Chapter 02: Processing of cereal grains

Feed processing refers to performing all the operations necessary to achieve the maximum potential nutritional value of a feedstuff. The process involves changing ingredients in such a manner as to maximize their natural value and the net returns from their use.

Feed processing may be accomplished by physical, chemical, thermal, bacterial or other alterations of a feed ingredient before it is fed. The primary reasons for processing feeds are:

1. **To make more profit**: Feed efficiency can be routinely improved by as much as 10-15 per cent by changing the method of feed processing. Thus profits may be enhanced by either reducing costs, or increasing production or both.
2. **To change moisture content:** Moisture content of a feedstuff may need to be changed to make it safer to store. Grains are generally stored with below 14 percent moisture.
   On the other hand, it may also be desirable to add water to a finely ground meal mixture at the time of feeding in order to lessen dustiness and to increase digestibility and palatability.
3. **To alter particle size:** Some feeds need to be reduced in size so that they can be consumed and are more digestible. In some cases, particle size is increased (agglomerated) by pelleting or cubing.
4. **To change density of feed:** The weight per unit volume or the bulk of the ration affects total intake. For this reason, very bulky feeds are sometimes pelleted or cubed in order to increase energy density and feed consumption. On the other hand, horsemen favour flaked grains rather than ground or pelleted to minimize digestive disturbances.
5. **To change palatability**: In most instances, feeds are processed in such a manner as to increase palatability.
6. **To increase nutrient availability.**
7. **To detoxify or remove undesirable components:** Some feeds may contain toxic substances, the excess consumption of which may cause decreased nutritive value of the feeds or may injure some vital organs or even cause death.
8. **To lessen moulds, salmonella and other harmful substances:** Moulds on feeds have long been a problem. Aflatoxin is a common term used for a group of toxins produced by fungi and is common in the expeller variety of groundnut cakes. Proper harvesting, drying and storage are important factors in lessening aflatoxin contamination and toxic production. Propionic and acetic acids will inhibit mould growth. Treatment with ammonia or ammonium hydroxide will detoxify feeds.
   Salmonella, rod shaped bacteria, is of importance from two distinct aspects; (a) food poisoning in man, and (b) disease in domestic animals. In meat meal it is invariably present and is destroyed by pelleting.
   Many anti-nutritional factors like saponins, tannins, gossypol etc. can be removed by autoclaving, heat and water treatment.

9. **To reduce storage, transportation space and cost:** Sometimes forages are processed in a certain way in order to reduce storage and transportation space.
10. **To improve keeping qualities:** Since feeds are seasonally produced, some of them must be stored for use in the non-growing season.

PROCESSING METHODS

Grain processing methods

Grain processing methods are divided conveniently into dry and wet processes. The primary objective is to improve the availability and digestibility of starch which is present at about 70-80 per cent in grains. However, the method of accomplishing this is complicated because: (1) the type of starch varies among grains in its digestibility; and (2) availability of starch even varies from one grain variety to another, particularly in milo.

Grain Processings

A. Dry Processings

1. Grinding
2. Dry rolling or Cracking
3. Popping
4. Extruding
5. Micronising
6. Roasting
7. Pelleting
8. Dehulling

B. Wet Processing

1. Soaking
2. Steam rolling
3. Steam flaking
4. Pressure cooking
5. Exploding
6. Reconstitution
7. Ensiling at high moisture content

A. DRY PROCESSING

Grinding

Grinding is that process by which a feedstuff is reduced to a particle size by impact, shearing or attrition. The process is most common, economical and simple, other than soaking. A wide variety of equipment is available and all of it allows some control of particle size. Coarsely ground grains are preferred for ruminants while finer ground grains are more common for poultry and swine.

Dry rolling or cracking

The method refers to passing grain without steam between a closely fitted set of steel rollers which are usually grooved on the surface. It breaks the hull and/or seed coat and results in an end product of coarsely ground grain sometimes referred to as flaking. Cattle seem to prefer flaked grain to finely ground grain, and are usually better for it.

Popping

Most readers are familiar with popped rice (khai) and popped maize which is produced by action of the rapid application of dry heat, causing a sudden expansion of the grain which ruptures the endosperm. For increasing digestibility all grains may be processed by this method, but it appears that it is especially effective in processing sorghum or other milo grains.Popped milo requires more storage space due to its light density.

Extruding

Extruding usually involves grinding the grain, followed by heating with steam in order to soften it, then forcing the softened steamed ground grain through a machine with a spiral screw which expels the grain through a tapered head to produce a ribbon like product. Extruding animal feeds is generally confined to pet foods.

Micronising

Micronising is essentially the same as popping, except that heat is provided in the form of infra-red energy.

Roasting

Roasting is accomplished by passing the grain through a flame or heating it to the desired temperature in some form of an oven for a period of time, resulting in some expansion of the grain, which produces a palatable product. The method may be used with whole soybeans to destroy heat labile inhibitors and thus improve nutritive value for poultry and swine.

Pelleting

Pelleting is accomplished by grinding the material and then forcing it through die openings by a mechanical process. Feedstuff usually is, but not always, steamed to some extent prior to pelleting. Pellets can be made into small chunks, or cylinders of different diameters, length and degrees of hardness. The advantages of pelleting feeds are as follows:

1. Feeds to be pelleted are usually ground first—the pellets so formed being appreciated by the consumer
2. Pelleting feed to a free flowing form, facilitates its handling and use in a self-feeder.
3. Pelleted feeds are usually less dusty and more palatable.
4. The feed reduces storage space requirement.

The process involves about 10 per cent more cost than non-pelleted concentrates.

Dehauling (Corticated form)

Dehulling is the process of removing the outer coat of grain, nuts and some fruits as the hulls arc high in fibers and low in digestibility in swine, poultry and other monogastric animals. The best known outer covering of cereal grains are barley hulls, oat hulls and rice hulls. Today hulls are combined with other residue from the milling of these cereal grains and are marketed as by-products.

The protein content of such unhulled (undecorticated) oilseeds as soybeans, cottonseeds, groundnuts, sunflowers, and safflowers is relatively low.

B. WET PROCESSING

Soaking

Hard grains soaked for 12 to 24 hours in water is a practice long in use by livestock feeders (which are not mechanically processed) for feeding of sore mouthed horses and mules. Benefits are also obtained by soaking oilseed by-products like mustard cake in water and thereby alleviating the toxicity factors like HCN.

Steam rolling

Rolling refers to a process by which grain is compressed into flat particles by passing it between rollers. Steam rolling is also called crimping, and steam crimping refers to exposing grain to steam for a short period of time, usually one to eight minutes, followed by rolling. The steam softens the kernel, producing a more intact, crimped-appearing product than that produced by dry rolling. Steam rolling offers little or no advantage in feed efficiency over grinding or dry rolling. However, the product may be useful for very young animals before their teeth are fully developed or for very old animals with badly worn teeth.

Steam flaking
Steam flaking grains are prepared in a similar manner but with relatively rigid quality controls. Grain is subjected to high moisture steam for a sufficient time to raise the water content to 18-20 per cent and the grain is then rolled to produce a rather flat flake. Thin flakes are better as they allow more efficient rupture of starch granules whereby a more desirable texture is produced.

Pressure cooking
The product is very similar to steam processed flaked grain. In the case of pressure flaking, the grain is subjected to steam under pressure for a short time, such as 50 psi (pounds per square inch) for one to two minutes. Steam is injected into the cooker till the grain in the chamber reaches a temperature approaching 300° F. The grain is then expelled from the cooker at a temperature below 200° F and with 20 per cent moisture these are flaked. 1$ comparison with steam flaking, flakes produced by pressure are less brittle.

Exploding
Exploding is the swelling of grain, produced by steaming under pressure followed by releasing to the air. Steam is injected into high-tensile strength steel 'bottles' to raise pressure to 250 psi. After about 20 seconds, a valve opens to let the grain escape as expanded balls with the hulls removed. Under high pressure, moisture is forced into the kernels, which when released into the air swell to several times the original size.

Reconstitution
Reconstituted grain is mature grain that is harvested at the normal moisture level (10-14 per cent), following which water is added to bring the moisture level to 25-30 per cent and the wet product is stored in an upright silo (for required compaction) for 15 to 21 days prior to feeding. The grains are rolled and ground at the time of removal.
Properly reconstituted milo (sorghum) and steam processed flaked milo give similar results with fattening cattle.

Ensiling at high moisture content
High moisture grain refers to grain harvested at a moisture level of 20 to 35 per cent and stored without drying in a silo. It may be ground before ensiling or ground and rolled stored in either of the two ways.

1. It may be ensiled (fermented) in an oxygen limiting (anaerobic type) silo.
2. It may be preserved by the addition of 1-1.5 per cent propionic acid (or a mixture of propionic acid with either acetic or formic acid) to inhibit mould on storage.This is a particularly useful procedure when weather conditions do not allow normal drying in the field and it obviates the need to dry the grain artificially.

Effects of storage and processing on physical and chemical properties of cereal grains

The main ways by which the physical and chemical properties of grain may be altered during storage and processing include:

a.) Particle size reduction
b.) Moisture addition
c.) Heat treatment (affect CHO and protein)
d.) Addition of chemicals
- Such as acid or alkali.

Particle size reduction:

- For reducing particle size using hammer mills and roller mills.
- There are two methods used for measuring fineness of grinding of grains. One method describes the particle in terms of geometric mean diameter and standard deviation .Other method presents the mean and variation as modules of fineness and modulas of uniformity (Ensor et al, 1970).
- The fineness of grinding depends on the several factors such as types of grain, moisture content, temperature, screen size, flow rate, tolerance setting, types of roller etc.

Heat treatment:

- Heat can affect both the carbohydrates and protein of grain.
- When starch in cereal grains is heated with presence of moisture, the granules swell (French, 1970) and at higher temperature gelatinization occur (Armstrong, 1972)
- Gelatinized starch is digested more rapidly (Delort -Laval and Mercier, 1976) because of its higher solubility.
- It would be slight effect of heating cereal grains on protein utilization.
- Pelleting of Pig diets decreased the lysine content by 6-8% but not sufficiently reduce the biological value of the protein (Eggum, 1973)
- Partial (16-25%) gelatilization of starch may occur during pelleting (Whistter and Paschall,1965)

Moisture addition:

- About 5% of growth rate and feed efficiency in pigs has been observed for wet feed.
- Reconstitution (three weeks of anaerobic storage) has been shown to improve digestibility by cattle, particularly of the protein fractions (Riggs and McGinty,1970)
- Reconstitution of sorghum increase the alcohol soluble fraction and decrease the glutelin content (Walker and Lichtenwalner ,1977), and this change would be

expected to improve the digestibility, but reduce protein quality(Eggum & Beames, 1983)

- Another beneficial effects of moisture is the inactivation of tannins (Reichert et al, 1980)

Addition of chemicals:

- Alkali causes swelling of the outer starch particles leading to a disruption of the seed coats and partial gelatilization of the outer starch granules (Barnes and Orskov, 1982) thus fibre digestion increased in fibrous grains.
- NaOH is effective as a preservation than $Ca(OH)_2$ because of its high solubility (Berger et al. ,1981)
- Ammonia effectively reduces mould growth but it needs a free ammonia atmosphere (Bothast et al., 1973).
- There are little effect of organic acids, as a preservation through the control of fungal organisms such as acetic acid, propionic acid on the physical and chemical properties of grains except for a reduction in the level of α- tocopherol (Lawrence, 1982)