Livestock Science 195 (2017) 27–37

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Associations of blood parameters with age, feed efficiency and sampling routine in young beef bulls

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ARTICLE INFO

Keywords:
Age
Beef cattle
Cholesterol
Osmolality
Slaughter
Triiodothyronine

ABSTRACT

Utilization of blood parameters as proxies for feed efficiency is an avenue to maximize profitability of the beef industry. Among other factors, age and sampling routine may impact the reliability of potential proxies for residual feed intake (RFI). Thus, the objectives were to assess associations of blood parameters with age and RFI under two sampling routines. Thirty-two crossbred bulls with an average body weight (BW) of 633 ± 93 kg and 369 ± 29 days of age were studied. Residual feed intake was calculated using average daily gain, BW and ultrasound traits for body composition. Seven blood samples for each bull were collected during a 33-day on-station sampling period and an additional sample was collected at slaughter for analysis of blood metabolites and hormones. Bulls were classified as younger (342 ± 17 days of age) and older (395 ± 4 days of age) and into efficient (−0.55 ± 0.70 kg DM/day) and inefficient (RFI=0.55 ± 0.29 kg DM/day). Means of blood parameters were compared between age and feed efficiency groups using a mixed model for on-station sampling and a general linear model for slaughter sampling. During the on-station sampling, glucose (P=0.01), potassium (P=0.01) and insulin-like growth factor 1 (P=0.01) were lesser in older bulls while urea (P=0.05), acetate (P=0.01), osmolality (P=0.01), testosterone (P=0.01) and follicle stimulating hormone (FSH; P=0.04) were greater in older bulls. At slaughter, carbon dioxide (P=0.01), brain-derived neurotrophic factor (P=0.05) and FSH (P=0.01) were greater in older bulls. Over the on-station sampling, osmolality (P=0.05) was greater in inefficient bulls while leptin (P=0.01) was greater in efficient bulls. On the day of slaughter, cholesterol (P=0.04) and alkaline phosphatase (P=0.04) were lesser in efficient bulls. Age and RFI classes interaction was observed for T_3 (P=0.01) during the on-station sampling where lesser T_3 blood levels where observed in efficient bulls within the younger group (P=0.01) and in older bulls within the inefficient group (P=0.05). Overall, these results support the association of blood parameters with variation in age and RFI and illustrate the impact of sampling routine on components of intermediary metabolism in yearling bulls, providing information to the development of proxies for RFI.

1. Introduction

Improvement of feed efficiency has received increased attention in the beef cattle sector as an opportunity to maximize economic and environmental sustainability of the beef industry. Residual feed intake is an emerging measure in the beef industry with applications in the identification of phenotypic proxies for feed efficiency (Arthur et al., 2004). Despite studies evaluating indicators of RFI in the bovine (Kolath et al., 2006; Montanholi et al., 2013; Richardson et al., 2004), there is a shortage of indicators for RFI with application in commercial herds. Therefore, there is a need for alternative measures to assess RFI in the bovine, and blood is a feasible matrix to provide insight into physiological, nutritional and metabolic processes (NRC, 2000). Blood parameters associated with energy metabolism have been related to RFI in beef cattle (Gonano et al., 2014; Kelly et al., 2011; Richardson et al., 2004; Walker et al., 2015). However, although it is known that factors such as age (Doornenbal et al., 1988) and stress (Minka and Ayo, 2009) can impact the profile of blood parameters, few studies have evaluated how these factors may influence profile of blood analytes in the context of RFI.

While cattle within a contemporary testing group are of similar age, they may differ in physiological maturity since puberty and sexual maturity occur between 280 and 400 days of age in beef bulls (Brito et al., 2012a) and can coincide with the period of performance test

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http://dx.doi.org/10.1016/j.livsci.2016.11.003
Received 9 February 2016; Received in revised form 2 November 2016; Accepted 6 November 2016

evaluation. Variation in developmental stage are associated with changes in physiological parameters associated with sexual development such as scrotal circumference (SC) (Pruitt et al., 1986) and the profile of blood hormones and metabolites of bulls (Doornenbal et al., 1988). In fact, the 90-day age range allowed in a contemporary group of yearling bulls (BIO®, 2015) can result in a 20% difference in testosterone levels between animals (Lunstra et al., 1978). Phenotypes that are commonly recorded in performance evaluation programs of beef bulls are adjusted for age (Schenkel et al., 2004). However, the use of proxies for productive performance traits, such as blood parameters, may be affected by the age-range accepted by the industry. Additionally, stress during management practices has impact on the levels blood parameters. For instance, thyroid hormones and cortisol levels in beef cattle increase in response to transportation (Fazio et al., 2005). Although cattle become familiar to repeated non-aversive procedures, novel experiences such as loading, transport and off-loading are strong stressors (Grandin, 1997). This may cause variation in levels of metabolites and hormones into the blood stream and may influence the association of such parameters with RFI.

Since physiological indicators such as blood parameters, are affected by variation in age and exposure to novel experiences, further understanding into the relationship of RFI with age and distress caused by sampling routine is needed to develop protocols for the use of blood parameters as possible proxies of RFI. Thus, the objectives of this study were to 1) investigate the fluctuation of blood parameters in relation to age and RFI during a 33-day sampling routine and at slaughter; and 2) investigate changes in blood parameters between on-station sampling and at slaughter in young beef bulls.

2. Material and methods

2.1. Animals and management

The study was in accordance with the guidelines of the Canadian Council on Animal Care Guidelines (2009). Thirty-two crossbred bulls, initially weighing 353 ± 67 kg (mean±standard deviation) and 256 ± 29 days of age and originally from the Elora Beef Research Centre (University of Guelph, Canada) were submitted to a performance evaluation upon a post-weaning backgrounding period. The overall breed composition based on pedigree records of the bulls consisted of 55% Angus, 30% Simmental and 15% other European breeds and crosses. Bulls underwent a gradual adaptation period to the facility, ration and pen-mates over a month prior to the start of the performance test. Bulls were fed *ad libitum*a high-moisture corn-based diet (Table 1) once daily between 08:30 and 09:30 h. Bulls were housed and managed in an indoor pen (36 by 28 m) with 2/3 of the area bedded with wood shavings that was replenished at least once weekly. The pen contained eight automated feeding stations (Insentec, B.V., Marknesse, The Netherlands) used to record individual feed intake. Bulls underwent a 114-day performance test during which daily feed intake, ADG, BW and ultrasound measurements of body composition were assessed on days 1, 57, 85 and 114 of the performance test. Scrotal circumference was measured at the end of the test using a scrotal measuring tape (Lane Manufacturing Inc., Denver, CO, USA) as described by Awda et al. (2013). Average BW and age of the bulls at the end of the performance test were 633 ± 93 kg and 369 ± 29 days of age, respectively. Following the performance test, 30 bulls were slaughtered in groups of two to four on eight days over a period of 23 days (26, 27, 33, 34, 40, 41, 47, 48 days following the end of the performance test). Day of slaughter for each bull was determined based on age, with older bulls slaughtered first. On the morning of slaughter, each bull was weighted and loaded into the truck at 07:00 h, travelled a distance of 25 km and arrived at the slaughter facility (University of Guelph, Canada) at 07:30 h, where the slaughter procedure was initiated at 08:00 h.

Table 1
Ingredients and chemical composition of the diet fed during experimental period.

Ingredient composition (as fed)	Percentage
High moisture corn	52.2
Alfalfa silage	42.5
Soybean meal	3.65
Premix[a]	1.65
Chemical composition (% DM basis)	Mean
Dry matter (%)	53.4
Crude protein (N x 6.25)	17.4
Neutral detergent fiber (%)	20.3
Acid detergent fiber (%)	13.4
Total digestible nutrients (%)	83.7
Net energy of gain (MCal/kg)	1.56
Net energy of maintenance (MCal/kg)	2.26

[a] Contains 93.6% soybean meal, 5.7% vitamin premix (4,400,000 IU/kg vitamin A, 1,100,000 IU/kg vitamin D, and 7700 IU/kg vitamin E), and 0.7% monensin premix (200 g monensin/kg).

2.2. Productive performance and calculation of traits

Backfat thickness (BKFT; mm), rumpfat thickness (RUMP; mm) and ribeye area (RBEA; cm^2) were assessed using real-time ultrasound as described by Montanholi et al. (2009). Briefly, backfat thickness was determined by measuring the minimum subcutaneous fat depth over the *longissimus* muscle in the fourth quadrant distal to the spine; rumpfat thickness was measured at the juncture of the *gluteus medius* and superficial *gluteus medius* muscles; and ribeye area was determined by scanning the *longissimus* muscle area.

Feed intake data was obtained from the automated feeding system. Individual daily dry matter intake (DMI, kg/d) was computed using only daily feed intake values with greater than a 98% probability of belonging to the normal distribution of daily feed intake. Average daily gain (ADG; kg/day) was determined by a regression of body weight on days on test, with four observations per animal. Average daily gain of BW, BKFT, RUMP and RBEA was determined by linear regression of each performance trait on days on test, with four observations per animal. Average BW, BKFT, RUMP and RBEA was calculated by computing the animals' intercept plus the average daily BKFT, RUMP and RBEA gain times 57.

Individual DMI, ADG, ABW and ultrasound measurements were used in the calculation of RFI. Several models were tested to calculate RFI, similar to the calculations by Montanholi et al. (2009). The most appropriate model explaining the variation in feed intake had a R^2 of 0.66 and was modelled as follows:

$$DMI = 2.66 - 0.19(ADG) + 0.02(BW) + 0.09(BKFT) - 0.05(RUMP) - 0.23(RBEA) + RFI$$

where RFI is the residual proportion of the model that represents the deviation of the observed feed intake from the expected feed intake.

2.3. Blood sampling and processing

Blood samples were obtained between 6:00 and 8:00 h on days 1, 5, 19, 22, 26, 28 and 33 of the on-station sampling period, with the first collection being 13 days prior to the end of the performance test and the last collection being 20 days following the end of the performance test. During on-station sampling, bulls were moved gently in small groups 4–6 bulls) at a time and were not overcrowded. Animals were restrained in a squeeze chute (Silencer®, Hydraulic Squeeze Chute, Moly Manufacturing Inc., Lorraine, USA), during which time they were properly handled. Blood was collected via jugular venipuncture using a 10 mL sodium heparin tube (Vacutainer ®, BD Inc., Franklin Lakes, USA) similarly described by Montanholi et al. (2013). Blood samples were also collected on day of slaughter during exsanguination, in 10 mL sodium heparin tubes for plasma and 10 mL silicone coated