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Body composition and net protein and energy requirements for weight gain of crossbred dairy cattle in grazing

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ABSTRACT - The body composition and net protein and energy requirements for weight gain of 5/8 Hostein-Zebu crossbred cattle raised in *Brachiaria decumbens* Spaft pasture were evaluated. In total, 16 bulls with 10 months of age and body weight (BW) of 180 ± 19.95 kg were used. The animals were kept with free access to pasture or with restricted grazing (from 6 to 10 h). Four animals were slaughtered at the beginning of the experimental period to estimate the empty body weight (EBW) and the initial body composition of the remaining animals. The other animals were slaughtered at the end of the 84-day trial period. The logarithm equations of the protein and energy body content were adjusted according to the logarithm of the empty body weight EBW. From these equations, the net protein and energy requirements for weight gain were estimated. There was an increase in fat (from 37.17 to 59.08 g/kg EBW) and energy (from 1.68 to 1.94 Mcal/kg EBW) concentrations, with increase in body weight from 150 to 250 kg. The protein and energy requirements for gaining 1 kg of EBW increased with the increase in body weight or empty body weight. The relationship between fat concentration in gain and protein requirements also increased, indicating that as the BW or EBW increase, more fat deposition in the gain is observed.

Key Words: nutritional requirements, crossbred dairy, pasture

Composição corporal e exigências líquidas de proteína e energia para ganho de peso de bovinos mestiços leiteiros em pastejo

RESUMO - Avaliaram-se a composição corporal e as exigências líquidas de proteína e energia para ganho de peso de bovinos mestiços 5/8 Holandês-Zebu criados em pasto de *Brachiaria decumbens* Spaft. Utilizaram-se 16 bovinos machos, não-castrados com 10 meses de idade e peso vivo de 180 ± 19,95 kg. Os animais foram mantidos com livre acesso ao pasto ou com pastejo restrito (das 6 às 10 h). Quatro animais foram abatidos no início do experimento para estimativa do peso do corpo vazio (PCVZ) e da composição corporal inicial dos animais remanescentes. Os demais foram abatidos ao final do período experimental, de 84 dias. Ajustaram-se as equações do logaritmo dos conteúdos corporais de proteína e energia em função do logaritmo do peso de corpo vazio PCVZ. Derivando-se essas equações, estimaram-se as exigências líquidas de proteína e energia para ganho de peso. Com a elevação do peso vivo de 150 para 250 kg, houve aumento nas concentrações de gordura (37,17 para 59,08 g/kg PCVZ) e energia (1,68 para 1,94 Mcal/kg PCVZ). As exigências de proteína e energia para ganho de 1 kg de PCVZ elevaram com o aumento do peso vivo ou do peso de corpo vazio. As relações entre as concentrações de gordura no ganho e as exigências de proteína também foram crescentes, evidenciando que, à medida que o peso vivo ou peso do corpo vazio aumentam, ocorre maior deposição de gordura no ganho.

Palavras-chave: exigências nutricionais, mestiços leiteiros, pasto

Introduction

The success of any activity requires maximum efficiency of the production means and total control of the factors involved. In Brazil, cattle are produced mainly in grassland (Neiva et al., 2006) making necessary to estimate the nutritional requirements under these conditions.

The first challenge in estimating the nutritional requirements is the measurement of the physical and chemical body composition, which varies during growth

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and may be influenced by age, maturity, gain rate, breeding, gender and nutritional level (Garret, 2000). With maturity, the proportion of fat increases and the proportions of water and body protein reduce. Young animals present higher proportions of protein and water and lower proportions of fat (Berg & Butterfield, 1976), which, according to Grant & Helferich (1991) is caused by the deceleration of the muscle growth, confirmed by the lower protein gain in the empty body weight (EBW) and the further development of adipose tissue.

According to Garrett (1980), breeding influences the growth rate and body composition. Animals with high growth rate, yield potential and maturity present higher maintenance cost. As described by Geay (1984), in animals of late maturity and high growth potential, the reduction in energy consumption affects more the protein retention and growth rate than the fat deposition. The fat proportion in the gain of females is higher than in steers, which is higher than in non-castrated males.

The net energy requirement for gain consists in the amount of energy deposited in body tissues, which depends on the proportions of fat and protein in the gain of EBW. The protein requirements vary in function of the fat-free dry matter content. Due to the variation in the gain contents and possibly the higher muscle growth of non-castrated and later animals, the net protein requirements for gains are greater in non-castrated and later animals.

In Brazil, studies on the nutritional requirements of cattle have been developed in feedlot system (Sources et al., 2005); thus, this work was aimed to estimate the body composition and the net protein and energy requirements to gain in crossbred cattle in pasture.

Material and Methods

The study was conducted at the Experimental Station of Pernambuco Company of Agricultural Research - IPA, in the city of Itambé, Pernambuco, located in a physiographic micro-region, State Coastal Zone, under the coordinates 07°25'00 "S and 35 ° 06'00" SWGr; and 190 m of altitude. The annual average temperature and rainfall are 25.1°C and 1.300 mm (Incarnation, 1980). Data from the experimental station confirmed during the trial period, from May to July 2003, total rainfall of 664.2 mm, corresponding to 51% of the annual average.

The animals used comprised 16 non-castrated male animals of dairy origin (5/8 Flemish-Zebu), with approximately 10 months of age and average live weight of 180 ± 19.95 kg, from different experimental stations of the IPA, exclusively raised in pasture, in an area of approximately 8 hectares, predominant composed of the species (*B. decumbens,* Stapf.) under continuous stocking, being supplemented only with commercial mineral salt.

The first 30 days were used for controlling endo and ectoparasites, as well as the adaptation of animals. The experimental period lasted 84 days, from May to July 2003, with animals being weighted every 28 days.

After the adjustment period, the animals were weighed, identified, and four animals were randomly selected to compose the reference group (RG), which was slaughtered at the first experimental day, resulting in initial estimates of empty body weight (EBW) and body composition for the remaining animals.

The remaining animals were divided into two diets: free grazing until slaughter (FGS), with unrestricted access to pasture, collective drinking fountain and salt cellar to mineral salt and restricted grazing (RG), with access to pasture for four hours/day, always in the morning from 6:00 am to 10:00 am, spending the rest of the time in a paddock with total area of 690 m^2, being 51 m^2 of covered area with 50% light interception capacity, collective drinking fountain and salt cellar for the mineral salt supply.

The average forage availability during the experimental period was 7,334 kg DM/ha with average of 28.97% of dry matter, 6.87% of crude protein and 73% of neutral detergent fiber. The mineral salt presented maximum levels of phosphorus (7%), calcium (17%), magnesium (1.88%), zinc (2,900 ppm), manganese (832 ppm), cobalt (125 ppm) and fluorine (0.12 ppm) on its composition.

At the end of 84 experimental days, the 12 remaining animals were slaughtered at average BW of 219 kg at the “Pedras de Fogo” city slaughterhouse, Paraíba. At the end of the day before slaughter, the animals were removed from the pasture and brought to the waiting corral, where they remained in solid fasting for about 16 hours, being immediately weighed and taken to the slaughterhouse.

During slaughter, the animals were killed by brain concussion and bled by section in the jugular vein, followed by skinning and withdrawal of the feet, head and tail, along with blood, being identified and weighed separately, resulting in their absolute weight. A blood sample of approximately 500 mL was collected immediately after bleeding and submitted to definitive drying for a period of 72 hours. A leather sample equivalent to 40 cm^2 was taken near the tail insertion to represent the carcass’ leather sample, which was subsequently added to that from the legs and head to compose body leather sample.

The guts were weighted after emptied and the value obtained was added to those from the organs and other parts of the body (head, legs, tail, leather, carcass and blood) to compose the body's final empty weight (BFEW).

One animal from each diet was randomly selected for the withdrawal of the head and the posterior and anterior limbs to make the physical separation of bone tissue, muscle, fat and leather (head and feet) in order to contribute to the body composition.

The carcass of each animal was divided into two half-carcasses, which were stored into cold chamber (-5°C) for 24 hours, after which, a sample corresponding to the section between the 9^{th} and 11^{th} ribs (H-H section) was withdrawn for further dissections and estimates of the proportions of bones, muscles and fat from the carcass, according to equations proposed by Hankins & Howe (1946):

Proportion of muscle: $Y = 16.08 + 0.80\ X$;

Proportion of fat: $Y = 3.54 + 0.80\ X$, and

Proportion of bones: $Y = 5.52 + 0.57\ X$

where: X = percentage of components in the H-H section.

From each animal, samples of viscera (rumen, reticulum, omasum, abomasum, small intestine, large intestine, internal fat and mesentery) and organs [liver, heart, kidneys, lungs, tongue, spleen, meat industry and scrap (esophagus, trachea and female reproductive tract) were proportionately obtained.

Except for blood samples, samples composed of organs (200 g), viscera (200 g), muscles (200 g), fat (250 g), leather (100 g), bones (100 g) and tail (100 g), after ground, were placed in 500 mL glass containers and put into stove at 105ºC during a period between 48 and 72 hours for determination of the fat dry matter (FDM).

Subsequently, the pre-degreasing of samples was carried out with successive washes in petroleum ether, resulting in the pre-defatted dry matter (PDDM). Then, the samples were ground into ball mill for later determination of the total nitrogen and ether extract (Silva & Queiroz, 2002). The fat removed in the pre-degreasing process was calculated as the difference between FDM and PDDM and added to results obtained for the residual ether extract in the PDDM for determination of the total fat content. From the knowledge on crude protein and ether extract contents in the PDDM and on the weight of sample submitted to pre-degreasing, the respective contents in the natural matter were determined. The fat and protein body contents were determined according to their respective concentrations in organs, viscera, leather, blood, tail, head and feet (fat and bones) and the separate constituents (fat, muscles and bones) from the H-H section, the latter representing the carcass physical composition.

The body energy determination was obtained from the body protein and fat levels and their caloric equivalent, as recommended by the ARC equation (1980):

$$EC = 5.6405\ X + 9.3929\ Y$$

where: EC = energy content (Mcal) = X body protein (kg), Y = body fat (kg).

The fat, protein and energy contents retained in the body of animals from each diet and to the data as a whole were estimated by regression equations of the logarithm of body fat, protein and energy content in function of the EBW logarithm, according to ARC (1980) and the following model:

$$Y = a + bX + e$$

where: Y = logarithm of the total fat (kg), protein (kg) and energy (Mcal) contents in the empty body, a = constant; b = regression coefficient of the logarithm from the respective contents in function of the EBW logarithm; X = EBW logarithm; and e = random error.

For each diet, the equations were obtained using the relative values from the reference animals, along with their respective diets.

Deriving from the equations for predicting the body fat, protein and energy content, according to the EBW logarithm, the equations for predicting the fat content in the gain and the net protein and energy requirements for the gain of 1 kg EBW were obtained from the following equation:

$$Y' = b.\ 10^{a}.\ X^{b-1},$$

where Y' = fat content in the gain, or net protein and energy requirement; *a* and *b* = intercept and regression coefficient, respectively, from predictive equations of the respective contents, and X = EBW (kg).

For the conversion of BW into EBW, within the range of weights included in the study, the regression equation obtained through the EBW of the 12 animals were used, according to their BW.

Results and Discussion

In the prediction of the empty body weight (EBW) from the body weight (BW) of animals used in this experiment, a significant linear effect ($P<0.05$) from diet was observed, resulting in the following equation, adjusted for all dataset: EBW = 7.6144 0.6973 PV, $r^2 = 0.91$, with a high determination coefficient, which allows inferring that the experimental data are well fit the to equations.

Aiming to enable the conversion of the gain requirements in EBW into requirements for gain in BW, the following equation was obtained: BW = (EBW - 7.6144) * 1.4341.

Therefore, under these conditions, the gain of 1 kg of EBW was the gain of 1.43 kg of BW.

The empty body weight of an animal of 200 kg of live weight, estimated from the equation above (147.07 kg) was 17.8 and 10.5% higher than that obtained by Zervoudakis et al. (2002) and Fregadolli (2005), respectively, working on dairy castrated crossbred animals raised on pasture with supplementation, and 17.4% lower than the value of 178.2 kg recommended by the NRC (1996): EBW = BW * 0891. The lowest values found in this study, compared to the NRC (2000), it may be in part related to the higher content in the gastrointestinal tract of animals maintained in pasture.

Similarly for the equation to predict the EBW, the high determination coefficients presented indicate proper adjustment of the experimental data to the model. The regression coefficients (b) of the equations (Table 1) showed an increase in the protein content to rates relatively equal to the increase in the empty body weight, similar behavior to that observed by Zervoudakis et al. (2002). According to Jorge et al. (2003), bone tissues presents low growth coefficient ($b<1$) being considered early; muscles have intermediate growth ($b = 1$) while fat is high ($b>1$).

Body fat, protein and energy concentrations increased as much as BW and EBW, for both diets and the dataset as a whole (Table 2). The greatest increases in the protein content are possibly due to the growth stage in the experimental animals. However, the relationship between fat and protein concentration in the body weight (g/kg or EBW) increased according to the EBW (Table 3), showing changes in tissues composition, with reduction on muscle growth and faster development of fat tissue, due to EBW, which presents higher growth rate at elderly ages (Berg & Butterfield, 1976). Thus, as the body weight increases, the protein deposition decreases and fat increases.

According to the NRC (2000), the body composition of cattle may be influenced by gender, breeding, age (maturity), weight gain rates, among others. The animals used in this study (5/8 Flemish-Zebu crossbred) are considered late, and they were slaughtered with an average age of 14 months, i.e. period in which significant growth could still be observed, with higher proportions of muscle in the carcass (62.47%), as reported by Melo (2005), who worked on the same animals and evaluated the carcass performance. According to Berg & Butterfield (1976), the bone tissue presents higher growth at very early age, followed by muscle tissue in intermediate ages and fat tissue in elderly.

Table 1 - Regression parameters of the logarithm of fat, protein and energy contents in the empty body weight (EBW) in function of the empty body weight logarithm of crossbred cattle in pasture

Diet	Parameter of regression equations		r^2
	Intercept (a)	Coefficient (b)	
	Fat (g/kg EBW)		
Free grazing	- 3.8960	2.1859	0.84
Restrict grazing	- 2.9089	1.7259	0.70
All together	- 3.3949	1.9586	0.73
	Protein (g/kg EBW)		
Free grazing	- 0.6673	1.0175	0.96
Restrict grazing	- 0.7038	1.0300	0.95
All together	- 0.7804	1.0671	0.94
	Energy (Mcal/kg EBW)		
Free grazing	- 0.4058	1.3027	0.93
Restrict grazing	- 0.1513	1.1803	0.95
All together	- 0.3670	1.2836	0.93

Table 2 - Body fat, protein and energy concentrations of crossbred cattle in pasture

BW (kg)	EBW (kg)	Feeding regime		
		Free grazing	Restrict grazing	All together
		Fat (g/kg EBW)		
150	112.21	34.28	37.95	37.17
175	129.64	40.69	42.14	42.69
200	147.07	47.25	46.18	48.18
225	164.50	53.97	50.09	53.64
250	181.94	60.81	53.89	59.08
		Protein (g/kg EBW)		
150	112.21	233.65	227.87	227.60
175	129.64	234.24	228.86	229.80
200	147.07	234.76	229.73	231.76
225	164.50	235.22	230.50	233.51
250	181.94	235.63	231.20	235.09
		Energy (Mcal/kg EBW)		
150	112.21	1.69	1.69	1.68
175	129.64	1.75	1.60	1.76
200	147.07	1.62	1.69	1.62
225	164.50	1.88	1.79	1.88
250	181.94	1.93	1.87	1.94

Table 3 - Relationship between body fat and protein concentrations in body weight or empty body weight for the whole dataset of crossbred cattle in pasture

BW (kg)	EBW (kg)	Concentration (g/kg)		Fat/crude protein ratio
		Crude protein	Fat	
150	112.21	227.60	37.17	0.16
175	129.64	229.80	42.69	0.18
200	147.07	231.76	48.18	0.21
225	164.50	233.51	53.64	0.23
250	181.94	235.09	59.08	0.25

Table 4 - Equations for predicting the fat content and net protein and energy requirements per kg of weight gain empty body, according to the EBW

Diet	Prediction equation
	Fat (g/kg EBWG)
Free grazing	$Y' = (2.7773 \cdot 10^{-4}) \cdot EBW^{1.1859}$
Restrict grazing	$Y' = (2.1287 \cdot 10^{-3}) \cdot EBW^{0.7259}$
All together	$Y' = (7.8894 \cdot 10^{-4}) \cdot EBW^{0.9586}$
	Protein (g/kg EBWG)
Free grazing	$Y' = 0.2188 \cdot EBW^{0.0175}$
Restrict grazing	$Y' = 0.2037 \cdot EBW^{0.03}$
All together	$Y' = 0.1759 \cdot EBW^{0.0671}$
	Energy (Mcal/kg EBWG)
Free grazing	$Y' = 0.5117 \cdot EBW^{0.3027}$
Restrict grazing	$Y' = 0.8330 \cdot EBW^{0.1803}$
All together	$Y' = 0.5513 \cdot EBW^{0.2836}$

As can be evidenced, the fat content in the gain increased as BW or EBW increased for animals from each diet and for the entire dataset, which strengthens the reports of Zervoudakis et al. (2002) and Fregadolli (2005) in researches with dairy crossbred animals in pasture.

The net protein requirements for the entire dataset increased in 3.2% when the BW and EBW increased from 150 to 250 kg and from 112.21 to 181.93 kg, respectively. This subtle increase in protein deposition can be explained by the fact that animals are still in the growth process. These results were 20% higher than those obtained with castrated animals reported by Zervoudakis et al. (2002), what may be attributed to the superiority in weight and age of the animals used by these authors. Moreover, according to Geay (1984), non-castrated animals have higher net protein requirements.

The gain composition of animals raised exclusively in pasture presented higher amounts of protein and lower of fat when compared to results observed in literature with animals raised in feedlot system (Silva et al., 2002).

The net energy requirements (Mcal/kg of EBWG) increased as the body weight of animals increased (Table 5). Results from several studies have found similar behavior, among them, Silva et al. (2002), working on non-castrated Nellore fed on different concentrate levels. According to Berg & Butterfield (1976), as the body weight increases, the fat content and the energy requirements increase proportionally.

The relationship between the fat concentrations in gain and the protein requirements (G/CP) obtained from the entire dataset increased from 0.30 to 0.46, with the increase in BW or EBW, respectively, showing that as the weight increases, more fat deposition in the gain is observed.

Table 5 - Fat concentration in the weight gain of empty body and net protein and energy requirements of crossbred cattle in pasture

BW (kg)	EBW (kg)	Feeding regime		
		Free grazing	Restrict grazing	All together
		Fat (g/kg EBWG)		
150	112.21	74.94	65.49	72.80
175	129.64	88.94	72.73	83.62
200	147.07	103.29	79.71	94.37
225	164.50	117.97	86.46	105.06
250	181.94	132.93	93.02	115.71
		Protein (g/kg EBWG)		
150	112.21	237.74	234.71	243.08
175	129.64	238.34	235.73	245.45
200	147.07	238.87	236.62	247.54
225	164.50	239.34	237.42	249.40
250	181.94	239.76	238.14	250.86
		Energy (Mcal/kg EBWG)		
150	112.21	2.14	1.95	2.10
175	129.64	2.23	2.00	2.19
200	147.07	2.32	2.05	2.27
225	164.50	2.40	2.09	2.34
250	181.94	2.47	2.13	2.41

According to Grant & Helferich (1991), this fact is related to the deceleration of muscle growth and faster development of the fat tissue, with the increase in the animal weight.

Conclusions

Increasing the live weight of animals from the category studied, an increment in body fat, protein and energy contents is observed. The net protein and energy requirements for an animal of 200 kg of BW are 247.54 g and 2.27 Mcal per kg of body weight gain of empty body, respectively.

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