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DEPARTMENT OF ANIMAL NUTRITION

Feed Technology Part 1
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Animal feed technology- Defined as the application of physical, chemical, biochemical, biological and engineering techniques to increase the nutrient utilization of feeds and fodders in animal system for the development of livestock and poultry and feed industry.

The Association of American Feed Control Officials (AAFCO) – 1909 (Established)

American Feed Manufactures Association (AFMA)- 1909 name changed to American feed Industry Association (AFIA) in 1985.

Food and Drug Administration (FDA)- 1906 in USA.

Food, Drug and Cosmetic Act- 1938, amendment- 1958.

Federal Food, Drug and Cosmetic Act- (1962).

Good Manufacturing practices (GMP's)- (1965).

Feed Production School (FPS)- (1950).

IGFRI- Indian Grassland and Fodder Research Institute, Jhansi (U.P.)

AAFCO Defi-

Complete feed: A nutritionally adequate feed for animals other than humans; by specific formula compounded to be fed as the sole ration and is capable of maintaining life and/or promoting production without any additional substance, except water, being consumed.

Concentrate: A feed used with another to improve the nutritive balance of the total and intended to be further diluted and mixed to produce a supplement or a complete feed.

Supplement: A feed used with another to improve the nutritive balance or performance of the total and intended to be

fed undiluted as a supplement to other feeds, (2) offered free-choice with other parts of the ration separately available or (3) further diluted and mixed to produce a complete feed.

Premix-

Premixes are formulations of one or more micro ingredients, 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 micro ingredients in the complete feed or concentrate mixture.

CLEFMA- Compound Livestock Feed Manufactures Association- 1967, 8 June

CLFMA vision To actualize the full potential of Animal Agriculture Industry of India and to converge the efforts of all sectors of Animal Production under one platform to get necessary recognition from all quarters of society for our contribution to the national economy.

Primary reasons for Processing of feeds-

To make more profit

To alter particle size

To change moisture content

To change palatability

To change the density of feed

To increase nutrient content

To increase nutrient availability.

To detoxify or remove undesirable factors

To improve keeping quality.

To lesson moulds, salmonella, and other harmful substances.

Particle size reduction procedures:

Cutting- Chaffing of green fodder, straw, hay

Crushing- Ball mills, percussion mills and jaw crushers

Shearing- rotary type knife and stationary bar cutter use the shear principle.

Impact grinding- Hammer mills, jet mills, centrifugal input mills

Mills that are commonly used in the feed industry-

1. Hammer mills: - grinding of both concentrates and forages.

The hammer tip may travel at speed of 7000-25000 feet per minute.]

Factor that affect of hammer mills-

Diameter and shape of screen opening-1. shape of screen are mostly round

2. Screen area

3. Moisture Content- inversely related capacity in tonnes/hours

4. Peripheral speed (Hammer tip speed)

5. Kind of feed- Concentrate > Roughages

6. Location of feed intake- (a) Central feeding < (b)Tangential feeding

7. Hammer tip and screen clearance- optimum clearance- 8mm(0.31”).

8. Hammer width and design.

9. Number of hammers

10. Feed rate

11. Air flow through the mill – 4000 cu. Meter/sq.

12. Maintenance condition of the mill

13. HP of the motor

2. Roller Mills – Crimping or Crushing of grains.

Two rolls- opposite direction in same speed or different

Same speed – Crushing

Different speed- Cutting and Shearing

Feed mixer-

Verticle Batch Mixer- Thousand of feed mills and farms.

They may be single screw or double screw for elevating the material.

The screw conveyor elevates and mixes the material as the mixer is filled.

Capacity – 0.5 to 5 tonnes.

Horizontal Mixer- Larger feed mills. The mixer shaft is accurately machine and mounted on bearing and its fitted with ribbons/paddles which thoroughly agitate and blend the ingredients to produce homogenous mix.

Double paddle horizontal mixer- curved paddle blades which scoop, lift and tumble materials as they conveyed to the centre of the mixer.

Ribbon blenders- principle is same as paddle mixer except that have double worm type ribbon. Large one- conveys the material forward and small one conveys its backwards.

Merits and Demerits of the Mixers

Attribute	Vertical mixer	Horizontal mixer
Cost :	**Relatively inexpensive and do a good job of dry mixing.**	**Expensive and do a good job of dry and liquid mixing**
Use :	**Used in thousands of feed mills and farms. Not used in larger feed mills.**	**Used in small mills as well as larger feed mills.**
Floor space:	**Require less floor space compared to floor mounted horizontal mixers**	**Require more floor space. Short leg mixers can be mounted to ceiling: However, these are not common.**
Time :	**Require 20 min. or more time per batch to obtain maximum mixing efficiency. These are slower.**	**Require 3-5 min. per batch and are faster than vertical mixers**
Power :	**requirements Consumes less power.**	**Consumes more power.**
Discharge of mixed feed :	**Opening at one place for discharge of the mixed feed.**	**Openings at several places along the bottom to aid in more rapid discharge.**

Cleanout :	**Cleanout will be to a lesser extent.**	**Cleanout is generally 100% and is more efficient.**
Mixing efficiency :	**Require more time to obtain maximum mixing efficiency; Lower mixing efficiency.**	**Mixes feed at peak efficiency in 3-5 min. Mixing efficiency approaches 99%**
General cleaning of the mixer :	**There is only one small discharge gate**	**Hinged drop bottom doors are furnished for cleaning the internal ribbons and tub of horizontal mixer.**
Liquid addition :	**Liquids such as molasses, fats can't be effectively mixed.**	**Molasses, fats, etc. can be mixed effectively.**

Factor that affect the mixing –

1. Physical property of ingredient
2. Mixer designer
3. Liquid addition

Processing Methods of Grains:

Dry processing methods:

Grinding 2) Dry rolling 3) Popping 4) Extruding 5) Micronizing 6) Roasting

B. Wet processing methods:

1) Soaking 2) Steam rolling 3) Steam processing & Flaking 4) Pressure cooking 5) Exploding 6) Pelleting 7) Reconstitution

Out of the above processing methods, grinding is the one commonly used for grains and other feeds. Soaking, extruding and pelleting of feed mixtures are also done in India.

1. Grinding- Process of Particle size reduction.

Simplest and least expensive method for preparing grain for feeding livestock.

Prerequisite for mixing, pelleting or extruding. which is accomplished with the help of hand stone mill, hammer mill and roller mills. Medium fine grinding is best.

Advantage of Grinding-

Increases the particle numbers and thereby increase the surface area which facilitates the digestive enzymes to act resulting in increased digestibility.

Improves the feed utilization and thereby increase the performance of the animal.

Mixing different feed ingredients is aided by grinding since uniformity of particle size helps in uniform mixing.

Pelleting and extruding of feed will be easy, more effective and efficient.

Segregation of particles or ingredients or nutrients will be avoided.

Selective feeding by livestock will be minimized or avoided. So wastage in feeding will be minimum.

Palatability of ingredients will be improved.

Energy loss due to mastication will be decreased.

Feed passage time will be decreased. Feed consumption will be increased. But decreased feed passage time reduce the digestibility of fibre in ruminants since residence time in the rumen is less.

2.Dry rolling: Rolled or cracked grain are usually prepared by passing the grain through a roller mill. The physical properties of dry rolled or cracked grain would be very similar to that of grains coarsely ground in a hammer mill. Depending upon the rate of flow and the tolerance set between the rollers, the grain can be rolled to a consistency that resemble finely ground grain. Wheat and barley are dry rolled for beef cattle rations.

3.Popping or puffing: Popping is produced by the action of dry heat (700 – 800 ° F or 370 – 425 ° C) for 15 to 30 seconds causing a sudden expansion of the grain which rupture the endosperm and this results in rupture of starch granules and makes the starch more available to the rumen microorganisms

and/or to the animal. Popped grains will have less moisture (3%) and will be bulky. Popping increases palatability and feed consumption by 5-10%. Popping increases the digestibility. Popped grains are good molasses carrier.

4.Micronizing: It is similar to popping except that heat is furnished in the form of infra-red energy. Micro waves with 3×10^{8} to 3×10^{11} cycles/ sec. that are emitted from the infra-red burners are used here. The grain is then rolled to produce a uniform dense product.

5.Extruding: Extrusion cooking has become an important part of the feed industry in the production **of pet feeds, fish feeds, feed for laboratory animals**, in the gelatinization of cereals for a variety of animal feed and in the cooking of soybean and pulses for control of growth inhibitors. This technology is also used for cooking meat, fish and feather meals for control of salmonella, the cooking of cereals/starch with urea for ruminants, etc.

Gelatinization of starch occurs in this process. Gelatinization is defined as the irreversible destruction of the crystalline order in a starch granule, so that the surface of every molecule is made accessible to solvents or reactants by a combination of moisture, heat, mechanical energy, pressure differential and/or by pH modification. It enhances the ability of starches to absorb large quantities of water leading to improved digestibility and improved feed conversion.

Extrusion cooking technology is becoming popular for manufacturing fish feeds since product densities can be readily controlled and so the feed is utilized by fish completely. These expanded feeds will hold their identity in water and will retain that identity in water without fragmentation for long periods of time. This helps top feeders (e.g. catfish) attain maximum feed conversion.

Density of expanded and gelatinized feed for catfish is 27 to 35 pounds per cubic feet and trout is 20 to 30 pounds per cubic feet.

6.Roasting: It is accomplished by passing the grain through flame resulting in heating to about 300°F (148.9°C) and some expansion of the grains which produces a palatable product. Moisture content of the grain is 5%. Roasting of whole soybeans inactivates enzymes or inhibitory factors, which improves the nutritive value for poultry and swine.

Wet Processing Methods-

1. Soaking: Grains soaked for 12-24 hrs in water has long been used for livestock feeding. Sometimes concentrate mixture is also soaked before

offering to swine. However, problems in handling and potential souring discouraged its large scale use.

2.Steam rolling: The grain is subjected to live steam for different periods of time depending upon the pressure used prior to rolling. In case of steam preconditioning at atmospheric pressure, grain is subjected to live steam for 8 to 20 min. and temperature and moisture content of grain are 210-215°F (100°C) and 16-20%, respectively. In case of pressure (20 to 60 psi.) preconditioning, grain is subjected for 50 sec. to 2 min. Temperature and moisture of the grain are 250 to 300 ° F (121 to 148.9°C) and 18-25% respectively. Pressure preconditioning of grains prior to rolling increases gelatinization of starch to 45-50%. Steam rolled grains are usually less dusty than dry rolled grains.

3.Steam processing and flaking: The process is a modification of steam rolling to which rigid quality control standards are practiced. After steam treatment, grain is passed through the roller mill. The tolerance set between the rollers depends upon the flatness of the flake desired. In order to produce a thin flake of grain, the capacity of the steam chamber should be approximately 1/3rd of that of the roller mill. If the steam processed and flaked material is to be stored for more than one day, it must be dried.

4.Pressure cooking: Pressure cooked grain are similar to steam processed and flaked grain. Grains are cooked with live steam at 50 psi for 1.5 min in air tight pressure chambers. Temperature of 300°F is obtained. The temperature is reduced to below 200°F and the moisture to 20% by passing them through cooling and drying tower prior to flaking. Pressure cooked grains are difficult to flake to the same degree of flatness (as steam processed grain) due to the spongy nature of the pressure cooked grain. The pressure cooked grain should be flaked fairly thin. The capacity of roller mill to handle pressure cooked grain is about 4 times that of pressure cooker. Pressure cooked flakes are less brittle and don’t break.

5.Exploding: It is accomplished by subjecting the grain to high pressure steam (to 250 psi) for about a very short time (20 sec.) followed by sudden decrease to atmospheric pressure. This results in rapid expansion of the grain kernels. Similar to popped grain, it produces a low density product.

6.Reconstitution: Reconstituted grain is mature grain (10% moisture) to which water is added to raise the moisture level to 25-30% and the wet product is stored in an oxygen-limiting silo for 14-21 days prior to feeding. Reconstitution of grain increases the solubility of the grain protein.

7.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 dusty and unpalatable feed material into more palatable easy to handle larger particles by application of optimum amounts of heat, moisture and pressure. The normal size of pellets is 3.9 mm to 19 mm though the maximum used pellet diameter is 6.25 to 9.4 mm. The shape is mostly cylindrical. If smaller pellets are required, it is economical to produce 3.9 mm pellets and reduce it to the desired particle size by crumbling process.

Advantages of Pelleting:

- Increases the palatability of feed and thereby improves the feed intake.
- Improves the feeding value of different feeds especially with roughages as compared to concentrates.
- Increases the density of feed and thereby reduce the storage space required.
- No segregation and selective feeding.
- Reduces the wastage of feed by the animal.
- Pelleted feed is in a free flowing form and can be handled mechanically thereby saving labour cost.
- Heat labile inhibitors are destroyed; gelatinization of starch occurs.
- Feeding pelleted feeds enhance the growth rate and milk production and reduce cost of the end product, meat/milk.

Roughage Processing Methods-

Dry Processing Methods

1. Baling 2. Field chopped 3. Grinding 4. Pelleting 5. Cubing 6. Dehydration.

Wet Processing Methods

1. Green Chopped
2. Soaking

1. Baling: It is one of the most common methods used to increase convenience of handling forage. The forage is cut and permitted to dry in the field. Dried forage is then baled with a stationary or field baler. It is very popular in developed countries.

2. Cubing: It is modification of wafer production. Density of long hay is 7 lb/cft while density of cubed hay and density of pelleted hay are 25-32 lb/ cft and 40 lb/cft, respectively.

3. Grinding: Grinding of roughages is a prerequisite for mixing and pelleting. These mechanical processes increase voluntary intake, nutritive value and facilitate preparation of complete feeds. Roughage should be ground to 1-2" (2.5-5 cm) long for roughage feeding alone or from 0.5 to 1.0" (1.3-2.5 cm) when it is to be incorporated in complete rations. The dust loss can largely be prevented by addition of 1% tallow or water to the material at the time of grinding. Addition of molasses to ground hay makes it highly palatable and increases feed intake.

The Effect of Grinding Roughages

Feeding of ground roughages reduces rumination and rumen retention time. Feed consumption is increased leading to better animal performance.

Fine grinding of roughage usually reduces digestibility of crude fibre due to faster rate of feed passage. Feeding finely ground feed to dairy animals result in a lower butter fat content in the milk due to lower rumen acetate production. In view of the cost of equipment, ever increasing cost of energy for running the equipment and transportation of straw to the feed plant and back to the farm, this method appears to be not feasible at farm level and questionable at commercial scale.

Grinding of low quality roughage increase the dry matter digestibility compared to high quality one. It is recommended that straws/stovers be chopped or coarsely ground prior to feeding.

4.Dehydration

Green forage such as alfalfa/lucerne can be preserved by dehydrating the forage at high temperature (600-1500°F) in a dehydrator for a short time (3-5 min.). It is usually done with the young growing and good quality forage. This method of forage preservation retains a maximum amount of dry matter and protein and there is no loss of leaves in the process. There is a loss of carotene (5-15%) during the process of artificial drying. Dehydrated alfalfa pellets (17% CP) are usually used as supplement to cattle rather than as primary source of roughage. These pellets are not palatable as compared to cubed or baled hay.