Behavior analysis of a first order degradation model when fitting the nutrient ruminal disappearance data

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Introduction There are several different models for describing the nutrient ruminal degradation of feeds. The use of a particular model in fitting a given degradability data set and estimating the degradability parameters implies the holistic examination of model goodness-of-fit, otherwise the validity of estimated parameters may be controvertible. One of the criteria for evaluating goodness-of-fit is model behaviour analysis. In the present work, the behaviour of a first-order model when fitting whole soybean ruminal degradability data was investigated.

Materials and methods DM and CP degradability data of two Iranian soybean cultivars (Sahar and Williams) as raw, roasted and steep-roasted (6 feeds in total), which was recorded at fixed incubation periods (1, 2, 3, 4, 8, 16, 24, 36 and 48 h) for each feed and yielded a total of 6 disappearance curves, were used in this study. The evaluated model was a rational function or inverse polynomial (linear over linear), which describe a rectangular hyperbola and assumes a variable fractional rate of degradation that declines with time (Lopez *et al*., 1999). Fractional degradation rate (/h), disappearance to time t (%) and extent of degradation (%) were calculated using the formulae $\frac{1}{t-L+T}$, $a+b\frac{t-L}{t-L+T}$ and $a+bk\int_{L}^{\infty}\left(\frac{t-L}{t-L+T}\right)\mathrm{e}^{-kt}\mathrm{d}t$, respectively. L is a discrete lag parameter (h) and was included in the model to represent the time interval before degradation commences, T is a time constant (h), and a, b and k are rapidly soluble fraction (%), slowly degradable fraction (%), and fractional passage rate (/h), respectively. The model was fitted to the DM and CP disappearance curves by nonlinear regression using the PROC NLIN of SAS to estimate ruminal degradation parameters. Model behaviour analysis was used to evaluate general goodness-of-fit (quality of prediction) of the model to each curve.

Results All curves could be fitted by the model using nonlinear regression and utilizing the PROC NLIN of SAS, as convergence to a solution occurred in all cases and the degradability parameters could be estimated (Table 1). However, when the model was unconstrained, (a + b) tended to a value larger than 1 which was unacceptable biologically, so the sum of these two parameter was constrained to be no greater than unity. Although non-convergence was not found, a large number of iterations were required and significant sensitivity to starting values was observed, which were symptomatic of an ill-conditioned or inappropriate model.

Table 1 Parameter estimates (SE in parentheses) of DM and CP ruminal disappearance of all feeds[1]

Item[2]	DM	CP
a	47.67 (1.672)	45.17 (4.088)
b	52.16 (1.625)	55.25 (3.014)
U	0.17 (0.410)	-0.42 (1.578)
T	11.80 (3.784)	13.83 (5.562)
L	2.65 (2.850)	2.81 (2.833)
E (*k* = 0.06)	64.23 (8.786)	58.46 (9.937)
E (*k* = 0.08)	60.37 (8.326)	55.09 (9.556)

[1]rather than present the parameter estimates for each rumen incubated feed, the mean of the parameters estimated over all incubated feeds are shown.
[2]*a*, rapidly soluble fraction (%); *b*, slowly degradable fraction (%); *U*, undegradable fraction (%), calculated as (1 - *a* - *b*); *T*, time constant (h), such *L* + *T* is the time taken for half of the slowly degradable fraction to disappear; *L*, lag time (h); *E*, extent of degradation (%); *k*, fractional passage rate (/h).

Conclusion Although the model could estimate the parameters of the DM and CP degradability data for the feeds used in this study and the values presented in Table 1 apparently are acceptable, the behaviour of the model when fitting reflected its inadequacy for this particular data set. It can be concluded that before presenting estimated parameters of models, examination of model goodness-of-fit through model behaviour analysis is necessary.

References

Lopez, L., France, J., Dhanoa, M. S., Mould, F., and J. Dijkstra. 1999. Comparison of mathematical models to describe disappearance curves obtained using the polyester bag technique for incubating feeds in the rumen. Journal of Animal Science 77, 1875-1888.