Urea contamination in Dairy Feed: Risks, Safe Limits and Practical Prevention under Indian Feeding Conditions

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ABSTRACT

Urea is a legitimate and economical source of non-protein nitrogen for ruminants, but the same compound turns into a serious hazard when it reaches dairy animals in the wrong amount, in the wrong form or at the wrong time. In India, which produced 247.87 million tonnes of milk in 2024-25 (DAHD, 2025), urea contamination of feed arises mainly from deliberate spraying of costly oilseed cakes to increase their apparent protein, from uneven mixing in compounded feed, and from careless storage of fertiliser urea on farms. In the rumen, urea is split into ammonia far faster than microbes can use it and the surplus can take over the liver within an hour. This article brings together the permissible level (1.0 percent of compounded cattle feed under IS 2052:2023), the toxic and lethal doses (0.3 to 0.5 and 1.0 to 1.5 g per kg body weight), the clinical picture, first-response steps, and a practical prevention plan that suits smallholder and commercial dairies. The priorities for quicker field testing, improved regulations and research on Indian cattle and buffaloes are highlighted in this article.

INTRODUCTION:

The burden that protein imposes on the feed cost is evident to anyone who has worked on dairy rations in India. Groundnut, mustard, cottonseed and soybean cakes are the traditional answers, and they are expensive. Urea is the cheap shortcut. A ruminant can turn the nitrogen in urea into microbial protein, so a small, well-managed dose is a sound economic tool and the history of its use in dairy cattle is long. The trouble is that the margin between a useful dose and a harmful one is narrow and it narrows further when the farmer or the feed supplier or animal is unaware of its presence. Urea has an incredibly small safety margin, meaning a minor overdose easily triggers fatal ammonia toxicity in ruminants.

Higher-yielding crossbred cows and buffaloes cannot meet their protein needs from crop residues and green fodder alone, so dairy farmers, from smallholders with two animals to large commercial units, depends on bagged concentrates, oilseed cakes and by-products bought from dealers. Every extra step between the feed mill and farm is another point at which the quality of the product goes unchecked. There is also a sound biological reason why urea attracts attention. Ruminants host a dense microbial community in the rumen that can capture simple nitrogen and rebuild it as microbial protein, which the cow then digests in the small intestine (Kertz, 2010). For this purpose, urea is a highly concentrated and economical source of non-protein nitrogen (NPN) that can partially replace conventional protein sources in ruminant diets without compromising animal performance, provided that ruminal microbial adaptation and adequate fermentable energy availability are ensured. However, its high nitrogen concentration and rapid hydrolysis in the rumen can pose a risk of ammonia accumulation and toxicity when inclusion levels or feeding practices are inappropriate. Although feed analysis may indicate a satisfactory crude protein content, this value does not necessarily reflect the proportion of nitrogen derived from urea or its rate of release in the rumen. Therefore, distinguishing between apparent crude protein content and the actual availability and safety of dietary nitrogen is fundamental to the effective and safe use of urea in ruminant nutrition.

Urea adulteration refers to the unintended, unnoticed or uneven distribution of urea in animal feed beyond the prescribed inclusion levels, posing a significant risk to livestock health and productivity. In India, the world's largest milk producer, increasing reliance on purchased concentrate feeds may increase exposure to such contamination. This article examines the sources, toxicological effects, safe and hazardous inclusion levels and preventive measures for managing urea contamination at farm and feed-chain levels.

1. How urea gets into dairy feed?

1.1 Unintentional Urea Toxicity Due to Improper Feeding Practices

Poisoning does not always involve bad actors. It often follows ordinary practice that slips: urea fed to animals that have not been adapted to it, a bag of fertiliser left within reach, urea-molasses treated roughage offered in large amounts, or a ration with too little energy and protein and too much dry fodder, where the rumen cannot use the ammonia released (Parkes, 2001; Shete & Hol, 2007). Feed that has been poorly mixed is a similar trap. The batch average may look acceptable on paper, yet a few scoops carry a very high concentration, and the animal that happens to eat them receives the full dose.

1.2 Deliberate adulteration of protein feeds

Deliberate adulteration occurs when urea is added to protein-rich feed ingredients or commercial protein supplements to artificially increase their apparent crude protein content and reduce production costs. Oilseed cakes and meals are sold on protein content, so spraying or blending urea into them raises the laboratory protein value at a fraction of the cost (Uppal *et al.*, 2004). Mustard cake, soybean meal and groundnut cake are the ingredients most often adulterated in this context. Since conventional crude protein estimation is based on total nitrogen content, nitrogen derived from urea is also included in the calculated crude protein value, potentially misleading feed manufacturers, dairy farmers, and nutritionists about the actual protein quality of the feed.

1.3 Why routine analysis misses it?

Most laboratories report crude protein by the Kjeldahl method, which measures nitrogen and multiplies it by 6.25. Urea carries about 46 percent nitrogen, so every 100 g of urea registers as roughly 280 g of crude protein, and the method cannot say whether the nitrogen came from amino acids or from urea (Anitha *et al.*, 2023). A cake that reads 40 percent protein on the report may therefore be partly fiction. The Bureau of Indian Standards (BIS, 2023) addresses the potential risks associated with urea inclusion in compounded cattle feed by prescribing a maximum permissible urea level and requiring its percentage to be explicitly declared on the feed packaging.

2. What urea does inside the rumen?

Rumen microorganisms produce urease, an enzyme that rapidly hydrolyses urea into ammonia and carbon dioxide following ingestion (Figure 1). Under normal conditions, ruminal ammonia serves as a nitrogen source for microbial protein synthesis, provided that sufficient fermentable energy is available to support microbial growth. However, the rate of urea hydrolysis may exceed the rate of microbial ammonia assimilation, particularly following the ingestion of excessive amounts of urea or diets deficient in readily fermentable carbohydrates (Kertz, 2010; Stanton & Whittier, 1998). Consequently, ammonia accumulates in the rumen, increasing ruminal pH and favouring the formation of unionised ammonia (NH_3), which is readily absorbed across the ruminal epithelium. The absorbed ammonia is transported to the liver, where it is converted into urea through the urea cycle. However, when ammonia absorption exceeds the liver's detoxification capacity, systemic ammonia concentrations increase, resulting in neurological and muscular dysfunction associated with ammonia toxicity (*Whitehair*, 1989; Gimelli *et al.*, 2023).

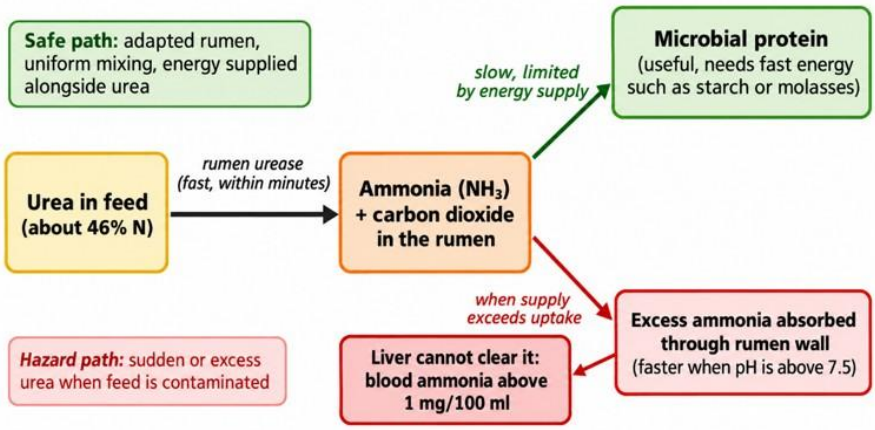


Figure 1. Fate of urea in the rumen

Two important considerations influence the risk of urea toxicity in ruminants. First, ruminal adaptation affects the capacity of the microbial population to utilize ammonia efficiently. However, raw soybean contains endogenous urease, which can accelerate urea hydrolysis when these ingredients are mixed, potentially increasing ammonia release before ingestion. Therefore, the selection and combination of feed ingredients are important determinants of the rate of urea hydrolysis (Stanton & Whittier, 1998). Second, an animal on a low-energy, low-protein, high-roughage diet is more vulnerable, because there is little fermentable carbohydrate to capture the ammonia (Parkes, 2001).

3. Optimum levels and lethal limits

Table 1 collects the main reference values. The Indian standard for compounded cattle feed fixes the maximum urea at 1.0 percent by mass, and where urea is added the feed must also carry a defined minimum of easily digestible carbohydrate to give the rumen something to work with (BIS, 2023). Parkes (2001) suggests a ceiling of 3 percent of the concentrate ration, which is more generous. For commercial feed sold in India the lower, statutory figure is the one to follow. According to ICAR (2024) urea should supply no more than one third of total dietary crude protein.

Table 1. Reference values for urea in dairy cattle diets

Parameter	Value	Source
Maximum urea in compounded cattle feed	1.0% by mass	BIS (2023), IS 2052:2023
Urea in concentrate ration	Not more than 3%	Parkes (2001)
Share of total dietary crude protein from urea	Not more than one third	ICAR (2024)
Toxic dose in cattle	0.3 to 0.5 g/kg body weight/day	Parkes (2001)
Potentially fatal dose	1.0 to 1.5 g/kg body weight/day	Parkes (2001)
Rumen ammonia associated with toxicity	Above 80 mg/100 ml	Whitehair (1989)
Blood ammonia associated with toxicity	Above 1 mg/100 ml	Whitehair (1989)

4. Effects of urea contamination on the animal

4.1 Acute poisoning: In acute cases the animal is often found already ill, because signs usually begin within an hour of eating the contaminated feed (Thompson, 2014). Early signs are restlessness, excessive salivation, frothing at the mouth and muscle tremors. These progress to abdominal pain, bloat, incoordination, weakness and laboured breathing, followed by violent struggling, bellowing and finally paralysis and collapse (Blood *et al.*, 1989; Gimelli *et al.*, 2023). Death can follow within about one to four hours of ingestion (Parkes, 2001).

4.2 Sub-acute and chronic effects: Not all cases of excessive urea exposure result in acute toxicity or mortality. Repeated consumption of excess rumen-degradable nitrogen may produce gradual and less readily detectable adverse effects, including reduced feed intake, decreased milk production, and deterioration in body condition. Prolonged exposure to excessive rumen-degradable nitrogen has also been associated with impaired reproductive performance in ruminants, although robust evidence from Indian dairy herds remains limited

4.3 Diagnosis and treatment: Diagnosis rests on the history of access to urea or suspect feed, the sudden onset of signs, and

laboratory confirmation. Rumen fluid should be collected early for ammonia and pH, and the feed should be kept for urea analysis. The standard approach is to slow ammonia reduction and absorption in the rumen by drenching 20-40 litres of cold water (cold water inhibits ureolytic activity). Also drench 4-5 litres of 10% acetic acid (vinegar) through a stomach tube, together with supportive care (Thompson, 2014; Gimelli *et al.*, 2023). The farmer's job in the meantime is to remove the suspect feed, keep other animals away from it, and call help without delay. Home drenching without proper training risks inhalation pneumonia and should not be attempted.

5. Preventive measures:

Prevention is cheaper than treatment and works on three levels: the feed supplier, the farm, and the ration. Table 2 sets out the measures that useful for Indian dairies.

Table 2. Practical measures to prevent urea contamination and poisoning

Measure	What to do in practice	Why it works
Adapt the rumen	Introduce urea slowly over 2 to 4 weeks, beginning at about 0.3% of the diet and raising it step by step.	Builds the population of microbes able to use the ammonia (Kertz, 2010)
Mix thoroughly	Blend uniformly at not more than 1% of dry matter; never top-dress or sprinkle urea over feed.	Prevents pockets of very high concentration (Stanton & Whittier, 1998)
Supply energy	Pair urea with molasses, grain or starch.	Matches ammonia release with energy for microbial growth (Kertz, 2010)
Store safely	Keep fertiliser urea in a locked area, away from feed, water and animals.	Removes the commonest accident route (Parkes, 2001)
Use slow-release forms	Choose Starea or urea-molasses mineral blocks made with BIS specification (IS 13451).	Releases nitrogen gradually and lowers the risk of a sudden spike (Shete & Hol, 2007)
Protect the young	Do not feed urea to calves below 6 months of age or below 200 kg body weight.	The rumen of young calves is not fully functional (Parkes, 2001)
Buy and test	Buy BIS-certified feed, read the urea percentage on the label, and test suspect oilseed cakes.	Check contamination before it enters the ration (BIS, 2023; Anitha *et al.*, 2023)

Urea spot test

The urease and bromothymol blue (BTB) spot test is a rapid, qualitative method for the preliminary detection of urea in animal feed. The method is based on the enzymatic hydrolysis of urea by urease, which produces ammonia and carbon dioxide, resulting in an increase in pH. This change in pH is indicated by a colour transition of BTB towards blue under alkaline conditions. For the test, 2 g of a representative feed sample is mixed with 20 mL of distilled water and shaken thoroughly for 10 minutes. Subsequently, 8 drops of the sample extract are transferred to a clean spot plate, followed by the addition of 3 drops of 0.1% BTB solution and 4 drops of 0.4% urease solution. The resulting colour change is observed and compared with appropriate positive and negative controls.

The development of a blue colour indicates a possible presence of urea and warrants further investigation. However, this test is intended for preliminary screening and cannot independently establish the concentration of urea or confirm feed adulteration. Quantitative analysis using a validated laboratory method is necessary for confirmation (Chanawanno *et al.*, 2023).

6. Future perspectives and directions

Future efforts to prevent urea contamination and adulteration in ruminant feed should focus on developing rapid, cost-effective, and user-friendly on-farm diagnostic tools, such as urease-based colorimetric test kits or paper strips, to facilitate preliminary screening of feed ingredients. These tools should be validated against established laboratory methods to improve their sensitivity and specificity. Another promising direction is to promote the use of controlled-release non-protein nitrogen sources, such as encapsulated urea and other slow-release nitrogen formulations, which may improve synchronisation between ruminal ammonia availability and microbial energy supply, thereby enhancing microbial protein synthesis and reducing the risk of rapid ammonia accumulation when appropriately formulated and fed.

CONCLUSIONS

Urea is economical source of non-protein nitrogen in ruminant nutrition; however, its safety depends on appropriate inclusion levels, uniform mixing, gradual adaptation, and adequate availability of fermentable energy. Accidental contamination or deliberate adulteration can compromise these safeguards and increase the risk of ammonia toxicity. Indian standards limit urea content in compounded cattle feed to 1.0%, while excessive intake can cause ammonia toxicity and mortality. Developing rapid on-farm screening tools, strengthening feed quality regulations, and expanding research on urea toxicity in Indian cattle and buffaloes are essential to minimise animal health risks and production losses.

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