AMMONIATION SOMETIMES PRODUCES DANGEROUS FEED

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summary

In the last decade an increasing number of farmers worldwide have adopted the technique of ammoniation as a means of increasing the utilisation of roughages by ruminants, Our work has identified problems with ammoniation which are similar to those encountered with ammoniated molasses in the 1950's. Since July 1984 there have been several outbreaks of hyperexcitability in cattle fed ammoniated roughages at the University of New England. Characteristically the animals have sudden outbreaks of galloping in circles and colliding with other animals or fences.

Reports of similar events have appeared in the last year from the U.S.A., South Africa, the U.K., the Republic of Ireland, Denmark, Sweden and Israel. The likelihood of hyperexcitability occurring can be reduced by limiting ammoniation to feeds with a low soluble sugar content, such as straw, and by injecting the NH_3 in a stack (rather than in an oven) at a time when the ambient temperature is below 30°C.

I. INTRODUCTION

(a) Background

From 1905 when ammoniation of straw was first described and patented by Lehmann in Germany, until the 1970's, ammoniation of feeds received very little application (Chomyszyn and Ziolecka, 1972). This was probably so because in spite of Lehmann's claims of improved digestibility and palatability, workers in the 1940's, 50% and 60's saw ammoniation only as a means of enhancing the level of non-protein-nitrogen (NPN) of feeds like sugar beet pulp (Millar 1944), molasses, citrus solubles, citrus pulp (Knodt et al. 1951), sugar cane bagasse (Chang et al. 1961), apple pulp, rice hulls, cotton seed hulls, straw and silage (Chomyszyn and Ziolecka 1972).

Serious consideration may also not have been given to the technique because there was no shortage of conventional ruminant feeds.

A third reason may have been that there were some reports showing that feeds rich in soluble sugar, such as molasses, after ammoniation, could cause hyperexcitability in cattle (e.g. Barrentine and Darnell 1954; Bartlett and Broster 1958) or, as in the case of ammoniated sugar cane bagasse (Chang et al. 1961) and ammoniated sugar beet pulp (Dudkin et al. 1969 quoted by Chomyszyn and Ziolecka 1972) contained the toxic 4(5) methyl-imidazole (4Me-I) blamed for the disorder.

(b) Renewed interest

In the 1970's it was re-discovered that ammoniation of fibrous residues not only enhances the NPN content of the feed but, more importantly, it also improves its digestibility and palatability (e.g. Waiss et al. 1972; Waagepetersen and Vestergaard Thomson 1977; Hartley and Jones 1978; Sundstøl et al. 1978; Tohral et al. 1978; Lawlor and O'Shea 1979). It is noteworthy that with the exception of Waiss et al. (1972), no reference was made to the

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desirability of screening ammoniated products for 4Me-I or other toxic compounds and by the time treatment with NH_3 reached widespread acceptance, the earlier problems had been forgotten.

In a recent comprehensive review on the utilization of straw as ruminant feed (Sundstøl and Owen 1984) it was shown that ammoniation is now well established in many parts of the world but no mention was made of the possible danger of hyperexcitability.

In the last year however, many, often unpublished, reports have appeared about the problem. This paper gives a brief desdription of "bovine bonkers" and the conditions under which it first appeared in Australia. Attention is also given to reports from elsewhere.

II. EXPERIMENTAL AND RESULTS

(a) Feeds

Batches of baled wheat straw, a failed wheat crop and rice straw were treated with 3.5% NH_3 (W/W on straw DM basis) in a plastic covered stack for approximately four weeks as described by Sundstøl et al. (1978) or in an oven at 85°c for 23 hours asdescribed by Perdok and Leng (1985). Ammoniation in an oven (An-Stra-Verter F.M.A., Fuglebjerg, 4250 Denmark), or thermo-ammoniation, was tested because of the attractively short treatment time with that method. Hyperexcitability developed in cattle within three days after feeding thermo-ammoniated rice straw harvested in 1984. Severe symptoms as described below and recorded in the video film "Bovine Bonkers" (Perdok and Leng 1984), were also seen in cattle fed the failed wheat crop which had either been thermo-ammoniated or ammoniated in a stack during hot weather.

(b) Symptoms

Affected animals showed the following symptoms: restlessness, rapid blinking, apparent impairment of vision, involuntary ear twitching, loss of balance, frequent urination and defaecation, rapid respiration, salivation, frothing at the mouth, bellowing, sweating and most markedly, sudden stampeding involving galloping in circles and colliding with other animals or fences. The symptoms lasted for up to 5 min and were often repeated at 20-30 min intervals. Rumen and blood ammonia levels were normal and so were the levels of calcium and magnesium in the blood (Perdok and Leng 1985). Thermo-ammoniated rice straw was also fed to lactating dairy cows and their milk was fed either raw, boiled or pasteurised to young calves. The cows themselves as well as the calves on raw or pasteurised milk developed the syndrome (Perdok and Leng 1985).

(c) Prerequisites

Further experiments showed that the following four prerequisites are all required for hyperexcitability to become apparent.

1) the feed must contain some soluble sugars prior to ammoniation. Tentative analyses suggest that feed with less than five percent alcohol soluble sugar is unlikely to cause problems.

2) anhydrous ammonia rather than urea as a source of ammonia must be used; aqueous ammonia is likely to be safer than anhydrous NH_3.

3) the material being treated must reach a temperature of at least 70°C shortly after injecting the NH_3.

4) ammoniated roughage must comprise at least fifty percent of the animal's ration.

III. DISCUSSION

(a) Worldwide problem

When the hyperexcitability syndrome was first observed in our laboratories in July 1984, only guesses could be made about the underlying causes. Since that time a lot of international attention has been focused on this poorly documented phenomenon. Table 1 lists the ammoniated feeds on which hyperexcitability has been reported so far.

All feeds listed in Table 1, except the molasses-urea blocks, have in common that they were all treated with anhydrous ammonia (NH_3). Most of the roughages listed were treated in a stack. It is likely that where this was done at ambient temperatures above 30°C, temperatures inside the stack would have exceeded the critical 70°C because of the exothermic reaction of NH_3 with the moisture in the roughage (Perdok and Leng 1985). Recently the interest in molasses-urea blocks was revived (Leng and Preston 1983) and it is disquieting to note that Morgan and Edwards (1985) reported hyperexcitability in several 2-4 months old calves and the death of sixteen of them after these calves and their nursing mothers had had access to molasses-urea-protein blocks in the pasture. It would appear to be prudent to avoid temperatures in excess of 70°C during manufacture of such blocks.

(b) Toxic milk

Our observation on a toxic compound (4Me-I or other) being transmitted through the milk received ample support from elsewhere. Table 1 suggests that especially sucking calves with no or low intake of ammoniated feeds themselves fall victim to the toxins. The implications of this for humans drinking milk produced by cows fed ammoniated feeds are unknown but could be serious, particularly for babies for whom cows' milk is the whole of, or a major part of, the diet.

(c) High sugar levels

Especially in the presence of heat, sugars and ammonia can form imidazoles and other N-hetorocyclic compounds. Of the chemicals formed in ammoniated molasses, 4 methyl-imidazole appeared to be the most likely one to cause hyperexcitability (Nishie et al. 1969; 1970). A common factor in the feeds listed in Table 1 is that almost all had fairly high soluble sugar levels. This is obvious in the case of molasses but also the roughages are mainly of a quality above that of straw. It is known that cereals like rice and wheat accumulate starch and sugar in the leaf sheaths and stem and that these carbohydrates are translocated to the grain at the time of grain formation (Boerema 1983; Blakeney and Matheson 1984; Wood 1960). Insufficient data are available to 'accept this hypothesis, but it appears plausible that roughages with a high sugar content will result when cereals are cut for hay before the sugars have migrated to the grain and transformed into starch. Where grain fill is prevented by floret sterility (Lewin and Heenan 1983) as was common in rice in Australia in 1984 (Lewin, pers. comm. 1985), disease or drought, it could also be hypothesised that the residual sugar level in the straw will be higher than in a healthy plant.

(d) Future

Recent preliminary results from several laboratories suggest that, as with ammoniated molasses, 4Me-I is at least one of the toxins formed during NH_3 treatment of roughages. Wiggins (1956) suggested acidifying ammoniated molasses to remove 4Me-I. Wiggins' work created very high expectations (The Sugar Journal 18:18), but failed to prevent the collapse of feeding systems based on ammoniated molasses, NH_3 treatment of roughages has too many advantages to allow it a fate similar to ammoniation of molasses. It is hoped that the joint efforts of

TABLE 1 List of ammoniated feeds on which hyperexcitability occurred and type and location of animals affected

Type of feed	Type of animal	Location	Source
Molasses	heifer calves	Mississippi, U.S.A.	Barrentine and Darnell 1954
Molasses	heifer calves	Kansas, U.S.A.	Richardson et al. 1954
Inverted molasses	steers	Louisiana, U.S.A.	Rusoff et al. 1954
Molasses	cattle and chicks	Trinidad	Wiggins 1956
Inverted molasses	steers	Oklahoma, U.S.A.	Tillman et al. 1957a
Inverted molasses	sheep	Oklahoma, U.S.A.	Tillman et al. 1957b
Inverted molasses	heifers and guinea pigs	U.K.	Bartlett and Broster 1958
Molasses and 4ME-I	rabbits, mice, chicks	California, U.S.A.	Nishie et al. 1969
Molasses and 4ME-I	laboratory mice	California, U.S.A.	Nishie et al. 1970
Ryegrass hay	nursing calves	Louisiana, U.S.A.	AABP 1984
Above average quality forages (lucerne, brome-grass, fescue, wheat and sorghum)	cows and their nursing calves	Illinois, U.S.A.	Anonymous 1984
Hay	newborn calves	Michigan, U.S.A.	Bell et al. 1984
Above average quality roughages	nursing calves	Indiana, U.S.A.	Hendrix and Lemenager 1984
Wheat hay	cows and their calves	Kentucky, U.S.A.	La Bore et al. 1984
Hay	cows	Kentucky, U.S.A.	D. Miksch, pers. comm. 1984
Hays of forage sorghum, hybrid sudan, cereal grain, brome and fescue	newborn calves	Kansas, California, Kentucky, U.S.A.	Simms et al. 1984
High quality roughages (sorghum, sudan-grass and cereal hays)	cattle	South Africa	Anonymous 1985
Oat hay (medium dough stage)	sheep	California, U.S.A.	W.N. Garrett, pers. comm. 1985
Wheat straw	yearling cattle	Israel	Z. Holzer, pers. comm. 1985
Ryegrass straw and grass hay	cattle and sheep	Danmark and Sweden	K.K. Madsen, pers. comm. 1985
Poor quality grass hay	Friesian steers	U.K.	Mason and Gibb 1985
Unknown	cattle	Republic of Ireland	V.C. Mason and M.J. Gibb, pers. comm. 1985
Molasses-urea-protein blocks	nursing calves	Oklahoma, U.S.A.	Morgan and Edwards 1985
Bermuda grass hay	nursing calves	Mississippi, U.S.A.	Morgan and Edwards 1985
Rice straw	yearling cattle, cows and calves	N.S.W. Australia	Perdok and Leng 1985
Failed wheat crop	yearling cattle	N.S.W. Australia	Perdok and Leng 1985

scientists all over the world now starting work on the issue will result in dispersal of the clouds which are presently building up over the future of the technique. In the meantime it appears prudent to restrict ammoniation to material with a known low sugar content such as mature straw of a healthy crop and to inject the NH_3 in stacks at night or during overcast weather when ambient temperatures are below 30°C.

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