowest ADG, CON calves intermediate and LUC+CON calves the greatest. Overall weight gains were greater for LUC+CON, intermediate for CON and the lowest for LUC calves. During Period 1, IGF-I and leptin concentrations were greater in CON calves than in their grazing counterparts ($P < 0.05$). During Period 2, IGF-I and leptin concentrations increased in all fattening strategies, and LUC+CON calves presented the greatest increases in the concentration of both hormones. Finally, serum IGF-I and leptin concentrations were related to live weight but not with weight gains. Moreover, only serum leptin at slaughter was related with intramuscular fat content.

Keywords: calves, IGF-I, leptin, growth, intramuscular fat

Introduction

Changes in the nutritional status are accompanied by changes in the concentrations of blood metabolites and hormones such as IGF-I and leptin (Lee et al., 2006), which in turn play important roles in metabolic adaptation of cattle to changes in weight and body condition (Leon et al., 2004). Monitoring these changes may provide valuable information about metabolic status and its relationship with performance at key moments of the production cycle.

Therefore, the aim of this study was to study the feasibility of using IGF-I and leptin concentration to monitor growth and development of calves under different fattening strategies.

Material and Methods

Twenty-one 5-month old Parda de Montaña purebred male calves were blocked by live weight (LW) after weaning and randomly assigned to one of three fattening strategies. A group of calves (CON) was fed a commercial feeding program, with concentrates (from 227 to 350 kg concentrate A, 11.5 MJ ME, 14.9% CP; from 350 to 450 kg concentrate B, 11.7 MJ ME, 13.7% CP) and straw on ad libitum basis until slaughter at 450 kg. A second group of calves (LUC) grazed in a 0.9-ha lucerne plot and were supplemented daily with 1.8 kg DM barley per calf until slaughter. The third group of calves (LUC+CON) had the same management as LUC calves for three months in a 0.9-ha lucerne plot

(Period 1), and thereafter they were fed concentrates for two months on ad libitum basis until they reached slaughter weight (Period 2).

Individual LW was obtained weekly, and these weights were used to calculate overall average daily gain (ADG) by linear regression of LW on date and ADG for Period 1 and Period 2. Concentrate intake was recorded daily on a group basis. Lucerne mass in each paddock was measured before (pre-grazing) and after grazing (post-grazing).

Calves were bled monthly at 8.00 a.m. by caudal venipuncture. Samples for IGF-I and leptin concentrations were collected in test tubes with no anti-coagulant to obtain serum, they were allowed to clot for 24 h and stored in aliquots before the serum was frozen at –20 ºC. Circulating IGF-I concentrations were quantified using a commercial EIA kit (OCTEIA® IGF-I, IDS, Boldon, U.K.), and intra- and inter-assay coefficients of variation were 3.4% and 6.2%, respectively. Serum leptin concentrations were determined using a competitive EIA for leptin in domestic animals (Sauerwein et al., 2004) with 6.6% and 11.5% intra- and inter-assay coefficients of variation, respectively.

When calves reached 450 kg LW, they were transported to a commercial abattoir (MercaZaragoza, Zaragoza, Spain) 6 km from the Research Centre. Calves were slaughtered immediately after to minimise pre-slaughter stress. They were stunned by captive bolt pistol and dressed according to standard commercial practices. A steak from the loin of each calf was sliced, minced and ground to determine using the Ankom Procedure (AOCS Am 5-04) with an Ankom extractor the intramuscular fat content.

Statistical analyses were performed with SAS v.9.1. (SAS Inst. Inc., Cary, NC, USA). Live weight and the concentrations of IGF-I and leptin were analysed using mixed models for repeated measures including feeding strategy, time and their interaction as fixed effects, and animal as the random effect. Weight gains and intramuscular fat content were tested by Analysis of Variance using the GLM procedure with feeding strategy as fixed effect. Least square means (LS Means) were estimated and differences between LS Means were tested using a t-test. Pearson's correlation coefficients between variables were calculated. For all tests, the level of significance was set at 0.05.

Results and Discussion

During Period 1 weight gains were only slightly greater for CON calves (1.524 kg/d) than for their grazing counterparts (1.332 and 1.325 kg/d, for LUC and LUC+CON calves respectively; s.e. = 0.1211, $P = 0.10$). During Period 2, LUC calves had the lowest weight gains, CON calves intermediate and LUC+CON calves the greatest (1.308, 1.529 and 2.017 kg/d respectively; s.e. = 0.1414, $P < 0.001$). Overall ADG was greatest for LUC+CON calves, intermediate for CON calves and lowest for LUC calves (1.576, 1.517 and 1.359 kg/d respectively; s.e. = 0.0785, $P < 0.01$).

Overall weight gains of CON calves were only 12% greater than those of LUC calves. On the one hand, LUC calves had a remarkable performance compared with data of other studies with steers and heifers grazing in lucerne at similar stocking rates (Schlegel et al., 2000; Lauriault et al., 2005), only McCaughey and Cliplef (1996) reported similar weight gains. In fact, the cattle in the abovementioned studies received no supplementation during grazing, which improves weight gains (Drouillard and Khul, 1999). Weight gains of calves that had been grazing increased when they were concentrate-fed, as Schlegel et al. (2000) reported in steers, although the magnitude of the increment

varies among studies depending on the severity and duration of the restriction and the type of feed given during realimentation (Drouillard and Kuhl, 1999; Hornick et al., 2000). The restriction of LUC+CON calves during Period 1 could be considered mild as their weight gains compared with those of CON calves were only slightly lower and the concentrations of IGF-I and leptin remained steady. During Period 2, weight gains of compensating calves were greater than 2 kg/d, which contradicts the general theory that the rate of compensation increases with the severity of the restriction (Berge, 1991). In contrast, Drouillard and Khul (1999) concluded that not severely restricted cattle, grown in high quality roughages, showed compensatory growth during the feedlot phase. During Period 2, LUC+CON calves increased their feed intake but not their feed conversion efficiency, which agreed with Hornick et al. (2000), who stated that compensation results mainly from increased feed intake. Other studies reported that compensating calves also had greater feed efficiency than continuously-grown counterparts (for review see Berge, 1991; Hoch et al., 2003), which did not occur in the current study.

Serum IGF-I concentrations of CON calves were greater than those of their grazing counterparts throughout Period 1 (Figure 1), reflecting the greater energy content of the concentrates compared with supplemented fresh lucerne. Concerning Period 2, IGF-I concentrations of LUC+CON calves doubled after the first month on concentrates and reached their maximum the following month. Moreover, in that moment, IGF-I concentrations of LUC+CON calves were greater than those of LUC calves, and CON calves had intermediate concentrations ($P < 0.05$).

In ruminants, differences in nutritional levels modify hormonal concentrations (Elsasser et al., 1989; Hoch et al., 2003). The differences appeared are related to the energy content of the diets (see Hornick et al., 2000) persisted until the end of Period 1. In fact, serum IGF-I concentrations of LUC+CON calves increased up to similar concentrations of CON calves after some days on concentrates, reaching their peak after 2-3 weeks after the start of the finishing period and showing a plateau thereafter. Similar results have been previously reported in several studies (Ellenberger et al., 1989; Hornick et al., 2000). It has been observed that calves showing compensatory growth had greater IGF-I concentrations than continuously grown calves (Ellenberger et al., 1989; Hornick et al., 1998), as in had been observed herein.

In the current study, serum IGF-I concentration and LW were closely correlated ($r = 0.65$, $P < 0.0001$), as other studies had already reported (Hornick et al., 1998; Cabaraux et al., 2003). However, the clear correlation between IGF-I concentrations and long- or short-term ADG observed in the abovementioned studies was not evident in the current study, as other studies had reported (Ronge and Blum, 1989; McKinnon et al., 1993).

Leptin concentration of grazing calves remained steady throughout Period 1 (Figure 1), whereas it increased in CON calves from the second month onwards. As a result, leptin concentrations of CON calves were on average 35% greater at the end of Period 1 than those of their grazing counterparts ($P < 0.05$). In Period 2, leptin concentration of CON and LUC+CON calves was similar after the first month of concentrate feeding of the latter ($P = 0.19$). Serum leptin concentration of all fattening strategies increased until the end of Period 2. Overall increase during Period 2 was

greater for LUC+CON calves (83%) than for LUC calves and CON calves, which had similar increases (24 and 20%, respectively).

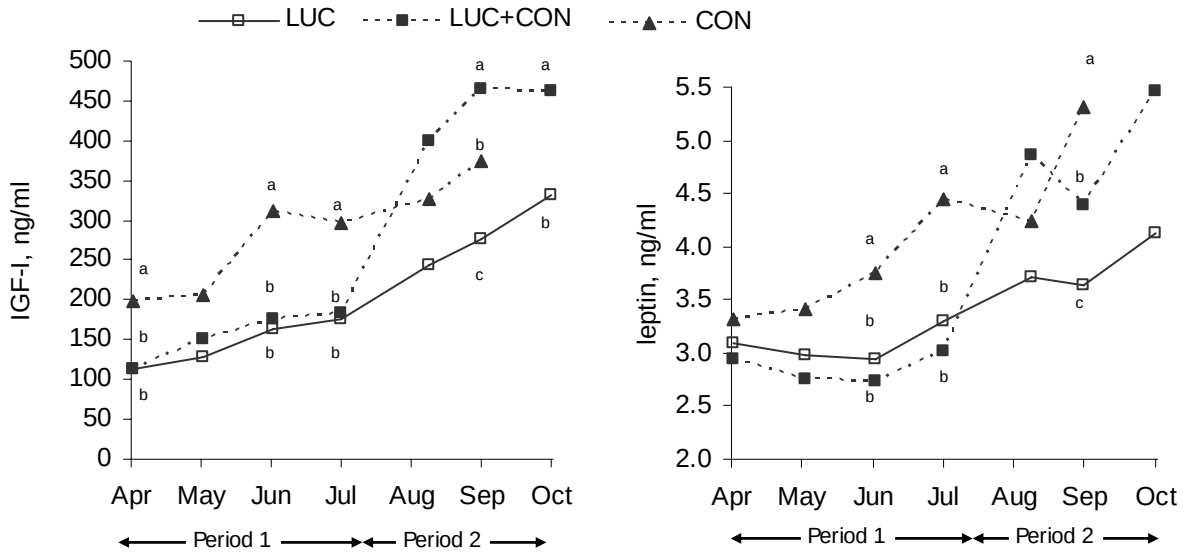

Figure 1. Evolution of serum IGF-I and leptin concentrations according to fattening strategy. Within a date, means with different letter differ at $P < 0.05$

Grazing calves had lower plasma leptin concentration than CON calves during Period 1 because leptin is highly sensitive to feeding level and reflects primarily differences in body fatness (Chilliard et al., 2005). The increases in leptin concentrations with concentrate feeding appeared after 55 days in CON calves and after 18 days in LUC+CON calves. This difference in the response of leptin to concentrate feeding might be explained by the difference in concentrate intake (Reist et al., 2003), as CON calves had lower concentrate intake in Period 1 (57.2 g DM/kg $LW^{0.75}$) than LUC+CON calves in Period 2 (92.5 g DM/kg $LW^{0.75}$). Other studies reported rapid increases in serum leptin concentrations with refeeding (Chilliard et al., 1999).

Serum leptin was correlated with LW (r = 0.41, $P < 0.001$) as other studies already reported in growing bulls (Geary et al., 2003; Bellmann et al., 2004). Furthermore, the aforementioned studies reported positive correlations between serum leptin and different fat deposits (Geary et al., 2003; Bellmann et al., 2004), which also appeared in the current study with a correlation between serum leptin at slaughter and intramuscular fat content (r = 0.70, $P < 0.001$).

Consequently, serum IGF-I and leptin concentrations reflect the nutritional status but are not able to predict in the medium- or long-term calf's growth rate.

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Changes in IGF-I and leptin concentrations caused by different nutrition levels may provide valuable information about metabolic status and its relationship with performance at key moments of the production cycle.

Is it feasible to use serum IGF-I and leptin concentrations to monitor growth and development of calves under different fattening strategies?

Materials and Methods

Three fattening strategies (n = 21) from 224 kg until slaughter (450 kg)

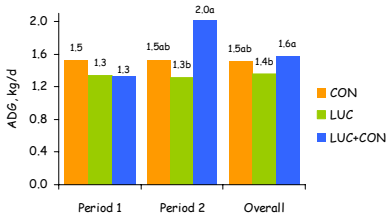
	Apr	May	Jun	Jul	Aug	Sep	Oct
CON	Ad libitum concentrates + straw						
LUC	Rotationally grazed lucerne + 1.8 kg DM barley/day						
LUC+CON	Period 1: Rotationally grazed lucerne + 1.8 kg DM barley/day				Period 2: Ad libitum concentrates + straw		

Parda de Montaña calves

- Weekly weights ➡ monthly average daily gain (ADG)
- Monthly blood samples to obtain serum to determine:
  - IGF-I concentration with a commercial kit
  - leptin concentration with a competitive multispecies EIA
- A steak from L. thoracis muscle for intramuscular (IM) fat quantification with an Ankom extractor

Results

Weight gains

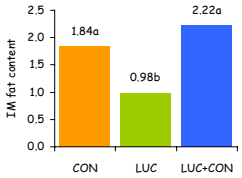


-Period 1: CON calves slightly greater ADG

-Period 2: **LUC+CON** calves had the **greatest ADG**

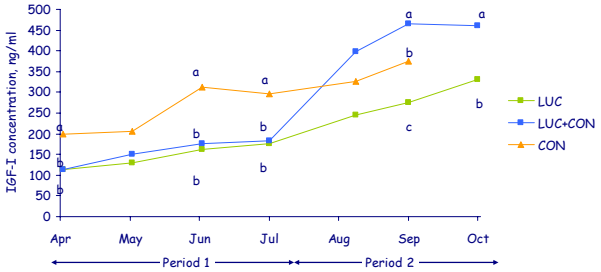
-Overall: **LUC+CON** calves had **greater ADG** than LUC calves, CON calves had intermediate ADG

IM fat

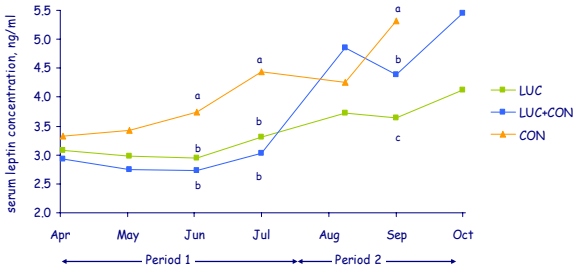


CON and **LUC+CON** calves had **greater IM fat** than LUC calves

IGF-1 concentrations



Leptin concentrations



-Period 1: **CON** calves had **greater IGF-I** and **leptin** concentrations than LUC and LUC+CON

-Period 2: IGF-I and leptin concentrations increased in the 3 fattening strategies. **LUC+CON** calves had the **greatest increases** in both hormones

Correlations

- Live weight was correlated with IGF-I (r = 0.65***) and leptin concentrations (r = 0.41***)
- IGF-I concentration was correlated with ADG in the previous and following month (from r = 0.45* to r = 0.74***) but not in the medium- or long-term
- Only leptin at slaughter was strongly correlated with IM fat (r = 0.70***)

In conclusion, IGF-I and leptin concentrations reflect the current nutritional status but are not useful to predict in the medium or long-term calf's growth rate and intramuscular fat content

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