

THE EFFECT OF EXTRUSION ON THE DEGRADABILITY PARAMETERS OF VARIOUS VEGETABLE PROTEIN SOURCES

By

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ABSTRACT

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The objective of this study was to determine the effect of extrusion, as a method of heat treatment, on the dry matter (DM) and crude protein (CP) degradability parameters of various vegetable protein sources commonly used in the Western Cape Province, South Africa. The feedstuffs used were lupins (LUP), full fat soybeans (SB), full fat canola seeds (FCS), soybean meal (SBM), canola meal (CM) and sunflower meal (SFM).

In the first trial, the degradability parameters were determined according to an *in sacco* degradability procedure. Four non-lactating Holstein cows, fitted with rumen cannulae, were used in the trial and all cows received the same basal lactation diet. The samples were incubated in dacron bags and bags were removed at intervals of 0, 2, 4, 8, 16, 24 and 48 hours. Dry matter and CP disappearance values were determined and fitted to a one-compartment model by means of an iterative least-square procedure in order to determine the DM and CP degradability parameters. Results indicated that extrusion significantly lowered the effective degradability of the DM-fraction (20.1% on average) of all the feedstuffs, except LUP, and the effective degradability of CP in all the raw materials (27% on average).

The second trial was an *in vitro* degradability trial that ran parallel with the *in sacco* degradability trial and was done with the aid of a Daisy^{II} Incubator (ANKOM Technology Corp., Fairport, NY). The same feedstuffs were tested in both trials. A composited sample of rumen liquor from two of the cows used in the *in sacco* trial was used for *in vitro* incubation of the samples. The data obtained in this trial were analyzed in a similar way to that of the *in sacco* trial. Due to a limited amount of residue left after incubation, CP disappearance could not be calculated at each time interval for SB and SBM in the *in vitro* trial. In this case, actual disappearance values after 8h were used to compare treatments. Extrusion significantly lowered the effective degradability (as determined *in vitro*) of DM in all the feedstuffs tested

(16.8% on average), as well as the effective degradability of CP in LUP, FCS, CM and SFM (21.8% on average). A comparison of the actual disappearance values after 8 hours incubation indicated that extrusion also lowered the rate of CP disappearance for SB and SBM.

The values obtained in the *in vitro* trial and those from the *in sacco* trial, for the same feedstuffs, were compared. It appeared as if the *in vitro* determined values were over-estimations of the *in sacco* determined values. A regression analysis showed a high correlation between the actual *in vitro* CP disappearance values after 8h incubation and *in sacco* determined effective degradability values.

The third part of this study was a set of chemical analysis to determine the effect of extrusion on certain nitrogen fractions of the feedstuffs tested in the above mentioned trials. Solubility in a mineral buffer solution was determined to estimate the potential rumen degradability of the protein. The buffer insoluble nitrogen (BIN) fraction of all the feedstuffs, except FCS, was significantly increased by extrusion. Extrusion lowered the acid detergent insoluble nitrogen (ADIN) content of all feedstuffs, except FCS, which could imply that the temperature reached during extrusion (115°C - 120°C) was not high enough to cause damage to the protein. The neutral detergent insoluble nitrogen (NDIN) fraction of extruded SB, SBM, CM and SFM was significantly higher than that of the raw feedstuffs. Extrusion left the NDIN-fraction of FCS and LUP unaltered. Comparison of the NDIN : ADIN ratio of extruded with that of the raw feedstuffs provided reason to believe that extrusion had a positive effect on all feedstuffs (except FCS).

Extrusion appears to be a useful method to decrease rumen degradation of vegetable protein sources, without causing heat damage. Furthermore, this means that protein sources of which the use have been limited due to its high rumen degradable protein (RDP) content, could be included in diets at higher levels following extrusion. The protein sources mentioned are also good sources of energy and the combination of energy and rumen undegradable protein (RUP) in the diet of the high-producing dairy cow could only be beneficial.

SAMEVATTING

DIE EFFEK VAN EKSTRUSIE OP DIE DEGRADERINGSPARAMETERS VAN VERSKEIE PLANTAARDIGE PROTEÏEN BRONNE

Die doel van hierdie studie was om die effek van ekstrasie op die droëmateriaal (DM) en ru-proteïen (RP)-degradeerbaarheidsparameters van verskeie plantaardige proteïenbronne wat algemeen in die Wes-Kaap (RSA), gebruik word, te bepaal. Ekstrasie is 'n metode van hitteprosesering wat algemeen gebruik word deur plaaslike en internasionale veevoervervaardigers. Die volgende grondstowwe is geëvalueer: lupiene, volvet sojabone, volvet canolasaad, sojaboon-oliekoekmeel, canola-oliekoekmeel en sonneblom-oliekoekmeel.

In die eerste proef is die degradeerbaarheidsparameters met behulp van 'n *in sacco* studie bepaal. Vier droë Holstein koeie met rumen kannulas is in die studie gebruik en al vier koeie het dieselfde basale dieet ontvang. Monsters is in dacronsakkies geïnkubeer en die sakkies is uit die rumen verwyder na onderskeidelik 0, 2, 4, 8, 16, 24 en 48 uur intervalle. Die waardes van DM- en RP- verdwyning is bereken en dan met 'n iteratiewe kleinste kwadraat prosedure op 'n een-kompartement model gepas om die *in sacco* DM- en RP-degradeerbaarheidsparameters te bepaal. Die resultate van die studie het getoon dat ekstrasie die effektiewe degradeerbaarheid van die DM-fraksie van al die grondstowwe, behalwe lupiene, betekenisvol verlaag het (met gemiddeld 20.1%), asook die effektiewe degradeerbaarheid van die RP-fraksie van al die grondstowwe (met gemiddeld 27%).

Die tweede proef was 'n *in vitro*-degradeerbaarheidsstudie wat met behulp van 'n ANKOM Daisy^{II} Inkubeerder uitgevoer is en wat parallel met die *in sacco*-studie gedoen is. Dieselfde grondstowwe is in beide proewe geëvalueer. 'n Saamgestelde monster van die rumenvloeistof van twee van die koeie wat vir die *in sacco*-studie gebruik is, is gebruik vir die *in vitro*-inkubasie van die monsters. Data-verwerking is op 'n soortgelyke wyse as dié van die *in sacco*-studie uitgevoer. As gevolg van 'n beperkte hoeveelheid residu na afloop van die inkubasies, kon die RP-verdwyning vir volvet sojabone en sojaboon oliekoekmeel nie bereken

word nie. In hierdie geval is waargenome verdwyningswaardes na 8h gebruik om behandelings te vergelyk. Hierdie studie het getoon dat ekstrusie die effektiewe degradeerbaarheid van DM (soos *in vitro* bepaal) in al die getoetste grondstowwe betekenisvol verlaag het (met gemiddeld 16.8%). Die effektiewe degradeerbaarheid van RP in lupiene, volvet canola saad, canola oliekoekmeel en sonneblom oliekoekmeel is ook betekenisvol verlaag (met gemiddeld 21.8%). 'n Vergelyking van die oorspronklike verdwyningswaardes van volvet sojabone en sojaboon oliekoekmeel na 'n inkubasieperiode van 8 ure het ook getoon dat ekstrusie die tempo van RP-verdwyning uit die rumen vertraag het.

Die *in sacco*- en *in vitro*-bepaalde waardes vir elke grondstof is vergelyk en dit kom voor asof die *in vitro*-waardes oorskattinge van die *in sacco*-waardes is. 'n Regressie-analise het verder getoon dat daar 'n hoë korrelasie was tussen die waargenome *in vitro* RP-verdwyningswaardes na 8 ure inkubasie en die beraamde effektiewe degradeerbaarheid, soos *in sacco* bepaal.

Die derde deel van die studie was 'n stel chemiese analyses wat uitgevoer is om die effek van ekstrusie op sekere stikstof (N)-fraksies van die grondstowwe, wat in bogenoemde proewe gebruik is, te bepaal. Die oplosbaarheid van N in 'n mineraal-bufferoplossing kan gebruik word as aanduiding van die potensiële rumendegradearbaarheid van die proteïene. Die buffer-onoplosbare N-fraksie van al die grondstowwe (behalwe volvet canolasaad) is betekenisvol verlaag deur ekstrusie. Ekstrusie het ook die suur-onoplosbare N-fraksie (ADIN) van al die grondstowwe (behalwe volvet canolasaad) betekenisvol verlaag. Dit kan moontlik daarop dui dat die temperatuur wat tydens ekstrusie (115°C - 120°C) bereik is, nie hoog genoeg was om die proteïene in die grondstowwe te beskadig nie. Ekstrusie het die N-fraksie wat onoplosbaar was in 'n neutrale oplossing (NDIN) betekenisvol verhoog in volvet sojabone, sojaboon-oliekoekmeel, canola-oliekoekmeel en sonneblom-oliekoekmeel en dit onveranderd gelaat in lupiene en volvet canolasaad). Die verhouding van NDIN : ADIN van die geëkstrueerde grondstowwe is vergelyk met dié van die rou grondstowwe. Dit blyk dat ekstrusie wel 'n positiewe effek op al die grondstowwe (behalwe volvet canolasaad) gehad het.

Dit wil dus voorkom asof ekstrusie wel aangewend kan word om die rumen-degradeerbaarheid van plantaardige proteïenbronne te verlaag sonder om die proteïen te beskadig. Dit kan daartoe lei dat proteïenbronne waarvan die gebruik voorheen beperk was as gevolg van die hoë rumen-degradeerbare proteïen-inhoud daarvan nou wel in rantsoene ingesluit kan word na die ekstrusie daarvan. Die proteïenbronne, soos genoem, is ook redelike bronne van energie en die kombinasie van energie en rumen nie-degradeerbare proteïen in die rantsoen van die hoog-produiserende melkkoei kan slegs voordelig wees.