

NitroShure Tool Kit

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NitroShure™ *Precision Release Nitrogen*

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NitroShure[™]

Precision Release Nitrogen

**OPTIMIZING RUMEN
PRODUCTIVITY**

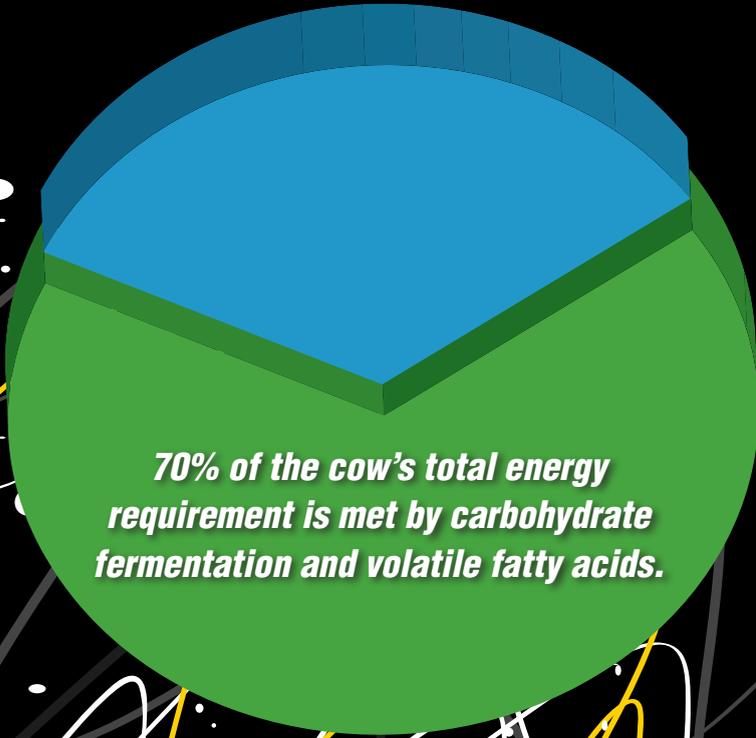
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PRECISION FEEDING EQU

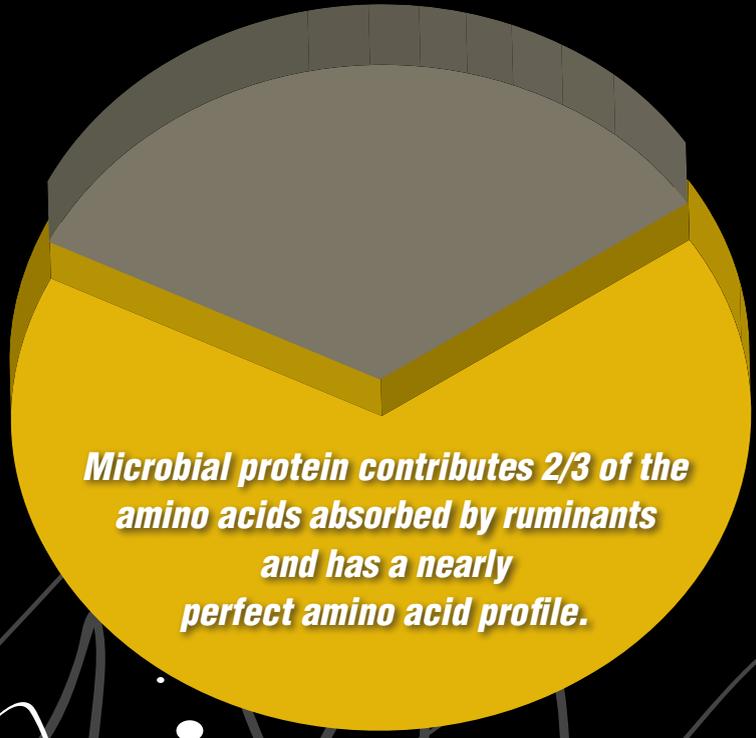
In an era of lower milk prices and escalating input costs, success depends on efficiency. The ruminant animal is the model of efficiency when it comes to the ability to convert fibrous feeds, low-quality protein and non-protein-nitrogen into valuable nutrients; microbial protein and energy in the form of volatile fatty acids. Microbial protein contributes about one-half to two-thirds of the amino acids absorbed by ruminants and has a nearly perfect amino acid profile – similar to that which is found in milk and meat products. Volatile fatty acids (VFA's), the result of carbohydrate fermentation, provide approximately 70% of the total energy requirement for ruminants. The primary VFA's (acetate, propionate, and butyrate) are used by the microorganisms for reproduction and growth, with the balance of the production being used by the ruminant itself. Improving carbohydrate digestibility increases energy available for milk production.

Maximizing rumen efficiency and the output of microbial protein and VFA's is the most significant factor impacting feed input costs and milk production. Rumen efficiency is influenced by many factors; carbohydrate type and nitrogen availability being highly important.

The role of nitrogen in microbial protein synthesis is well known but underestimated. Using Balchem's Precision Release Nutrient technology, your cows receive a more consistent and sustained level of nitrogen to the rumen; maximizing microbial protein output.



70% of the cow's total energy requirement is met by carbohydrate fermentation and volatile fatty acids.



Microbial protein contributes 2/3 of the amino acids absorbed by ruminants and has a nearly perfect amino acid profile.

ALS RUMEN EFFICIENCY

NitroShure™ *Precision Release Nitrogen* uses Balchem's proprietary encapsulation technology to provide a more consistent nitrogen supply to rumen microbes, maximizing microbial protein yield, improving dry matter digestibility and increasing carbohydrate digestibility while providing greater flexibility in formulating high performance dairy rations.

NitroShure™
Precision Release Nitrogen

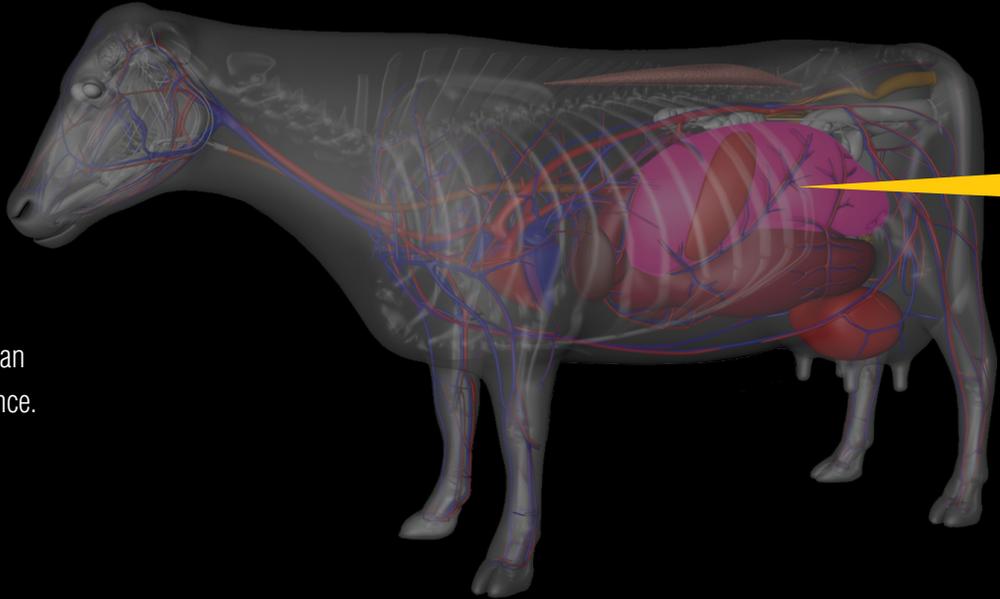
- **Improve Digestible Protein Yield and Quality** – Replace low-quality proteins with NitroShure. Balancing nitrogen release with available carbohydrates in the rumen leads to improvements in high-quality, microbial protein production.
- **Improve Fiber Digestion and Dry Matter Utilization** – Microbial mass and activity are increased when available carbohydrates and nitrogen are balanced, resulting in greater dry matter utilization, fiber digestion and volatile fatty acid production.
- **Create Ration Space** – Replace less dense sources of protein with NitroShure to create approximately 2 pounds of dry matter space in the ration. The additional space can be used to increase dietary levels of forage, non-fiber carbohydrate or other key ration ingredients to improve milk and milk component production.
- **Lower Ration Costs** – Replace more expensive protein sources with NitroShure to reduce purchased feed costs.



REAL SCIENCE

NITROGEN'S ROLE IN MAXIMIZING RUMEN EFFICIENCY

Increasing microbial growth and efficiency allows the cow to get the most nutrition out of her ration. When you maximize the microbial population, you increase the amount and quality of the protein available to the cow. At the same time, carbohydrate digestion is improved. Thus providing more energy as well. By optimizing rumen microbial protein synthesis you can reduce nutrient input costs and improve cow performance.



- 1.** When nitrogen and carbohydrate availability are in balance and accessible to rumen microbes, the overall microbial population and biomass increases.

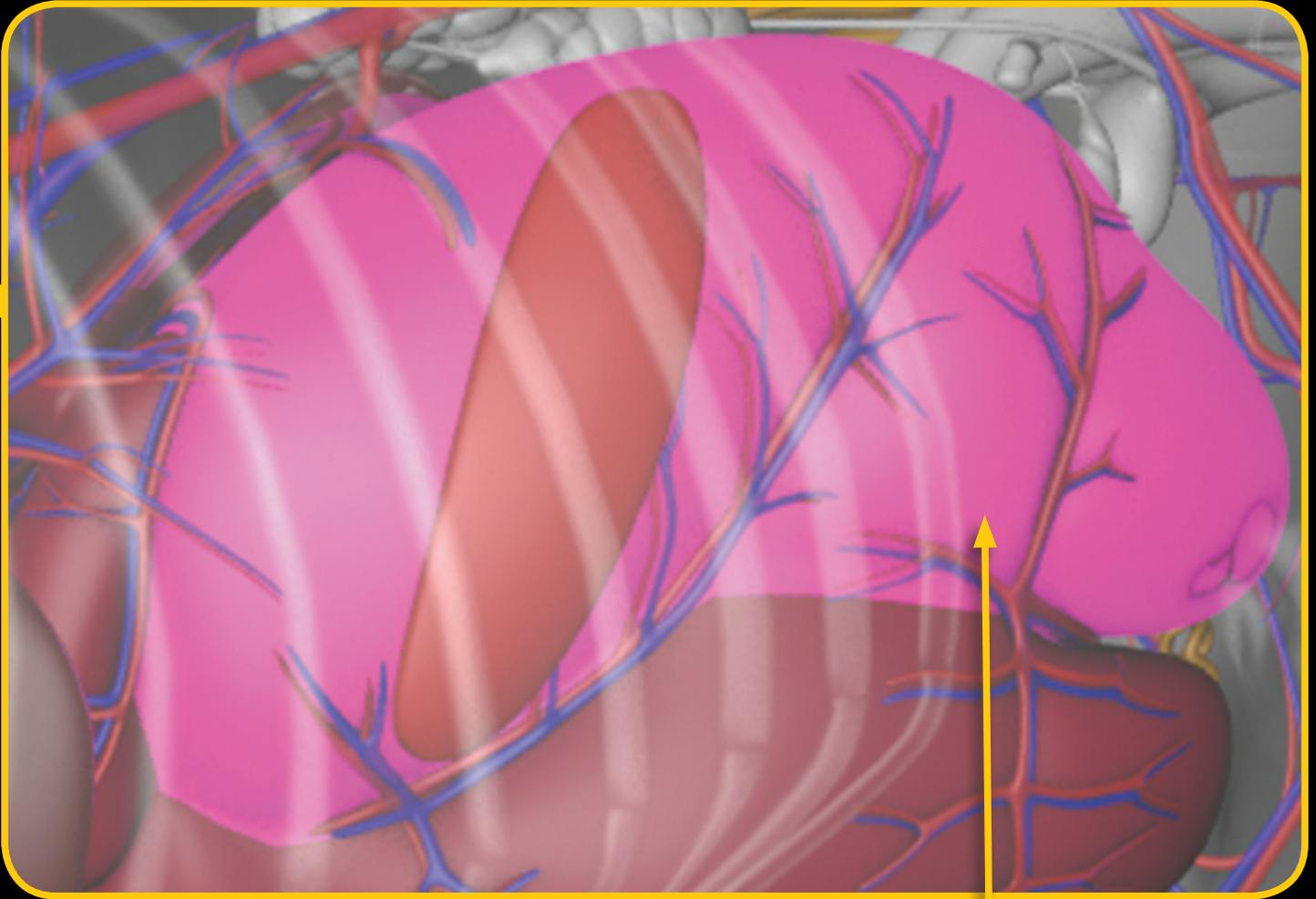


- 2.** To achieve this “balanced state” you must include a variety of feedstuffs, ranging from fast to slow degradation rates of dietary protein and carbohydrate. Synchronizing nitrogen with carbohydrate availability is essential for optimized microbial yield.



- 3.** High-quality nitrogen sources are essential for the most efficient rumen function. NitroShure™ *Precision Release Nitrogen* replaces other high cost or low-quality protein sources and combines the benefits of urea with Balchem's precision release technology to better balance nitrogen with carbohydrate availability.





5. Rumen bacterial protein is the highest quality protein available to the cow; the amino acid composition is similar to that of milk and very close to what the mammary gland requires for milk and milk protein synthesis.



4. Maximizing the bacterial biomass is essential for optimizing carbohydrate digestion; offering greater break-down and utilization of dietary dry matter. Dietary carbohydrates are fermented to produce volatile fatty acids like propionate, acetate and butyrate. Propionate is of particular importance because it is the precursor for glucose production in the liver (via gluconeogenesis).

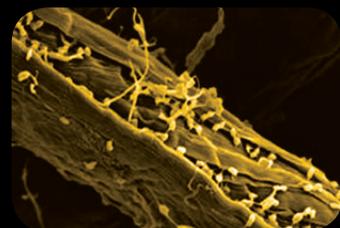


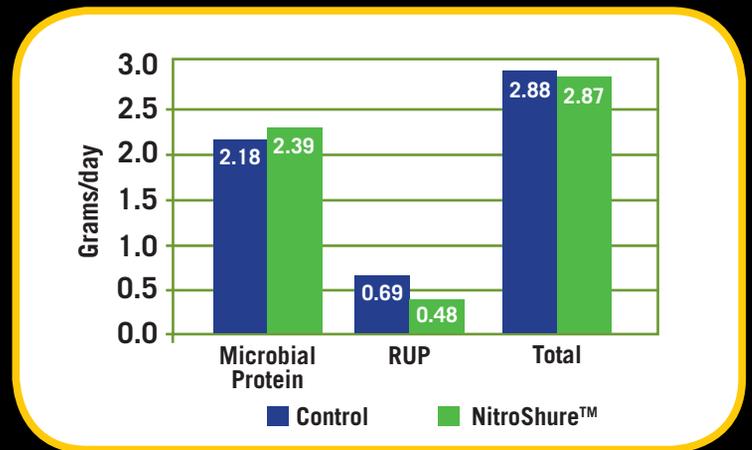
Image by Dr. Lydia-Marie Joubert.

REAL RESULTS

Studies show that rumen ammonia levels vary significantly based on diet and feeding frequency, peaking shortly after feeding then dropping rapidly until the next feeding. Rumen ammonia levels will often drop below levels needed to maintain maximum bacterial growth and DM digestibility for several hours during the day. NitroShure™ Precision Release Nitrogen is proven to fill the gap between fast-release urea and the slower nitrogen release of traditional protein sources to better balance nitrogen and carbohydrate availability in the rumen. Balancing nitrogen and carbohydrate availability can increase rumen microbial populations and fermentation efficiency, improving fiber and carbohydrate digestibility and microbial protein yield.

Improved digestion gives you more from less.

According to research conducted by Garrett et al., replacing a portion of the soybean meal with a blend of NitroShure, corn and molasses delivered an equivalent amount of protein by generating more microbial mass, representing 286 grams/day more microbial protein in a cow eating 22.5 kg dry matter intake.



NitroShure also increased digestion of dry matter, neutral detergent fiber and total carbohydrate, leading to more total energy available to the cow as a result of improved rumen microbial fermentation.

Digestibility			
Item	Control	NitroShure™	Difference
Dry Matter	60.0%	65.6%	9.3%
Crude Protein	77.6%	84.8%	9.3%
NDF	53.7%	59.4%	10.6%
ADF	52.5%	55.3%	5.9%
Total Carbohydrate ¹	46.6%	50.7%	8.8%

¹ g NDF + g NSC digested per day



In a 2010 study by Highstreet et al., California State University, feeding NitroShure versus urea improved overall lactation performance.



Variable	Control - Urea	NitroShure™	P Value
DM Intake, lb/d (kg/d)	62.6 (28.5)	63.3 (28.8)	NS
Milk Yield, lb/d (kg/d)	103 (46.8)	105 (47.7)	0.14
Fat Yield, lb/d (kg/d)	3.66 (1.66)	3.81 (1.73)	0.01
Protein Yield, lb/d (kg/d)	2.86 (1.30)	2.95 (1.34)	0.01
Milk Fat, %	3.57	3.67	0.01
Milk Protein, %	2.78	2.82	0.01

ReaShure®
Precision Release Choline

NitroShure™
Precision Release Nitrogen

NiaShure™
Precision Release Niacin

VitaShure® -C
Precision Release Vitamin C

KeyShure®
Chelated Minerals

To learn more about the complete portfolio of encapsulated nutrients and chelated minerals from Balchem, visit **anh.balchem.com**.



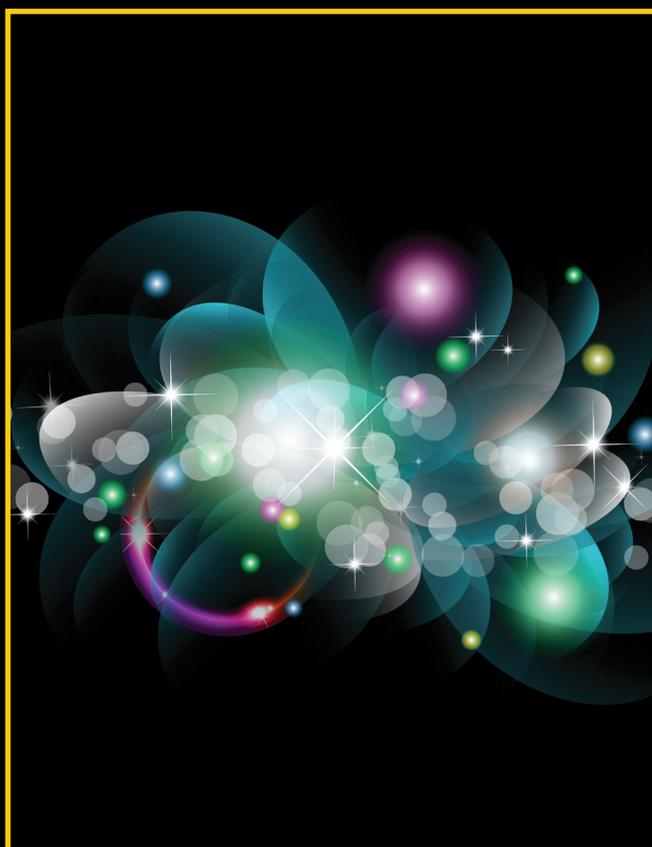
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For more ways to improve transition management, visit **www.transitioncow.net**. You'll find the summaries of the newest research, blog posts from transition nutrition and management experts and tools to help get your transition cows off to a smoother, faster start.



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TECHNICAL REPORTS

NitroShure™: An Important Tool for Optimizing Rumen Productivity in Challenging Economic Times

Charlie Sniffen, Ph.D. and Clay Zimmerman, Ph.D.

When milk prices and dairy profit margins are good, such as 2014, many of us become lax in fine-tuning rations and paying attention to optimizing rumen microbial yield. With today's low milk prices and rising feed protein prices, we need to fine-tune our rations to enhance microbial growth in the rumen.

Why should we do this?

With a good controlled fermentation (controlling pH or acidity) in the rumen, we will do two things:

1. Maximize the energy derived from fiber, starch and other carbohydrates fed
2. Optimize microbial protein flow from the rumen

This results in high quality protein production in the rumen and can reduce the need to feed more expensive ingredients to meet the energy and amino acid requirements of the cow.

Meeting the needs of the rumen microbiome is in many ways more complicated than meeting the needs of the cow. When the needs are not met correctly, individual microbes in the rumen reduce their growth and change their fermentation behavior, resulting in the production of unwanted fermentation acids, like lactic acid, which reduce rumen pH.

One of the biggest requirements is for rumen degradable protein (RDP): ammonia (NH_3) and amino acids from protein degraded in the rumen. With the right blend of nitrogen sources, fiber digestibility is enhanced; resulting in a more controlled acidity in the rumen. Additionally, the fermentation results in a higher production of acetate and butyrate, enhancing milk fat production by the cow. The goal should be to maintain a level of ruminal NH_3 that optimizes microbial activity and to avoid situations where NH_3 is wasted (too high) or is insufficient (too low) to support optimal microbial activity.

Avoid Peaks and Valleys

The challenge we have is that microbial digestion of fiber is slower than digestion of starch and other carbohydrates. This discrepancy in the rate of digestion of various carbohydrates has become more of a challenge recently, because there has been a push to reduce the amount of protein we feed to cows. This change results in a bigger challenge in providing the NH_3 and amino

TURN UP

Rumen Productivity

TURN DOWN

Ration Cost



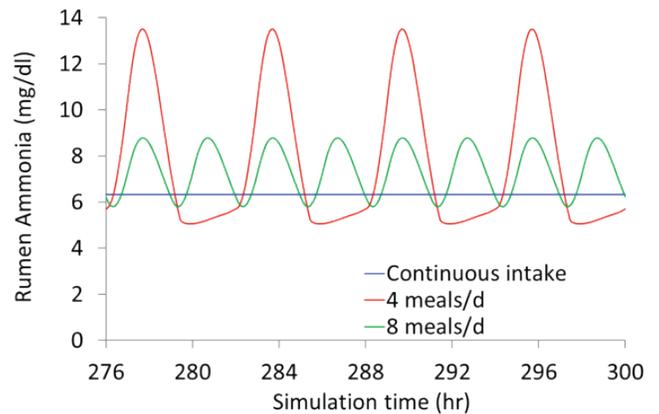
acids needed by the fiber-digesting bacteria for fiber digestion. We have oversimplified ration formulation by adding raw urea and relying on the NH₃ coming from the rapid breakdown of the forage protein sources. We need to control the release of NH₃ in the rumen to balance the needs of the slower growing fiber-digesting bacteria. This balance can be achieved by providing a steadier ruminal supply of NH₃ throughout the day to avoid the peaks and valleys in ruminal NH₃ that can occur with inconsistent meal patterns (*Figure 1*). This is where the relatively new technology of a controlled release NPN source can better meet the needs of the fiber-digesting bacteria. Research has shown that with this technology, fiber digestibility is enhanced, rumen pH is better controlled and microbial yield is increased, increasing metabolizable amino acid supply to the cow.

NitroShure™ is a controlled release NPN source for dairy diets. When properly formulated into diets at rates up to 0.40 lbs/cow/day, NitroShure provides the following benefits:

- Increased microbial protein yield
- Increased fiber digestibility
- Increased yield of milk, milk fat and/or milk protein (*Table 1*)
- Creates space in the diet (0.20 lbs of NitroShure can replace in excess of 1 lb of soybean meal or 1.4 lbs of canola meal), providing formulation flexibility
- May result in moderate diet cost savings, depending on the price of feed proteins and formulation strategies
- Can reduce out-of-pocket feed costs

Contact your Balchem representative for more information about NitroShure. Let us show you how NitroShure can be successfully incorporated into your diets to improve microbial protein yield, increase fiber digestibility and improve dairy profitability.

Figure 1. Theoretical rumen ammonia levels with varying meal patterns simulated in CNCPS v7



Source: Dr. Mike Van Amburgh, Cornell University

Table 1. Effect of Feeding NitroShure™ Versus Urea on Lactation Performance of Dairy Cows

Variable	Control - Urea	NitroShure™	P Value
High Cows DM Intake, lb/d	62.6	63.3	NS
High Cows Milk Yield, lb/d	103.4	105.0	0.14
High Cows Fat Yield, lb/d	3.66	3.81	0.01
High Cows Protein Yield, lb/d	2.86	2.95	0.01
High Cows Milk Fat %	3.57	3.67	0.01
High Cows Milk Protein, %	2.78	2.82	0.01
MUN, mg/dl	13.3	13.6	0.11

Source: Highstreet et al. (2010), Livestock Science 129:179–185.

NitroShure™

Precision Release Nitrogen

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NitroShure™

Precision Release Nitrogen

NitroShure™ Precision Release Nitrogen uses Balchem's proprietary encapsulation technology to provide a more consistent nitrogen supply to rumen microbes, maximizing microbial protein yield, and improving dry matter digestibility, while providing greater flexibility in formulating high performance dairy rations.

Product Information:

Content – 89% Urea

Application:

Feed to dairy cattle to provide rumen micro flora with a sustained source of nitrogen for use in synthesizing microbial protein.

Ingredients:

Urea, fats and caramel color

Feeding recommendation:

Feeding rates:

Maximum – 250 g/cow/day

Minimum effective rate – 10 g/cow/day

Substitution rate:

For every 100 grams of soybean meal to be replaced, substitute 20 grams of NitroShure.

For every 100 grams of canola/rapeseed meal to be replaced, substitute 15 grams of NitroShure.

General Guidelines:

Maintain a minimum of 1 kg/cow/day of soybean/rape seed/canola meal in the diet

- a) If using CPM, maintain peptide balance at 100% or greater
 - Can reduce target peptide balance from 110% to 102%
- b) If currently feeding urea:
 - Continue using urea up to 90 g/cow/day with NitroShure
 - Maintain a minimum 10 g/cow/day of urea in the ration
 - Add NitroShure to desired level to a maximum of 225 g/cow/day of NitroShure plus urea



- c) Target Rumen Degradable Protein (RDP) levels
 - CPM - 10.0% of DM
 - AMTS, NDS, Dalex with CNCPS v6.1 biology - 9.0% of DM
- d) Total ration soluble protein should be kept between 32 and 38% of total crude protein
- e) Use high-quality ingredients in combination with NitroShure to back-fill the space created by removing the alternative protein source
 - Forage
 - High starch concentrates (e.g., high moisture corn, corn meal, barley meal, sorghum and bakery)
 - High sugar concentrates (e.g., molasses, bakery/candy and citrus pulp)
 - High fermentable fiber concentrates (e.g., citrus, soyhulls and beet pulp)
 - Fat

Packaging:

25.0 kg (55.1 lb.) poly-lined bags

11.3 kg (25.0 lb.) poly-lined bags

Availability

NitroShure is available through most animal feed outlets. Contact Balchem to find a local supply of NitroShure.

NITROSHURE™ PRECISION RELEASE NITROGEN

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just snap the QR code or
enter the url below.



• <http://anh.balchem.com/anh/nitroshure>

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Benefits:

NitroShure™ *Precision Release Nitrogen* is a valuable tool for helping producers and nutritionists reduce ration costs while increasing the amount of high-quality protein available to the cow.

- **Improve Digestible Protein Yield and Quality**—Replace low-quality proteins with NitroShure. Synchronizing nitrogen release with available carbohydrates in the rumen leads to improvements in high-quality, microbial protein production.
- **Improve Fiber Digestion and Dry Matter Utilization** – Microbial mass and activity is increased when available carbohydrate and nitrogen is balanced, resulting in greater dry matter utilization, fiber digestion and volatile fatty acid production.
- **Create Ration Space** – Replace less dense sources of protein with NitroShure to create approximately 2 pounds (0.9 kg) of dry matter space in the diet. The additional space can be used to increase dietary levels of forage, non-fiber carbohydrate or other key ration ingredients to improve milk and milk component production.
- **Lower Ration Costs** – Replace more expensive protein sources with NitroShure to reduce purchased feed costs.

Economics:

Studies show that NitroShure™ *Precision Release Nitrogen* is proven to help fill the nitrogen availability gap between fast release urea and the slower nitrogen release of traditional protein sources to better synchronize nitrogen and carbohydrate availability in the rumen. Balancing nitrogen and carbohydrate availability can increase rumen microbial populations and fermentation efficiency, improving fiber and carbohydrate digestibility and microbial protein yield. Research studies show that improvements in rumen fermentation can lead to increases in milk yield and component production. For a complete review of the research, contact your Balchem representative.

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Evaluating Rumen Nitrogen Sources

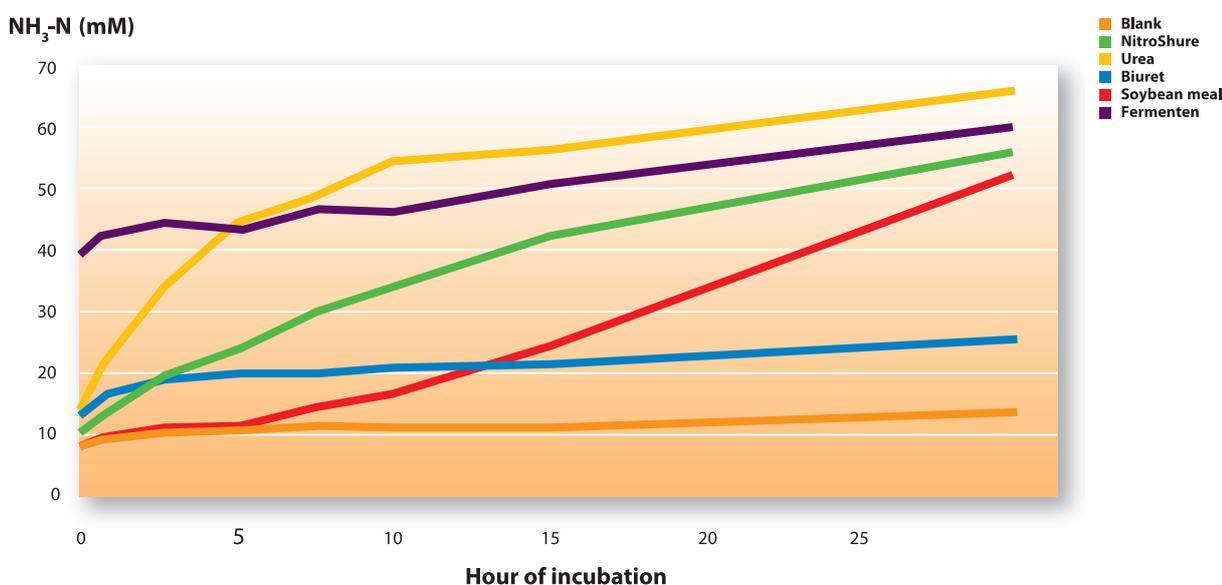
When the rate of degradation of carbohydrates to nitrogen in the rumen is right, microbial protein production is maximized. Several nitrogen sources exist, but are not all equal. Some release nitrogen in a more timely fashion than others.

Research

The results of research by Di Lorenzo and Di Costanzo in 2007 show how several rumen nitrogen sources compare in their ability to provide $\text{NH}_3\text{-N}$ for rumen microbial protein synthesis (Figure 1).

Figure 1

Ability of nitrogen sources to provide $\text{NH}_3\text{-N}$ for rumen microbial protein synthesis



Di Lorenzo and Di Costanzo, 2007

A follow-up study included Optigen and demonstrated that Optigen has a nitrogen release profile similar to that of soybean meal. On the surface, this may seem to be a good thing if one is replacing soybean meal with Optigen. However, this is not the best release profile.

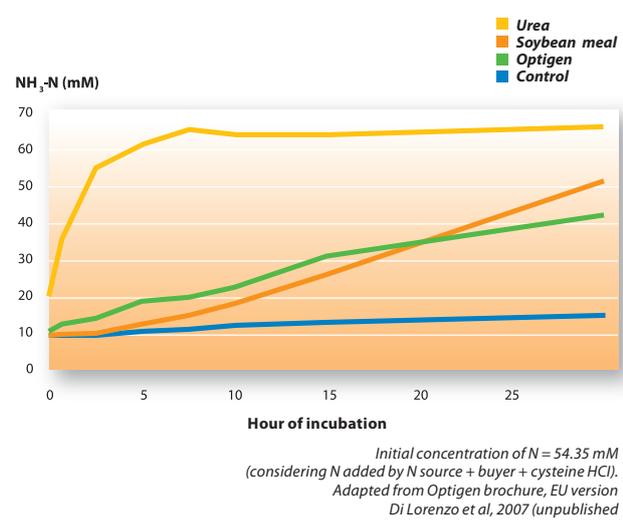
Nitrogen Source Comparison

- **Raw urea releases nitrogen too quickly.**

Microbes in the rumen use available carbohydrates and rumen ammonia to synthesize microbial protein. This can be done efficiently as long as both carbohydrate and ammonia are available at the same time or synchronized, if you like. The disadvantage of raw urea is that, as the graph shows, it is released very rapidly elevating rumen ammonia levels rapidly. As ammonia levels increase beyond the point where there is enough readily available carbohydrate for microbes to capture it and convert it to microbial protein the excess ammonia is absorbed and much of it is excreted as urinary nitrogen or milk urea nitrogen.

- Soybean meal releases nitrogen too slowly.**
 Soybean meal has a much slower release pattern. In fact it is too slow to provide adequate ammonia in the presence of rapidly fermented carbohydrate sources, such as ground corn and barley, to optimize microbial protein production. Having a release pattern similar to soybean meal in this situation is not beneficial.
- Optigen's nitrogen release curve is not optimal.**
 The release pattern of Optigen is actually slower than that of soybean meal at later times (Figure 2). Considering that approximately 30% of soybean protein bypasses digestion in the rumen, the release pattern of Optigen would suggest that a significant portion of its urea completely escapes rumen fermentation. If released post-ruminally, this urea (ammonia) would contribute directly to increases in urinary nitrogen excretion and MUN.

Figure 2
NH₃-N concentration of different sources of N in batch incubations

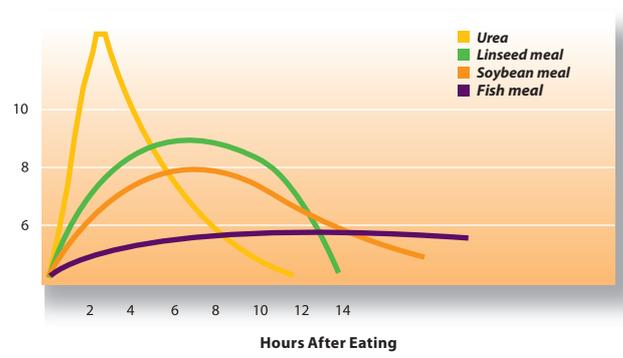


The NitroShure™ Advantages

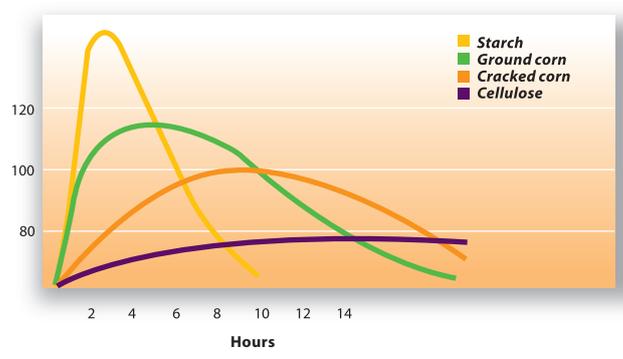
In comparison, the release pattern for NitroShure™ precision Release Nitrogen is well timed: slower than urea, but faster than soybean meal (Figure 3). The NitroShure advantages are:

- Timely nitrogen availability.**
 Ammonia release is better synchronized with the carbohydrate fermentation, increasing the capture of nitrogen as microbial protein.
- More complete release of urea nitrogen in the rumen.**
 Nitrogen must be available in the rumen for the synthesis of microbial protein.

Figure 3
 NH₃-N (mg/dl)



VFA (mM)



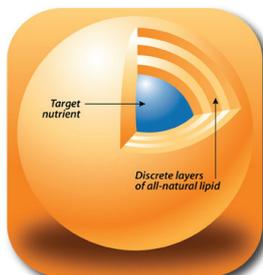
NitroShure™

Precision Release Nitrogen

Practical Guidance for Feeding *Precision Release Nitrogen*

NitroShure™ Precision Release Nitrogen is urea protected by Balchem's proprietary encapsulation technology (Figure 1). Conceptually it is much like an M&M. Encapsulation controls the rate at which the urea is released in the rumen thus providing a more consistent supply of rumen nitrogen for use by bacteria.

Figure 1
True Encapsulation



Unprotected urea is almost instantly soluble in the rumen. Because there is significant urease (an enzyme that hydrolyzes urea to ammonia) in the rumen, the addition of urea to diets can lead to rapid spikes in rumen ammonia nitrogen levels. When ammonia levels become too high, too fast, rumen bacteria cannot capture the nitrogen for conversion to high quality microbial protein and it is absorbed into the bloodstream. The liver must then detoxify the ammonia by converting it back to urea which takes energy that could otherwise be used for milk production. Some of the urea may recycle back to the rumen; however, a significant amount of it is excreted in milk as milk urea nitrogen (MUN) or in the urine.

Balancing Energy and Nitrogen

In order for rumen bacteria to grow efficiently, and effectively digest fiber and carbohydrates, they must have a good balance of both energy and nitrogen. In other words, both energy and nitrogen have to be available at similar times to maximize rumen fermentation. When this occurs, bacteria are able to capture nitrogen and synthesize microbial protein. More bacteria means better digestibility of fiber, more energy, and more high quality microbial protein. The end result is better performance by the cow, more milk yield and more milk components.

Sources of energy and protein are digested in the rumen at different rates (Figures 2 and 3). Some are fast, some are slow, and some are intermediate. Fast sources of protein can be effectively utilized if there is a corresponding and balanced

source of rapidly fermentable energy. Conversely, when nitrogen is released more slowly there needs to be a corresponding source of slower fermenting energy in order to efficiently utilize that nitrogen. When protein and energy are not in balance microbial growth, nutrient digestibility and performance can be adversely affected.

Figure 2

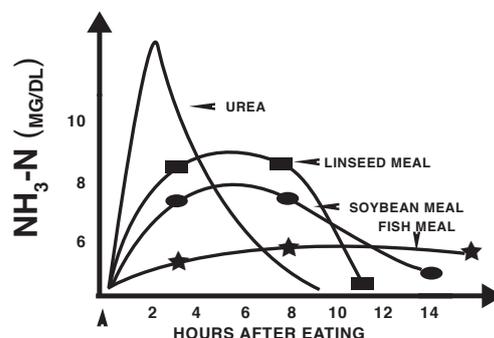
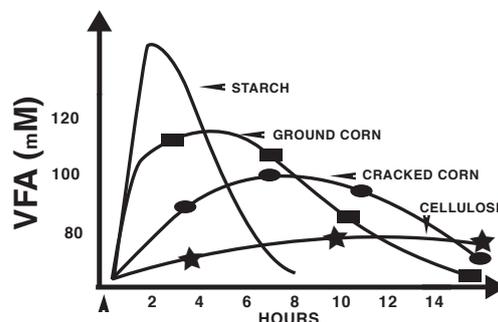


Figure 3



For example, when feeding high levels of unprotected urea, rumen ammonia nitrogen levels will rise very quickly. While bacteria utilizing rapidly fermentable energy sources such as sugars and fast degrading starches can capture some of this nitrogen, much of it will be absorbed from the rumen into the blood. The result is lost energy due to detoxification and lost nitrogen via MUN and excretion in urine. In addition, nitrogen levels rapidly decrease in the rumen, which may lead to inadequate nitrogen levels to maintain optimum bacterial growth later in the fermentation process.

Feeding high levels of vegetable proteins can also result in the energy-nitrogen ratio becoming unbalanced. Diets high in non-structural carbohydrates (e.g., sugars and starches) have resulted in lower rumen nitrogen levels when peptide levels (vegetable proteins supply peptides) become too high (Jones et al., 1998.) Maeng et al., (1976) observed that bacterial growth in vitro increased substantially when amino acids replaced 25% of urea nitrogen but as higher amounts were replaced bacterial growth declined.

Feeding 45 to 90 g of NitroShure *Precision Release Nitrogen* in diets improves energy-nitrogen balance. A slower release of urea-nitrogen by NitroShure compared to unprotected urea reduces ammonia spikes post-feeding and provides a more consistent supply of ammonia needed for bacterial growth. By providing a more sustained availability of ammonia nitrogen, NitroShure helps ensure that bacteria will have available nitrogen for optimizing bacterial growth even when feeding vegetable protein based diets.

Currently feeding urea?

Feed 45 to 90 g of NitroShure, replacing all but about 10 g of urea (remember fast energy sources such as sugars and fast starches need some readily available nitrogen). If needed to maintain current ration protein level, remove some vegetable protein and back-fill dry matter (DM) space with energy, effective fiber or other nutrients that will improve overall ration quality.

Inadequate Dietary Levels of Soluble Nitrogen?

Feed 45 to 90 g of NitroShure. Reduce vegetable protein or other low quality protein to maintain current ration protein level and back-fill DM space with energy, effective fiber or other nutrients that will improve overall ration quality.

For every 100 grams of soybean meal to be replaced, substitute 20 grams of NitroShure. For every 100 grams of Rapeseed to be replaced, substitute 15 grams of NitroShure

Vegetable proteins provide peptides and amino acids that have been shown to stimulate microbial protein production. Do not replace all vegetable protein with NitroShure. Maintain 1 to 2 kg of supplemental vegetable protein in the diet.

General Feeding Rates:

- Maximum rate – 250 g/cow/day
- Minimum effective rate – 10 g/cow/day

General Guidelines:

Maintain a minimum of 1 kg/cow/day of soybean/canola meal in the diet

- If using CPM ration balancing software, maintain peptide balance at 100% or greater
 - Can reduce target peptide balance from 110% to 102%
- If currently feeding urea:
 - Continue using urea up to 90 g/cow/day with NitroShure
 - Maintain a minimum 10 g/cow/day of urea in the ration
 - Add NitroShure to desired level to a maximum of 225 g/cow/day of NitroShure plus urea
- Target Rumen Degradable Protein (RDP) levels
 - CPM - 10.0% of DM
 - AMTS, NDS, Dalex with CNCPS v6.1 biology – 9.0% of DM
- Total ration soluble protein should be kept between 32 and 38% of total crude protein
- Use high quality ingredients in combination with NitroShure to back-fill the space created by removing the alternative protein source
 - Forage
 - High starch concentrates (e.g., high moisture corn, corn meal, barley meal, sorghum and bakery)
 - High sugar concentrates (e.g., molasses, bakery/candy and citrus pulp)
 - High fermentable fiber concentrates (e.g., citrus, soyhulls and beet pulp)
 - Fat

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RESEARCH SUMMARIES

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NitroShure™

Precision Release Nitrogen

Balchem Research Summary

In vitro release of ammonia nitrogen
from various nitrogen sources in
batch culture

A summary of a study conducted by N. DiLorenzo and A. DiCostanzo. "In vitro release of ammonia nitrogen from various nitrogen sources in batch culture."

Background

Meeting rumen degradable protein (RDP) requirements of cattle is necessary for optimized carbohydrate digestion in the rumen, and to maximize bacterial crude protein (CP) synthesis. Not balancing available nitrogen with available energy may cause temporary nutrient deficiencies for bacteria (Newbold and Rust, 1992). Degradation kinetics of protein sources differ greatly, even amongst NPN sources, are highly variable and are influenced by DMI. In vivo determination of protein degradation kinetics can be expensive, time-consuming and highly variable. A simple *in vitro* procedure to determine NH₃-N release was developed (modified from Kung et al., 2000). In spite of being a static system, relative differences amongst protein sources can provide an indication of NH₃-N release in vivo. This study was conducted to determine the relative rates of release of several NPN sources, including NitroShure™ Precision Release Nitrogen, compared to SBM.

Materials and Methods

Batch culture incubations were conducted using 250-mL flasks fitted with a one-way rubber stopper gas release valve. Each flask was inoculated with 200 ml of a nutrient buffer:rumen fluid solution (4:1 ratio). Rumen fluid came from a cannulated steer fed a 95% corn silage 5% protein supplement diet. The nutrient buffer solution contained a mixture of macro and micro minerals, buffer and cysteine hydrochloride as a reducing agent.

Nitrogen sources tested included: 1. NitroShure™ (NTS), 2. Feed grade urea (URE), 3. Biuret (BIU), 4. Fermenten® (FER; Church & Dwight Co., Inc. Princeton, NJ), 5. Soybean meal (SBM). Flasks containing no added nitrogen sources were also incubated to serve as blanks (BLK). Four flasks per treatment were incubated per period and there were two periods in the study. All flasks received equal amounts of nitrogen from each source (155 mg; equal to 2 g of SBM) based on their nitrogen content.

During the fermentation, 10 ml samples were taken from each flask at 0, 0.5, 2, 4, 6, 8, 12 and 24 h of incubation. Each sample was analyzed for NH₃-N by Kjeldahl (Kjeltec 2300 Analyzer Tecator™, Herndon, VA).

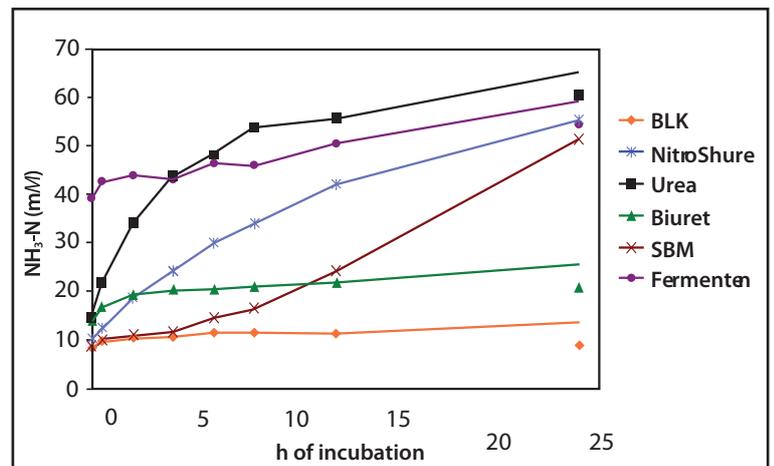
The proportion of NH₃-N released from the total incubated N (N provided by the N source + N in the nutritive solution) was calculated as follows:

$$\text{Proportion of NH}_3\text{-N released from incubated N(\%)} = \frac{[\text{TRTmM} - \text{BLKmM} / \text{mM Media}] \times 100}{\text{mM Media}}$$

Where: TRTmM was the NH₃-N value observed for each treatment at a given incubation time, BLKmM was the NH₃-N value observed for BLK at a given incubation time and mM Media was the total mM of N provided by the N source and the N in the nutritive solution.

Results and Discussion

Figure 1 shows the results of NH₃-N concentration changes over time of incubation. There were significant ($p < 0.01$) treatment x time interactions. At 6 h, deamination from SBM protein began to be significant as seen by NH₃-N accumulation relative to the BLK ($p < 0.02$). This, in part, reflects a lag time for hydration, initiation of protein hydrolysis to peptides and amino acids by rumen bacteria, uptake of peptides and amino acids and the subsequent deamination of amino acids by bacteria to form volatile fatty acids and ammonia. The lag may also reflect incorporation of absorbed peptides and amino acids directly into microbial protein rather than deamination. Ammonia accumulation associated with SBM became significantly different from the BLK at six hours ($p < 0.02$).

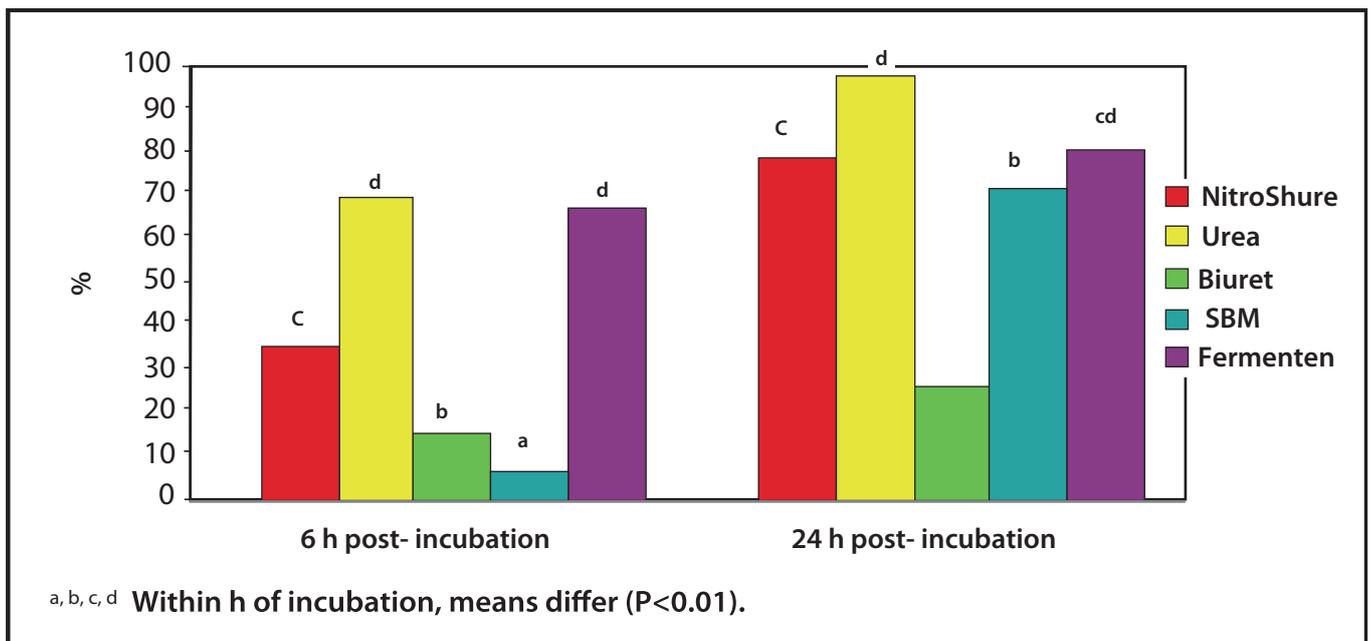


Biuret had an initial release followed by little change over the 24-hour incubation. The initial release probably reflects the fact that feed grade biuret can contain as much as 15% urea. The minimal change in ammonia release over time is not surprising since the rumen fluid donor steer was not acclimated to biuret. Studies have shown that it can take up to several weeks of feeding biuret for animals to develop a high level of biuretase enzyme needed to hydrolyze biuret to ammonia. From 4 to 24 hr Biuret had the lowest release of $\text{NH}_3\text{-N}$ of all sources.

Urea shows a rapid release of ammonia into the media. This is not surprising as urea has high solubility and rumen fluid typically has high levels of urease enzyme. Urea and Fermenten® had the greatest ($p < 0.01$) proportion of N released from incubated N at 6 hr after incubation (Figure 2). Urea had significantly higher ($p < 0.01$) $\text{NH}_3\text{-N}$ release than NitroShure at all times. The lipid coating on NitroShure effectively reduced the rate of $\text{NH}_3\text{-N}$ production compared to Urea.

Rumen ammonia levels typically peak about two to three hours post-feeding and then rapidly decline. This occurs despite good feed management practices such as frequently pushing feed up to cows (Lycos et al., 1997). Balancing energy and ammonia availability in the rumen can improve the capture and utilization of N resulting in more microbial protein, less excretion of ammonia into the environment and better utilization of carbohydrates for energy. Sources of $\text{NH}_3\text{-N}$, such as urea, that are rapidly released can elevate peak rumen ammonia levels resulting in increased blood urea levels which will result in increased MUN and N excretion in urine. This is not to suggest that urea does not have a place in certain dietary situations. However, feeding sources of protein with slower N release such as NitroShure can contribute to a more balanced rumen ammonia pool which will be important to maximizing microbial growth and animal performance.

Figure 2 Proportion of $\text{NH}_3\text{-N}$ released from the total incubated N (N provided by N source + N in the nutritive solution) at 6 and 24 h post-incubation.



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Balchem Research Summary

Effects of the Addition of NitroShure to Lactating Cow Diets on Microbial Efficiency and Metabolism in Continuous Culture of Rumen Contents

A summary of a study conducted by J. Garrett.

Background

Reducing the rate at which ammonia is released from urea into the rumen may allow rumen bacteria to more effectively capture the nitrogen released. Slowing the rate of release of ammonia from urea can be accomplished by encapsulating it with lipids. NitroShure™ *Precision Release Nitrogen* uses Balchem's proprietary encapsulation technology to provide a more consistent nitrogen supply to rumen microbes, maximizing microbial protein yield, improving dry matter and carbohydrate digestibility while providing greater flexibility in formulating high performance dairy rations.

This study was designed to look at the effects of NitroShure replacement strategies in lactating cow diets on microbial growth and efficiency as well as digestibility of dietary components in continuous culture systems.

Materials and Methods

Lactating dairy cow diets were formulated using CPM and were balanced for a cow producing 100 pounds of milk per day. There were six experimental diets (*Table 1*). The Control diet contained 12.30% soybean meal (48% CP) and 0.65% urea with a total CP of 17.3%. In diets NS2 and NS3, NitroShure replaced 72% and 100%, respectively, of urea in the diets. In diets NS3, NS4 and NS5 urea was set at 0.55% of DM. Soybean meal was then replaced by NitroShure on an equivalent nitrogen basis. The percentages of soybean meal and NitroShure were: 10.84, 0.28; 8.65, 0.68 and 6.38, 1.12, respectively for diets NS3, NS4 and NS5. This would represent an approximate feeding rate of 68 g/h/day of NitroShure in NS3, 168 g/h/day in NS4 and 277 g/h/day in NS5. In diets NS3, NS4 and NS5 molasses and ground corn were added to make up for sugars and starch removed as soybean meal was replaced with NitroShure. The composition of the diets is shown in *Table 2*.

Table 1. Diet Composition, Dry Matter %

Ingredient	Diets					
	Control	NS1	NS2	NS3	NS4	NS5
Soybean Meal, 48%	12.30	12.30	12.30	10.84	8.65	6.38
NitroShure	0.00	0.46	0.65	0.28	0.68	1.12
Urea	0.65	0.18	0.00	0.55	0.55	0.55
Corn Silage	27.71	27.71	27.71	27.74	27.74	27.74
Mixed Haylage	2.59	2.59	2.59	2.59	2.59	2.59
Alfalfa Hay	10.53	10.53	10.53	10.54	10.54	10.54
Flaked Barley	3.69	3.69	3.69	3.70	3.70	3.70
Ground Corn	26.79	26.79	26.79	27.83	29.35	30.91
Molasses	1.66	1.66	1.66	1.85	2.11	2.38
Soybean Hulls	6.37	6.37	6.37	6.38	6.38	6.38
Whole Cottonseed	4.06	4.06	4.06	4.07	4.07	4.07
Corn Gluten Meal	1.02	1.02	1.02	1.02	1.02	1.02
Rumen Inert Fat	0.90	0.90	0.90	0.90	0.90	0.90
MinVit	1.73	1.73	1.73	1.73	1.73	1.73

Table 2. Diet Analysis, Dry Matter %

Analysis, % DM Basis	Diets					
	Control	NS1	NS2	NS3	NS4	NS5
Crude Protein	17.3	17.5	17.4	17.1	17.5	17.6
Soluble Protein, %CP	32.7	34.6	33.1	35.1	41.9	44.1
NDF	33.0	34.3	31.5	31.1	33.1	32.1
ADF	20.3	21.4	19.6	20.1	20.4	19.7
NSC	34.1	32.3	33.2	34.8	36.1	36.5
Starch	29.6	27.9	28.4	29.8	31.1	31.7
Sugar	4.4	4.4	4.8	5.0	5.0	4.5
Ether Extract	3.1	3.0	3.2	3.2	3.4	3.4
Ash	5.8	5.9	5.9	5.8	5.7	5.6
NFC ¹	40.8	39.3	42.1	42.9	40.3	41.3

¹ Calculated Non-fiber Carbohydrate

Conditions used in the continuous cultures were: liquid dilution rate, 13.0%/hr; solids dilution rate, 4.5%/hr; solids retention time, 22 hr; feed intake 100 g DM/day and feeding frequency, 4 times per day every 6 hours. The fermentation temperature was 39°C. Each diet was fermented in triplicate using 9-day fermentations with effluent composited during the last 3 days of the fermentations. The pH of the cultures was monitored every half-hour. Data were analyzed using General Linear Model Procedures of SAS and a Duncan's Multiple Range Test was used to compare individual treatment means.

Results and Discussion

Partial or complete replacement of urea with NitroShure did not significantly affect digestibility of dietary components (*Table 3*, Control vs. NS1 and NS2). However, in the diet where urea was completely replaced by NitroShure (NS2) DM digestibility tended to decrease. This appeared to be related in part to a reduction in NDF digestibility. While not significant, NSC digestibility also tended to be lower when urea was completely removed from the diet, which combined with lower NDF digestibility, resulted in a tendency for lower total carbohydrate digestibility. This may suggest that retaining at least small amounts of urea in diets might be warranted.

Table 3. Digestion Coefficients for Dry and Organic Matter, Crude Protein, Fiber and Nonstructural Carbohydrates

Item, Digestion %	Diets					
	Control	NS1	NS2	NS3	NS4	NS5
Dry Matter	60.0 ^{a,b,c}	58.6 ^{b,c}	56.6 ^c	57.7 ^{b,c}	65.6 ^a	63.1 ^{a,b}
Organic Matter	50.1	48.8	49.5	48.4	53.2	51.7
Crude Protein	77.6 ^{a,b}	72.4 ^b	80.8 ^{a,b}	78.2 ^{a,b}	84.8 ^a	85.9 ^a
NDF	53.7 ^{a,b}	54.6 ^{a,b}	49.4 ^b	48.9 ^b	59.4 ^a	53.0 ^{a,b}
ADF	52.4	51.4	51.2	48.8	55.3	54.8
NSC ¹	84.7	84.0	81.5	83.7	85.9	84.9
Total Carbohydrate ²	46.6 ^{a,b,c}	45.9 ^{a,b,c}	42.6 ^c	44.3 ^{b,c}	50.7 ^a	48.0 ^{a,b}

¹ Includes sugar and starch

² g NDF + g NSC digested per day

³ a,b,c Values with different superscripts differ, p<0.05

The results of partial replacement of soybean meal with a NitroShure, corn and molasses mix are shown in *Table 3* (Control vs. NS3, NS4 and NS5). Dry matter, organic matter, NDF, ADF, NSC and total carbohydrate digestibilities were all highest for diet NS4 although not statistically different from the control. Crude protein digestibility was highest in NS5. Dry matter, organic matter, NDF, ADF, NSC and total carbohydrate all tended to decrease as higher levels of soybean meal were replaced by NitroShure (NS4 vs. NS5). Fermentation pH was not significantly affected by diet (data not shown).

The effects of diet on nitrogen partitioning and microbial growth and efficiencies are shown in *Table 4*. Replacing urea with NitroShure tended to lower ammonia nitrogen relative to the control although the differences were not significant. When NitroShure partially replaced soybean meal, rumen ammonia levels increased. Satter and Slyter (1974) reported that rumen ammonia levels of approximately 6.1mg/dl were adequate for maximal microbial activity. However, others (Reynal and Broderick, 2005; Boucher et al., 2007) have reported improved animal performance and/or microbial activity at higher levels of rumen ammonia. The replacement of soybean meal with NitroShure increased rumen ammonia levels compared to the control particularly in the NS4 and NS5 diets. These diets also exhibited the highest digestibilities of dry matter, organic matter, protein, NDF, ADF and total carbohydrates. Partial replacement of soybean meal with NitroShure tended to numerically increase microbial yield compared to the control diet. Microbial efficiencies were generally higher when NitroShure replaced some soybean meal in the diets compared to the control, albeit not significantly higher. When NitroShure replaced SBM, efficiencies of carbohydrate use were maintained, similar to those on the control diet, while other efficiencies such as TVFA/kg carbohydrate digested and TVFA/kg microbial N were improved, showing that NitroShure was at least as effective as SBM in promoting use of nutrients for microbial growth rather than conversion to VFA.

Table 4. Nitrogen Partitioning, Microbial Growth and Microbial Efficiency

Item	Diets					
	Control	NS1	NS2	NS3	NS4	NS5
Non-ammonia N, g/d	2.88 ^{a,b}	2.94 ^a	2.93 ^a	2.91 ^{a,b}	2.87 ^{a,b}	2.82 ^b
Ammonia N, mg/dl	6.13 ^{a,b}	5.30 ^b	5.32 ^b	4.66 ^b	7.58 ^{a,b}	9.23 ^a
Bypass N, g/d	0.69 ^{a,b}	0.86 ^a	0.60 ^{a,b}	0.67 ^{a,b}	0.48 ^b	0.44 ^b
Microbial N, g/d	2.18	2.08	2.33	2.23	2.39	2.37
Efficiencies						
Microbial N/kg DMD	36.3 ^b	35.5 ^b	41.3 ^a	38.8 ^{a,b}	36.5 ^b	37.5 ^b
Microbial N/kg OMD	47.0	46.1	51.2	50.3	48.6	49.6
Microbial N/kg CHOD	46.9 ^b	45.3 ^b	55.0 ^a	50.6 ^{a,b}	47.2 ^b	49.3 ^{a,b}
TVFA/kg CHOD	8.78 ^{a,b}	8.78 ^{a,b}	9.45 ^a	8.83 ^{a,b}	7.98 ^b	7.99 ^b
TVFA/kg Microbial N	189 ^{a,b}	194 ^a	172 ^{a,b}	174 ^{a,b}	169 ^{a,b}	162 ^b

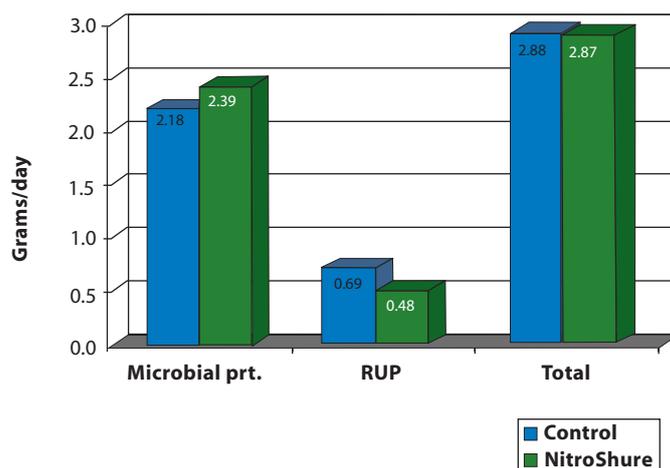
Efficiency of microbial growth, (g microbial N/kg carbohydrate digested) was highest when NitroShure replaced all the urea in the diet (NS2). This suggests that NitroShure was superior to urea in promoting conversion of digested carbohydrate to microbial mass. A large decrease in VFA produced/kg microbial N on this treatment support this contention.

Replacing 72 to 100% of urea with NitroShure reduced rumen ammonia levels. The slow release rate of ammonia from NitroShure appeared to have provided inadequate ammonia to support maximum nutrient digestion particularly when all urea was removed from the diet. On a practical basis this would suggest that when incorporating NitroShure into diets attention must be paid to maintaining adequate soluble protein levels in the diet.

Partial replacement of SBM with NitroShure resulted in increased rumen ammonia levels, which appears to have improved nutrient digestibility. Microbial metabolism and growth were improved over that of the control when up to 0.68 g/100g diet DM as NitroShure replaced 3.65 g SBM/100 g diet DM (NS4). There was no benefit to replacement of greater amounts of SBM with NitroShure. This may result from an excessive decrease in rumen peptide levels associated with feeding less SBM. Soybean meal is a good source of peptides. In diet NS4, in which 0.68 g NitroShure/100 g DM replaced 3.65g SBM, total NAN flow was maintained equal to that of the control. Although equal in quantity, the composition of the NAN in the control and NS4 differed (*Figure 1*) with diet NS4 providing more high quality microbial protein.

Replacing SBM with NitroShure, a highly concentrated source of nitrogen, has the added advantage of creating space in the diet. This space can then be filled with other ingredients that can improve the overall quality of the ration. In this study, removal of 3.65 % of SBM DM permitted the inclusion of a greater quantity of starch and sugar, which was efficiently used by the microbes.

Figure 1. Impact of Replacing Soybean Meal with a Mixture of NitroShure, Corn and Molasses (Diet NS4 on Non-ammonia Nitrogen Flow.



Conclusions

1. Replacing all urea with NitroShure tended to decrease DM and NDF digestibility. Urea supplies fast ammonia which matches up with fast sugars and starches. It is possible that replacing all urea with NitroShure may have resulted in inadequate fast ammonia in early fermentation and thus tending to lower overall digestibility.
2. NitroShure successfully replaced SBM resulting in numerically increased digestibility of DM, crude protein, NDF, ADF and total carbohydrate. In addition microbial yield and efficiency were higher when NitroShure replaced a portion of SBM. This may have resulted from NitroShure increasing rumen ammonia relative to SBM and thus stimulating bacterial growth.
3. Substituting 0.68 g NitroShure for 3.65 g SBM (185 g per kg) gave the best overall response in this study.
4. Replacing SBM with the more concentrated N source NitroShure creates space in the dist that can be filled with other ingredients that improves overall ration quality.

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Balchem Research Summary

Response of Holstein cows to replacing urea with a slow rumen release urea in a diet high in soluble crude protein.

A summary of a study conducted by A. Highstreet, et al. "Response of Holstein cows to replacing urea with a slowly released urea in a diet high in soluble crude protein. *Livestock Science* 129 (2010) 179-198.

Background

Rumen bacteria are able to utilize ammonia and available fermentable carbohydrates to produce high-quality microbial protein. In fact, some bacterial species have a requirement for ammonia to maximize microbial growth and optimally digest feed to produce protein and energy for the cow. Ammonia is derived primarily from dietary non-protein nitrogen, recycled urea and the degradation and deamination of dietary rumen degradable proteins (RDP). The level of ammonia in the rumen is affected by many factors including level and source of RDP, level and fermentability of carbohydrate sources, the balance between rates of fermentation of protein and carbohydrate, rumen pH and rate of passage. Inadequate levels of fermentable carbohydrate can also lead to elevated levels of rumen ammonia because without available energy, bacteria cannot convert peptides, amino acids and ammonia to microbial protein. As rumen ammonia levels rise, increasing amounts are absorbed from the rumen. Ammonia in the blood is transported to the liver where it is converted to urea (this process requires energy). Some of this urea will be excreted either in milk (milk urea nitrogen, MUN) or in urine. Both of these pathways of excretion are undesirable and represent lost efficiency of protein utilization. Alternatively some of the urea produced by the liver will be recycled back to the rumen via saliva or direct transfer from the blood to the rumen across the epithelial tissues. The proportion excreted vs. recycled increases as blood urea increases.

Urea is an inexpensive source of protein. It is very soluble and is rapidly hydrolyzed to ammonia in the rumen. This can be beneficial when there are rapidly fermentable sources of carbohydrates in the diet such as sugars and fast starch. However, over-feeding urea can cause a rapid spike in rumen ammonia levels. If bacteria are unable to capture the released ammonia it is absorbed and processed as described above. It is possible to slow the rate of release of urea by lipid encapsulation. By doing so it may reduce spiking of ammonia levels and allow bacteria to better capture the ammonia as it is released more slowly. This can result in increased microbial growth and thus high quality metabolizable protein for the cow, increased carbohydrate digestibility (more energy) and lower MUN and urea nitrogen excretion (more efficient protein utilization). The purpose of this trial was to determine if replacing urea with NitroShure™ *Precision Release Nitrogen*, a slow-release nitrogen source, could enhance performance of early and mid-lactation cows.

Materials and Methods

The trial was conducted on a commercial dairy. Approximately 360 cows were grouped based on milk production and days in milk (DIM). The early lactation groups averaged 79 \pm 3.1 DIM (48.6 kg milk/day) and the mid-lactation groups averaged 258

\pm 6.5 days (41.9 kg milk/day) at the start of the experiments. The early and mid-lactation groups were analyzed as separate experiments but ran concurrently. The experimental diets consisted of a control diet containing urea and the NitroShure diet in which urea was replaced with NitroShure. The experiments were a switch back design and consisted of two four-week periods. Treatments were reversed within pens. Cows were milked 3 times daily and were fed a TMR twice daily. Pen intakes were monitored using Feed Watch (Valley Agricultural Software, Tulare, CA, USA). Feed and TMR samples were taken at the beginning and middle of the last week of each period. Milk production was monitored using meters and milk was sampled on day 27/28 of each period. Urine samples were collected on day 25 from 22 to 25 random cows from each treatment group. Only cows that remained in their initial respective pens throughout the entire study were used in the analysis.

Results and Discussion

The treatments' TMR ingredient compositions only varied in that urea was replaced by NitroShure (Table 1). The chemical composition of the TMRs is shown in Table 2. Nutrient compositions were very similar. The NitroShure TMR tended to have slightly lower NDF and ADF and had higher sugar content. The NitroShure diet was also lower in soluble protein, which probably reflects the inclusion of slow-release NitroShure. Soluble protein levels in both TMRs were relatively high at approximately 42%.

Milk production was not significantly increased in either early or mid-lactation cows due to replacing urea with NitroShure (Table 3). Milk production values were numerically higher, 0.8 and 0.7 kg, for early and mid-lactation cows, respectively. In early lactation cows, milk fat and milk protein, yield and percentages, were significantly increased with NitroShure. In the mid-lactation cows, milk components were not different between treatments. MUN levels tended to be high for NitroShure-fed cows in early lactation and were significantly higher in the mid-lactation cows. This seems counterintuitive to the concept of slower release of nitrogen. However, urinary nitrogen and urea were not different between treatments.

The authors suggested that since the diets had high soluble protein levels, peak rumen ammonia levels would be expected to be high as well (not measured). Studies in which rumen ammonia levels have been elevated through the infusion of ammonium salts have shown decreased acetate to propionate ratios (Grummer et al., 1984; Song and Kennelly, 1989; Song and Kennelly, 1990). The authors speculated that adding NitroShure may have reduced peak ammonia levels resulting in an increase in the acetate to propionate ratio and that this may explain the increased milk fat synthesis.

Table 1. Ingredient Composition of Diets.

Ingredient (kg/ton DM)	Urea	NitroShure
Alfalfa hay	150	150
Rolled corn grain	160	159
Cottonseed, whole linted	96	97
Soy hulls	53	53
Canola meal, solvent	136	134
Almond hulls	83	83
Yeast culture	4	4
Urea mineral	18	0
NitroShure mineral	0	17
Rumen inert fat	20	19
Alfalfa haylage	65	67
Corn silage	217	217

Table 2. Nutrient Composition of Diets

Nutrient Composition, g/kg	Urea	NitroShure	P
Dry Matter	587	588	1.00
Organic Matter	918	918	0.96
aNDF	340	334	0.07 ^a
ADF	253	249	0.13
Lignin	57	57	0.94
Starch	155	157	0.75
Sugars	31	36	0.02
Crude protein	180	178	0.76
Soluble protein	434	416	0.05
Total fatty acids	55	56	0.50

Table 3. Effects of Diet on Productive Performance of Cows

	Urea	NitroShure	P
Early Lactation Group (79 DIM)			
Yield			
Milk (kg/d)	46.9	47.6	0.14
Fat (kg/d)	1.66	1.73	0.01
True protein	1.30	1.34	0.01
Lactose	2.21	2.25	0.10
Components, (mg/kg)			
Fat	35.7	36.6	0.01
True protein	27.8	28.2	0.01
Lactose	47.1	47.2	0.63
MUN	13.3	13.6	0.11
Mid-Lactation Group (258 DIM)			
Yield			
Milk (kg/d)	38.9	39.6	0.22
Fat (kg/d)	1.48	1.52	0.11
True protein	1.21	1.22	0.43
Lactose	1.84	1.87	0.20
Components, (mg/kg)			
Fat	38.5	38.7	0.49
True protein	31.4	31.2	0.09
Lactose	47.1	47.2	0.74
MUN	12.0	12.2	0.04

Conclusion

1. Replacing urea with NitroShure in high soluble protein diets resulted in significantly increased milk component content and yield in early lactation cows while milk yield tended to be higher. Increasing milk fat and protein could be explained by improved fiber digestibility and microbial protein yield resulting from better utilization of ammonia with NitroShure vs. urea by rumen bacteria.
2. Similar trends were seen in mid-lactation cows but the numbers were not significant. This may be related to the later stage of lactation (258 vs. 79 DIM) of this group of cows.
3. MUN was not different between treatments.

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