

## Use of Different Non Protein Nitrogen Sources in Ruminant Nutrition: A review

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### Abstract

Review was carried out on the use of different nitrogen sources in ruminant nutrition. Non-protein nitrogen (or NPN) is a term used in animal nutrition to refer collectively to components such as urea biuret uric acid and a number of other ammonia compounds which are not proteins but can be converted into proteins by microbes in the ruminant stomach. Urea is a simple compound that contains 46.7 percent of nitrogen compared to 16 percent for most proteins. There is no question but that urea and other non protein nitrogen substances can be fed safely to ruminants to replace part of the dietary protein. When urea with feed sources enters the rumen, it is rapidly dissolved and hydrolyzed into ammonia by bacterial urease. The amount of urea included in concentrate mixtures for cattle or sheep should not exceed 3 percent and usually the addition of 1 to 1.5 percent will prove adequate. In the total ration, the amount of urea should not exceed 1 percent. At these levels of intake, urea has proved an effective for growing and fattening beef cattle and for dairy cattle Urea may cause toxicity and even death in ruminants if it is fed inadequately mixed with other feeds or in too large a dose. The toxic signs can easily be recognized. The slow-release of nitrogen from biuret is better matched to the energy in the diets of cattle consuming low-quality forages, thus improving the utilization of forage and reducing the metabolic cost of eliminating excess nitrogen in urea-based diets. Dried poultry waste (DPW) contains a true protein and high amount of NPN in the form of rumen degradable uric acid. Uric acid can be utilized by rumen microbes for protein production. Poultry manure can safely be supplemented to ruminant animals for considerable increase in performance.

**Keywords:** Non protein nitrogen , urea, biuret, poultry manure

### 1. Introduction

The primary aspect distinguishing ruminants and non-ruminants is of course the difference in their digestive systems. Non-ruminants can digest only real proteins and use only them in their body, while ruminants can utilize all nitrogen compounds (Burgstaller, 1983). It is known that NPN compounds make, among many feeding materials, of 20-30% of the whole nitrogen in field grass, 50% of the nitrogen in silages and 40-50% of the whole nitrogen in the containing segments of especially things like roots, nodes, onions and the ratio decreases as the plants ripen (Ozgen, 1978; Burgstaller, 1983). Ruminants are capable of utilizing different protein sources due to their stomach physiology. Rumen microorganisms synthesize protein from substances containing nitrogen to build up their cells and ruminants use this aspect of the microorganisms to satisfy some and sometimes all of their need for proteins from nonprotein nitrogen compounds (Kirchgessner, 1985). Animals with simple stomachs (pigs and chickens) cannot make use of large concentrations of NPN compounds because of a lack of enzymes and bacteria to break down the NPN to ammonia and synthesize it into protein.

Protein rich leguminous forages are not widely grown in many areas grazed by ruminants, and vegetable protein supplements are usually expensive or unavailable. Among the problems facing the livestock in the tropics is the low protein tropical grasses and the high cost of alternate sources of protein such as the Soybean and other oil cake. Feeding grass, fodder and concentrates of low nutritive value doesn't always meet the nutritional needs of ruminants, hence they should be replaced with suitable alternatives in feed one of such alternative is the use of non-protein nitrogen (NPN) compounds. A portion of nitrogen in feeds for ruminants may be provided in the form of simple nitrogen compounds (non-protein nitrogen / NPN) that are degraded in the rumen to release ammonia (NH<sub>3</sub>), which is used by rumen microorganisms to produce amino acids (Nadeem *et al.* 2014). It has long been recognized that supplemental nonprotein nitrogen (NPN) is most efficiently utilized in rations low in protein and relatively high in digestible energy. It is also widely accepted that supplemental NPN is utilized better when small rather than large amounts are added to ruminant rations (Satter and Roffler, 1977).

The ability of the micro-organisms in the rumen of cattle and sheep to utilize these NPN sources to form true protein that can be converted to meat and milk by the animals represents an important contribution to human's food supply. The objective of this paper was to review the different non protein nitrogen sources and their importance in ruminant nutrition.

## 2. The Different NPN Sources

Non-protein nitrogen (or NPN) is a term used in animal nutrition to refer collectively to components such as urea biuret uric acid and a number of other ammonia compounds which are not proteins but can be converted into proteins by microbes in the ruminant stomach (Wikipedia, 2015). NPN could also be defined as nitrogenous feed nutrient that are not bound together by peptide bonds and are found within or outside the animal's body system. All NPN's generate ammonia in the rumen which enters the liver and finally converted to urea.

### 2.1. Urea the most common NPN

Urea is the principle commercial source of NPN for use in ruminant diets. Urea is a simple compound that contains 46.7 percent of nitrogen compared to 16 percent for most proteins. When plant protein feeds, such as soybean meal, are high priced, it is economical to use urea as a protein supplement in ruminant rations. Urea, the cheapest solid nitrogen source, is a white crystalline water-soluble powder that is used as a fertilizer. Urea contains 46% nitrogen; thus each kilogram of urea is equivalent to 2.88 kg of crude protein ( $6.25 \times 0.46$ ), which in most rations equals a digestible crude-protein content of 200%. To improve the flow characteristics, urea is processed into feed-grade urea (42% nitrogen), in which each grain of urea is covered with kaolin or some other non-hygroscopic substance. One kilogram of urea plus 6 kilograms of maize or other grain furnishes the same amount of nitrogen as 7 kilograms of soybean meal or an equivalent high-protein feed, but it may be lower in energy content since urea adds no useful energy

The cheaper fertilizer urea can be use, however, when mixed with liquid feeds or even in solid feeds if added in the form of a suspension or solution in molasses. Urea stops bacterial growth and fermentation in concentrations over 10% but it has a very bitter taste and limits intake if used at high levels. It has been known for quite a long time that urea can be recycled and used as a source of nitrogen for the rumen microorganisms (Stanton & Whittier 1998).

When urea with feed sources enters the rumen, it is rapidly dissolved and hydrolyzed into ammonia by bacterial urease. The ammonia can then be utilized by the bacteria for synthesis of amino acids required for their growth (Panday, 2010). Urea is commonly incorporated into various supplements designed for feeding dairy cattle, beef cattle, and sheep.

The most important applications of urea in the true pastoral areas, are usually during periodic severe droughts (Morris (1958). Morris (1958a) stated that supplements of wheat and urea improved the survival rate and increased the roughage intake. Ryley (1961) found that with the small addition of sorghum, urea reduced body weight loss, improved birth weight of calves, reduced neonatal mortality, and led to higher milk yields and calf growth rate. Beames (1963) has reported the conditions that the addition of urea to the ration enabled the animals to survive during drought. An earlier study by Harris and Mitchell (1941) showed that lambs could gain in body weight and store body nitrogen on rations containing 40 to 65 percent of the nitrogen in the form of urea, the rates of gain were less than desired for efficient lamb fattening operations.

Urea is fed as a replacement for a part of the protein in a ration. The ability of microorganisms present in the rumen of ruminants, use of feeding urea reduces the need for imported protein supplements with no deleterious effects on the animal. Treating with urea is based upon its transformation into ammonia. The amount of urea included in concentrate mixtures for cattle or sheep should not exceed 3 percent and usually the addition of 1 to 1.5 percent will prove adequate (panday, 2010). Urea toxicity has been documented many times and is characterized by an over-consumption of urea containing feeds or feeding of urea without a suitable fermentable carbohydrate source. Primary causes include: Poor mixing of feed, Errors in ration formulation, Inadequate period of adaptation, Low intake of water, Feeding of urea in conjunction with poor-quality roughages, Low feed intake prior to exposure to feed containing urea and Rations that promote a high pH in rumen fluid(Blezinger, 1998). It appears to be great scope here for supplementing the low quality forage available during the dry season where beef cows are exposed to nutritional stress during pregnancy or lactation, which may seriously impair their lifetime productivity. As the level of urea increased, average milk production and body weights decreased and the efficiency of nitrogen utilization decreased somewhat. Cows can consume as much as 272 grams of urea in their daily feed without evidence of any adverse effect. The cows produced an average of 21.3 kilograms of 4 percent fat-corrected milk per day on a concentrate mixture containing linseed meal plus 1.2 percent of urea, 20.7 kilograms on soybean meal, and 20.6 kilograms of milk on a mixture of soybean meal and linseed meal. The basal ration consisted of cereal grains, wheat bran and molasses as concentrates and grass hay and maize silage for roughage.

### 2.2. BIURET

It is a compound ( $\text{NH}_2\text{CONHCONH}_2\text{H}_2\text{O}$ ) derived from the condensation of two urea molecules. It is a condensation product of urea. It has also been subjected to much attention recently as a potential source of NPN because of its solubility and slow rate of degradation. It is an ammonium salt source which readily releases ammonia for microbial action in the rumen (Panday, 2010). Biuret is produced from urea by heating, contains

41% nitrogen (256% CP). It is only slightly soluble in water and is not toxic as the ammonia is slowly released in the rumen. It therefore has definite advantages over urea for use in dry feeds, although it is more expensive. An adaptation period of two weeks to two months is required before obtaining a response to feeding biuret. This adaptation is rapidly lost when biuret is not fed.

Since, it is slowly degraded in the rumen; it is able to bring about a slow but continuous source of ammonia (Fonnesbeck et al., 1975). It is non-toxic. So, large amount of it can be safely consumed by animal without complication. Degradation of biuret in the animal's body system is brought about by an enzyme biuretase. Biuret can be incorporated into supplements at higher concentrations compared with urea. Some disadvantages of biuret as nitrogen source includes: Biuret is quite expensive costing as much as 8 times equivalent quantity of urea, the biuretase enzyme needed for biuret degradation is not automatically built up in animals system. Sometimes, it may require up to 6 months for a young ruminant to build up biuretase. Daily and alternate-day supplementation of biuret to ruminants consuming low-quality forage does not adversely affect forage intake, nutrient digestibility, site of digestion, or microbial efficiency compared with unsupplemented animals (Currier et al., 2004). Cattle supplemented with biuret gained 3.15 lb/hd/day compared to urea supplemented cattle that gained 3.09 lb/hd/day.

### 2.3. Poultry Litter as Source of NPN for Ruminants

Dried poultry waste (DPW) contains an contains true protein and high amount of NPN in the form of rumen degradable uric acid. Uric acid can be utilized by rumen microbes for protein production. As uric acid is not easily dissolved in the rumen fluid and the ammonia is only slowly released, it is therefore more efficiently utilized than other non-protein nitrogenous sources. The rumen micro flora seems to take about 3 weeks to adapt before it can fully utilize uric acid (Sayed and Fathy, 2010). Though heterogeneity was observed in the many reports reviewed, the general consensus was that poultry manure/litter contains high level of crude protein (15 to 38%), fiber (11 - 52%), and rich in minerals (Ca: 0.81 - 6.13%; P: 0.56 - 3.92; K: 0.73 - 5.17), dry matter (61 - 95%). It is because of these nutrients that poultry manure has been deliberately mixed into ruminant livestock diets. Its Organic matter digestibility (OMD) ranges from 60 to 65, crude protein (CP) - 69.9, crude fibre (CF) - 29.9 and nitrogen-free extract (NFE) - 71.4% (Lanyasunya et al., 2006).

Dried poultry waste can be used in supplements for both growing and finishing diets (Bierman et al., 1996). It is found that poultry manure can be used as a feeding material for ruminants by ensilaging it with nutrition substance containing easily digestible carbohydrates like crops, root materials from plants, molasses, fruit juice and left-overs from canned food industry; ensilaging is more economical compared to other methods, it has a lower rate of nutrition loss and additionally the unwanted smell of manure can be removed by ensilaging, making it no longer a problem for the animals to consume it (Ak, 1990).

Use of poultry litter as a source of non-protein nitrogen in ruminant feeding is becoming increasingly popular in terms of utilization of waste products and in decreasing feed costs (Mapoon et al. 1979). In a study to utilize dried caged chicken manure as a protein source in beef cattle rations, 15 and 30% of dried caged chicken manure was added to the animals' concentrated feed. At the end of the research, the daily live weight gains were found to be 774 g in the control group, 758 g in the group where 15% manure was used and 729 g in the group where 30% manure was used (Akkilic *et al.*, 1976). Similarly, Holstein bulls fed with two levels of poultry litter (15 and 30% of the ration), gained average daily weights(kg) of 1.27 and 1.17 respectively (Trevino et al., 2002). In agreement with this Lanyasunya et al.(2006) also reported as beef cattle fed poultry manure based diets recorded body weight gains ranging from 0.91 to 1.31 kg/d. Poultry manure added in the rate of 30% to corn silage increases the milk production and quality in cattle and additionally there is not a significant decrease in the fat ratio of the milk (Ko *et al.*, 1990). Dairy goats supplemented with poultry manure registered 10.15% higher milk production compared to those on barley based diets. In intensive lamb feeding, lambs with rations supported with 40% dried poultry manure has shown 237 g of live weight gain and consumed 6.07 kg of food for a kg of live weight gain (Ak and Okuyan, 1991).

The efficacy of poultry litter as NPN source depends on the quantity and quality of the bedding materials. Where the poultry litter is undiluted and collected directly, it tends to be supportive of the ammonia (NH<sub>3</sub>) production, and is usually higher than when wood shaving or straws are used. Poultry litter mainly consists of Uric Acid which is degraded by rumen microbes to yield ammonia (NH<sub>3</sub>) and it could be a very rich source of ammonia for both livestock and industrial utilization. There are however, health considerations as to why a product (faeces) of one species of livestock should be used to feed another livestock.

### 2.4. Ammonia Hydroxide

NH<sub>3</sub> is a gas which usually dissolves in water. It is the cheapest source of nitrogen that can be used in feeding, but being toxic and difficult to handle. It is mostly used to increase the nitrogen content of low-protein feeds by ammoniation on an industrial scale. Low-protein feed (e.g., rice hulls or beet pulp) is allowed to react with the ammonia, usually under high pressure and temperature. The ammonia becomes chemically bound and is not

released until the feed is fermented in the rumen. The amount of ammonia that can be utilized by the bacteria will depend on how many bacteria there are, and how rapidly they are growing. In other words, it will depend on the amount of fermentable feed consumed. Feeds high in TDN are more fermentable than those low in TDN. Therefore, more ammonia (NPN) can be utilized when feeds high in TDN are used. This is illustrated in figure 1 where an increase in TDN "opens the gate" and allows greater ammonia use by supporting greater bacterial numbers (Satter and Roffler, 1977).

During the past 10 years, ammoniation of roughages has gained wide acceptance by beef producers, especially as a way of making a quality feedstuff out of wheat straw and other crop residues in drought years. Feed analyses routinely show an increase in the crude protein content of wheat straw by 4 to 6 percentage points by ammoniation. Thus, a straw at 4 percent CP prior to ammoniation often tests 9 percent CP after ammoniation. However, this protein is in the form of ammonia hydroxide, an NPN source. Research has shown that beef cows make some use of this NPN source, but respond very well to additional supplementation with "natural" protein. This clearly points out that the primary reason for ammoniating forages is to increase fiber and energy intake and digestibility, and not to meet all of the protein needs of the cows (Marston et al., 1998). Ammoniating low quality forages increases digestibility 10 to 15 percent. The increase in digestibility is a result of the water and ammonia combining to cause breakdown of the fiber components of the forage. The ammoniation process essentially pre-digests the fiber so when animals consume the treated forage, breakdown of tough fiber components already has started and total digestibility is increased. An increase in digestibility means an increase in available energy content of the residue.

Ammonium Polyphosphate is a common supplier of phosphorus and nonprotein nitrogen in liquid supplements. For use in feed it must be produced by the thermal process, which yields a clear solution of ammonium polyphosphate of high purity. It is handled in liquid form and has the advantage over phosphoric acid (also a common source of phosphorus in liquid feed) of not being corrosive. The 11-37-0 grade contains 11% nitrogen (equivalent to 68.8% CP) and 16.1% phosphorus.

### 3. Factors Affecting the Use of NPN Sources as Ruminant Feed

Urea poisoning is one of the common toxicities found in ruminants especially cattle. It is rapidly hydrolyzed upon entry into the rumen resulting in peak rumen ammonia concentrations within the first hour of consumption. However, ammonia that is not utilized for microbial synthesis is absorbed across the gastrointestinal tract, with increasing ruminal ammonia concentrations resulting in increased rate of absorption (Huntington, 1986). Increased blood ammonia concentrations alter hepatic metabolism by increasing ureagenesis may also affect glucose metabolism in the liver and peripheral tissues (Huntington et al., 2006). Poisoning may occur periodically when ruminants gain access to large quantities or are fed large amounts of urea; when they are not adapted to it or when feeds are improperly mixed or high urea concentration is present in low energy, low protein, and high roughage diets (Ortolani et al., 2000). To avoid poisoning, the amount of urea included in concentrate mixtures for cattle or sheep should not exceed 3 percent and usually the addition of 1 to 1.5 percent will prove adequate. In the total ration, the amount of urea should not exceed 1 percent (Dinesh Panday, 2010).

Only animals with a functioning rumen can utilize urea; therefore it should not be given to young calves and monogastric animals. Unlike protein, urea does not contain energy, phosphorus or sulphur; hence a feed mixture containing urea should be supplemented to make up for these deficiencies. Diets low in energy and high in fiber are more commonly associated with non protein nitrogen toxicosis. Highly tasty supplements (such as liquid molasses) or improperly maintained lick tanks may lead to consumption of lethal amounts of non protein nitrogen. Early signs include muscle tremors (especially of face and ears), protrusion of eyeballs, abdominal pain, drooling, passing large amounts of urine, and grinding the teeth. Tremors progress to lack of coordination and weakness. Fluid in the lungs leads to difficulty breathing and gasping. Horses may exhibit head pressing. Eventually, there is a bluish tinge to the skin and mucous membranes, difficulty breathing, an absence of urine output, fever, and metabolic abnormalities (Barry et al., 2011).

Biuret is not available commercially so that its utilization has no practical significance at present. It has no nutritional advantage over urea except that it is much less toxic at usual intake levels. Mixtures of urea and biuret might prove more practical than either one alone.

It is argued that fresh poultry manure can contain pathogenic microorganisms like Salmonella and Proteus, that can create drawbacks for animal health and therefore for it to be used in feeding animals, it is advised to be ensilaged or dried, especially pathogenic microorganisms that can harm animal health can be eliminated with these methods and additionally, these microorganisms should not be able to live in the rumen environment considering the microorganism population, rumen pH and enzyme effects in ruminants' digestive systems, or at least, their numbers will be reduced to a point where they will not be able to be harmful (Ak and Okuyan, 1991).



#### 4. Summary and Conclusion

The complete substitution of non-protein nitrogen for protein in purified diets for ruminants results in the following: (1) Growth, feed efficiency and nitrogen retention are reduced by 35% and attempts to improve performance with amino acid supplementation, either singly or in combination, or by the use of other nitrogenous adjuncts have been largely unsuccessful. (2) Reproduction has been demonstrated by heifers fed protein-free diets and bulls fed these diets are fertile. Several normal offspring have been obtained from bulls and heifers raised since 84 days of age on these diets. Cattle have been maintained for more than 4 yr. on diets without protein. (3) A moderate milk production is possible when cows are fed diets devoid of protein and the composition of the milk is essentially similar to the milk produced from cows fed natural diets. Small additions of dietary protein seem to stimulate milk production. (4) Ruminants fed diets free of protein have depressed concentrations of the branched-chain volatile fatty acids, but ruminal synthesis of the “B” vitamins is apparently normal. (5) The amino acid pattern of ruminal protein hydrolyzates obtained from ruminants fed urea as the sole source of dietary nitrogen appears to be similar to the patterns from ruminants fed protein containing diets. (6) Ruminants fed protein free diets have depressed free blood plasma concentrations of the “essential amino acids” and increased concentrations of glycine and serine.

Numerous research studies have proven that, poultry manure has the potential to replace many expensive grain meal-based protein supplements and as a substitute for legumes during the dry season, thus decreasing feed costs and sustain higher ruminant livestock productivity. Farmers can get maximum feed value when the manure is protected from the quality deteriorating factors (rain, strong sunshine/winds) through proper handling. Biuret's physical properties enable it to be utilized in situations where grazing cattle are fed low-quality, low-energy forages or in feedlot situations where a NPN "safety" factor is desired. The slow-release of nitrogen from biuret is better matched to the energy in the diets of cattle consuming low-quality forages, thus improving the utilization of forage and reducing the metabolic cost of eliminating excess nitrogen in urea-based diets.

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