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DEPARTMENT OF ANIMAL NUTRITION

Feed Technology Part 2
DATE- 08/02/24 – 17/02/24

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Pelleting of Roughages-

Roughages are usually ground before they are pelleted, size of the pellets range from 12/64" to 48/64" (4.8 mm to 19.1 mm). Pelleted roughages weigh about 40 lb/cft as compared to 5-6 lb/cft for long hay.

Pelleting poor quality roughages will markedly increase the consumption of roughage. In pelletising complete feeds incorporation of concentrate mixture at 30% level appear to be the upper limit for optimising the feed intake, otherwise feed intake is decreased. **Feeding pellets particularly with a higher concentrate content to ruminants may cause parakeratosis - a degeneration of the rumen papilla.** That is pelleting of diets low in forage has an adverse effect. Feeding of roughage pellets ad libitum as the only feed result in increased feed consumption and milk production and decreased milk fat production. This effect on milk fat can be reduced by using large pellet size and by making pellets from coarsely ground roughages.

Straws---- Structural carbohydrates (cellulose and hemicellulose) ↑

Starch type carbohydrates, nitrogen and minerals ↓ and varying amounts of lignin. ↑

Straws contain low levels of soluble carbohydrates (1-2%).

- High quality roughage is usually low in lignin and high in protein and is highly digestible. Low quality roughages are usually low in protein, high in lignin and are poorly digestible.
- Much of the small amount of N in the straw is probably in the insoluble acid detergent fibre (ADF) fraction and unavailable to the rumen microbes.
- With most poor quality roughages, animals may consume only **about 60-80g/Wkg $^{0.75}$/day**, an amount hardly enough even to support maintenance requirement of an adult animal. So animal lose body weight.
- **Methods of Improving the Feeding Value of Poor Quality Roughages-**
- **Supplementation with Deficient Nutrients-**
- The purpose of supplementing a poor quality roughage is to correct nutrient imbalances and thereby create optimum rumen conditions for efficient microbial fermentation.
- Enrichment with urea and molasses.
- Ensiling with animal wastes such as faeces and urine.

- Supplementation with green fodders either leguminous or non-leguminous.
- Supplementation with legume straws (Sunnhemp, horsegram, cowpea and gram straws)
- Supplementation with urea-molasses liquid supplements.
- B. Treatments: The main objective of treating a poor quality roughage is to increase its digestibility and or voluntary intake so as to increase the intake of digestible energy.
- **Methods of Improving the Nutritive Value of Poor Quality Roughages-**

Physical methods	Chemical methods	Physico-chemical methods	Biological methods
Soaking	Alkali- NaOH, $Ca(OH)_2$	Combination of physical and chemical treatments	Enzyme
Chopping	Ammonium Gases, aqueous	e.g. NaOH/ pelleting: NaOH/ steam	Rotfungi
Grinding	Urea- ammonia		Mushrooms
Pelleting	Acids- H_2SO_4, HNO_3,		
Wafering	Salts- Na_2CO_3, Nacl		
Steam Under pressure	Gases Chlorine, SO_2		
Irradiation	Oxidizing agents H_2o_2, O_3		

Physical Treatments-

Soaking of wheat straw increased the dry matter intake and volatile fatty acid production but has **no effect on the digestibility of nutrients**. The paddy straw is rich in oxalate and the major portion of it is present in the form of soluble potassium and sodium oxalates and small fraction is present in the insoluble form of calcium oxalate. Soaking of paddy straw removes some of the oxalates and

may improve the nutritive value of straw and **improve Ca retention more** importantly.

Chopping of rice straw or maize stover increased the voluntary intake of these roughages.

Chaffing or Chopping of Fodder: Chaff Cutter

Animals are prone to eat only the leaves of plant material wasting the stem part. By chaffing the green fodder or dry fodder selective feeding and thus wastage of fodder can be avoided. Fodders are chopped uniformly into fine (0.5 cm) or coarse (1-2 cm) particles. There are two types of Chaff cutters.

1. Hand operated: a) Sickle type chaff cutter

   b) Hand operated chaff cutter

2. Power Operated:

Chaff-cutters working on 5 HP or 10 HP are useful for medium size to big Dairy Farms. The Chaff cutter is fabricated from heavy duty angle iron. The impellar is made from 1 /2'' M.S. (mild steel) plates with 3 straight knives. The impellar is fully enclosed and the sliced or chaffed material is thrown from the overhead spout. The knives can be accurately adjusted to give around 3 /8'' (9.4 mm) cut chaff. It has a gear box for forward and reverse motion so that any clogging of chaffed material is immediately released by reversing the motion. The feeding of fodder is done either by hands or by a belt conveyor. The machine can be made mobile on wheels for toeing it from one place to another. Output: 1000 kg to 2000 kg/hr with 5 to 10 HP motor (output depends on quality and condition of fodder).

Advantages of Chopping of Roughages

1. It avoids wastage.
2. It facilitates feeding of roughages and concentrates together in the form of complete feed.
3. Chopping of green fodder facilitates good silage making
4. It facilitates mixing with other ingredients of ration and checks the selective feeding.
5. It facilitates easy handling due to increased bulk density.
6. It improves digestion due to exposure of relatively larger surface area of roughages for microbial digestion. Boiling under high pressure or steaming

method: Among all the physical treatments, this method **has greater effect on improvement of feeding quality of straw.**

7. The basic and precise technology behind this process is to break the chemical bonds (ligno-cellulose/ligno-hemicellulose) through steaming at high pressure which in turn increases the digestibility of the final product.

Chemical treatments: The aim of chemical treatment is to increase lignin solubility or decrease the bonds between lignin and other cell wall constituents, thereby making cellulose and hemicellulose more susceptible to (rumen) microbial attack. This increases the voluntary feed intake as well as the digestibility of straw. Several types of chemicals such as sulphuric acid (acid), sodium hydroxide, potassium hydroxide, calcium hydroxide, sodium carbonate or ammonium hydroxide (alkalies), hydrogen peroxide, sulphur dioxide, sodium chlorite or ozone (oxidizing agents) have been investigated for treatment of crop residues.

1. Treatment with NaOH: This process was first used on straw in Germany in 1919, during Ist world war when there was a critical shortage of livestock feed. Straw was treated with NaOH under high pressure and temperature. The product was called as 'fodder cellulose'. This process was very expensive and only relevant in emergency situations. It can be of two major types.

1. Wet method: This includes Beckmann method, modified Beckmann method or Torgrimsby method and dip method.

2. Dry method.

- **Beckmann's method:** Proposed in 1921, it consists of treating chopped straw in 8-10 times its weight of **1.2 to 1.5% (W/V) solution of NaOH for at least 4 hours.** The treated straw was drained and washed with a large quantity of water until free from alkali [(i.e.) it should be neutral to litmus paper]. As NaOH is caustic and rapidly attacks animal tissues, it should be thoroughly washed with water. The treatment dissolved 20-25% of DM from the straw and therefore, was lost.
- **Modified Beckmann method:** An improvement over the Beckmann method, it **uses less NaOH and less water;** DM loss is reduced; there is no pollution problem because it is a closed system.
- **Dip treatment:** This method was developed by Sundstol and coworkers (1981) in Norway and Tanzania. After draining the excess alkali solution,

the straw is allowed to 'ripen' for 3-6 days as there is evidence to show that digestibility of treated straw increases during the '**ripening' process.**

- **Dry method:** With a view to eliminate the disadvantages of the Beckmann system, Wilson and Pigden (1964) evolved a dry process. The straw is **sprayed or sprinkled with NaOH while being mixed. 4 to 6 kg of NaOH dissolved in 200 litres of water is adequate to wet 100 kg straw**. The treated straw is moist and has pleasant odour. Intake of straw is increased by 30-40%. Digestibility is increased by 10-15 percentage units.
- **2. Treatment with calcium hydroxide**: It is a cheaper, safer to use and easily available chemical; but its low solubility in water and being a weak base has deterred researchers in their studies with fibrous feeds. With spray treatment Ca $(OH)_2$ has consistently been inferior to NaOH, unless longer reaction time is allowed. Ensiling Ca $(OH)_2$ treated straw (**4 kg $Ca(OH)_2$ /100 kg straw)**, with enough water to give 50% moisture in freshly treated straw, for 90 to 150 days has resulted in higher fermentability of treated straw. Longer incubation period gave higher treatment effect.
- **Treatment with combination of calcium and sodium hydroxides:** Combined treatment produced some what better gains than either of the hydroxide alone, and treatment with 4% NaOH produced significantly greater gains than with 4% $Ca(OH)_2$. Treatment of straw with $Ca(OH)_2$ will be effective when the treated straw does not constitute more than 70% of the diet, because the calcium content increases more than the normal requirement (1.5 to 2.0%). One approach could be to use lower concentration of $Ca(OH)_2$ either alone or in combination with urea or NaOH. Due to high cost of the chemical, problems of pollution, corrosive nature of the chemical and addition of sodium to animal diets, NaOH treatment could not find popularity.
- 3. **a. Treatment with anhydrous NH_3-** The stack method for ammonia treatment of straw was developed by Sundstol and coworkers in Norway during 1970-75. Stacks of straw were wrapped with polyethylene cover and injected with 3% of anhydrous ammonia. This method has become popular and was standardised under Indian conditions for wheat straw, cotton straw and paddy straw. **The effect of ammonia treatment on the digestibility of straw is less than that of dip treatment with NaOH.** When materials with a high sugar content (5% e.g. hays) are treated with anhydrous NH_3 at high temperature (70°C) a poisonous compound **'4-methyl imidasol'** can be formed which may cause **hyperexcitability** (crazy cow or angry cow or bovine bonker) in farm animals and may also

be transferred into the milk of dairy cows. With straw, treated at environmental temperatures, the risk of this disturbance should be negligible.

- **b. Treatment with aqueous NH_3-** Aqueous ammonia (20-35%) is also used commercially for treatment of straw. One advantage here is that at ammonia concentration of about 20% the solution can be transported and handled at normal temperature and pressure.
- **c. Ammoniation through urea hydrolysis:** Anhydrous or aqueous ammonia are costly, not freely available and even if available transportation of equipment is difficult and need to be handled with much care. Fertilizer grade urea which is well known to the farmer can also be used to generate ammonia from urea hydrolysis. Urine has also been used as source of NH_3 for straw treatment. Ammonia treatment through urea hydrolysis is a promising alternative to several problem ridden chemical treatments because of simple technology and low cost involved in it.
- **Effect of Ammonia Treatment on Feeding Value of Wheat Straw-**
- Ammoniation of straw improves the quantity of cellulose (hemicellulose) for microbial attack, because the small NH_3 molecules are able to penetrate the **inter fibroid spaces of the crystalline cellulose in order to break down the H-bridges.** In contrast with NaOH, ammonia is too weakly alkaline to have an appreciable effect on (hemi) cellulose-lignin bonds. The effect of wheat straw ammoniation using 5% urea as a source of ammonia at 40% added moisture level was evaluated by chemical analyses and in sacco polyester bag technique. Ammoniation had changed the colour of straw from **yellow to dark brown.** The pH of treated straw measured after 24 h aeration was 8.86. Ammoniation has enhanced the rate of rumen degradability of wheat straw by more than 60% and potential degradability by 10% compared to those of untreated straw. Ammoniation through urea hydrolysis has many advantages. It is relatively inexpensive, creates no known pollution problems, acts as preservative of high moisture material preventing mould attack, NPN is added to the straw and treated straw is pliable and palatable.

- **Biological Treatments**
- Enzyme treatement: Cellulase solution is sprayed on straw at 25 mg/100 kg straw.
- Fermentation: Chopped straw is pretreated with 3-5% NaOH, and steamed at 120°C for 15 min; then fermented with bran type media cultured with cellulolytic microorganisms at 40-50°C for 2 days.
- White-rot fungi, mushrooms and other microbes
- The efficient utilization of lignocellulosic straws is limited because of metabolic block caused by lignin which occurs in a range of 3 to 13%. Some of the white-rot fungi like ***Phanerochaete chrysosporium*** degrade lignin to the extent of 65-75% while other fungi like ***Ganoderma applanatum*** and ***Coriolus versicolor*** degrade over 45% of lignin in the lignocellulosic materials. Preference is given to species which degrade only lignin but not hemicelluloses.
- Indo-Dutch Project on Bioconversion of Crop Residues Studies have been conducted on white-rot Basidiomycetes, often belonging to the non-toxic and edible mushrooms.
- Zadrazil process: Straw was treated with **Pleurotus sp**. The process has enormous losses of organic matter. It is unfit for small level operations at farmer's level.
- Karnal process: It is essentially a biological treatment of ligno- cellulosics in a solid substrate fermentation (SSF) system under non- sterile conditions which causes a promising improvement in the enhancement of quality of straw. It is a two stage technique wherein cereal straws are pretreated **with 4% urea and 40% moisture** and ensiled for 30 days in the first stage and followed by second stage in which the urea treated material is mixed thoroughly with **1% single superphosphate, 0.1% calcium oxide** and then moisturise to 60-65% before inoculation with 3% ***Coprinus fimetarius*** (alkali tolerant strain) culture grown on millets. The solid substrate fermentation was terminated at mycelial stage of growth of ***C. fimetarius***. The use of urea in the first stage has many advantages. Besides breaking the ligno-carbohydrate bonds in the treated straw, ammonia also helps in creating conducive environment (high pH), increases CP content from 3-4% to 12-14% and acts as a chemical sterilent in preventing the growth of unwanted organisms.

- In the second stage, the fungus traps the excess free ammonia in the urea-treated straw and synthesize amino acids. Thus there was substantial increase in the amino acid content of fungal treated straw. Considerable dry matter losses were there. However, dry matter losses were reduced from 35% to 7% by applying certain modifications.
- **Densified Feed Blocks-** Densification of such complete feeds (compressed feed blocks) reduces the volume of feed which makes its handling, storage and transportation easy. For the production of 'feed blocks', the mixture of roughage and concentrate is compressed in a machine.