DOI: 10.5433/1679-0359.2014v35n4p2019

Prediction of body chemical composition of Morada Nova ram lambs using the composition of ribs section between 9th and 11th

Predição da composição química corporal de cordeiros Morada Nova usando a composição da seção entre a 9ª e 11ª costelas

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Abstract

The determination of the chemical composition of the body and carcass is important in nutritional and growth regulation studies. The purpose of this study was to develop equations to predict the chemical composition of the body and carcass using the chemical composition of a section from 9-11th rib in Morada Nova lambs. Forty-eight Morada Nova lambs with an initial weight of 12.05 ± 1.81 kg, were used. Eight animals were slaughtered at the beginning of the trial as a reference group in order to estimate the initial empty body weight and body composition. The remaining animals were assigned to a randomized block design with eight replications per block and five diets with increasing metabolizable energy contents (0.96, 1.28, 1.72, 2.18, and 2.62 Mcal/kg of dry matter). Animals were slaughtered when the mean of body weight of the group reached 25 kg. Body chemical composition was determined by evaluating the composition of the right half of the carcass, as well as, by using a sample between the 9–11th ribs (the HH section) from the left half of the carcass. According to Pearson's correlation coefficient, the use of the HH section precisely predicted the percentages of protein (r = 0.89), ether extract (r = 0.81) and minerals (r = 0.83). Equations were developed to estimate the percentage of protein, ether extract, ash in the carcass from the following components in the HH section: %CP in the carcass = –21.05 + 3.052*%CP in the HH section (r^2 = 0.83); %EE in the carcass = –6.443+2.879*%EE in the HH section (r^2 = 0.76); %Ash = 4.52-0.362*%Ash in the HH section (r^2 = 0.15); %Water = 7.55+0.878*%Water in HH section (r^2 = 0.85). The cut from the 9-11th ribs satisfactorily predicted the protein and ether extract contents in the empty body, with values of r = 0.84 and 0.78, respectively. The crude protein and ether extract contents of the empty body can be satisfactorily estimated from chemical composition of the HH section; however, more information must be generated to obtain more reliably applicable equations.

Key words: HH section, nutritional requirements, sheep

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Recebido para publicação 06/11/12 Aprovado em 24/02/14

Resumo

A determinação da composição química do corpo e da carcaça é importante em estudos sobre regulação nutricional e do crescimento. O objetivo do presente estudo foi desenvolver equações para predição da composição química do corpo e da carcaça utilizando a composição química da seção entre a 9-11ª costela em cordeiros Morada Nova. Foram utilizados quarenta e oito cordeiros Morada Nova com peso inicial de 12,05 ± 1,81 kg. Oito animais foram abatidos no início do experimento para servir como grupo referência com o objetivo de estimar o peso do corpo vazio inicial e a composição corporal. Os animais remanescentes foram distribuídos em delineamento em blocos inteiramente casualizados com oito repetições por bloco e cinco dietas contendo níveis crescentes de energia metabolizável (0,96; 1,28; 1,72; 2,18 e 2.62 Mcal/kg de matéria seca). Os animais foram abatidos quando a média de peso corporal do grupo alcançou 25kg. A composição química corporal foi determinada pela avaliação da composição da meia carcaça direita, bem como, pela utilização de uma amostra entre a 9-11ª costela (seção HH) obtida na meia carcaça esquerda. De acordo com o coeficiente de correlação de Pearson, a utilização da seção HH foi sensível para predizer as porcentagens de proteína (r = 0,89), extrato etéreo (r = 0,81) e minerais (r = 0,83). Equações foram desenvolvidas para estimar a percentagem de proteína, extrato etéreo, cinzas na carcaça dos seguintes componentes na seção HH: %PB na carcaça = –21,05 + 3,052*%PB na seção HH (r^2 = 0,83); %EE na carcaça = –6,443+2,879*%EE na seção HH (r^2 = 0,76); %Cinzas = 4,52-0,362*%Cinzas na seção HH (r^2 = 0,15); %Água = 7,55+0,878*%Água na seção HH (r^2 = 0,85). O corte a partir da seção entre as costelas 9-11ª serviu satisfatoriamente para predizer os conteúdos de proteína e extrato etéreo no corpo vazio, com valores de r = 0,84 e 0,78, respectivamente. Os conteúdos de proteína bruta e extrato etéreo do corpo vazio podem ser satisfatoriamente estimados a partir da composição química da seção HH; contudo, mais informações devem ser geradas para obtenção de equações mais seguramente aplicáveis.

Palavras-chave: Exigência nutricional, ovinos, seção HH

Introduction

Several countries have already set nutritional norms for their sheep herds, taking into account the peculiarities of their realities (AFRC, 1993; NRC, 2007). In Brazil, many studies have been conducted for estimations of the nutritional requirements of sheep, which will very soon allow performing meta-analysis on many experiments with the goal of publishing a table of nutritional requirements of beef sheep, including hair sheep.

The first step for determining nutritional requirements is to measure the body composition of the animals, which may be obtained by direct or indirect methods. Although the direct determination of body composition by grinding and analyzing all body tissues is the most reliable method, it is expensive, time consuming, and laborious. Numerous methods have been developed to estimate both body and carcass compositions, including linear measurements (KIRTON et al., 1985; TRENKLE, 1986), ultrasound (STANFORD et al., 1985; GUIROY et al., 2001), carcass specific gravity (KRAYBILL; BITTER; HANKINS, 1952; MILLER et al., 1988), dilution techniques (e.g. urea; WELLS; PRESTON, 1998), as well as assessing tritium or deuterium contents (CROOKER; WEBER; ANDREW, 1998). However, some of these methods have inconsistent repeatability, high costs, or are justifiable only under certain experimental conditions (MILLER et al., 1988; STANFORD; JONES; PRICE, 1998).

According to Marcondes, Valadares Filho and Paulino (2009), the method of rib cuts (HANKINS; HOWE, 1946) has been become the validation aim for Brazilian conditions, where studies on cattle, especially Zebu cattle, predominate. Hankins and Howe (1946) found significant correlations of 0.83, 0.91, and 0.53 among the contents of protein, ether extract and ash in the 9-11th rib section (HH section) and those obtained by chemical analysis of the carcass. In a study on Angus and Holstein cattle, Nour and Thonney (1994) concluded that HH

section composition can be used with precision for predicting carcass composition, except for minor adjustments with relation to the breed. The indirect method based on the 9-11th cut has been widely used in cattle because it is a cheap and fast method (MARCONDES et al., 2012).

Few attempts have been made to predict the body chemical composition of goats using body parts (FERNANDES et al., 2008). Medeiros (2001) found a high correlation (r = 0.76) between the fat chemical composition of the 9-11th rib section and the body fat of Saanen kids. Similarly and Teixeira (2004) reported that the 9-11th rib section and neck had the highest accuracy in predicting the body composition of F1 Saanen×Boer kids. Teixeira (2004) suggested the use of the neck to estimate the body composition to minimize damage to the carcass due to the removal of the 9-11th rib section. Fernandes et al. (2008) indicated that the chemical composition of organs plus blood and the 9-11th rib section accurately predicted the composition of protein, fat, ash, and water in the body. Nonetheless, more work is needed to evaluate the accuracy and repeatability of this component to predict carcass composition. Therefore, the purpose of this study was to develop equations to predict the chemical composition of the body and carcass using the chemical composition of the 9-11th rib section of Morada Nova lambs.

Material and Methods

Experimental site

This trial was conducted at the Department of Animal Science at the Federal University of Ceara, in Fortaleza, state of Ceara (CE), Brazil, from February to June 2010. Humane animal care and handling procedures were followed according to the University's animal care committee.

Animals, housing aad experimental diets

Forty-eight Morada Nova lambs, non-castrated males, with an average initial body weight (BW) of 12.05 ± 1.81 kg at about two months of age, were used. First, the animals were identified, dewormed and placed in individual stalls with feeding troughs to supply the diets and water. After a ten-day adaptation period, eight animals were randomly selected and slaughtered to serve as reference for the empty body weight (EBW) estimates and the initial body composition.

The remaining lambs (n = 40) were allocated randomly to five treatments that consisted of increasing levels of metabolizable energy (0.96, 1.28, 1.72, 2.18, and 2.62 Mcal/kg DM) obtained from different roughage:concentrate ratios (95:5, 80:20, 60:40, 40:60, and 20:80). The experimental design used was a randomized block with five replications. Tifton 85 hay was used as roughage.

The experimental diets were formulated according to the NRC (2007). Animals were fed twice daily (at 8:00 a.m. and 4:00 p.m.) *ad libitum*, allowing up to 10% orts. The diets were fed as a total mixed ration. Daily DM intake (DMI) was determined by difference between the weight of offered and orted diets. Every day, before feeding the animals, the diet orts of each animal were removed and weighted, and data were recorded in spreadsheets for daily control. Samples of feed and orts were weighed daily, sampled and frozen for subsequent chemical analysis.

Diet digestibility determination and prediction of diet metabolizable energy

Digestibility trials were conducted eight times throughout the experiment to determine the metabolizable energy (ME) of the diet. Indigestible neutral detergent fiber (iNDF) was used as a marker to estimate fecal dry matter excretion, as described by Casali et al. (2008). Faeces were collected for three consecutive days, every 15 days during the

experimental period, at 8:00 a.m. on the first day, at noon on the second day, and at 4:00 p.m. on the third day.

The amount of iNDF in the faecal samples, orts, concentrates, and Tifton 85 hay were obtained through *in situ* incubations over a period of 240 hours in the rumen of a cow. After this period, the samples were washed in water until it became totally clear. Subsequently, they were boiled for 1 hour in a neutral detergent solution (VAN SOEST; ROBERTSON; LEWIS, 1991), washed with boiling water, then acetone, and finally dried in a forced-air oven at 55°C for 24 hours. The remains were weighed and considered to be the iNDF (CASALI et al., 2008).

The dietary digestible energy (DE) was estimated to be 4.409 Mcal/kg of the total digestible nutrients (TDN), and DE was converted to metabolizable energy (ME) using an efficiency of 82% (NRC, 2000).

Chemical analysis

Forage, concentrate and refuse samples were dried in a forced air oven at 55°C for 72 hours, then ground in a knife mill with a 1 mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA, USA). The samples were analyzed for contents of dry matter (DM; AOAC, 1990; method number 930.15), mineral matter (MM; AOAC, 1990; method number 924.05), crude protein (CP; AOAC, 1990; method number 984.13), ether extract (EE; AOAC, 1990; method number 920.39), and acid detergent fiber (ADF; AOAC, 1990; method number 973.18). To analyze neutral detergent fiber (NDF), the samples were treated with thermostable alpha-amylase without using sodium sulfite, and corrected for residual ash (MERTENS, 2002) and residual nitrogenous compounds (LICITRA; HERNANDEZ; VAN SOEST, 1996). The total carbohydrate content (TC) was calculated according to Sniffen et al. (1992) (Eq.[1]):

$$TC\ (\%) = 100 - (\%CP + \%EE + \%ash) \quad (1)$$

The non-fibrous carbohydrates (NFC) were calculated using the equation adapted from Weiss (1999) (Eq. [2]):

$$NFC\ (\%) = 100 - (\%NDFap + \%CP + \%EE + \%ash) \quad (2)$$

For the concentrates, due to the presence of urea in their formation, the NFC was calculated using the adapted equation from Hall (2000) (Eq.[3]):

$$NFC = 100 - ((\%CP - \%CP\ derived\ from\ urea + \%\ of\ the\ urea) + \%NDFap + \%EE + \%ash) \quad (3)$$

Diets were composed of Tifton 85 hay (as roughage) and concentrates based on corn grain, soybean meal, urea, limestone, dicalcium phosphate, sodium chloride, and a mineral premix (Tables 1 and 2).

Table 1. Chemical composition of the ingredients in g/kg DM.

Nutrient (g/kg)	Tifton hay	Corn meal	Soybean meal	Concentrate				
				1	2	3	4	5
Dry matter	953.6	891.0	951.8	967.0	962.4	954.3	958.3	947.3
Organic matter	873.8	879.3	885.7	930.4	889.2	911.9	919.5	903.2
Crude protein	78.9	91.4	546.3	298.6	525.5	279.3	221.3	188.9
Ether extract	14.6	53.9	29.1	25.4	29.7	36.7	34.2	30.8
Ash	79.8	11.7	66.1	36.6	73.2	42.4	38.8	44.1
NDF[A]	754.0	176.6	154.3	128.7	132.0	142.9	140.6	145.8
NDIN[B]	0.44	0.38	0.56	0.14	0.23	0.14	0.15	0.14
ADF[C]	447.2	82.8	145.4	96.7	75.2	44.0	48.6	47.2
ADIN[D]	2.66	5.44	0.38	0.04	0.32	0.04	0.04	0.04

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continuação

Lignin	51.2	8.1	37.3	9.5	13.8	16.4	18.9	19.4
Cellulose	304.4	24.1	55.3	35.7	72.0	33.7	33.5	35.3
Hemicellulose	306.8	93.8	8.9	32.0	56.8	98.9	92.0	98.6
TC[E]	826.7	842.9	358.4	675.1	393.6	662.0	680.6	693.7
FC[F]	701.3	138.8	104.2	96.0	99.5	110.7	95.3	104.0
NFC[G]	125.3	704.1	254.2	579.1	294.1	551.3	585.3	589.7

[A]NDF = neutral detergent fiber.
[B]NDIN = neutral detergent insoluble nitrogen.
[C]ADF = acid detergent fiber.
[D]ADIN = acid detergent insoluble nitrogen.
[E]TC = total carbohydrates.
[F]FC = fibrous carbohydrates.
[G]NFC = non-fibrous carbohydrates.
Source: Elaboration of the authors.

Table 2. Composition of the experimental diets.

Ingredient	Level of metabolizable energy (Mcal/kg DM)				
	0.96	1.28	1.72	2.18	2.62
Tifton hay	95	80	60	40	20
Concentrate	5	20	40	60	80
Corn meal[A]	626.3	158.7	694.5	724.6	756.1
Soybean meal[A]	326.2	806.5	285.3	248.8	225.9
Urea[A]	37.7	30.0	12.5	11.2	5.1
Limestone[A]	-	-	-	5.4	6.6
Dicalcium phosphate[A]	-	-	-	-	0.7
Sodium chloride[A]	8.6	4.0	7.0	9.3	5.0
Mineral premix[A,B]	1.2	0.8	0.7	0.7	0.6
Chemical components					
Dry matter (g/kg)	954.3	955.4	953.9	956.4	951.2
Ash (g/kg DM)	38.0	78.5	64.8	55.2	51.2
Crude protein (g/kg DM)	89.9	168.2	159.1	164.4	166.9
Ether extract (g/kg DM)	24.9	26.7	27.9	22.4	27.6
Neutral detergent fiber (g/kg DM)	722.5	629.6	509.6	386.0	267.4
Acid detergent fiber (g/kg DM)	429.6	372.8	285.9	208.0	127.2
Lignin (g/kg DM)	49.1	43.7	37.3	31.8	25.8
Cellulose (g/kg DM)	293.2	259.8	197.6	142.8	89.6
Hemicellulose (g/kg DM)	293.0	256.8	223.7	178.0	140.2
Fibrous carbohydrates (g/kg DM)	671.1	581.0	465.1	337.7	223.5
Total carbohydrates (g/kg DM)	817.3	735.7	764.6	754.0	746.3
Non fiber carbohydrate (g/kg DM)	146.2	154.7	299.5	416.3	522.8
TDN[C] (g/kg DM)	280.1	344.6	453.9	593.9	723.6
TDN:CP[D]	3.12	2.04	2.85	3.61	4.33

[A]Centesimal concentration in relation to the concentrated portion of the diets.
[B]Composition: Ca 7.5%; P 3%; Fe 16.500 ppm; Mn 9.750 ppm; Zn 35.000 ppm; I 1000 ppm; Se 225 ppm; Co 1000 ppm.
[C]Total digestible nutrients.
[D]Total digestible nutrients:Crude protein.
Source: Elaboration of the authors.

Performance and slaughter procedures

Animals were weighed weekly to follow the average weight gain (AWG), and when the BW mean of the treatment reached 25 kg, the animals were slaughtered. On this occasion, one animal from the group with the lowest energy concentration in the diet was also slaughtered (animals placed in the treatment with 0.96 Mcal/kg DM of ME). This procedure was carried out for each group until all the animals were slaughtered. Before slaughter, shrunk body weight (SBW) was measured as the BW after 18 hours of feed and water fast. At slaughter, lambs were stunned by using a cash knocker and killed by exsanguination by using conventional humane procedures.

Blood was weighed and sampled. The gastrointestinal tract was weighed full, then emptied, washed out, and weighed again after draining together with the weight of the organs and other body parts (carcass, head, skin, blood, hooves, and tail). The body was separated into individual components, which were weighed separately. This included the internal organs (liver, heart, trachea + lungs + tongue + esophagus, bladder, kidneys, reproductive tract, and spleen), the cleaned digestive tract (rumen, reticulum, omasum, abomasum, and small and large intestines) and fats (omental, perirenal, mesenteric, and heart fat). The empty body weight (EBW) was computed as SBW at slaughter minus the digestive tract contents.

After slaughter, all carcasses were weighed hot (approximately 1 h after slaughter) and then after cooling at −4°C for approximately 24 h. After 24 h of chilling, the chilled carcasses were weighed again and then cutted longitudinally in half with a band saw. The 9-11th rib section (the 9th, 10th, and 11th ribs, according Hankins and Howe (1946)) was removed from the left carcass.

The organs, blood, paws, and head were ground together with the right half carcass and the 9-11th rib section in an industrial meat grinder. The feet were cut into cubes and were pre-degreased by immersion in petroleum ether. The samples of each animal were thawed, dried in an oven with air circulation at 55ºC, then ground in a blender. The mass of ground organs + blood + feet + head and right half carcass and leather were homogenized, sampled and placed in a forced ventilation oven at 55ºC for 72 hours. The pre-dried samples were processed with a multiprocessor.

After this procedure, the samples were defatted by extraction in ether in a Soxhlet apparatus (AOAC, 1990; method number 920.39). After extraction with ether, the samples were ground in a ball mill and stored in closed containers. The dry matter contents (defatted) were treated in an oven at 105ºC to a constant weight, then the ash and crude protein levels were determined as described for the ingredients of the experimental diets on fat-free samples.

Statistical analyses

The experimental design was a randomized block (initial body weight), with five treatments, according to the mathematical model $Yij = \mu + \alpha i + \beta j + eij$, where Yij = the value observed in the plot that received the treatment i in the block j; μ = the general average of the population; αi = the effect of the treatment i = 1, 2, 3, 4, 5; βi = the effect of the block j = 1, 2; eij = random error.

The prediction of body chemical composition by means of the methodology described by Hankins and Howe (1946) was evaluated for its precision by using Pearson's correlation coefficient (r) and, because of its accuracy, by adjusting the linear regression equation between the predicted (independent variable) and observed (dependent variable) values. Equation parameters were tested jointly in the following hypothesis by the F test: F: H_0: $\beta_0 = 0$ and $\beta_1 = 1$, H_a = not H_0.

Data estimated by section between the 9th and 11th ribs and observed in the carcass and in the empty body were compared by means of regression

analysis, so H_0: $\beta_0=0$ and $\beta_1=1$ and H_a: not H_0. A significant difference was found between the observed and estimated values with a P value lower than 0.05.

The statistical analyses were performed using PROC GLM of SAS version 9.0 (SAS, 2003). An orthogonal partition of the sum of the square of treatments into linear, quadratic and cubic degree effects was obtained by analysis of variance. The regression equation was adjusted when significance was observed, using PROC REG SAS (9.0).

Results and Discussion

Statistical analyses of the regressions found in this study (Table 3) showed that the null hypothesis for the four chemical components was not rejected, i.e., the HH section provides a satisfactory estimate of the ether extract and crude protein contents in the carcass of Morada Nova sheep (Table 4).

Table 3. Estimates of parameters, descriptive values of probability for null hypothesis, coefficient of determination (r^2) and Pearson's correlation coefficient (r) for estimated and observed values of the percentages of ether extract, crude protein, ash and water.

Item	Regression					
	Intercept		Inclination coefficient			
	Estimate	P Value	Estimate	P value	r^2	r
Ether extract	0.830	0.003	0.867	***	0.66	0.81
Crude protein	1.794	0.021	1.041	***	0.79	0.88
Ash	11.251	0.817	0.555	0.865	0.68	0.83
Water	7.552	0.065	0.878	***	0.87	0.93

Source: Elaboration of the authors.

Ether extract content obtained by means of the HH section was underestimated in 18.27% and the ash content was overestimated in 54.71% (Figure 1). For crude protein values, the content of this component in the section HH appeared lower than value of 0.83% obtained directly from the carcass (Table 4).

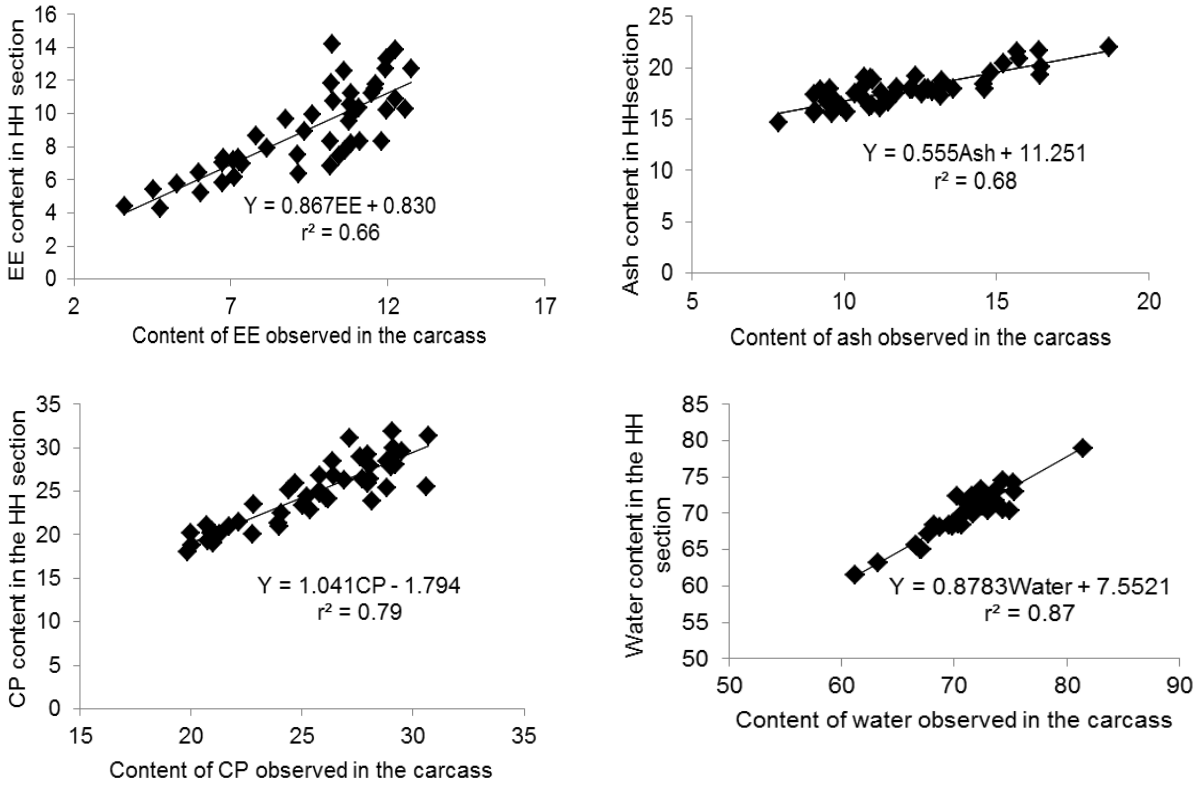
By evaluating the estimate of carcass chemical composition by means of the HH section, a satisfactory correlation was observed between the estimated and the observed values for protein, ether extract, and ash. The best Pearson's correlation coefficient (r) was found for water content (r = 0.93), followed by protein (r = 0.88), ash (r = 0.83), and ether extract content (r = 0.81) (Table 3). Hankins and Howe (1946) observed a significant correlation of 0.83 for protein in the prediction for chemical composition in cattle carcasses, a value close to the one obtained in the present experiment. Powel and Huffman (1968), when evaluating different methods of carcass chemical composition prediction, reported that the method developed by Hankins and Howe (1946) was the most accurate method for the estimation of ether extract ($r^2 = 0.94$) and protein content ($r^2 = 0.96$) in the carcass.

Table 4. Means and amplitudes of variation for percentages of ether extract, crude protein, ash and water in the carcass of animals and in the HH section.

Component	Carcass composition	HH section composition
	Ether extract	
Mean (%)	25.80	28.83
Standard deviation (%)	2.41	2.58
Amplitude of variation (%)	3.63 – 12.75	4.29 – 14.21
	Crude protein	
Mean (%)	25.96	25.13
Standard deviation (%)	3.20	3.76
Amplitude of variation (%)	19.86 – 30.72	18.02 – 31.88
	Ash	
Mean (%)	11.57	17.90
Standard deviation (%)	2.48	1.66
Amplitude of variation (%)	7.85 – 18.69	14.63 – 22.02
	Water	
Mean (%)	71.68	70.48
Standard deviation (%)	3.57	3.37
Amplitude of variation (%)	61.23 – 81.49	61.23 – 79.00

Source: Elaboration of the authors.

Figure 1 Relationship between the contents of the ether extract (EE), crude protein (CP), ash and water observed in the carcass and in the HH section.



Source: Elaboration of the authors.

According to Marcondes, Valadares Filho and Paulino (2009), for an indirect estimation of the chemical composition of an animal, equation to estimate these values from chemical composition of the HH section are needed. Some studies have already been carried out in Brazil to estimate in cattle, and some equations have been developed (SILVA et al., 2002; HENRIQUE et al., 2003; PAULINO et al., 2005). Valadares Filho, Paulino and Magalhães (2006) compiled Brazilian data and elaborated equations for predicting water, ether extract, protein, and minerals contents in the empty body weight of Zebu cattle, but additional studies for validation of these equations are needed.

The parameters of the regression equation percentages observed in the empty body for ether extract, crude protein, ash and water, according to the percentages of these components in the cutting of the 9-11th ribs, are in Table 5.

Table 5. Relationships among chemical components observed in the empty body and estimated by means of the HH section in Morada Nova lambs.

Component	Estimating equation	Mean standard error	r^2	r
Ether extract (EE)	Y=0.238 + 0.952X	1.39	0.89	0.94
Crude protein (CP)	Y=-1.226 + 1.035X	1.42	0.90	0.95
Ash	Y=12.254 + 0.4696X	1.67	0.13	0.37
Water	Y=11.696 + 0.828X	1.27	0.85	0.92

Y = estimate chemical component; X = component in HH section
Source: Elaboration of the authors.

Thus, the composition of the empty body of Morada Nova sheep was estimated (Table 6) based on protein, fat, ash, and water contents in the HH section. The observed values for ether extract, protein and water contents of the empty body were highly correlated (Figure 2) with estimated values using the chemical composition of the HH section for protein, fat, and water, with values of Pearson's correlation coefficient (r) equal to 0.94, 0.95 and 0.92, respectively. Peron et al. (1993), working with cattle, found significant correlations of 0.93 and 0.99 for protein and fat, respectively. Henrique et al. (2003) and Alleoni et al. (1997) also concluded that the percentage of ether extract in the empty body estimated by the HH section was highly correlated with the chemical composition of the empty body.

The results reported by Hankins and Howe (1946) and Kelly et al. (1968), when working with cattle in a study comparing the content of minerals in 9-11th rib cuts with the contents found in the carcass, found lower coefficients of correlation, which led the authors to conclude that the use of this cut for predicting the content of minerals in the carcass would be questionable. Linear regression between the empty body composition and the composition of the HH section was done to obtain prediction equations of the chemical composition of the empty body (EB) (Table 3).

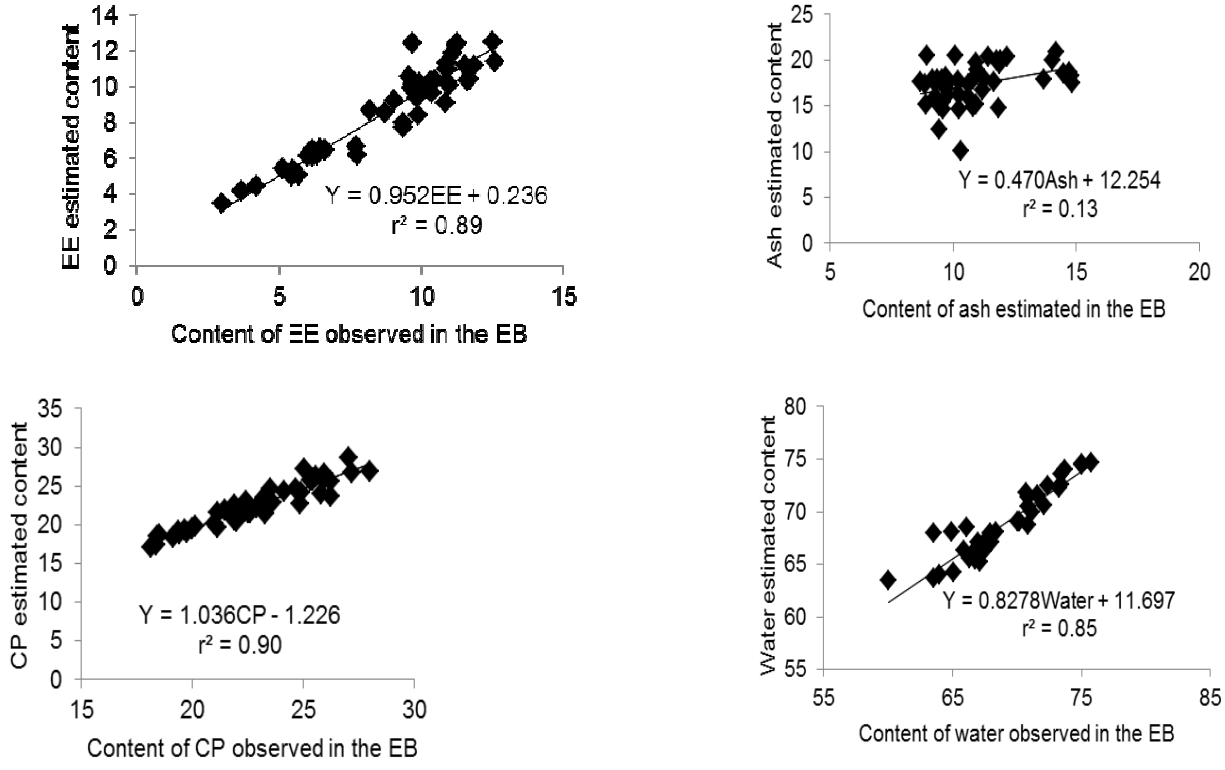
Values of the contents of ether extract, protein, and water of the empty body estimated using the chemical composition of the HH section were close to the values observed when the chemical composition of the carcass was used for determining the body content of the empty body (Table 6). For ash content in the empty body, the value obtained was overestimated by 39.90% when the chemical composition of the HH section was used (Figure 2).

Table 6. Means and amplitude of variation for percentages of ether extract, crude protein, ash and water observed in the empty body and estimated by means of the HH section.

Component	Observed composition	Estimated composition
	Ether extract	
Mean (%)	9.64	9.20
Standard error (%)	2.55	2.57
Amplitude of variation (%)	3.01 – 12.57	2.42 – 12.47
	Crude protein	
Mean (%)	22.53	22.20
Standard error (%)	2.69	2.93
Amplitude of variation (%)	18.13 – 27.99	17.04 – 28.61
	Ash	
Mean (%)	10.63	17.69
Standard error (%)	1.77	2.26
Amplitude of variation (%)	8.68 – 14.84	10.01 – 20.89
	Water	
Mean (%)	65.95	68.03
Standard error (%)	3.62	3.25
Amplitude of variation (%)	60.09 – 75.76	63.46 – 74.71

Source: Elaboration of the authors.

Figure 2. Relationship between the observed contents of ether extract (EE), crude protein (CP), ash and water in the empty body (EB) and estimated by means of the HH section.



Source: Elaboration of the authors.

According to Paulino et al. (2005), although the coefficient of determination obtained by regression between the values of ash content in the EB estimated using the chemical composition of HH section and the one obtained using the carcass composition were lower than those concerning the protein and ether extract contents, this does not invalidate the method of estimation, as was previously discussed for the estimation of the physical composition of the carcass.

The generated equations did not reflect a high degree of precision for the mineral content, as well as, the one obtained for the other constituents. Several authors have pointed out lower precision of the estimate of mineral contents in the empty body or in the carcass from the composition of ribs cuts (HANKINS; HOWE, 1946; LANNA et al., 1995; HENRIQUE et al., 2003).

The 9-11th rib section has been widely used to predict body (LANNA et al., 1995; ALLEONI et al., 1997) and carcass (HANKINS; HOWE, 1946, MILLER et al., 1988; LANNA et al., 1995) composition in cattle. Medeiros (2001) and Teixeira (2004) reported a high-precision body composition estimate using the chemical composition of the 9–11th ribs in goats. However, the inclination and intercepts of the regressions differed according to the population. The results showed that the section HH was moderately accurate and precise in predicting body fat, but it was unsatisfactory in the prediction of protein, water and ash body content (FERNANDES et al., 2008).

The equations adjusted for ether extract and protein contents in the empty body presented high coefficients of determination and reduced estimation standard errors as a function of the ether extract and protein contents in the HH section, which allows us highly precisely infer that it is possible to estimate body composition from the 9-11th ribs of Morada Nova lambs, corroborating the results described by Paulino et al. (2005) for Nellore x *Bos taurus* crossbred cattle.

From ether extract, protein, ash and water carcass and chemical composition of the section between the 9th and 11th ribs were obtained equations for predicting chemical composition of the empty body for Morada Nova lambs:

%EE = –6.443+2.879*%EE in HH section (r^2 = 0.76);

%CP = –21.05+3.052*%CP in HH section (r^2 = 0.83);

%Ash = 4.52-0.362*%Ash in HH section (r^2 = 0.15);

%Water = 7.55+0.878*%Water in HH section (r^2 = 0.85)

Conclusion

The results presented in this study indicate that the chemical composition of the organs plus blood and the 9–11th rib section accurately predict the composition of protein, fat, ash, and water in the body in Morada Nova lambs.

Further experiments should be conducted with more animals to assess the validity of the results obtained in this experiment.

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