AN EVALUATION OF DEGRADABLE PROTEIN AND NONPROTEIN NITROGEN ON INTAKE AND DIGESTION BY DOHNE MERINO SHEEP FED WHEAT STRAW

by

JOUBERT VAN EEDEN NOLTE

THESIS SUBMITTED IN PARTIAL COMPLIANCE OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF SCIENCE (AGRICULTURE)

(ANIMAL SCIENCE)

UNIVERSITY OF STELLENBOSCH

Supervisor:

A. V. Ferreira, Ph.D (Agric.)
Department of Animal Sciences
University of Stellenbosch

Co-supervisor:

H. H. Köster, Ph.D (Agric.)
OTK Ltd.

December 2000
Stellenbosch

ABSTRACT

An Evaluation of Degradable Protein and Nonprotein Nitrogen on Intake and Digestion by Dohne Merino Sheep fed Wheat Straw

by

Joubert van Eeden Nolte

Supervisor: Dr. A. V. Ferreira

Co-supervisor: Dr. H. H. Köster

Department: Animal Sciences

University of Stellenbosch

Degree: M.Sc. (Agric.)

South Africa, like many other developing countries throughout the world, has a rapidly growing human population, resulting in a consequent increased demand for food. Ironically, this increased food supply has to be produced on a smaller area of available agricultural land, which means that agricultural production processes have to become more efficient. Furthermore, the majority of the people in these countries are unschooled and poverty is a common phenomenon. Therefore, animal scientists are faced with the challenge and the responsibility to provide affordable, high quality food to these people.

One way of reaching this objective is to improve the utilisation of low-quality, high roughage feedstuffs like crop residues and dry natural grass pastures. In the winter rainfall area of South Africa alone, about 460 000 ha of wheat straw are annually available. The ruminant animal has the ability to utilise the relatively unavailable energy (cellulose, hemi-cellulose and pectin) in the fibre component of these low-quality forages. Unfortunately, various factors, of which a N deficiency is the pre-dominant one, limit the utilisation of these feedstuffs. If the ability of the ruminant to utilise low-quality, fibrous energy sources is improved, these abundantly available and relatively inexpensive crop residues and natural pastures can be converted into high quality protein food for human consumption.

Therefore, in order to rectify the N deficiency caused by these low-quality forages, the supplemental N requirement to optimise the fermentation and digestive processes of the ruminant animal has to be determined. The first study was conducted to determine the supplemental rumen degradable protein (RDP) requirement, to maximise the digestible organic matter intake (DOMI) of Dohne Merino sheep fed wheat straw. Keeping the high cost of natural protein supplementation in mind, the purpose of the second study was to determine the amount of true protein that can be replaced by nonprotein nitrogen (NPN) in RDP supplements fed to Dohne Merino sheep consuming wheat straw.

In both trials animals had *ad libitum* access to low-quality wheat straw (3.2% CP; 74.2% NDF) and water. In the first trial, RDP (calsium caseinate: 90% CP; 100% rumen degradable) was intraruminally administered at 07h00 and 19h00, at the following levels: 0, 40, 80, 120 and 160 g/d. Intake, fermentation and digestion were monitored to determine the RDP requirement to maximise DOMI. Digestible organic matter (OM) intake displayed a quadratic increase with elevated amounts of RDP ($P < .01$), and was maximised at an estimated 3.15 g RDP/kg $BW^{.75}$ or 11.6% of DOM. Forage OM intake tended to increase quadratically ($P = .15$) with higher RDP levels. Microbial nitrogen (MN) flow to the duodenum and microbial efficiency increased quadratically ($P \leq .04$) and fluid dilution rate tended to increase in a quadratic manner ($P = .15$) with increased RDP supplementation levels. Ruminal ammonia nitrogen (NH_3-N) and total volatile fatty acid (VFA) concentrations increased linearly ($P \leq .07$), while rumen pH exhibited a variable response to increased RDP levels (cubic; $P = .08$). Increasing RDP supplementation to Dohne Merino wethers consuming wheat straw, generally enhanced forage utilisation and DOMI.

In the second trial, urea replaced different levels of casein N on an isonitrogenous basis, ranging from 0 - 100%. Since true protein is much more expensive than urea, the purpose of this study was to determine the maximum natural protein level that can be replaced by urea in RDP supplements, without adversely affecting intake and/or fermentation and digestive processes. The control treatment provided all of the RDP in the form of calcium caseinate (90% CP; 100% rumen degradable). The percentages of supplemental RDP from urea in the other treatments were 25, 50, 75 and 100%. The 100% urea treatment was balanced with maize starch to contain 40% CP and all other treatments received the same amount (150 g/d) of starch. Intake of forage OM showed a weak decreasing trend (linear; $P = .16$) with

increasing urea levels. Ruminal digestibilities of OM and NDF were not affected ($P \geq .18$) by urea level. Increasing urea levels resulted in linearly reduced total tract OM and NDF digestibilities ($P \leq .10$). As a result, DOMI declined (linear; $P < .01$) with increasing proportions of urea. Effects of increasing urea proportions on duodenal N flow, microbial efficiency and fluid dilution rate were minimal. Ruminal NH_3-N tended to increase quadratically with increasing urea levels ($P = .14$). Total VFA concentration decreased linearly ($P = .03$), while rumen pH increased in a linear manner ($P = .08$) with increasing urea proportions. Branched-chain volatile fatty acids (BCVFA`s) and valerate decreased linearly ($P \leq .05$) with increasing urea levels, while other VFA`s and the acetate:propionate ratio were generally not affected by treatment ($P \geq .16$). It appears as though ruminal and total tract OM and NDF digestibility criteria, as well as DOMI reached maximum values at substituting 25% of casein for urea. It is therefore concluded that replacing 25% of casein with urea in RDP supplements, will maintain effective utilisation of low-quality forages by sheep.

SAMEVATTING

`n Evaluasie van Degradeerbare Proteïen en Nie-proteïen Stikstof op Inname en Vertering van Koringstrooi deur Dohne Merino Skape

deur

Joubert van Eeden Nolte

Studieleier: Dr. A. V. Ferreira

Mede-studieleier: Dr. H. H. Köster

Departement: Veekundige Wetenskappe

Universiteit van Stellenbosch

Graad: M.Sc. (Agric.)

Ontwikkelende lande, insluitend Suid-Afrika, word gekenmerk deur `n vinnige bevolkingsaanwas. Dit lei tot `n verhoogde vraag na voedsel, wat op `n gevolglik kleiner-wordende beskikbare kommersiële lanbbou-area geproduseer moet word. Die doeltreffendheid van produksieprosesse in die landbousektor moet dus noodgedwonge verbeter word. Die oorgrootte meerderheid van die bevolkings in ontwikkelende lande is ongeletterd en armoede en hongersnood is soms `n algemene verskynsel. Veekundiges word dus gekonfronteer met die uitdaging en verantwoordelikheid om bekostigbare, hoë kwaliteit voedsel aan hierdie mense te voorsien.

Een van die mees doeltreffende metodes om hierdie probleem aan te spreek, is om die benutting van lae kwaliteit, hoë-vesel voerbronne, bv. oesreste en droë grasweidings te verhoog. In die winterreënstreek van Suid-Afrika alleen, is 460 000 ha koringstrooi jaarliks beskikbaar. Herkouers beskik oor die besondere vermoë om die relatief onbeskikbare energie (sellulose, hemi-sellulose en pektien) in die veselkomponent van hierdie lae kwaliteit voere te benut. Verskeie faktore, waarvan `n N-tekort die mees prominente is, beperk egter die benutting van hierdie voerbronne. Die uitdaging is dus om die herkouer se vermoë om hierdie voere te benut, te optimaliseer. Sodoende word `n geredelik beskikbare, onderbenutte en relatief goedkoop voerbron omgeskakel in hoë kwaliteit proteïen vir menslike gebruik.

Die N-aanvullingsbehoefte om die fermentasie- en verteringsprosesse van die herkouerdier te optimaliseer moet dus bepaal word, sodat die N-tekort in herkouers, wat soortgelyke weidings benut, reggestel kan word. Gevolglik was die doel met die eerste proef om die behoefte aan rumen degradeerbare proteïen-(RDP)-aanvulling, vir die maksimum inname van verteerbare organiese materiaal (VOM) van Dohne Merino skape wat koringstrooi ontvang, te bepaal. Weens die hoë koste van natuurlike proteïenaanvulling, was die doel met die tweede proef om die hoeveelheid ware proteïen in RDP-aanvullings, vir Dohne Merino skape wat koringstrooi ontvang, wat met nie-proteïen stikstof (NPN) vervang kan word, te bepaal.

In beide eksperimente het die diere *ad libitum* toegang tot koringstrooi (3.2% RP; 74.2% NBV) en water gehad. In die eerste proef is RDP (kalsiumkaseïnaat; 90% RP; 100% rumen degradeerbaar) teen 07h00 en 19h00 intraruminaal toegedien, teen die volgende peile: 0, 40, 80, 120 en 160 g/d. Inname, fermentasie en vertering is gemonitor om die RDP behoefte vir die maksimum inname van VOM te bepaal. Verteerbare OM-inname het `n stygende kwadratiese tendens ($P < .01$) getoon met verhoogde RDP-peile en het `n maksimum bereik by `n aanvullingspeil van 3.15 g RDP/kg metaboliese liggaamsmassa ($LM^{.75}$) of 11.6% van VOM. Organiese materiaalinname vanaf koringstrooi het geneig om kwadraties toe te neem ($P = .15$) met verhoogde RDP-peile. Mikrobiese stikstof-(MN)-vloei na die duodenum en mikrobiese effektiwiteit het kwadraties toegeneem ($P \leq .04$) en vloeistof deurvloeitempo het `n neiging vir `n kwadratiese toename ($P = .15$) met verhoogde RDP-peile getoon. Rumen-ammoniakstikstof (NH_3-N) en vlugtige vetsuur-(VVS)-konsentrasies het lineêr toegeneem ($P \leq .07$), terwyl rumen pH `n wisselende reaksie (kubies; $P = .08$) met stygende RDP-peile getoon het. Verteerbare OM-inname en benutting van koringstrooi is verbeter deur stygende peile van RDP aanvulling by Dohne Merino hamels.

In die tweede proef is kaseïen op `n iso-stikstof basis met verskillende ureumpeile, vanaf 0 - 100%, vervang. Omdat ureum baie goedkoper is as natuurlike proteïen, was die doel van die tweede proef om die hoeveelheid natuurlike proteïen in RDP-aanvullings te bepaal wat met ureum vervang kan word, sonder om inname, fermentasie en vertering te benadeel. Die kontrolebehandeling het 100% van die RDP in die vorm van kalsiumkaseïnaat (90% RP; 100% rumen degradeerbaar) voorsien, terwyl ureum in die ander behandelings onderskeidelik 25, 50, 75 en 100% van die kaseïen-N vervang het. Die 100% ureumbehandeling is met mieliestysel tot 40% RP gebalanseer en dieselfde hoeveelheid stysel (150 g/d) is by al die

ander behandelings ingesluit, om moontlike effekte van stysel op rumenfermentasie te elimineer. Organiese materiaalinname vanaf koringstrooi het `n swak dalende tendens getoon met stygende ureum insluitingsvlakke (lineêr; P = .16). Rumenverteerbaarheid van OM en neutraal bestande vesel (NBV) is nie deur die ureumpeil beïnvloed nie (P ≥ .18). Toenemende ureumpeile het gelei tot `n lineêre afname in totale kanaal OM en NBV-verteerbaarheid (P ≤ .10). Gevolglik het VOM inname lineêr afgeneem (P < .01) met stygende ureum insluitingspeile. Die effek van behandeling op duodenale N-vloei, mikrobiese effektiwiteit en vloeistof deurvloeitempo was minimaal. Rumen-ammoniakstikstof-(NH_3-N)-konsentrasie het `n stygende kwadratiese tendens getoon (P = .14) met toenemende ureum peile. Totale vlugtige vetsuur-(VVS)-konsentrasies het lineêr gedaal (P = .03), terwyl rumen pH lineêr toegeneem het (P = .08) met stygende ureum insluitingsvlakke. Vertakte ketting VVS`e en valeriaansuurkonsentrasies het lineêr gedaal (P ≤ .05) met stygende ureumpeile, terwyl die ander VVS`e en die asynsuur:propioonsuurverhouding oor die algemeen nie deur behandeling beïnvloed is nie (P ≥ .16). Dit blyk asof VOM inname, sowel as rumen- en totale kanaal verteerbaarheidsmaatstawwe, by 25% vervanging van kaseïen-N met ureum-N `n maksimum bereik het. Die gevolgtrekking is gemaak dat die doeltreffende benutting van lae kwaliteit ruvoere deur skape, gehandhaaf sal word deur 25% van die ware proteïen in RDP-aanvullings met ureum te vervang.