Review Article

Anti-Nutrient in Fodders: A Review

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Abstract

Fodder is the plant and its parts that can be fed to animal and which provides nutrients and energy. Crop/plants which are grown especially for animal feeding purpose that, so called forage which is the base feed stuff for animal. The utility of the leaves, pods and edible twigs of shrubs and trees as animal feed is limited by the presence of anti nutritional substances. Among the different roughes, legumes, ferns, trees and other non traditional feed of animal contain some anti-nutritional quality material in green as well as in its dry state. Stuff like Nitrate, Oxalate, Mimosine, Tanin, Sinogen, Saponins & BOAA and others are harmful for ruminants and animal. Anti quality stuff (AQS) may be regarded as a class of toxic compounds, which are generally not lethal. They diminish animal productivity but may also cause toxicity during periods of scarcity or confinement when the feed rich in these substances is consumed by animals in large quantities. Consumption of such chemical containing fodder above critical limit is fatal, and its regular use even at below limit reduced the growth and quality of its products.

As there is huge shortage of green fodder so proper precaution regarding its amount and methods of use may help to overcome from the problem. Thus, it is essential to aware with the different toxicant and its myth. ANFs may be regarded as a class of these compounds, which are generally not lethal. They diminish animal productivity but may also cause toxicity during periods of scarcity or confinement when the feed rich in these substances is consumed by animals in large quantities.

Keywords: Anti quality stuff (AQS), fodder quality, toxicity, toxic limits and Reduced growth.

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Status and overture

Livestock is an important and integral part of Indian agriculture and rural economy. Livestock is the main source of livelihood for a majority of the rural population. The contribution of livestock to the National GDP is about 9 % and 25 % to agricultural GDP [1]. Livestock contributes about 15-20 % to the farmer's household income**,** even after that Indian livestock discarded and are highly malnourished. At present, the country faces a net deficit of 61.1% green fodder, 21.9 % dry crop residues and 64% in terms of concentrated feeds [1]. The available natural fodders are poor in quality with regards to energy, protein and minerals. Further, on feeding poor quality fodder the quality of produce hampered which directly losses in farmers income. The farmers investing about 60% of total cost of milk production on feed and fodder only, thus good quality of green fodder having sufficient nutritive value are the demand of the day. Although, green fodder, hay and silage contains good amount of animal nutrient, but there maintenance, ways of consumption and presence of some anti quality material also alarm us. Among the different quality controlling aspects anti quality materials/substances are also of prime importance.

Anti-quality or anti-nutritional material

It is those substances generated in natural feed stuffs by the normal metabolism of species and by different mechanisms (for example inactivation of some nutrients, diminution of the digestive process or metabolic utilization of feed) which exerts effect contrary to optimum nutrition [2]. Anti nutritional factors are substances which both by themselves or through their metabolic products, interfere with feed utilization and affect the health and production of animal or which act to reduce nutrient intake, digestion, absorption and utilization and may produce other adverse effects [3].

Nitrate

Nitrate is the form of nitrogen that the plant roots take up from the soil, and is transported to the leaves. Excess

nitrates accumulate in plants when they are stressed. Drought or hot dry winds put forage under water stress often resulting in nitrate accumulation. Damage caused by hail or frost impairs photosynthesis resulting in excess nitrates. Cool cloudy weather can also cause the problem. During initial growth, much of the nitrate taken up by the plant is used for root and shoot development. At this stage, the roots are able to take up more nitrate than is required and it accumulates in the stems and leaves of the plant. As the plant develops, the leaves of the plant are able to convert more nitrate into plant protein, therefore less "surplus" nitrate is found in the plant as it matures. Some of the fodder crops such as Sudan grass, pearl millet [4] and oats [5] can accumulate nitrate at potentially toxic levels. Most of the nitrate accumulates in stem, followed by leaves and very little in the grains [5] Nitrate poisoning is better described as nitrite poisoning. When livestock consume forages, nitrate is normally converted in the rumen from nitrate - nitrite - ammonia - amino acid to protein. When forages have an unusually high concentration of nitrate, the animal cannot complete the conversion and nitrite accumulates. Nitrite is absorbed into the blood stream directly through the rumen wall and converts haemoglobin (the oxygen carrying molecule) in the blood to met haemoglobin, which cannot carry oxygen. The blood turns to a chocolate brown colour rather than the usual bright red. An animal dying from nitrate (nitrite) poisoning actually dies from asphyxiation, or lack of oxygen. Factors affecting the severity of nitrate poisoning are the rate and quantity of consumption, type of forage, energy level or adequacy of the diet.

Table 1 Anti-Nutritional factor in forage crops

Sl. No	Anti nutritional/ Anti quality substances	Fodder crops
1.	Nitrate	Sudan Grass, Pearl millet, Oats
2.	Oxalates	Guinea Grass, Bajra and Napier Grass Hybrid, Setaria Grass, Kikyu Grass, Buffel grass
3.	Saponins	Lucern
4.	Tannins	Fodder tree/Shrubs
5.	Cynogens	Sorghum, Sudan grass, Jhonson grass
6.	Mimosine	Subabul
7.	BOAA	Lathyrus

Table 2 Level of nitrate in forage (dry matter basis) and potential effects on animals [6]

Nitrate Content (ppm)	Effect on animals
0-1000	This level is considered safe to feed under all conditions.
1000-1500	This level should be safe to feed to non pregnant animals under all conditions. It may be best to limit its use to pregnant animas to 50 per cent of the total ration on a dry basis.
1500-2000	Feeds are fed safely if limited to 50 per cent of ration's total dry matter.
2000-3500	Feeds should be limited to 35-40 per cent of total dry matter in the ration. Feeds containing over 2000 ppm nitrate nitrogen should not be used for pregnant animals
3500-4000	Feeds should be limited to 25 per cent of total dry matter in ration. Do not use for pregnant animals.
>4000	Feeds containing over 4000 ppm are potentially toxic. Do not feed

Precaution

Nitrates are more likely to accumulate in annual forages than in perennial crops. Nitrates are a concern immediately following a period of drought or wet, dull weather. The risk of nitrate toxicity can be reduced, but not eliminated, by taking the following steps:

- Dilute the nitrate content of the total ration by feeding a combination of low and high nitrate feeds.
- Feed the ration in two or three meals per day rather than just one meal per day.
- Allow cattle to adjust to low levels of nitrate before increasing the nitrate content of the ration.
- Ensure that livestock are being fed a balanced ration for the level of production that is expected.

Most feeds that contain nitrate can be fed to cattle if managed properly with balanced diet.

Oxalates

Oxalate is an anti quality nutrient which under normal conditions is confined to separate places. However, when it is processed and/or digested, it comes into contact with the nutrients in the gastrointestinal tract. After released, oxalic acid binds with nutrients, rendering them inaccessible to the body. If feed with excessive amounts of oxalic acid is consumed regularly, nutritional deficiencies are likely to occur, as well as severe irritation to the lining of the gut [7]. Strong bonds are formed between oxalic acid, and various other minerals, such as Calcium, Magnesium, Sodium, and Potassium. This chemical combination results in the formation of oxalate salts. Oxalates react with calcium to produce insoluble calcium oxalate, reducing calcium absorption. This leads to a disturbance in the absorbed calcium: phosphorus ratio, resulting in mobilization of bone mineral to alleviate the hypocalcaemia. Prolonged mobilization of bone mineral results in nutritional secondary hyperparathyroidism or osteodystrophy fibrosa [8]. Young plants contain more oxalate than older plants [9]. During early stages of growth, there is a rapid rise in oxalate content followed by a decline in oxalate levels as the plant matures [10]. The distribution of oxalate in plants is uneven. Several researchers reported that oxalate content is highest in leaf tissue, followed by stem tissue [9, 11, 12].

Precaution

Dietary oxalate can be degraded by rumen microbes into CO_2 and formic acid. Ruminants adapted to diets with high oxalate content can tolerate oxalate levels that are lethal to non-adapted animals. Moreover, it has been shown that the transfer of rumen fluid from animals in Hawaii to Australian ruminants resulted in complete elimination of the toxic effects of mimosine and the bacteria involved in such effects have been identified [13]. Evidence also exists that rumen microbes can be genetically manipulated [14].

Saponins

Saponins are glycosides containing a polycyclic aglycone moity of either C_{27} steroid or C_{30} triterpenoid (collectively termed as sapogenins) attached to a carbohydrate. Saponins are characterized by a bitter taste and foaming properties. The structural complexity of saponins results in a number of physical, chemical, and biological properties, which include sweetness and bitterness, foaming and emulsifying, pharmacological and medicinal, haemolytic properties, as well as anti-microbial, insecticidal activities. Saponins reduce the uptake of certain nutrients including glucose and cholesterol at the gut through intra-lumenal physicochemical interaction. Hence, it has been reported to have hypo cholesterolemic effects [15]. [16] Observed that 4-7 weeks of *ad lib.*feeding of *Albizia stipulate (Siris)* gave rise to toxic manifestation of sheep. The toxicity of broom breed (*Gutierrezia sarothrae*), a resinous shrub believed to be due to its saponin content. Symptoms include listlessness, anorexia, weight loss and gastroenteritis [17]. In non-ruminants (chicks and pigs), retardation of growth rate, due primarily to reduction in feed intake, is probably major concern [18]. The adverse effect of saponins can be overcome by repeated washing with water which makes the feed more palatable by reducing the bitterness associated with saponins. Saponins are among several plant compounds which have beneficial effects. Among the various biological effects of Saponins are antibacterial and anti-protozoal [19]**.**

Precaution

The concentration of saponins can be overcome by repeated washing with water which makes the feed more palatable by reducing the bitterness associated with saponins [20]. Add other legumes and roughes in ration along with siris leaf (which are toxic to animal).

Tannins

Tannins are water soluble phenolic compounds with molecular weight greater than 500 and hydro-lysable tannins and condensed tannins are two different groups of these compounds [21] which differ in their nutritional and toxic effects. Tannins have a property of binding to protein to form reversible and irreversible complexes due to the existence of a number of phenolic hydroxyl groups. They occur almost in all vascular plants. Hydrolysable tannins and condensed tannins are two different groups of these compounds. Generally, tree and shrub leaves contain both types of tannins [22]. The condensed tannins have more profound digestibility-reducing effect than hydrolysable tannins, whereas, the latter may cause varied toxic manifestations due to hydrolysis in rumen. Tannins may form a less digestible complex with dietary proteins and may bind and inhibit the endogenous protein such as digestive enzymes [23]. The tannin-protein complexes are astringent and adversely affect feed intake and all plants contains phenolic compounds but their

type and concentration may cause negative animal responses. When herbivore forage on tannin rich plant, tannin-protein complexes can reduce the digestion of forage protein. Tannins' directly affect digestibility of cell wall by binding with microbial enzyme in the rumen. The reduced digestibility of cell wall compounds restricts the digestible energy that animal gain from forage plants.

Table 3 Tannins containing plants and effect on ruminants due to its fodder consumption

Sl No	Fodder Tree/Shrub	Common name	Area of Distributi-on	Effected Animal	Nutritional Effect	Reference
1.	*Acacia aneura*[a], *A. cyanophylla*, *A. nilotica* (pods), *A. sieberiana*[b] (pods), *Terminalia oblongata* *Ziziphus nummularia* *Prosopis cineraria*	Mulga, wattle, Babul, Paper bark yellow wood Jharberi Khejri	all mainland states of Australia,and others	Sheep	Reduction in N digestibility decreased wool yield and growth; decreased S absorption Reduced feed intake, poor growth and loss in weight.	[24] and [25]
2.	*Albizia chinensis*[d]	Sirris	Assia, S E Assia	Goat	Reduced *in sacco* N digestibility	[26]
3.	*Leucaena leucocephala*[c]	Subabul	Assia, S E Assia	Poultry	Poor N retention, low apparent metabolisable energy value	[27]
4.	*Prosopis cineraria*	Khejri, long tree	Australia Assia and others	Rabbit	Reduced feed intake & growth, cecotrophy increased protein digestibility	[28]

Precaution

The concentration of condensed tannins above 4 per cent has been reported to be toxic for ruminants as they are more resistant to microbial attack and are harmful to a variety of micro organisms. Physical methods like soaking and drying and heat treatment before feeding of forage can reduce the toxic level of tannin. Several studies indicate that tannin-rich leaves, in combination with concentrate rations, could be fed to animals without any adverse effect [29]. This happens because animals consume protein in excess of their requirement from the concentrate and therefore, the anti-nutritional effects of tannins were masked. Moreover, these studies do not show the utilization of tree leaf proteins for which they are mostly fed.

Cynogens

Cyanogens are glycosides of a sugar or sugars and cyanide containing aglycone. It can be hydrolyzed by enzymes to release HCN by enzymes that are found in the cytosol. Damage to the plant occurs when the enzymes and glycoside form HCN. The hydrolytic reaction can take place in the rumen by microbial activity. Hence, ruminants are more susceptible to CN toxicity than non- ruminants. The HCN is absorbed and is rapidly detoxified in the liver by the enzyme Rhodanese which converts CN to thiocyanate (SCN). Excess cyanide ion inhibits the cytochrome oxidase which stops ATP formation, and further tissues suffer energy deprivation and death follows rapidly [30]. The lethal dose of HCN for cattle and sheep is 2.0-4.0 mg per kg body weight.

Table 4 Prussic acid (HCN) concentration in forages [32]

HCN Concentration in (ppm)		Potential Effect on Livestock	Remarks
Dry Matter	Fresh Harvested		
0-500	0-100	Forage is generally safe and should not cause toxicity.	Safe to Use
500-1000	100-200	Potentially toxic and forage should be fed at a restricted rate in the diet.	Dangerous
>1000	>200	Very dangerous to livestock and will usually cause death.	Toxic/ Poisonous

The lethal dose for cyanogens would be 10-20 times greater because the HCN comprises 5-10 per cent of their molecular weight. For poisoning, forage containing this amount of cyanogens would have to be consumed within a few minutes and simultaneous HCN production would have to be rapid. HCN level will be high in young seedlings rather than in matured seedlings. [31] reported that the forage prussic acid percentage of the second cut was significantly lower than the first cut, probably due to degradation of the acid and a higher metabolic activity of the plant due to higher temperatures during growth processes which can reduce the prussic acid accumulation, these low amounts of FPAP (Forage Prussic Acid Percentage) are not toxic to animals.

Precaution

As levels of HCN is found high in younger sorghum crop which are found unwanted and out of place i.e grown under energy stress condition and crop not get proper irrigation. Thus try to exclude fodder from such plant. Further, Post harvest wilting of Cynogenic leaves may reduce the effect of cyanide toxicity. Sorghum, Sudan and Johnson grass must kept for drying at least six hour before its use. Fodder HCN concentration >200 ppm in fresh green fodder and >1000 ppm in dry fodder drying, ensiling or allowing the forage to mature will reduce prussic acid concentration. Retest the plant sample before feeding.

BOAA

β-N-oxalyl-L-α,β-diaminopropionic acid (β-ODAP or BOAA), a naturally occurring amino acid, possesses potent neuro-toxic activity and has been shown to be responsible for outbreaks of neurolathyrism following consumption of *Lathyrus sativus***.** β-ODAP occurs naturally as two isomeric forms with the α-form being approximately 5% of the total. According to toxicological studies, this isomer is less toxic than the major, β-isomer. The level of β-ODAP in dry seed varies considerably according to genetic factors and environmental conditions. *L. sativus* grown in nutrient solutions that are zinc-deficient or rich in ferrous iron produced seed with elevated levels of β-ODAP. β-ODAP is biosynthesized during the ripening of the seed and is further increased during germination. The ingestion of ODAP causes neuro-lathyrism, a neuro-degenerative disease that damages upper motor neurons, causing irreversible paralysis of the lower limbs and sometimes death in humans and animals [33]. In Ethiopia, other studies reported ODAP content in seeds varying from 5.4 to 8.9 g/kg DM [35] or 2.0 to 4.5 g/kg DM [34]. The green parts and the straw contain lower concentrations of ODAP: 1.9 to 3.4 and 1.3 to 2.1 g/kg DM respectively [36].

Precaution

Do not use in large amount and tender fodder. Water soaking or hot water soaking for few hours reduced the toxicant. It is advised to feed lathyrus to the big animals with straw and other dry feed Bhusa.

Mimosine

Mimosine, a non-protein amino acid structurally similar to tyrosine, occurs in a few species of Mimosa and all species of closely allied genus Leuceana. Concern has arisen because of importance of *L. leucocephala* in which the level of mimosine in the leaf is about 2-6% and varies with season and maturity. In non-ruminants animals, mimosine cause poor growth, alopecia, eye cataracts and reproductive problems. Levels of Leucaena meal above 5-10 % of the diet for swine, poultry and rabbits generally result in poor animal performance.

The main symptoms of toxicity in ruminants are poor growth, loss of hair and wool, swollen and raw coronets above the hooves, lameness, mouth and oesophageal lesions, depressed serum thyroxine level and goiter. Some f these symptoms may be due to mimosine and other's to 3,4 dihydroxypyridine, a metabolite of mimosine in the rumen. Reduction in calving percentage due to Leucaena feeding has also been noted [37].

Precaution

A solution to a mimosine problem could be the development/selection of low mimosine containing cultivars. However, low mimosine types are found to be unproductive and low vigour. The approach is to feed leucaena mixed with other feeds. [35] Suggested that use of Leucaena fodder may be restricted to 30% of green forage in the case of cattle and buffalo, and 50% for goats. The effect of Leucaena and mimosine can be reduced by heat treatment [38], by supplementation with amino acids or with metal ions such as Fe^{2+}, Al^{3+} and Zn^{2+}.

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