CHAPTER-5

Feed Processing and Fodder Conservation -

Importance of processing of feed, compounding of feed - milling, grinding, mixing, pelleting etc.; conservation of fodder - hay, silage, straw, methods of making hay and silage.

Objectives

1. To acquaint with the advantages of feed processing.
2. To prepare compound feeds involving the processes of grinding, mixing, pelleting etc.
3. To conserve green fodders in form of hay and silage.
4. To improve the nutritive values of straws with urea treatment.

Introduction

Processing of feeds has several advantages from animal production point of view. For making compound feed, grinding of different feed ingredients is the first step. Then, the ingredients are mixed in fixed proportions for different categories of animals. The mixed ingredients can be converted into pellets. Green fodders should be conserved in form of hay and silage for use during the scarcity periods. The nutritive value of poor quality roughages like straws can be improved by urea/ammonia treatment.

Importance of processing of feeds

1. To alter particle size: Some feeds need to be reduced in size to increase their intake or digestibility e.g. grinding. In some instances, particle size is increased by pelleting or curbing to overcome dust problem, to prevent selectivity and to improve handling efficiency.
2. To change moisture content: The moisture content of a feedstuff may need to be changed to make it safer to store (reduced to 10% level), more palatable, more digestible, or to prepare it for other processes (moisture level is increased).
3. To change density of feed: Bulky feeds (low density feeds) reduce feed intake. These are sometimes prepared for the purpose of limiting energy intake. These are prefered in feeding of horses because they causes digestive disturbances. Grains are flaked

rather than ground or pelleted. Very bulky feeds are pelleted or cubed to increase energy density and feed consumption. Transportation cost is reduced and storage space required is less.

4. To change palatability: Feeds are processed to increased acceptability and feed intake. Molasses, flavours and fats are added. Processing may be used to decreased palatability and limit feed consumption e.g. Salt-feed mixtures.
5. To increase nutrient content: When used alone and in their natural state, few feedstuffs meets the requirement of the animals.
6. To increase nutrient availability: Starch (70-80% of DM) and protein appear to be less available in jowar than in other grains but new processing techniques produced dramatic improvements in the feeding values of jowar. This is attributed to a gelatinization of the starch granules, rendering them more digestible. Pelleting of feeds increases the utilization of phosphorous for chicken and pigs.
7. To detoxify or remove undesirable ingredients. Considerable control of gossypol (the yellow pigment of cotton seed that is toxic to simple-stomached animals) is possible by heating. Addition of iron salts rupture pigments glands and thus protect against egg discoloration. Heating soybeans destroys, trypsin and chymotrypsin. Toxicity of linseed meal can be removed by adding two or three parts of water to the meal and allowing it to stand for 12 to 18 hours at a temperature between 22 to 37°C.
8. To improve keeping qualities: High moisture grains may be preserved by either drying or chemical treatment (adding an organic acid), or they may be stored in oxygen limiting silos. Similarly, green fodders are also conserved as silage.
9. To lesson moulds, salmonella and other harmful substances: Sometimes feeds are subjected to a certain process to ensure safety and avoid contamination, especially from moulds and salmonella. Proper harvesting, drying and storage are important factors in lessening aflatoxin contamination and toxin production. Propionic and acetic acids will inhibit moulds growth. Hence, they are used increasingly in the preservation of high- moisture grains. Treatment with ammonia or ammonium hydroxide will detoxify feeds.
10. To make more profit: Feed efficiency can be routinely improved as much as 10% and occasionally by as much as 15 to 20% by changing the method of grain processing.

Compounding of feeds

The compounding of animal feed includes processing of raw materials of wide ranging physical, chemical and nutritional characteristics into a homogenous mixture suitable to obtain a desired nutritional response from the animals. Certain feed ingredients such as cereals, oil seed cakes, soybean meal, meat meal, blood meal, fish meal undergo processing prior to their inclusion into a compounded feed.

Once the raw material is purchased, it is stored in the godowns on wooden planks placed away from the walls. The ingredients could also be stored in concrete or steel silos or in bins. The proper storage of raw materials is not only essential to prevent physical losses but it is also an important aspect of quality control. The feed compounding process consists of a) grinding of ingredients; b) mixing of ground materials, c) further processing, if needed, d) packaging.

Grinding

It is a particle size reduction process which is the simplest and least expensive method for preparing feeds for livestock feeding. It is a prerequisite for mixing, pelleting etc. and it varies from fine to coarse. It is usually accompanied by hammer mill which reduces the particle size by means of impact grinding. Medium fine grinding is the best. Very fine grinding makes feeds dusty with lowered palatability resulting in poor animal performance.

Advantages of grinding

- Increases the particle numbers and thereby increases the surface area for better action of digestive enzymes in the rumen with enhanced digestibility and animal performance.
- Grinding results in better mixing of feed ingredients facilitating in better extrusion and pelleting.
- Segregation of particles is avoided.
- Selective feeding by livestock will be minimized and hence wastage in feeding.
- Increase is palatability of feed & diagobility of fobre. Energy loss due to mastication will be decreased. Feed passage time will be decreased. Feed consumption will be increased. But decreased feed passage time reduces the digestibility of fibre in ruminants since residence time in the rumen is less.

Mixing

Small quantities of animal feed can be adequately mixed manually using shovels. The ground raw materials should be layered one above one another, and then mixed and turned to form one heap. Mixing of the heap at least 3 to 4 times may produce an acceptable product. Micro-ingredients such as vitamins, minerals, antibiotics, etc. are first mixed with diluents e.g. wheat bran and then it is added to ensure uniform mixing.

For mixing of large quantities of feeds, mechanical mixers such as vertical mixers, horizontal mixers are used for uniform mixing. The most important operation in a feed mill is mixing and this is the single operation that would be required in a plant to define it as a feed mill. The aim of mixing is to disperse the ingredients of a certain formula so that each small unit of the whole has the same proportion of each ingredient as in the original formula.

The addition of various liquids to feeds include molasses, vegetable and animal fats, fish solubles, phosphoric acid, choline chloride, etc. These are added to enhance palatability (e.g. molasses), energy (fats) and other nutrient content of the rations. However, addition of any liquid can complicate feed mixing operations. Special equipment for preheating and spraying of liquid are needed to avoid the agglomerate formation. Agglomerate formation can result in suboptimum microingredient distribution.

Liquids are preheated to reduce their viscosity. Molasses is preheated to 95 to l00°F while fat to 140 to 210°F. When liquids are added to the mixer, they should be sprayed over the entire length of the mixer. Before doing so, allow the dry feed ingredients to mix for short time. This allows the microingredients to be dispersed throughout the moisture. The maximum amount of the molasses that can be successfully employed to the feeds is governed by the viscosity of molasses and by the absorptive quality of ingredients.

Microingredient premixing

Premixes are formulations of one or more microingredients, such as vitamins, minerals, or drugs mixed with diluent and/ or carrier ingredient. Diluent and carrier should be inert and inactive. Premixes are used to facilitate uniform mixing of the microingredients in the complete feed or concentrate mixture.

Diluent is an edible substance used to mix with and reduce the concentration of nutrients and/or additives to make them more acceptable to animals, safer to use and more capable of being mixed uniformly in feed. The mixing properties of the original ingredients are not drasticaily altered. Carrier is an edible material to which ingredients are added to facilitate uniform incorporation of the latter into feeds. The active principles are absorbed, impregnated or coated into the edible material in such a way as to physically carry the active ingredient. When a carrier is used with a microingredient, the mixing properties are drastically altered.

Microingredients are nutritional adducts or drugs that are added to the feed at very low levels. Dispersion of such low concentrations of active ingredients presents a challenge to the manufacturers of the compound feed. This challenge can be met by the premix-the dilution of an active component with a suitable carrier.

Physical characteristics of microingredients such as particle size, particle shape, specific weight, hygroscopicity, susceptibility to electrostatic charges, adhesiveness of the particles due to physical properties, such as rough surfaces or additions of adhesives such as oils influence mixing them with the other feed ingredients. Microingredients have a very small particle size and high density compared to other feed ingredients. A significant uptake of moisture by a microingredient can seriously hamper its ability to distribute and mix well. A hygroscopic ingredient can affect the chemical stability of any moisture sensitive component. This problem may be dealt with during formulations by complexation or through a coating that acts as a moisture barrier.

Types of mixers

1. **Vertical batch mixer:** They may be single screw or double screw for elevating the material. However, single screw mixer is popular. These are relatively less expensive and little slower than horizontal mixers. These are not normally used in larger feed mills. It consists of a vertical bin tapering to a point at the bottom. A tube containing a vertical screw conveyor elevates and mixes the material as the mixer is filled. The screw conveyor continuously elevates the product and distributes it over the top of the mixer. Repeated elevation of· the product produces blending. Some mixers use two screw conveyors and few use other elevating devices. Normally screw is driven from the top but it can be driven from the bottom. These units range in capacity from 0.5 to 5 tonnes.

2. **Horizontal mixer:** This mixer is the most commonly used in larger feed mills. This mixer has right and left hand augers which conveys the material from one end of the mixer to the other while it is tumbled within the mixer. These mixers are equipped with openings at several places along the bottom to aid in more rapid discharge. The mixer shaft is accurately machined and mounted on bearings and is fitted with ribbons/paddles which thoroughly agitate and blend the ingredients to produce homogenous mix. The ribbon assembly /paddle is housed in a tub, the lower half of which is circular. Suitable speed reduction drive is provided to drive the mixer shaft at the designed speed to achieve proper mixing with or without liquid additives.

3. **Double paddle horizontal mixers:** These have curved paddle blades which scoop, lift and tumble materials as they are conveyed to the centre of the mixer, where they are continuously over lapped and cross blended. In addition to the cross blending action, a turbulent upward and downward movement is secured which provides the intense type of action required to blend solids and liquid additives including mOfasses blended with dry materials. These mixers have a side loading-cuminspection platform.

4. **Ribbon blenders:** The principle of these blenders is the same as paddle mixers except that they have double worm type ribbons. The large one continuously conveys the material forward and the small one conveys it backwards. Material to be mixed is conveyed from end to end, top to bottom or side to side in the mixer. This continuous

cross blending action tends to thoroughly mix the composition. The mixer is more suitable for blending powdery material of uniform fineness. In order to empty the mixer more rapidly than the product can be conveyed away with most elevators, a surge bin is usually provided. The mixed feed is dumped into the surge bin and another load can be mixed while the surge bin is emptying.

Factors affecting mixing of ingredients

These include physical properties of solids (particle size, shape, density, coefficient of friction, resilience and electrostatic charge) and liquids (density and viscosity). Particle segregation, during or after mixing has been attributed to differences in physical properties of materials and the design of the mixer. A decrease in particle size is necessary to attain a sufficient number of particles for dispersion into each portion of feed. Where very small amount of microingredients are added, the required particle size is very small. The electrostatic properties, roughness of the mixer and cohesiveness are important factors that cause segregation when very small particles are mixed. Mixing time to achieve good distribution increase with very small particles. The rate of mixing is dependent on the properties of the materials being mixed as well as type of equipment used. Differences in the performance of mixing equipment are reduced when the materials have nearly the same particle size and density.

Pelleting

Pelleted feeds are agglomerated feeds formed by extruding individual ingredients or mixtures by compacting and forcing through die openings by any mechanical process. The purpose of pelleting is to change the raw materials in to higher palatable and easy to handle product by applying optimum amount of heat, moisture and pressure. The normal size of pellets is 3.9-19 mm, though the maximum used pellet diameter is 6.25-9.4 mm. The shape is normally cylindrical. If smaller pellets are required, it is economical to produce 3.9 mm pellets and reduce them to desired particle size by crumbling.

Advantages

- o Improves the feeding value of different feeds especially with roughages as compared to concentrates
- o Increases the density of feeds and reduce the storage space required.
- o Segregation of feed ingredients and selective feeding is avoided and wastage of feed is minimized.
- o Pelled feed is in a free flowing form and can be handled mechanically saving the labour cost.

- Gelatinization of starch occurs and heat labile antinutritional factors are destroyed.
- Increases the palatability, feed intake, Growth rate and milk production

Conservation of fodders

A. Hay making

It is the process of preservation of green fodder by drying process. Hay refers to grasses or legumes that are harvested, dried and stored at 85-90% DM. Fodder crop is harvested before maturity (50% flowering stage) when it is still green. The crop is spread over a place in rows and then put on hay racks for further drying under sun. The fodder has to turned around from time to time and should not be exposed to severe sunshine to avoid decarotinisation. Non-leguminous fodders like oats, jowar and Anjan grass and leguminous fodders like berseem and lucerne can be converted into hay. Maize and barley are not suitable for hay making. The non-leguminous crops should be harvested after flowering stage and when 50% florescence is there. For leguminous crops, the harvesting should be done just when the flowering starts.

Characteristics of a good hay

- Hay must keep the characteristic green colour of the crop.
- It should be soft and pliable.
- It should be prepared in such a way that there is less loss of leaves due to shattering and maximum amount of green colour is retained by the hay.
- The hay should be free from dust, mould and bad odour.
- The aroma of the finished product should be such that it is relished by the animals.
- It should not have more than 15% of moisture so that it can be safely stored without risk of fermentation and combustion.

Crops suitable for hay making

The fodder crops having soft and pliable stems are more suitable for hay making. Green oats is the best crop for hay making. However, green berseem, lucerne, cowpea, guar, natural grasses, etc. can also be used for hay making if proper care is taken in curing whereby shattering of leaves is avoided. Annual and perennial grasses like dub, anjan, etc. can also form good hay. Maize, sorghum, bajra, etc. are more suitable for silage making than for hay making. To prepare hay of thick stemmed crop, it is advantageous to crush the stem or chop the fodder itself, Early cut graminacious crops are most suitable for making good quality hay which are very nutritious and sometimes may be compared with the crop for second cutting.

Fig. 5.1. Oat hay prepared at NDRI, Karnal

Method

The aim of hay making is to reduce the water content of the green crop to a level low enough so that the plant and bacterial enzymes do not act on the plant nutrients. The moisture content in the green crop is reduced to 20% and for bailing and storage, it should range between 15-20%. In no case more than 20% of moisture should be allowed in Indian conditions, otherwise, due to fermentation the hay gets very hot and nutrients are lost. Sometimes, there is spontaneous combustion. A practical method of determining the safe limit for hay storage is to twist a wisp of hay in the hands. If the stems are twisted and there is no indication of moisture, it can be stored.

In situations like India, there is, however, greater prospect of making good quality hay both in the sun as well as on the farm. During the kharif season (wet and hot), the crops may be harvested in the early September when the monsoons are at decline and during rabi (dry and cold) season the crop may be harvested during February-March for hay making.

For the efficient production of good quality hay, the crop should be harvested early in the morning when the dew has dried. However, some experiments have shown that there is no advantage in delaying the cutting grasses. After cutting, the grasses are left as such for few hours for the curing. After about 4 to 5 hours, if there is a good sunshine, the fodder may be turned upside down with the hay rack. If it is September and October by afternoon, the moisture may come down from 75 to 40%. In the evening, small loose heaps (windows) can be formed with the hay rack and fodder is left. On the next day one or two turnings are given and by afternoon the moisture level will come down to 25%. At this stage it can be baled and kept in baled form or if it is heavy rainfall area it can be stored on tripod stand. The tripod system of hay making has an advantage that if there is rain the water will pass down and there is proper aeration from below which inhibits the fermentation.

Various methods of drying the forages have been tried in India like drying the crops on fencing, wires, roofs tops, tree tops, galvanized tin sheets, tripod stand, etc. Care should be taken to avoid shattering of leaves in leguminous crops like berseem, lucerne, cowpea, etc. For heavy rainfall areas, hay curing sheds have been developed where monsoon grasses are dried.

Factors affecting the nutritive value of hay

1. Stage of harvesting

The nutritive value of the fodder goes down as the plant matures. At a very early stage the protein and energy contents of the fodder are very high but the dry matter yield of the fodder per unit area is very low. At the later stages when the crop is full bloom, the protein value goes down and the digestibility of nutrients is also reduced. The total yield of dry matter is increased. In order to get more nutrients per hectare, the crop should be harvested just at preflowering stage or when about 10% of the crop is in bloom. This is the time when plenty of sunshine is also available for hay making. Under high moisture and temperature fungi and moulds may grow on the hays. Such infested hays are unpalatable and harmful to the farm animals and men. In later case, allergy to the farmer handling the infested hay has been reported. Common salt and fungicides like phosphoric acid have used to check the growth of moulds. Curing of hay under normal sunshine condition does not affect the nutritive value of the hay. However, if the crop is not quickly dried and left in the field unattended, then there are heavy losses.

2. Shattering of leaves

This loss is more common in leguminous crops like berseem, lucerne, cowpea, etc., where the leaves dry earlier than the stems. If drying is prolonged without proper turning, the leaves become brittle and shatter. Sometimes this loss becomes very serious since leaves are richer in proteins, vitamins, minerals, etc. than the stems. This loss can be reduced if the forages are-chaffed before curing them for hay. Leguminous hays should be transported from the field early in the morning so that with dew there is less shattering of leaves.

3. Fermentation

After the crop is harvested, the plant enzymes act on the soluble carbohydrates forming thereby carbon dioxide and water. In a normal hay making process, some of the nutrients are lost which results in the higher crude fibre content of dry matter of hay as compared to the green fodder analysed before hay making. Although major changes during hay making occur in the carbohydrate fraction but other nutrient like protein is also affected. Proteins are also hydrolysed to amino acids which may be lost. In a normal curing there is a loss of about 5~9% of dry matter.

4. Oxidation

If the green fodder is exposed to the sun for a longer period without proper turnings, nearly all the carotene may be lost. In green fodder, it is between 150-200 ppm of dry matter and due to bleaching it can be reduced to 5-10 ppm. Rapid drying of the crop on tripod system conserves the maximum amount of carotene. Sunlight has a beneficial effect on vitamin D_2 formation.

5. Leaching

During hay making, if heavy rains prolong, severe losses due to leaching occur which causes loss of protein, NFE, soluble minerals and vitamins. The crude fibre content is increased.

B. Silage making

Silage: It is the green material produced by controlled fermentation of green fodder containing high moisture level. Fresh fodder when packed in a container and allowed to ferment under anaerobic conditions producing volatile fatty acids which preserve the material for a long time with minimum loss of nutrients is called as silage. The process of silage making is called ensiling.

Characteristics of a good silage

Among the physical characteristics, it should have acceptable aroma without mould growth. A good silge is greenish yellow and is highly palatable to the animals. A fermentation loss of 10-15% cent is acceptable. Chemically, its pH value should be between 4-5, in proportion to lactic acid, other volatile substances should be less, ammonia should not comprise more than 10-12% of total nitrogen. Concentration of butyric acid should be less than 0.2 %.

Suitable crops

Soluble carbohydrate rich crops like maize, sorghum, bajra, napier, oat etc. are suitable for ensiling. Cultivated and natural grasses are very good substrate for ensilage. The crops used for the purpose should have about 65%. Legumes may contain 60-65% moisture. The crop should have solid stem so that small amount of air is trapped. For hollow stemmed crops, trampling should be adequate. Stage of harvesting is also an important aspect. For silage, maize should be harvested at dough stage, sorghum and bajra at milk to dough stage and natural grasses at flowering stage. Leguminous crops may also be ensiled with cereal crops in different ratios (2-4: 1).

Method

There could be several methods, however, the principle is same that green crops harvested at 65-75% moisture level can be ensiled or better chopped/chaffed. The mass is packed in silos, so that it contains no or vey less air after trampling down. After proper packing, the material is packed/sealed with mud/straw/polythene sheets. The soluble carbohydrates in the fodders are converted mainly to lactate and other organic acids by lactic acid bacteria. The resulting product is acidic in nature (pH=4.0). At this pH undesirable butyric acid production is inhibited and so also the degradation of proteins to ammonia and amines. This can be achieved by proper compaction of the chaffed fodder. The exclusion of air from silo minimizes the loss of nutrients due to respiration and encourages the growth of lactate producing bacteria, prevents the growth of aerobic organisms producing heat at the expense of nutrients. The silo should be airtight which can be done by providing polythene sheets all around (top, side and bottom). Inoculation with lactic acid bacteria (e.g. Lactobacillus plantarum) results in lactic acid production provided that forage contains sufficient amount of soluble carbohydrates. Silage is ready after 4-6 weeks. Higher moisture (>70%) should be avoided as it promotes undesirable clostridia. As far as possible, soil contamination should be avoided.

Tower and trench silos can be used for silage making. Silos should have air tight walls having no cracks whether they are above or below ground. If above ground, air may enter through cracks and moulds may grow while below the ground invites rain water and spoilage.

Fig. 5.2. Silage making

Advantages of silage making

- Silage can be prepared from green fodders when weather does not permit hay making.
- Silage can be prepared from plants which have thick stems and normally not suitable for hay making (e.g. sorghum, maize etc.)
- Weeds can be used alongwith major crops for ensiling. The process also destroys weed seeds.
- It is highly palatable to cattle and buffaloes.

Improvement in straw quality with urea treatment

Straws and stovers are less palatable, less digestible and have lower nutrient content (protein, energy, minerals). Urea/ammonia treatment is a simple technology which can be adopted by the farmers for improving the quality of straws ike paddy straw, wheat straw etc.. Urea treatment is a chemical method of improving the digestibility nd the nutritive value of the straws. Both protein and energy content of the straw goes up (Table 5.1).

Table 5.1. Protein and energy contents of treated and untreated wheat straw

Type of straw	Crude protein (%)	TDN (%)
Untreated straw	3.0	40.0
Treated straw	8-9	50-55

One quintal of straw is spread as a layer over a space of 2 meter radius. Four kg of urea is dissolved in 50 liters of water in a big drum and urea solution is sprayed with gardener's sprinkler or with bucket full of the solution, over the straw layer. This is followed by another layer of one quintal of straw over the previous layer. Similarly, the urea solution (4 kg in 50 liter of water) is again sprayed over the second layer, The straw is thoroughly pressed before the next layer of straw is put over it. Likewise, a stack of 12.5 quintals of straw can be made from 1 bag full of urea (50 kgs).

The top of the stack should take the shape of a dome. The whole of the stack has to be covered from all sides and from top to the base, preferably with polythene or with untreated unchopped paddy straw. It can also be covered traditionally by "Koop". A period of three weeks is required for proper action.

Precautions

- Use clean water for dissolving urea.
- Layer after layer, the stack should be thoroughly pressed to remove the air pockets

The stack should be properly covered from all sides to minimize the spoilage with rain.

- The stack should be opened from one side after 3 weeks for feeding the treated straw to the a1nimals. The stack should preferably be closed with untreated long paddv straw.
- Before offering the treated straw to the animal, it should be left in open for half an hour to remove the smell of ammonia.

Advantages

1. Crude protein increases 3 times.
2. Total digestible nutrient increases by 10-15% units.
3. Straw becomes more palatable and digestible.

Constraints in the adoption:

1. The technology is effective in areas where green fodder is not available
2. For treatment, it requires labour, farmer need neighbors' help to prepare treated straw.
3. Requires sufficient clean water.
4. Can be mostly used at large farms.

Review Questions

1. What are the advantages of processing of feeds?
2. Explain grinding, mixing and compounding of feeds.
3. What is the importance of hay and silage making? What are crops suitable for hay or silage making?
4. What are the characteristics of good hay and silage?
4. How would you prepare hay and silage?