

Prediction of digestibility of neutral detergent solubles using the Lucas principle

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ABSTRACT

Results from sheep digestibility trials, performed at the Danish Institute of Agricultural Sciences in the period from 1984 until now, were analysed according to the Lucas principle. The Lucas principle means that across feeds, apparent digestibilities of nutrients in cell contents can be ascribed to a constant true digestibility and to an endogenous loss, which is a constant proportion of feed dry matter (DM). Based on mean digestibilities for 493 feed samples, a true Neutral Detergent Solubles (NDS) digestibility of 101.3% and an endogenous loss of 90.2 g NDS per kg ingested DM were estimated.

KEY WORDS: ruminants, neutral detergent solubles, digestibility

INTRODUCTION

Prediction of digestibility of different fractions of the feed cell content based on the chemical analysis using the Lucas formula is well known (Van Soest, 1994). The principle behind the Lucas formula is, that a nutrient, independent of the feed, has a constant true digestibility, and the endogenous loss of the nutrient in the faeces is a constant proportion of the feed DM intake (Lucas et al., 1964).

The aim of this paper is to present analyses using the Lucas principle to estimate digestibility of total cell contents (NDS) based on sheep digestibility trials performed in Denmark during the last 18 years. Preliminary results from the data analysis have been presented earlier (Weisbjerg et al., 2002).

MATERIAL AND METHODS

Data

The digestibility data used are from sheep digestibility trials performed in Denmark from 1984 until now. A total of 5754 digestibility determinations were in the database. However, not all trials involved all chemical analyses on faeces, therefore

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the data base for NDS digestibility had 2337 observations after outliers also had been deleted. The chemical composition of the feeds is shown in Table 1. The feeds tested covered a very broad range from concentrates over forages to straw. The number of trials equals the number of sheep (observations). In most cases there have been 4 repetitions per feed, in few cases more. This means that the number of feed samples, involved in this analysis, is 504. From the total database only the following outliers were deleted: 9 observations for one feed (which was a product sold as rapeseed meal) with extreme low protein digestibility, 12 observations with extreme high digestibility of NDS covering 3 samples of very ash rich fodder beet top, 8 observations of whole crop wheat silage with very high ash content and 26 observations on fodder beets with outlying neutral detergent fibre (NDF) digestibility. Further, 26 observations were deleted due to NDF or NDS digestibilities above 100%.

Table 1. Chemical characteristics for the feeds in the database available (2337 observations) for NDS digestion calculations, % in DM

	Mean	Minimum	Maximum
Crude ash	8.2	1.7	21.8
Crude protein ¹	16.4	3.1	51.2
NDF	46.9	8.0	84.4
NDS ²	44.9	10.6	89.0

¹ 2247 observations, ² calculated as DM - (crude ash + NDF)

Animals and feeding

The sheep used were mature castrated male sheep of Leicester breed, most weighing between 80 and 100 kg liveweight. The sheep were fed at maintenance level which was approx. 800-1000 g DM per sheep per day. If necessary, experimental feeds were supplemented with either hay or soyabean meal to avoid depression of digestion due to lack of either protein or structure. When supplements were given, digestibilities of experimental feeds were calculated by difference, after determination of digestibility of the supplement feeds.

Chemical analysis

DM of concentrates was determined at 100°C, and of forages at 80°C. For silages, DM % was corrected for loss of volatile products. Protein was analysed using the Kjeldahl procedure. Ash-free NDF was determined using a Fiber-Tec system, according to Van Soest et al. (1991) modified with an overnight pre-treatment with α -amylase (A6380, Sigma) at 38°C was followed by addition of sodium sulphite and a heat stable α -amylase (Termamyl, Novo Nordisk, Denmark) during neutral detergent boiling.

Calculations

NDS content was calculated as the difference between organic matter and NDF content. Apparently digested NDS in percent of feed DM were regressed

against the content of NDS in percent of DM. According to the Lucas principle, this regression gives true digestibility as the regression coefficient, and the endogenous loss (as percent of feed DM) as the intercept.

RESULTS

In Figure 1a the apparent digestibility of NDS is plotted against the NDS concentration in the DM. Figure 1a shows non-linear increasing digestibility with increasing NDS concentration. When the digested amounts in percent of feed DM are regressed against the content of the nutrients in DM, the linear relationships shown in Figure 1b are found. The regression shows that using the simple Lucas principle, NDS has a true digestibility of 103%, and that the endogenous loss of

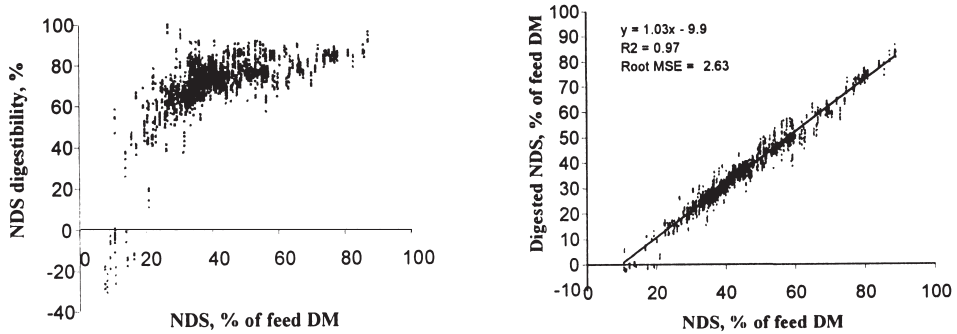


Figure 1. a) Apparent NDS digestibility plotted against NDS concentration. b) Apparently digested NDS in % of feed DM plotted against NDS concentration

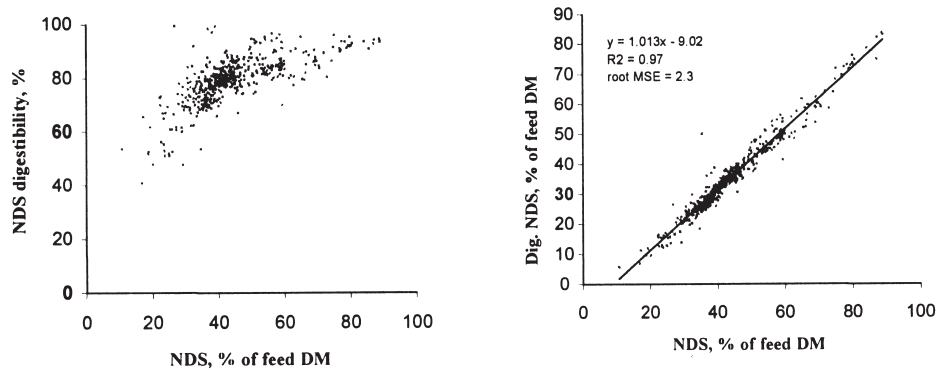


Figure 2. As Figure 1, but on mean values for feed samples, and after deletion of straw samples and 2 feed samples (see text)

NDS is 99.1 g per kg feed DM. Generally only minor systematic deviations due to feed type were found. When mean residuals were calculated within feed type, only ammonia treated straw, straw and cotton seed products showed considerable mean residuals, and these were negative. This means, that these feed types predicted

digestible NDS to be higher than observed. To reduce influence of random error on the estimates, means per feed sample were used. Further, 9 straw samples were deleted together with 2 feed samples (one hay and one maize silage sample) with large residuals. This resulted in 493 observations, as shown in Figure 2. Regression analysis on this material resulted in estimation of a true digestibility of 101.3% for NDS, and 90.2 g NDS as endogenous loss per kg feed DM.

DISCUSSION

Regression analyses were performed both on individual observations and on means for feed samples. The analysis on sample means after deletion of straw samples, gives probably the biologically most reasonable estimates for normal feed samples. The present analyses show, that NDS is highly digestible, and true digestibility was estimated to be slightly above 100%. The loss of endogenous NDS in the faeces was estimated to 90.2 g per kg ingested DM. Earlier studies have shown that crude protein and crude fat have true digestibilities of 94 and 96% and endogenous losses in the faeces of 34 and 10 g per kg feed DM, respectively (Weisbjerg et al., 2002). This means that the endogenous loss of 'calculated carbohydrates' is approximately 46 g per kg ingested DM ($90 - (34+10)$). True digestibilities above 100% are un-biological, and are probably due to a simultaneous overestimation of true digestibility and endogenous loss. The reason for this is probably that the endogenous losses are not a constant proportion of feed DM intake, but are also dependent on the content of fibre (NDF) in the feed. As the content of NDS is highly negatively correlated with NDF content, this can explain that the true digestibility of NDS was estimated to be above 100%. This was confirmed from the reduction in estimates for both true digestibility and endogenous loss obtained when straw samples were omitted. In a review by Van Soest (1994) true digestibilities of NDS from 83 to 116% and endogenous losses from 99 to 182 g for ruminants were cited, and with higher endogenous losses for cattle than for sheep. These literature values, although slightly higher for endogenous loss, are in agreement with the results in the present study, which are based on a large number of observations varying widely in both feed types and chemical composition.

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