

ABSTRACT

Development and evaluation of polymer coated urea as a potential slow-release urea supplement for ruminants

by

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The rate of hydrolysis of urea in the rumen of animals is a major limitation when considering the substitution of natural protein with urea in the formulation of rations. The aim of this study was to evaluate polymer coated urea prills with variable coating thickness and evaluate its potential as a slow-release NPN compound. A new slow-release urea compound, made by coating prilled feedgrade urea with a co-polymer of urea-formaldehyde resin and a castor-coconut alkyd was initially evaluated for urea-nitrogen concentration in distilled water in order to evaluate its potential as a slow-release urea product for ruminants. Amino/alkyd or polyester blends are among the cheapest of the modern synthetic systems and are considered because it is non-toxic, low-cost, biodegradable and easy to manufacture. A 2 x 2 x 2 x 2 factorial design was used and 16 individual products were made and evaluated. The Wurster method was used to encapsulate urea prills. The slopes of the urea release curves represented the release rate of the encapsulated products and were compared to identify the process variables, which had an effect on release rate. Two of the coating variables, coating weight and alkyd: resin ratio, had a major effect ($P = 0.0001$) on the release rate of urea. The crushing strength of encapsulated products was significantly ($P = 0.0001$) higher than that of untreated urea. Results motivated the evaluation of the products in the rumen of sheep in terms of rumen ammonia and blood urea N concentrations. Four slow-release products were made after interpreting results from the first study, and differed on account of the coating weight

and the composition of the co-polymer. Fifteen fistulated wethers were randomly allotted into 5 groups and intraruminally received an equivalent of 15g urea. Rumen ammonia and blood ammonia were taken at 0, 1, 2, 4, 6, 8, 12, 16, 20, 24, 36 and 48 h after administration of the various treatments. Slow release urea (SRU) resulted in significantly lower rumen ammonia peaks ($P = 0.0001$) than untreated urea, while the peaks were also significantly delayed. Untreated urea resulted in the maximum concentration at two hours after administration of the urea ($P = 0.0685$) while the SRU's reached a maximum at six hours after administration in the rumen. No significant differences between the four different SRU types were found. Responses in blood urea-N was similar to that observed for rumen ammonia nitrogen. The encapsulation was effective in decreasing the rate of ammonia release from the urea for up to six hours after administration. In a third trial four Dohne Merino wethers were used in a 2 x 2 Latin square design. They received a SRU product equivalent to 0.4 g urea per kg body weight orally. Rumen liquor and blood samples were taken at 0, 1, 2, 4, 6, 8, 12, 16, 20, 24, 36 and 48 h after intake. Difficulty was initially experienced with ingestion and palatability of the SRU products due to the strong formaldehyde and butanone odour present in the coating. The maximum rumen ammonia (NH_3) concentration for the SRU were lower than that of untreated urea (17.5 mg N/dl vs. 66.9 mg N/dl). The time to reach blood urea levels also differed considerably (6 h vs. 24 h for blood urea nitrogen) between treatments.

The encapsulation of urea prills shows potential solutions to reduce the solubility of urea and also reduce the hygroscopic nature of urea and improve the palatability and storage characteristics thereof.

Keywords: Slow-release urea, encapsulate, copolymer, urea formaldehyde rumen ammonia, blood urea nitrogen, solubility, palatability, storage characteristics.

SAMEVATTING

Ontwikkeling en evaluering van polimeer bedekte ureum as 'n
potentiële stadig vrystellende ureum supplement vir herkouers
deur

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Die vinnige tempo waarteen ureum in die rumen na ammoniak omgesit word, is die grootste beperking in die optimale benutting van ureum, as vervanging van natuurlike proteïen in herkouerrantsoene. Die doel van hierdie studie was om 'n stadig vrystellende ureumproduk te ontwikkel wat die rumenammoniakvlak gedurende 'n aansienlike periode van die dag bokant 'n sekere vlak kan hou. 'n Nuwe stadig vrystellende ureumproduk, vervaardig deur ureumkorrels met 'n kopolimeer van ureum-formaldehidhars en 'n kastor-en klapperalkied te bedek, is geëvalueer om die potensiaal as stadig vrystellende nie-proteïen stikstof (NPN)-produk vir herkouers te ondersoek. Die veiligheid, biodegradeerbaarheid, lae koste en maklike vervaardiging van amino/alkied-kopolimere maak dit een van die goedkoopste sintetiese sisteme om vir stadig vrystellende sisteme te oorweeg. 'n $2 \times 2 \times 2 \times 2$ Faktoriale ontwerp is gebruik om 16 individuele produkte te vervaardig. Die Wurster-metode is gebruik om individuele korrels te enkapsuleer met die polimeer en die potensiaal van die produkte is aanvanklik geëvalueer deur die ureumstikstofvrystelling in gedistilleerde water te meet. Die hellings van die vrystellingsgrafieke is vergelyk om die veranderlikes te bepaal wat die grootste invloed op die vrystellingstempo van ureum uit die geënkapsuleerde produkte het. Resultate dui dat twee veranderlikes 'n betekenisvolle effek het op die

vrystellingstempo, nl. dikte van die omhulsel, en die samestelling van die kopolimeer ($P = 0.0001$ en $P = 0.0135$, onderskeidelik) het. Die samedrukbaarheid van die geïnkapsuleerde produkte was ook betekenisvol hoër ($P = 0.0001$) as die van onbehandelde ureumkorrels, wat lei tot verbeterde bergings- en hanteringseienskappe. Interpretasie van resultate lei tot die vorming van vier stadig vrystellende produkte. Vyf groepe van 3 volwasse rumengefistuleerde Dohnmerinohamels is in 'n proef gebruik om die potensiaal van die produkte verder te ondersoek. 'n Ekwivalent van 15 g ureum is direk in die rumen van elke dier geplaas en ammoniak- en bloedmonsters is 0, 1, 2, 4, 6, 8, 12, 16, 20, 24, 36 & 48 ure na dosering geneem. Die stadig vrystellende ureumprodukte het 'n betekenisvol laer maksimum waardes vir beide ammoniak- en bloedstikstofureum getoon ($P = 0.0001$). Onbehandelde ureum het 'n maksimum rumenammoniakstikstof konsentrasie reeds twee ure na toediening bereik in vergelyking met ses ure vir die stadig vrystellende produkte. Geen betekenisvolle verskille in hierdie parameters is tussen die geïnkapsuleerde produkte gevind nie, terwyl geen interaksie is tussen hoofeffekte voorgekom het nie. In 'n derde proef is vier Dohnmerinohamels gebruik om die vrystellingstempo, in terme van rumenammoniak- en bloedureumstikstof te bepaal waar die stadig vrystellende produk en onbehandelde ureum direk aan die diere gevoer is. 'n Ekwivalent van 0.4 g ureum/kg liggaamsmassa is gevoer. Aanvanklik is inname- en smaaklikheidsprobleme ondervind, moontlik as gevolg van die sterk butanon- en formaldehydreuk van die omhulsel. Die rumenammoniakstikstof het 'n laer maksimum (17.5 vs. 66.9 mg N/100 ml) as die van onbehandelde ureum gehad terwyl die tyd wanneer maksimum konsentrasie bereik word ook aansienlik later was. Die polimeer inkapsulering van ureumkorrels toon potensiaal as 'n stadig vrystellende ureumproduk deurdat dit die oplosbaarheid van ureum in die rumen verlaag. Bykomende voordele is dat die omhulsel die higroskopisiteit verlaag en die samedrukbaarheid verhoog, beide eienskappe wat die hantering- en bergingseienskappe bevorder.

Sleutelwoorde: Stadig vrystellende ureum, enkapsulering, kopolimeer, ureumformaldehyd, rumenammoniak, bloed ureum stikstof, oplosbaarheid, smaaklikheid, bergingseienskappe.