

THE UTILIZATION OF AGRICULTURAL  
BY-PRODUCTS IN RUMINANT FEEDING



By

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APPROVAL SHEET

**Title:** THE UTILIZATION OF AGRICULTURAL BY-PRODUCTS  
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## INTRODUCTION

In Egypt, there are more than 11 million tons of low quality roughages including different straws, i.e. rice, wheat, bean, straw, rice hulls, cotton seed hulls, cotton stalk, corn stover, corn cobs, sugarcane bagasse and pith (El-Shazly, 1983). Eighty five percent of animal feeds in Egypt are roughages. The present available animal feeds hardly suffice 60% of the existing animal population (cattle, buffalo, sheep and goats). The suggesting solution of the problem of animal feed shortage is to utilize the non-traditional agricultural by-products into animal feeds after treating and supplementing it (Waga and El-Shazly 1983).

The marked improvement in the feeding value of straw obtained when treated with caustic soda (NaOH) encouraged a number of scientists to study other chemicals and methods for upgrading of straw as feed. One of the first systematic studies of the effect of ammonia on straw was carried out in Germany about 50 years ago (Kronberger, 1933). In a laboratory experiment he studied the effect of increasing amounts of ammonia on the colour and water solubility of wheat straw. In the USSR Nikolaeva (1938) used aqueous ammonia and obtained a marked increase in digestibility of the straw. Thus  $\text{NH}_4\text{OH}$  solution were recommended for treatment of straw

to be fed to farm animals.

In 1954 F. Juncker in Denmark applied for a patent (2141/54) for ammonia treatment of straw for animal feed. Juncker reported that ammonia treated straw was used as feed for his cattle and that satisfactory results were obtained.

Digestibility experiments with sheep fed straw treated with steam and thereafter ammonia showed that the digestion coefficients (%) for organic matter was increased up to 60.5 (Fyrileiv and Ulvesli, 1958). The nitrogen content of the straw was increased up to 13.4 g/kg DM.

In 1959 Zafren (USSR) published results from a production trial with growing bulls fed untreated or ammonia treated rye straw. Based on the daily gain of the animals it was estimated that the energy value of the treated straw was more than twice that of untreated straw. The extra nitrogen supplied could replace 20-25% of the protein-N in the ration.

Zafren (1961) described a method whereby straw was treated with 3% ammonia or 120 l of a 25% solution per ton. The treatment could be carried out in pits, trenches or stacks covered with plastic film. It was

necessary to expose the straw to air for 4 or 5 days to get rid of excess ammonia before feeding it to animals. In an experiment with yearling cattle the daily gain was significantly greater for ammonia treated straw than for untreated straw.

The loss of ammonia from treated straw is not only a pollution problem. Between one third and two thirds of the ammonia disappears when the stack is opened (Sundstøl, 1982). Small scale experiment carried out recently (Borhami et al., 1982) show that it is possible to capture almost 100% of the ammonia by spraying the straw with acid when opening the stack.

Therefore, in mid 1982, Beef Production Project in Animal Production Research Institute, Egypt established two centers (Noubaria and Itay El-Baroud Center) for distributing anhydrous ammonia to treat straws in the farms.

Urea is a crystalline solid produced technically from ammonia and carbon dioxide. It is easily dissolved in water and is widely used as fertilizer or fed directly to ruminants as a source of NPN (46.6% N).

Urea is inherently safer to use than ammonia. Many countries which do not have access to anhydrous or aqueous ammonia, will usually have urea available since it is one of the commonest nitrogen fertilizer sources. Hence methods

of using urea to generate ammonia in situ in straw are very important for many places. Urease enzyme which decompose urea to ammonia are present in some crop residues, and are also present in certain seed meals (e.g. raw soybean meal) and in urine (Sundstøl and Coxworth, 1984).

In the present study, it was aimed to utilize the non-traditional agricultural by-products into animal feeds after treating with anhydrous ammonia. It was therefore, intended to investigate the effect of treatment rice straw and corn stalk with anhydrous ammonia on palatability, performance of lambs, digestibility, nitrogen balance and its feeding value.

The urea also was used as a source of ammonia to compare the effect of treatment rice straw and corn stalk with anhydrous ammonia and urea on improving the feeding value.

## REVIEW OF LITERATURE

A. Utilization of field crop residues:

Crop residues are used primarily for beef production, at the present time in the U.S. and Canada. It also used in rations of growing calves or lactating beef cows where a high quality forage is needed (Klopfenstein, 1978, Ward 1978).

The obvious advantage to the use of crop residues as feed is that there is no direct cost of production, the cost being charged to the grain produced. The two primary disadvantages of feeding residues are the effect of removal on soil erosion and tilth and the low quality of the residues as feedstuffs (Larson, 1979).

Corn plant residues vary in quality more than do wheat straws, location, water availability and maturity at harvest are all important factors. Berger et al., (1979) have shown that the quality of corn stalk decreases from the time the grain is physiologically mature until several weeks after normal grain harvest.

The greatest improvement due to management practice is possible with corn stalk. At physiological maturity of the plant, the stalk contains considerable amounts of sugars, but digestibility of the residue decrease with weathering (Lamm, 1976) due to the plant

respiration and microbial activity (Berger et al., 1979). The earlier the stalk is harvested, the higher the quality, an increase of 0.81 kg/d in gain and of 19% in efficiency was obtained simply by advancing time of harvest (McDonell and Klopfenstein, 1980).

Probably the most economical use of crop residues is the grazing of corn stalk or milo stubble fields after grain harvest (Vetter and Boehlje, 1978; Ward, 1978).

Rice straw appears to be no better than wheat straw, Digestibility of rice straw is inhibited to a large extent by silica (Garret et al., 1976).

#### B. Chemical treatment of field crop residues:

The vast majority of the research conducted in the last 20 years has dealt with the improvement of field crop residues so that they can be used in diets for growing and lactating beef animals. Two major approaches to improve feeding quality have evolved. The first is the enhancement of quality through management practices and the second is the chemical treatment to improve digestibility (Klopfenstein, 1978).

Many chemicals have been screened in laboratory experiments for potential to enhance digestibility. However, only four chemicals are being routinely used in experimentation with animals. These are sodium hydroxide, ammonia, calcium hydroxide and potassium hydroxide (Jackson, 1977).

Modes of action of chemical treatment of crop residues have been described by Waller (1976). Chemical treatment solubilizes some of the hemicellulose while not changing the cellulose content. Extent of bacterial digestion in vitro is increased for both cellulose and hemicellulose. Sodium hydroxide appears much more effective than either calcium or ammonium hydroxide.

Chemical treatment of crop residues has been investigated and practised for many years (Beckman, 1921). However, intensive research and application has developed mainly in the last 15 years (Jackson, 1977).

Sodium hydroxide has been the chemical most widely used for residues treatment in the past (Klopfenstein, 1978, Jackson, 1978, Mowat 1981). However because of cost, safety on rate of passage, changes in soil sodium levels and problems of marketing systems, little application is expected in the U.S. and Canada (Berger et al.

1980, Klopfenstein and Owen, 1981). Calcium hydroxide (hydrated lime) does not have the same disadvantage but is a weaker base and requires more reaction time (Klopfenstein and Owen, 1981).

Application of ammonia (either as anhydrous gas or aqueous liquid) to crop residues indicates that it may also improve residue feeding quality. Ammonia appears to react in a manner similar to NaOH. However, the reaction time is much longer (requiring up to 20 days) than with NaOH treatment (24 hr) and the residue must be stored in an airtight structure so there will be no loss of ammonia (Waller, 1976).

Ammonia appears to have the greatest potential for immediate use in practical situations (Sundstøl et al. 1978; Klopfenstein and Owen, 1981, Mowat, 1981, Ward et al. 1981). Ammonia has the advantage that it supplies NPN as well as delignifying the plant, that residue do not need to be ground or mixed for treatment, that treatment is relatively easy and that a delivery system to the farm already available in most parts of the U.S. and Canada. The primary disadvantages are the need for a gas tight system (plastic cover or oven) and the lower and/or slow rate of reaction at low temperature. Waagepeterson and Thomsen (1977) have shown that rate of reaction of  $\text{NH}_3$ , is