51st International Congress of Meat Science and Technology
August 7-12, 2005 – Baltimore, Maryland USA

PREDICTIVE VALUE OF METABOLIC HORMONE CONCENTRATIONS ASSESSED IN BEEF CALVES WEANED AT TWO DIFFERENT AGES ON FINAL CARCASS QUALITY PARAMETERS

Denise L. Meyer,* Eric P. Berg, Monty S. Kerley, Wolfgang Pittroff‡
and Duane H. Keisler

University of Missouri—Columbia†, Columbia, Missouri, USA
‡University of California—Davis, Davis, California, USA

Key Words: leptin, IGF-1, growth hormone, insulin, carcass composition

Introduction

From a physiological perspective, the endocrine response of an animal may be viewed as a dynamic indicator of the interactive components of an animal's genetic capability in a given environment. We assert that if accurate predictions could be made at weaning or even 30 d prior to slaughter, by using physiological profiling in conjunction with a modeling system, producers would have more insight on individual animal needs. This has potential to maximize growth and development, thus allowing the producer to maximize their profit when the cattle are marketed.

The following study examines the possibility of incorporating four important metabolic hormones into such a system and their potential to predict end carcass United States (US) quality grade at the time of weaning. Leptin, insulin, insulin-like growth factor-1 (IGF-1), and growth hormone (GH) are all major determinants of protein and fat deposition in growing cattle. More specifically, leptin is a protein hormone produced by adipocytes and is transported to receptors located throughout the body (Houseknecht et al., 1998). In livestock, focus has been given to leptin for its ability to predict body fat mass. As livestock gain weight, and specifically fat mass, leptin levels increase in association with increased size and numbers of adipocytes. As a result of increased leptin levels, feed intake decreases (Friedman, 1998). Recent studies have focused on serum leptin levels and carcass composition of mature cattle at harvest (Geary et al., 2003; Buchanan et al., 2002; Wegner et al., 2001). These same studies found correlations between serum leptin levels and different fat depots (ex. Intramuscular, intermuscular fat) at the time of slaughter.

Insulin, like leptin, is a lipogenic hormone (Roemmich and Rogol, 1999), thus expectations are that that a positive relationship would exist between serum insulin and body fat mass. Furthermore, insulin has been reported to stimulate leptin secretion (Houseknecht et al., 1998); thus leptin and insulin levels are expected to correlate well.

In contrast to leptin and insulin, GH plays a critical role in repartitioning nutrients from fat depots to increase protein accretion, especially in the earlier stages of growth. The influence of GH asserts itself soon after birth of the neonate and directly or indirectly influences the rate of cell multiplication and differentiation in several tissues and organs throughout the body. This cell growth continues up until sexual maturity when GH levels decrease (Isaksson et al., 1985). Although earlier studies using GH levels alone to predict end carcass measurements were unsuccessful, using GH levels in conjunction with other developmental hormones in a model to predict final carcass measurements may prove to be a more feasible option (Connor et al., 1999; Connor et al., 2000).

In addition to GH, IGF-1 is also known to affect body composition (Maccario et al., 2000), as IGF-1 is regulated by GH. IGF-1 levels have been reported to increase congruent with protein accretion in cattle. By analyzing serum IGF-1, GH, and insulin concurrently with serum concentrations of leptin, at weaning (90 days of age vs. 205 d of age) a better understanding of calf body composition during growth may be determined (Maccario et al., 2000; Hornick et al., 2000), with the ultimate goal of establishing an equation useful in the prediction of animal performance and final carcass composition.

Objectives

The objective of this study was to determine the predictive value of serum concentrations of GH, IGF-I, insulin, and / or leptin, in beef calves weaned at two different ages and implanted or non-implanted with a growth promotant, on final carcass quality parameters.

Methodology

Cattle population

The use of animals in this study was approved by the Animal Care and Use Committee. One hundred-and-forty Angus X Gelbvieh and purebred Angus steers derived from two of the University of Missouri Beef Farms were randomly assigned to one of two weaning groups. Steers were EW (early weaned; averaged 90 d of age; n=70) or TW (traditional weaned; averaged 205 d of age; n=70). Steers were either implanted (EWI or TWI) with Synovex-S growth promoting implants at weaning and reimplanted 80 d after weaning or not implanted (EWN or TWN). Steers were randomized into treatments using sire and farm as variables. Blood samples were collected at d 0 (21 d after the acclimation period and weaning) for both groups and every 28 d thereafter until harvest.

Sample collection, handling and hormonal analysis

Blood samples were collected from the jugular vein and the final blood sample was taken at exsanguination. Serum was then harvested and stored frozen until analysis. Serum concentrations of leptin, GH, IGF-1 and insulin were assayed as described by Delavaud et al. (2000), Lalman et al. (2000), Chelikani et al. (2004), and Kolath et al. (2005).

Carcass data collection

Steers were harvested at a commercial packing plant at an average live weight of 523 ± 46 kg. Each animal was tagged with a sequence number following exsanguination, prior to hide removal. Hot carcass weights were documented for each animal.

After a 24-hour chill period, additional carcass measurements were collected. Ribeye areas were measured using the reverse blot image technique (Martin, 1991), which allows ribeye areas to be obtained at grading chain speeds.

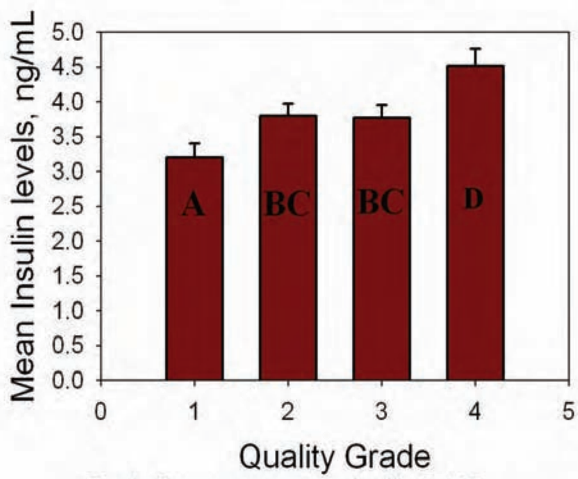
Fat thicknesses were determined using a USDA preliminary yield grade ruler (USDA, 1997) at an anatomical location perpendicular to the vertebral column and ¾ the distance, caudal the ribeye muscle. To determine preliminary yield grades, the fat measurements were then adjusted, correcting for any atypical fat distribution.

Marbling scores were identified by an experienced USDA grader using the USDA marbling standards (USDA, 1997; Abundant, Moderately Abundant, Slightly Abundant, Moderate, Modest, Small, Slight, Traces, and Practically Devoid). Maturity scores were also assessed using the USDA standards (USDA, 1997) for animals older than "A" maturity.

Statistical Analysis

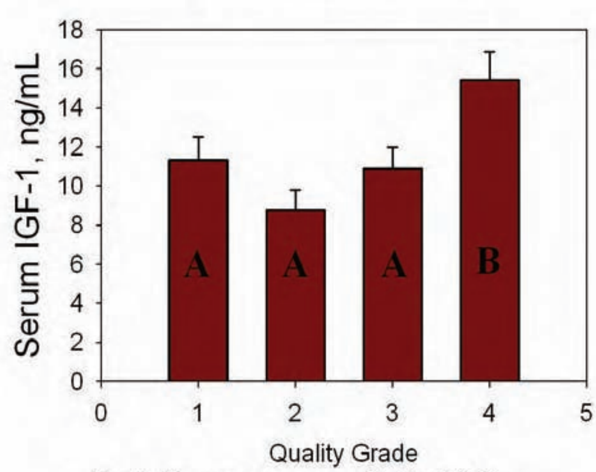
Proc GLM and LSMEANS in SAS v9.1 system (Cary, North Carolina, USA) were used to analyze hormone levels and their relationship to US Quality Grade. In analyzing hormone data collected at weaning the following model was used: *hormone = quality grade | weaning status.* Analysis of the hormone data acquired 30 d prior to slaughter, with implant status as an additional treatment, the following model was used: *hormone = quality grade| weaning status | implant treatment*. US Quality Grades* were assigned to one of four levels for statistical analysis: Marbling scores assigned to 1 of 4 quality grade categories, Quality Grade 1 = Select (n = 30); quality grade 2 = Low Choice (n = 42); quality grade 3 = Average Choice (n = 36); quality grade 4 = Premium Choice or better (n = 24). [*Note USDA quality grades Select = low quantities of intramuscular fat, Premium Choice or better = Very high quantities of intramuscular fat

Figure 1. Mean insulin levels (ng/mL) at weaning and final quality grade.



Bars lacking a common superscript differ P<0.05

Figure 2. Mean IGF-1 levels (ng/mL) at weaning and final quality grade.



Bars lacking a common superscript differ P<0.05

within the *longissimus dorsi* muscle at the 12/13th rib interface.]

Results & Discussion

At Weaning

*Se*rum leptin levels at weaning had no relationship (P > 0.49) with final carcass quality grade in EW or TW steers. This may be due to the low amount of fat found in weaned calves, attributing to lower levels of leptin, making it more difficult to establish a relationship. Serum insulin levels, however, accounted for 18% of the variation in final carcass USDA quality grade and weaning status. There were main effects observed in quality grade (P = 0.004; Figure 1) and weaning status (P = 0.001) with no quality grade by weaning status interactions (P > 0.05).

Serum IGF-1 levels also had a significant relationship with final quality grade, accounting for 10% of the variation in quality grade. A quality grade main effect was observed (P = 0.017) with no quality grade by weaning status interaction (Figure 2).

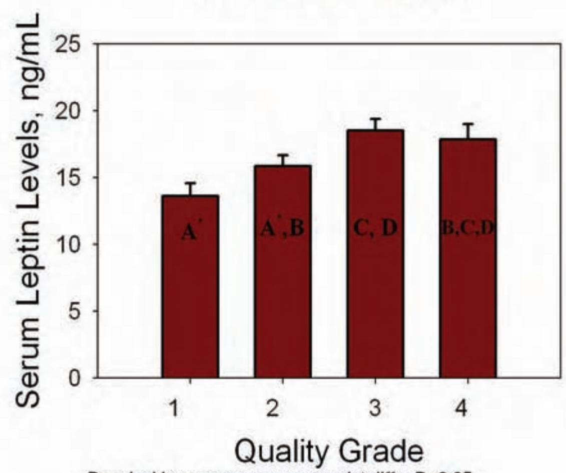
Serum GH levels (ng/ml) at weaning had no main effect on quality grade (P > 0.05). This is not surprising considering the volatile nature of growth hormone, especially in growing calves. These results also support previous findings as mentioned in the introduction.

30 d Prior to Slaughter

Although serum leptin levels had no relationship with final quality grade at the time of weaning, they accounted for 18% of the variation in quality grade and weaning status 30 d prior to slaughter. Quality grade and weaning status main effects were significant (P=0.0008, Figure 3 and P = 0.0053, respectively), with no implant treatment effects. Because implant treatment had no effect, it was removed from the model.

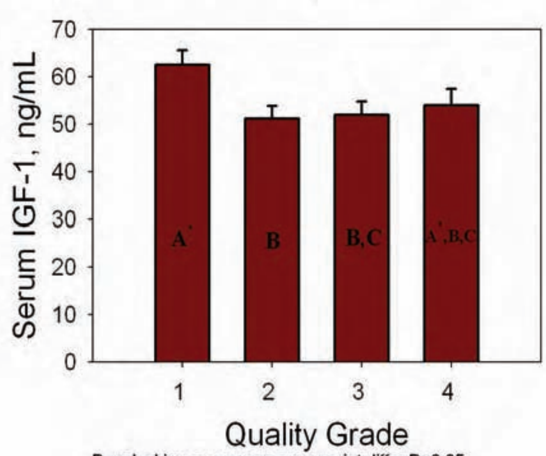
These findings correlate with those observed by Brandt et al. (unpublished data), where final carcass quality grade was associated with serum leptin levels

Figure 3. Mean Leptin levels 30 d prior to slaughter and final quality grade.



Bars lacking a common superscript differ P<0.05
A* approaching significance P = 0.067

Figure 4. Mean IGF-1 levels 30 d prior to slaughter and final quality grade.



Bars lacking a common superscript differ P<0.05
A* approaching significance P = 0.073

in beef animals. Serum insulin levels were found to have both treatment and weaning status main effects (P=0.0065 and 0.0009, respectively); however, no quality grade main effects were found. This indicates that insulin may be a better predictor of final quality grade at the time of weaning rather than later in the feeding period. Alternatively, serum IGF-1 levels remained a strong predictor throughout the feeding period, having quality grade, weaning status and treatment main effects (P = 0.0229, Figure 4, P = 0.0373 and P < 0.0001, respectively) with no interactions at 30 d prior to slaughter. Once again, GH had no relationship with final carcass quality grade. GH can be easily influenced by season, physiological maturity as well as many other factors, so its inability to be a solid predictor is not surprising.

Conclusions

These data provide evidence that incorporating serum concentrations of insulin and IGF-1 into a modeling program for predicting final carcass quality grade at the time of weaning and incorporating serum concentrations of leptin and IGF-1 into a modeling program for predicting final carcass quality 30 d prior to slaughter may strengthen a prediction equation incorporating these variables along with physical measurements (e.g. body weight, ultrasound fat thickness) taken at the same time point.

References

Buchanan, F. C., C. J. Fitzsimmons, A. G. Van Kessel, T. D. Thue, D. C Winkelman-Sim, S. M. Schmutz. 2002. Association of a missense mutationi n the bovine leptin gene with carcass fat content and leptin mRNA levels. Genet. Sel. Evol. 34(1): 105–16.

Chelikani PK, Ambrose JD, Keisler DH, Kennelly JJ. Effect of short-term fasting on plasma concentrations of leptin and other hormones and metabolites in dairy cattle. Domest Anim Endocrinol 2004;26:33–48.

Connor, E. E., S. M. Barao, L. W. Douglass, S. A. Zinn, and G. E. Dahl. 1999. Predicting bull growth performance and carcass composition from growth hormone response to GHRH. 77: 2736–2741.

Connor, E. E., S. M. Barao, E. Russek-Cohen, and G. E. Dahl. 2000. A two-sample method for assessing growth hormone response to GHRH challenge: use as a predictor of gain in beef bulls. J. Anim. Sci. 78: 1954–1959.

Delavaud, C., F. Bocquier, Y. Chilliard, D. H. Keisler, A. Gertler, and G. Kann. 2000. Plasma leptin determination in ruminants: effect of nutritional status and body fatness on plasma leptin concentration assessed by a specific RIA in sheep. J. Endocrinol. 165:519–526.

Friedman, J. M. 1998. Leptin, leptin receptors, and the control of body weight. Nutri. Rev. Feb; 56(2 Pt. 2):s38–46. Review.

Geary, T. W., E. L. McFadin, M. D. MacNeil, E. E. Grings, R. E. Short, R. N. Funston, D. H. Keisler. 2003. Leptin as a predictor of carcass composition in beef cattle. J. Anim. Sci. 81 (1): 1–8.

Hornick, J. L., C. Van Eenaeme, O. Gerard, I Dufrasne, L Istasse. 2000. Mechanisms of reduced and compensatory growth. Domest. Anim. Endocrinol. 19(2): 121–132. Review.

Houseknecht, K. L., C. A. Baile, R. L Matteri, and M. E. Spurlock. 1998. The Biology of Leptin: A Review. J. Anim. Sci. 76: 1405–1420.

Isaksson, O. P., S. Eden, J. Jansson. 1985. Mode of action of pituitary growth hormone on target cells. Ann. Rev. Physiol. 47: 483–499.

Kolath WH, Kerley MS, Golden JW, Keisler DH. 2005. The relationship between mitochondrial function and feed efficiency in Angus steers. J. Anim Sci in press

Lalman, D. L., Williams, J. E., Hess, B. W., Thomas, M. G & Keisler, D. H. (2000) Effect of dietary energy on milk production and metabolic hormones in thin, primiparous beef heifers. J. Anim. Sci. 78: 530–538.

Maccario, M., S. Grottoli, M. Procopio, S. E. Oleandri, R. Rossetto, C. Gauna, E. Arvat, E. Ghigo. 2000. The GH/IGF-I axis in obesity: influence of neuro-endocrine and metabolic factors. Int. J. Obes. Relat. Metab. Disord. 24 Suppl 2: S96–99. Review.

Martin, E. L. 1991. A rapid method to determine beef ribeye areas at grading chain speed. J. Anim. Sci. 69 (Suppl. 1): 341.

Roemmich, J. N., and A. D. Rogol. 1999. Hormonal changes during puberty and their relationship to fat distribution. Am. J. Human Biology. 11: 209–224.

USDA. 1997. USDA Official United State standards for grading of carcasses beef: Agric. Marketing Serv. USDA Washington, D. C.

Wegner, J., P. Huff, C. P. Xie, F. Schneider, F. Teuscher, P. S. Mir, Z. Mir, E. C. Kazala, R. J. Weselake, and K. Ender. 2001. Relationship of plasma leptin concentration to intramuscular fat content in beef from crossbred Wagyu cattle. Can. J. Anim. Sci. 81: 451–457.