QUANTIFICATION OF THE DIGESTIVE FRACTIONS OF CRUDE PROTEIN AND NEUTRAL DETERGENT FIBER OF SMALL RUMINANTS' DIETS

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Abstract: A predição das frações digestíveis da proteína bruta (PBd) e da fibra em detergente neutro (FDNd) é importante para se quantificar o conteúdo energético das dietas de pequenos ruminantes. O objetivo do estudo foi de desenvolver equações para estimar as frações digestíveis da PB e FDN de dietas de caprinos e ovinos sob condições tropicais. Foi realizada uma meta-análise à partir de 27 experimentos (21 com ovinos (n=766), e seis com caprinos (n=156)). Para a fração da PBd, três modelos foram desenvolvidos (CP-Lucas, CP-Bicomp and CP-Exp). Para a fração de FDNd, foram desenvolvidos dois modelos (linear e não linear). Todos os três modelos de PB tiveram ajustes adequados, mas devido ao maior erro quadrático médio de predição, alguma variação foi percebida no CP-Exp. Ambos os modelos de FDN apresentaram baixa acurácia, conforme demonstrado pelo coeficiente de correlação de concordância (CCC = 0,5055 e 0,4197 para NDF-linear e NDF-não-linear, respectivamente), significa que mais dados podem ser necessários para aumentar a precisão. Conclui-se que as equações propostas são adequadas para essa estimativa. No entanto, novos estudos em condições tropicias deverão ser conduzidos para melhorar a estimativa da fração digestível da FDN.

Palavras-chave: caprinos; equações; fração digestível; ovinos

Introduction

The total digestible nutrients (TDN) of small ruminant's diet could be estimated from its chemical composition, adopting a series of equations in which the digestible fractions of the nutrients are obtained separately and then summed.

Considering that the digestible fractions of crude protein (CP) and neutral detergent fiber (NDF) are related to the energy content available in feeds, prediction equations could be fit based on this principle, estimating energy availability from chemical composition of feeds. In addition, equations to estimate the digestible fractions of small ruminants' diets from chemical composition, in tropical conditions, are still not available.

The main objective of this study was to develop equations, by means of a meta-analysis, that predict the digestible fractions of CP and NDF from different goat and sheep diets under tropical conditions, from the chemical composition of feed.

Material and Methods

This study was composed by two sub models to estimate nutrient apparent digestibility. The original database used in this meta-analysis consisted of a total of 902 animals from 27separate studies with goats (6 studies; n=156 treatment means) and sheep (21 studies; n=766 treatment means) conducted in Federal University of Bahia, Bahia Southwest State University, and Santa Cruz State University facilities between 2013 and 2016.Data were collected regarding species, performance, dietary composition (% of DM), nutritional fractions intake (g/day) and apparent digestibility (%).

True digestibility coefficients and metabolic fecal contribution were the main parameters fitted to the models. Three different approaches were used to evaluate CP digestibility (CP-Lucas, CP-Bicomp and CP-Exp). Considering Lucas nutritional entity test, a bicompartmental model that approaches different fractions of protein (soluble and undegradable), and an exponential model as an attempt to reproduce a dynamic degradation system. Two more models were for digestible NDF (NDF-linear and NDF-nonlinear): the first considered chemical components, intake and diet composition, the latter a nonlinear relationship between NDF and lignin.

The models were evaluated on the basis of Akaike's information criterion (AIC) and root mean square error (RMSE) adjusted to random study effect according to St, Pierre (2001). The comparison between mathematical adjustments was performed using MES program (Model Evaluation System, version 3.1, Texas A&M University) according to Tedeschi (2006). Predicted and observed values were considered to be similar when the null hypotheses were not rejected. All statistical procedures were performed using 0.05 as critical level for Type I error occurrence.

Results and Discussion

The CP-Lucas equation, submitted to the nutritional entity test, was:

$$\mathrm{dCP} = 0.8229 \times \mathrm{CPI\ (g)} - 8.2060\ (\mathrm{R}^2 = 0.9207; \mathrm{AIC} = 3726.2);$$

where: dCP= digestible protein, CPI= crude protein intake.

The CP-Bicomp model was derived from the ell content crude protein apparently digested and cell wall crude protein digested intake:

$$dCP = 0.8614 \times (CPI - NDIPI) + 0.7356 \times (NDIPI - ADIPI) - 5.0846\ (R^2 = 0.9287; AIC = 2793.0);$$

where: dCP= digestible protein, cell content crude protein= (CP intake (CPI) - neutral detergent insoluble protein intake (NDIPI)), cell wall crude protein= (neutral detergent insoluble protein intake (NDIPI) – acid detergent insoluble protein intake (ADIPI)).

The exponential model (CP-Exp):

$$dCP = 0.9410 \times (CPI - NDIPI) + 0.6589 \times \left(NDIP \times 1 - e^{-(0.8188 + 0.1676 \times ADIP)}\right) - 1.4193 \; (R^2 = 0.8455; AIC = 2718.6)$$

where: cell content crude protein as previously defined, NDIP= neutral detergent insoluble protein concentration, ADIP= acid detergent insoluble protein concentration

The specie effect was not significant for any of the variables , neither for the slope nor for the metabolic fecal contribution, resulting in joint equations for the dCP estimation.

The NDF-nonlinear model, was:

$$DpdNDF = 5.1963 - 0.00184 \times D - 46.5361 \times CP + 111.54 \times CP^2 + 0.0052 \times NDFI(lw) - 3.6828 \times iNDF - 6.3406 \times iNDF^2 - 0.00026 \times (DMI(lw) \times iNDF) - 0.0019 \times (DMI(lw) \times CP) + 26.4659 \times (iNDF \times CP)(R^2 = 0.9622; AIC = -1270.3)$$

where: CP= crude protein, NDFI(lw)= intake of NDF as a percentage of live weight, iNDF= concentration of iNDF, DMI(lw)= intake of DM as a percentage of live weight, D= variable associated to specie, where D= 0 for goats or D=1 for sheep.

The NDF-nonlinear model was:

$$Reduced\ dNDF = \{0.6227 \times (NDF - L) + [1 - (L \div NDF)^{0.85}]\}(R^2 = 0.6487;\ AIC = 2465.5)$$

$$Complete\ dNDF = D1 \times \{0.4876 \times (NDF - L) + [1 - (L \div NDF)^{0.85}]\} + D2 \times \{0.7451 \times (NDF - L) + [1 - (L \div NDF)^{0.85}]\} (R^2 = 0.6487;\ AIC = 2481.3)$$

where: NDF and L as previously defined, D= variable associated to specie (D1 = 0 and D2 = 1 for sheep and D1 = 1 and D2 = 0 for goat).

All three CP models had adequate adjustments, but because of higher MSEP (mean square error of prediction), some variation was perceived in the CP-Exp. Both NDF models had low accuracy as demonstrated by the concordance correlation coefficient (CCC=0.5055 and 0.4197 for NDF-linear and NDF-nonlinear, respectively), meaning that more data might be necessary to increase model accuracy.

Conclusion

All three CP equations can be used to estimate this digestible fraction in sheep and goats diet; it will depend on the available input data. As to NDF models, it is recommended some caution because resulting data will alter the energy estimates until further studies can be added to the data bank.

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