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RESEARCH ARTICLE

Indirect calorimetry to estimate energy requirements for growing and finishing Nellore bulls

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Abstract

Determination of nutritional requirements is the basis for diet formulation. The objectives of this study were to determine the net energy requirements for maintenance (NE_m) and weight gain (NE_g) in Nellore bulls during the growing and finishing phases, and to estimate efficiency of metabolizable energy (ME) utilization for maintenance and gain (k_m, k_g). Five Nellore bulls were housed in individual pens at the Universidade Federal de Minas Gerais (Belo Horizonte, Brazil) and evaluated over four experimental periods at 210, 315, 378 and 454 kg shrunk body weight (SBW), approximately. During each period, heat production (HP) was quantified by open circuit indirect calorimetry for three feeding levels: *ad libitum*, restricted and fasting. The NE_m requirement was determined by linear regression between the Log of HP and the ME intake (MEI) for the *ad libitum* and restricted levels. This requirement was also determined by quantifying fasting heat production (FHP). The NE_g requirement was calculated by the difference between MEI and HP during *ad libitum* feeding. The k_m and k_g were calculated by the relationship between net energy (NE) and ME requirements for maintenance and weight gain (ME_m, ME_p), respectively. The NE_m requirements per kg of metabolic empty body weight ($EBW^{0.75}$) fluctuated between 348 and 517 kJ d^{-1}, showing a decreasing trend with age, and were higher than the values reported in the literature. The NE_g requirements ranged between 48.3 and 164 kJ kg^{-1} $EBW^{0.75}$ d^{-1}, and varied according to age and weight gain. The k_m values varied between 58.6 and 69.7%, while k_g varied between 23.4 and 40.2%. We concluded that NE_m and NE_g requirements were influenced by age and possibly by the level of stress, nervousness and activity of animals into the respirometry chamber. Further studies should quantify HP with records of positional changes (time spent standing *vs*. lying down). Additionally, HP quantification should be repeatedly performed in the same experimental period to obtain a representative value of NE_g requirements.

Keywords: calorimetry, efficiency of energy utilization, energy requirements, Zebu cattle

1. Introduction

Energy is the most limiting factor for animal productivity. In 1963, Lofgreen and Garrett introduced a net energy (NE) system for the growing and finishing phases of beef cattle, which separates NE requirements for maintenance (NE_m) from those for weight gain (NE_g) (Lofgreen and Garrett

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1968). This system is the basis of the NRC (2000) model. Determination of nutritional requirements is the basis of diet formulation and is aimed at increasing the expression of genetic potential and improving feed efficiency. Accurate nutritional requirements would promote productive, economic and environmental viability of beef cattle farming.

Between 65–70% of the total energy needed for meat production is used to meet maintenance requirements (Ferrell and Jenkins 1985). The literature suggest that *Bos indicus* have lower energy requirements for maintenance than *Bos taurus* breeds (NRC 2000; Sainz *et al.* 2013). Regarding the requirements for weight gain, Marcondes *et al.* (2010a) indicated that smaller breeds at maturity (i.e., with faster adipose tissue accretion, such as Zebu cattle) have, at the same absolute weight and gain rate, higher NE_g requirements than *B. taurus*.

Brazil has the largest cattle herd in the world with 212.3 million head. Nellore breed and its crosses entail about 50% of this population, which contribute 80% of meat production in the country (IBGE 2015). Given the importance of this breed, determining energy requirements will improve productive efficiency of the herd and the economic return to the farmer. Energy requirements can be determined by calorimetry or comparative slaughter. The latter technique is destructive, laborious and can lead to sampling errors. Furthermore, it requires more animals and time for gathering the data. Calorimetry allows for multiple measurements on the same animal, thus reducing the random error. Calorimetry is questioned for underestimating heat production (HP) *vs*. comparative slaughter, and because it works with animals confined into respirometry chambers (Miller and Koes 1988; Patience 2012). Since comparative slaughter is widely used in Brazil to determine requirements in Nellore cattle, it is necessary to evaluate calorimetry as an alternative technique.

The objectives of this study were to determine NE requirements for maintenance and weight gain in Nellore bulls by calorimetry during growing and finishing, and to establish efficiency of metabolizable energy (ME) utilization for both functions.

2. Materials and methods

2.1. Animals and experimental facilities

The experiment was conducted in the Veterinary School of Universidade Federal de Minas Gerais (UFMG), in Belo Horizonte (Brazil), between June 30, 2008 and January 12, 2010. Belo Horizonte is located at an altitude of 900 m, with 23°C average temperature, 65% relative humidity, and 1 600 mm annual rainfall, characterizing a tropical altitude climate.

Five Nellore bulls with (180±12.4) kg initial body weight (BW) and (10±0.5) mon of age, were individually housed in 3-m^2 covered pens. Animals were adapted to handling, diet, and the respirometry chamber during the first 2 mon. The energy balance tests and determination of requirements started after the adaptation period. The tests included apparent digestibility, urine collection and calorimetry, and were conducted during four different periods, each one lasting 4 mon, approximately. Average shrunk body weight (SBW) in each period was 210, 315, 378, and 454 kg, corresponding to 13.6, 17.8, 21.9, and 26.3 mon of age.

2.2. Feed

The diet consisted of Tifton 85 (*Cynodon* spp.) hay, mineral salt, and a corn-soybean meal supplement. It was formulated to ensure an average daily gain (ADG) of 700 g per animal, following recommendations by Marcondes *et al.* (2010a, b). The roughage/concentrate ratio varied depending on the age of the animals. Diet composition is presented in Table 1.

Animals were fed twice a day at 8:00 and 17:00 throughout the experimental period when they were in the barn, and once a day (at 8:00 h) when they were into the chamber. The amount of feed offered changed, depending on the objectives of the experiment, with *ad libitum* and restricted feeding periods. The daily amount of feed offered was adjusted during *ad libitum* feeding so that rejected feed (orts) represented between 5 and 10% of the offering. Orts were daily weighed and sampled for dry matter (DM) analysis. The dry matter intake (DMI) was calculated as the difference between feed offered and orts. Animals were fed at 1.15 times the NRC (2000) maintenance requirements (0.32 MJ NE_m kg^{-1} metabolic empty body weight, $EBW^{0.75}$) during restricted feeding. The same diet was offered to all animals, changing only the amounts offered.

2.3. Animal handling

Before starting the experiment, animals were treated with ivermectin (1%, w/v, Ourofino, Cravinhos, Brazil) and received an injection of vitamins A, D_3 and E (A-D-E Injetável Emulsificável, Pfizer, São Paulo, Brazil). All animals were weighed at the beginning of the experiment and at 14 d intervals until the end. To determine average SBW, animals were weighed at the same times during 2 consecutive days under a previous 12-h fasting. Additional weighings were conducted during calorimetric measurements.

A performance test was conducted for at least 30 d in each period, prior to the digestibility trials, recording SBW and *ad libitum* DMI. These data were extrapolated to data obtained in the respirometry chamber to estimate NE_g of feed and efficiency of ME utilization for weight gain (k_g).