A2. Adjusted Crude Protein

Reference:

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Scope:

The calculation for adjusted crude protein is applicable to forages.

Basic Principle:

In non-heat-damaged forages, CP is highly correlated with the digestible protein (DP) content of forages [%DP = .94 (%CP) - 3.5; r = .95]. The regression coefficient of this equation (.94) estimates the true digestibility of CP in forages and the intercept (-3.5) estimates endogenous fecal loss of CP. Crude protein reflects the total nitrogen (N) content of feeds and provides a good estimate of DP in feeds that are not heat-damaged. However, there are instances when CP overestimates protein availability.

Studies indicate that heat-damage lowers protein digestibility in some low moisture silages (haylages). The degree of caramelization and browning of the forage is evidence of heat damage. Feeds that are dark brown or black have been extensively damaged by heating. The nonenzymatic browning (Maillard) reaction requires water, but not oxygen, and produces heat. It involves the condensation of carbohydrate degradation products with protein to form dark-colored, insoluble polymers. Sugar residues appear to condense with amino groups at a 1:1 ratio.

While developing the detergent system of fiber analyses in forages, Van Soest observed that materials dried at high temperatures resulted in high fiber values and the fiber contained nitrogen which was difficult to remove with detergent or pepsin. From this observation, he developed the concept that detergent could be used to partition protein into fractions that vary in their digestibility and availability in the rumen. Acid detergent insoluble nitrogen (ADIN, sometime called ADFN) in forages represents primarily heat-damaged or bound protein that is indigestible or poorly digested by animals.

Mertens has shown that ADIN also exists in forages that have not been heated and observed that this non-heat-damaged ADIN is related to the lignin and to a fraction of protein in forages. His work suggests that 5-12% of the nitrogen in non-heat-damaged forages is isolated as ADIN (lower values for grasses than legumes). This naturally occurring ADIN probably is the truly indigestible protein in feeds. The ADIN in heat-damaged feeds contains both the ADIN naturally occurring in the feed and the ADIN associated with heat-damaged Maillard products. The heterogeneity of ADIN may explain the difficulty in measuring it (especially with NIR) and its lack of constant biological availability.

Neutral detergent insoluble nitrogen (NDIN), which is measured without the use of sodium sulfite as is used in the amylase neutral detergent fiber (aNDF) method, consists of ADIN plus insoluble fibrous proteins and cell wall bound protein. Van Soest suggests that the difference between NDIN and ADIN represents the protein that is slowly degraded in the rumen but is digested in the intestines. Cornell scientists use the difference between NDIN and ADIN in a computer model to estimate the amount of protein that escapes fermentation in the rumen (so called escape, bypass or undegraded protein).

It should be recognized that heating can have both positive and negative effects on protein utilization by the animal. Heating generally results in lowered digestibility of protein. Digestibility of ADIN varies from 0 to 60% depending on the feed ingredient, and the time and intensity of heating. At low heat inputs, this negative effect of heating can be compensated by reducing the solubility of proteins, which makes them less degradable in the rumen This reduces the potential loss of protein in the rumen (as ammonia) and actually increases protein utilization efficiency when feeds are slightly heated. Thus, for most feeds, no adjustment of CP is needed when ADIN (% of N) is less than 14%, CP is partially adjusted when ADIN is between 14 and 20%, and CP is completely adjusted for ADIN when it is above 20%.

<u>Calculation:</u> ADFCP/CP Ratio

$$\text{RATIO} = \frac{\text{ADFCP}}{\text{CP}} \times 100$$

Where ADFCP = % acid detergent fiber crude protein
CP = % crude protein

Calculation: Adjusted Crude Protein (ACP)

1) If ADFCP/CP ratio is less than 14 (all ADIN is considered digestible):

$$ACP = CP$$

Where CP = % crude protein

2) If ADFCP/CP is equal to or greater than 14 and less than or equal to 20 (only ADIN above 7% is indigestible):

$$ACP = CP - \left[\frac{RATIO - 7}{100} \times CP\right]$$

Where Ratio = ADFCP/CP ratio calculated above
CP = % crude protein

3) If ADFCP/CP ratio is greater than 20 (all ADIN is considered indigestible):

$$ACP = CP - ADFCP$$

Where CP = % crude protein
ADFCP = % acid detergent fiber crude protein