

MODELS FOR LUCERNE QUALITY GRADING

by

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ABSTRACT

A study was conducted to develop and identify an evaluation system (model) to predict lucerne hay quality. Two hundred and ten lucerne hay samples for chemical analyses and *in vitro* digestibility determinations were obtained from different cuttings during two seasons (100 samples for 1998/1999 and 110 for 1999/2000), at different times in a season and from different lucerne producing areas (sites) in the Northern Cape, South Africa. One hundred and eighteen of these samples were used for essential amino acid analysis. Thirty of the 210 samples and an additional 42 lucerne hay samples were obtained during one season (1999/2000) to estimate protein degradation (*in sacco*). Twelve Dorper lambs fitted with a rumen cannula were used in the degradation study.

The variation in nutritive value of South African lucerne hay was evaluated as an initial study. The highest moisture content recorded (9.35%) was safely below the critical moisture level of 15% for effective storage. The coefficient of variation ($CV = \pm 15\%$) of crude fibre (CF), acid detergent fibre (ADF) and neutral detergent fibre (NDF) emphasized the need for analysis to ensure accurate diet formulation. This also applied for ash ($CV = 22.11\%$), crude protein (CP) ($CV = 11.6\%$), non-fibre carbohydrate (NFC) ($CV = 34.0$), effective ruminal protein degradability (ERPD) ($CV = 18.9\%$) and essential amino acids (EAA) ($CV = 14.5\% - 27.1\%$). The effective protein degradation parameters a, b and c showed the highest CV (106.8% - 306.4%). The mean *in vitro* organic matter digestibility (IVOMD) value (67.6%) seems to be representative ($CV = 5.4\%$) of the IVOMD for the lucerne hay population used.

Lower ERPD values (average 47.7%) than usually reported, were observed. The influence of acid detergent fibre nitrogen (ADF-N) on the rumen undegradable protein (RUP) of lucerne hay was negligible. Heat damage occurred to a small percentage (3.5%) of the samples. Lucerne hay had a high lysine (4.55g/100g CP) and low methionine (0.44g/100g CP) content. Methionine, lysine and isoleucine were, in a descending order, the least detectable in lucerne hay for milk synthesis.

A second study was conducted to include protein quality, according to the United Kingdom metabolizable protein system (MP), into the total forage index (TFI) system to determine the quality of lucerne hay more accurately. This model (lucerne quality index) was compared to the chemical analysis and existing models for the determination of lucerne hay quality. The following models were used to estimate lucerne hay quality:

- a) Relative feed value (RFV) = % digestible dry matter (DDM) $\times$ dry matter intake as a % of body weight (DMI) $\times$ 0.775
- b) Total forage index (TFI) = RFV + % CP $\times$ 6
- c) Adjusted total forage index (ATFI) = RFV + adjusted crude protein (ACP) $\times$ 6.
- d) Lucerne quality index (LQI) = IVOMD $\times$ DMI + MP $\times$ 6, expressed as an index.

NDF ($r^2 = 0.57$) compared to ADF ($r^2 = 0.48$) was a more accurate estimator of IVOMD. The NDF content of lucerne hay also played an important ($P < 0.0001$) role in regression equations to predict the quality models RFV ($r^2 = 0.86$), TFI ($r^2 = 0.82$) and ATFI ($r^2 = 0.84$) respectively as well as IVOMD ($r^2 = 0.57$) and ERPD ($r^2 = 0.50$). A high relationship occurred between these various models ($r^2 > 0.90$). A moderate correlation ($P < 0.0001$) was however observed between LQI and respectively ADF ($r^2 = 0.50$), NDF ($r^2 = 0.50$), IVOMD ($r^2 = 0.56$), CP ($r^2 = 0.50$), RFV ($r^2 = 0.51$), TFI ($r^2 = 0.56$) or ATFI ($r^2 = 0.55$). No significant ($P > 0.05$) predictor for the ERPD fractions (a, b and c) were observed. LQI could be predicted from ADF ($r^2 = 0.50$) or ADF, ERPD and CP ($r^2 = 0.94$) in a multiple regression equation.

The results of the present study clearly indicated that a large variation occur in the energy and protein composition as well as the utilization of nutrients in South African lucerne hay. This emphasizes the need for a rapid and accurate quality evaluation system for lucerne hay in practice. LQI seems to be a better quality evaluation system than to those currently available. The relationships with LQI in the present study is based on a relatively small number ($n = 30$) of lucerne hay samples. Further research with a larger number of lucerne hay samples is needed to confirm these results. The usage of near infrared reflectance spectroscopy (NIRS) for the rapid nutritional evaluation of lucerne hay (LQI) also needs urgent investigation.

OPSOMMING

Navorsing is onderneem om 'n evalueringstelsel (model) te ontwikkel en identifiseer vir die bepaling van lusernkwiteit. Tweehonderd en tien lusernhooi monsters vir chemiese ontledings en *in vitro* verteerbaarheidsbepalings is ingesamel vanaf verskillende snysels gedurende twee seisoene (100 monsters gedurende 1998/1999 en 110 gedurende 1999/2000), verskillende tye binne 'n seisoen en vanaf verskeie lusernproduserende gebiede in die Noord-Kaap provinsie van Suid-Afrika. Eenhonderd en agtien van hierdie monsters is vir essensiële aminosuuronloedings gebruik. Dertig van hierdie 210 monsters en 'n verdere 42 lusernhooi monsters is verkry gedurende een seisoen (1999/2000) om proteïendegradering (*in sacco*) te beraam. Twaalf Dorperlamms toegerus met rumenfstels is vir die studie gebruik.

Die variasie in voedingswaarde van Suid-Afrikaanse lusernhooi is in 'n eerste studie geëvalueer. Die hoogste voginhoud gemeet (9.35%) was veilig onder die kritiese vogvlak van 15% vir effektiewe opberging. Die koëffisient van variasie ($CV = \pm 15\%$) vir ruvesel (CF), suurbestande vesel (ADF) en neutraalbestande vesel (NDF) het die noodsaaklikheid van ontledings vir akkurate dieetformulering beklemtoon. Dit het ook gegeld vir as ($CV = 22.11\%$), ruprotein (CP) ($CV = 11.6\%$), nie-veselagtige koolhidrate (NFC) ($CV = 34.0\%$), effektiewe rumendegradearbaarheid van protein (ERPD) ($CV = 18.9\%$) en esensiële aminosure (EAA) ($CV = 14.5\% - 27.1\%$). Die effektiewe, proteïendegradearbaarheids parameters a, b en c het die hoogste CV (106.8% - 306.4%) getoon. Die gemiddelde *in vitro* organiese materiaal verteerbaarheid (IVOMD) waarde (67.6%) blyk verteenwoordigend te wees ($CV = 5.4\%$) van die lusernhooi populasie wat gebruik is.

Laer ERPD waardes (gemiddeld 47.7%) wat algemeen gerapporteer word, is verkry. Die invloed van suurbestandevesselstikstof (ADF-N) op die rumenondegradeerbareprotein (RUP) van lusernhooi was onbeduidend. Hittebeskadiging is by 'n klein persentasie (3.5%) van die lusernhooi monsters waargeneem. Lusernhooi het 'n hoë lisien (4.55g/100g CP) en 'n lae metionieninhoud bevat. Metionien, lisien en isoluesien, was in 'n dalende volgorde, die mees beperkte EAA vir melksintese.

'n Tweede studie is uitgevoer om proteïnkwaliteit, ooreenkomstig die metaboliseerbare proteïnstelsel (MP) van die Verenigde Koninkryk, in te sluit by die totale ruvoerindeksstelsel (TFI) om die kwaliteit van lusernhooi meer noukeurig te bepaal. Hierdie model (lusernkwaliteit-indeks) is vergelyk met chemiese ontledings en bestaande modelle om die gehalte van lusernhooi te bepaal. Die volgende modelle is gebruik om die kwaliteit van lusern te bereken:

- a) Relatiewe voerwaarde (RFV) = % verteerbare droë materiaal (DDM) × droëmateriaalinname as % van liggaamsgewig (DMI) × 0.775
- b) Totale ruvoerindeks (TFI) = RFV + % CP × 6
- c) Aangepaste totale ruvoerindeks (ATFI) = RFV × aangepaste ruproteïen (ACP) × 6
- d) Lusernkwaliteitsindeks (LQI) = IVOMD × DMI + MP × 6, as 'n indeks uitgedruk.

NDF ($r^2 = 0.57$) in vergelyking met ADF ($r^2 = 0.48$) was 'n meer akkurate beramer van IVOMD. Die NDF inhoud van lusernhooi het ook 'n belangrike rol ($P < 0.0001$) gespeel in regressievergelykings om onderskeidelik die kwaliteitmodelle RFV ($r^2 = 0.86$) en TFI ($r^2 = 0.84$) asook IVOMD ($r = 0.57$) en ERDP ($r = 0.50$) te voorspel. 'n Hoë verwantskap is tussen hierdie verskillende modelle ($r^2 > 0.90$) gevind. 'n Matige korrelasie ($P < 0.0001$) is egter waargeneem tussen LQI en onderskeidelik ADF ($r^2 = 0.50$), NDF ($r^2 = 0.50$), IVOMD ($r^2 = 0.56$), CP ($r^2 = 0.56$), RFV ($r^2 = 0.51$), TFI ($r^2 = 0.56$) of ATFI ($r^2 = 0.55$). Geen betekenisvolle ($P > 0.05$) beramer vir die ERPD fraksies (a, b en c) is waargeneem nie. LQI kon voorspel word vanaf ADF ($r^2 = 0.50$) of ADF, ERPD en CP ($r^2 = 0.94$) in 'n meervoudige regressievergelyking.

Die resultate van die huidige studie het duidelik getoon dat daar 'n groot variasie voorkom in die energie- en proteïensamestelling, asook benutting van voedingstowwe, in Suid-Afrikaanse lusernhooi. Dit beklemtoon die noodsaaklikheid van 'n vinnige en akkurate evalueringstelsel vir lusernhooi in die praktyk. Dit wil voorkom asof LQI 'n beter evalueringstelsel van lusernkwaliteit is as ander stelsels wat tans gebruik word. Die verwantskap met LQI in die huidige studie is gebaseer op betreklik min ($n = 30$) lusernhooi-monsters. Verdere navorsing met meer lusernhooi-monsters is nodig om bogenoemde resultate te staaf. Die gebruik van infrarooispektroskopie (NIRS) vir vinnige bepaling van die voedingswaarde van lusernhooi verg ook dringende aandag.