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**Original Article****Storage of feed ingredients and finished feed****Akash Rathod and Manish Kumawat**

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All types of feed ingredients, as well as compound feeds, require special care during storage to prevent deterioration in quality and loss. Good storage is essential because the value of the feed that is presented to animals depends on it. Feed spoils during storage and the extent of deterioration depends very largely on the storage conditions (Ebenezea *et al.*, 2020).

The storage godowns for raw materials and finished products should be separate. Raw materials are received from various sources and utilization of food grains unsuitable for human consumption is common. In such situations, infestations may occur and spread from one material to another. Cleaning, insecticide spraying and fumigations may help in checking infestation. Stacking of different materials should be done in such a way that there are minimum chances of cross infestation.

Godowns are classified into following 3 categories:

Type of Godown	Capacity
Small sized godowns	less than 1000 MT
Medium sized	1000 MT - 5000 MT.
Large sized	Above 5000 MT

Deterioration of raw materials as well as finished products may occur due to high moisture content, rancidity, mould and fungi growth etc. Immediate removal of damaged materials from the godowns may help in checking further deterioration of the remaining stock. Further the deterioration of raw materials may occur due to long storage of raw materials, especially rice polish fine, rapeseed meal, grains. Normally such materials should not be stored in godown / silos not more than a month. First In First Out (FIFO) system should be adopted.

The raw materials with moisture content more than 10 per cent may result in drayage loss during storage. The longer the duration of storage, more will be the moisture loss. To compensate moisture loss in filled finished product bags, extra feed should be filled in each bag depending upon season and duration of storage in the godowns (Garg *et al.*, 2013).

**Losses and deteriorative changes which occur during feed storage**

Environmental factors, such as moisture (feed moisture content and relative humidity), temperature, light, and oxygen influence deteriorative changes and losses in feedstuffs. These affect the feedstuff either directly or by influencing the rate of development of insects and fungi which consume the feed during storage.

The following are the major factors which affect the quality and weight of feedstuffs during storage:

1. major losses due to human theft, fire and the consumption of scavenging animals, such as rats and birds
2. damage due to rain and condensation, and to high temperatures
3. damage by insects
4. damage by fungi
5. changes in the quality of the feeds due to enzymatic actions and the development of oxidative rancidity

**1. Physical Loss**

Significant loss can occur as an accumulative effect of individually small, but regular theft. Less obvious are the losses caused by scavenging animals, particularly rats and mice. Food stores are notorious breeding grounds for such animals.

**2. Water and Heat Damage**

High levels of moisture content and relative humidity cause direct losses by making it difficult to use the material in its original form. Cereals will store quite well at 10-12% moisture. In general, moisture levels of 10% or less should be sought. Fungal growth increases moisture content also.

High temperatures also affect the rate of loss and damage in feeds, another reason why feeds in tropical zones should not be stored as long as in temperate areas. High temperatures in feeds may occur not only because of environment and the way in which they are stored but because of the heat generated by the growth of fungi and insects. Increases in temperature within large stacks of feed have been known to cause 'spontaneous combustion' followed by fire losses. Increase in temperature may reduce the availability of the amino acids in feeds.

### 3. Insect Damage

Feeds are attractive places for insects, including various species of moths, weevils and beetles, which consume the feed. All grow well at normal temperatures in feed stores. At temperatures from 26-37° C they can reach epidemic proportions. Insects thrive better on ground materials.

#### Common insects found in cattle feed raw materials

Popular Name	Product in which generally found
Rice weevil ( <i>Sitophilus spp.</i> )	Maize, sorghum, wheat bran, rice polish, cowpea
Lesser grain borer ( <i>Rhyzopertha spp.</i> )	Rice polish, pulses, tapioca
Warehouse beetle ( <i>Trogoderma spp.</i> )	Groundnut
Flour beetles ( <i>Tribolium spp.</i> )(bran bugs)	Maize gluten, cakes, meals, brans and polishes
Flat grain beetles ( <i>Cryptolestes spp.</i> )	Maize, rice and wheat
Grain moth ( <i>Coreysa spp.</i> )	Maize, wheat, milo and rice

Whole cereals or oil cakes can therefore be stored longer than meals made from them. Insects cause damage through weight loss, the exposure of the feed to further damage by fungi and through oxidation, and the introduction of contaminating bacteria.

### 4. Fungal Damage

Fungi grow at relative humidity above 65%, moisture contents generally above 15% (although some mycotoxin producing fungi grow well at only 9-10% moisture) and temperatures which are specific to the fungal species. Most fungal growth occurs at temperatures above 25° C and relative humidity above 85%. Higher temperatures and moisture levels favour increased growth. Fungal growth causes weight loss, increases in temperature and moisture, staleness (off-flavour), discolouration and, perhaps worst of all, some common species produce mycotoxins. Mycotoxins, the best known of which are called aflatoxins, are known to be toxic to some species of fish at least. Sorghum, maize and its by-products, groundnut, cottonseed, cassava, coconut and sunflower are ingredients especially prone to contamination with mycotoxins.

### 5. Chemical changes during storage

Cereals are characterized by relatively low protein and high carbohydrate contents contained in kernel. The germ is rich in protein, fat, sugar and minerals whereas, the endosperm is low in protein, fat and ash contents.

The various chemical changes that occur during storage are due to increased activity of endogenous and exogenous enzyme responsible for quantitative and qualitative changes in carbohydrates, proteins and fats of the cereals in addition to colour, flavour and texture.

#### Carbohydrate

In India, the temperature and relative humidity varies greatly which causes physical and biochemical changes in grains during storage, such as bursting and gelatinization of starch and depending upon the moisture content. Amylases hydrolyse the starch into dextrose and maltose and significantly increase the content of reducing sugars during storage. Storage of wheat grains above 12 per cent moisture increased sucrose, glucose, fructose and raffinose contents. Storage of cereals with high moisture content also produces sour odour due to production of alcohols and acetic acid.

#### Protein

The high temperature and use of chemicals in grains during storage (Fig. 2.8) denature the proteins and make them less dispersible in water, deteriorates the gluten quality and increase the free amino acid contents. The formation of certain sulphur containing amino acids impart bad odour. The free amino acids may also undergo mail lard reaction combining with the reducing sugars giving browning of the grains. The type of deterioration is possible at temperature above 20°C and relative humidity between 60-70 per cent.

#### Lipid

Oxidation of lipids especially the unsaturated fatty acids results in typical rancid flavour, odour and taste. Hydrolysis of lipids also increases free fatty acid contents, which is considered as a sensitive index for grain deterioration (Garg *et al.*, 2013).

#### Micronutrients

Vitamin potency decreases during storage (and processing), particularly in premixes which also contain minerals. Naturally occurring vitamins in feed-stuffs also deteriorate on storage. Vitamin C is particularly susceptible, as is thiamine (vitamin B<sub>1</sub>).

### Considerations for storage procedures

The method of storage depends on the type of ingredient. Some specific suggestions are included followed by some 'do's' and 'don'ts' on storage generally.

**Vitamins**

Vitamins and vitamin mixes are extremely expensive ingredients and should be given special care. Their volume is usually small because their inclusion rate is low, so storage space is not normally a limiting factor. Vitamins should not be mixed with minerals before storage. Vitamins and vitamin premixes should be kept either in the manufacturer's containers or in air-tight light-proof containers. They should not be kept in hot sunny rooms. They should be kept in the coolest place available, preferably under air-conditioning. Stocks should be turned over at least every six months.

**Dry Compounded Feeds**

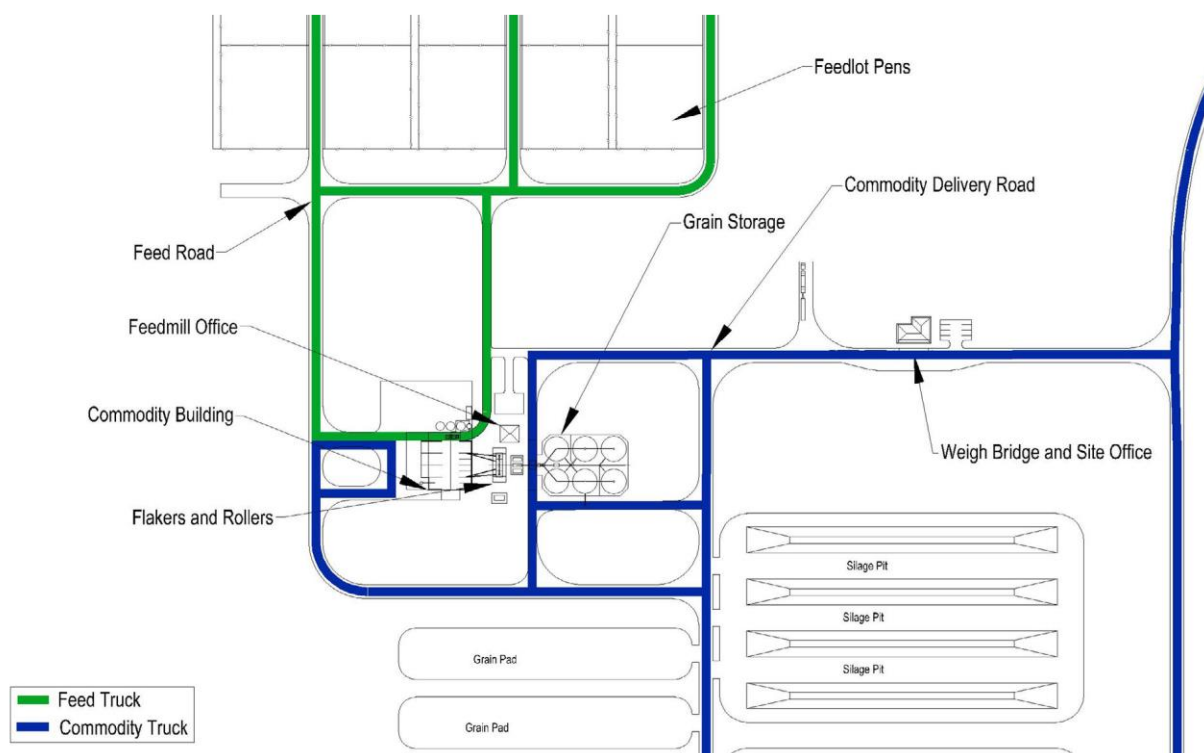
Mixed feeds are more prone to damage than individual ingredients. This is because of interactions between different ingredients and because of cross contamination with insects and fungi. Mixed feeds which have undergone a heat treatment during production, such as steam pelleting, store better than other mixtures because many of the damaging factors will have been destroyed.

**Lipids**

Keep in sealed, preferably plastic, containers, in a cool dark place. Ensure that they have had antioxidants added to them when manufactured.

**Molasses**

No special care necessary in tropical countries but, in temperate zones, molasses may require heating in winter before this product can be used in a mixed feed.



*Paths for receipt and storage areas should not affect the flow of operational traffic around the feedlot.*

**General Recommendations for Dry Storage - "Do's" and "Don'ts"**

- PROVIDE a building for storage which is secure and can be adequately locked. Ensure that its roof will protect the feed from rain and that surface water cannot enter the store. Provide it with ventilation points (windows are not necessary or recommended). Ventilation entry points should be low on the side facing the prevailing wind and high on the opposite side. Orient the building so that one of the long sides faces the prevailing wind. Ensure that all entry points are meshed to prevent entry by birds, rats etc.
- DO NOT accept deliveries of raw materials which are visibly damp or mouldy or which are obviously infested with insects.

- The bulkiness and associated storage space required for a given volume of feedstuff varies

Feedstuff	Feed Storage Requirement		
	lb/bushel	lb/ft.3	ft.3/ton
Wet brewers grains	81	65	31
Whole corn	56	45	44
Soybean meal	52	42	48
Soybean hulls, pelleted	50	40	50
Cottonseed meal	47	38	53
Corn silage	44	35	57
Corn gluten feed	41	33	61
Hominy feed	35	28	71
Soybean hulls, loose	35	28	71
Oats	32	26	77
Whole cottonseed	31	25	80
Wheat midds	25	20	100
Rice bran	25	20	100
Cottonseed hulls	19	15	133
Dried brewer's grains	19	15	133
Dried distiller's grains	19	15	133
Peanut skins	14	11	182
Cotton gin trash	9	7	286

- ALWAYS keep the store clean. Floors and walls should be regularly swept. Spilled material must be removed and the contents of broken bags or containers used first. Cleared areas of the store must always be cleaned before new materials are placed there.
- ARRANGE your store so that new deliveries are not put in front of old stocks. The oldest materials MUST be used first.
- MAKE small stacks. Large stacks of sacks lessen insect damage, which occurs mainly at the surface, but cause heat generation, with other consequential damage. In the tropics, I believe that small stacks which are used rapidly are better than large ones which remain stagnant for long periods. If possible, RAISE the sacks off the ground by stacking them on wooden pallets (platforms).
- PLAN your ingredient purchases carefully so that you do not need to keep too great a quantity in stock. Obviously, you will want to store greater quantities of seasonally cheap or scarce materials but do not be tempted to buy a year's supply just because they are cheap now. It may prove very expensive indeed if half of them have to be thrown away. As a general rule, don't keep materials longer than the following guidelines:

	Tropical Zone	Temperate Zone
Ground Ingredients	1-2 months	3 months
Whole Grain and Oilcakes	3-4 months	5-6 months
Compounded Dry Feeds	1-2 months	1-2 months
Vitamin Mixes (kept cool etc.)	6 months	6 months
Wet Ingredients	2-3 hours	2-3 hours
Frozen Materials	2-3 months	2-3 months

- ENSURE that ingredients are clearly and indelibly labelled so that those drawing from the store are sure that they are drawing the correct ingredient (some look very similar when ground) from the oldest batch.
- DON'T walk on the stacks of compounded feeds unnecessarily. This will break the pellets on the surface and lead to the production of a lot of wasteful fines (dust).
- DON'T allow sacks to rest against the outer walls of the store - leave a space between the stacks and the wall.
- DON'T allow staff to sleep or eat in the feed store nor, preferably, to smoke.

## Animal feed storage guidelines

### General Recommendations

1. Store all feed and ingredients at a cool temperature (ideally below 77° F although this is not possible at outside locations under summer conditions).
2. Keep feed dry to prevent fungal or bacterial growth.
3. Prevent rodent or insect entry into feed.
4. Use antioxidants to preserve fats and oils in ingredients and feed.
5. Use stable forms of vitamins.
6. Expiration dates (usually on container) are required for all food items.
  - Known shelf life of some products is marked on container (e.g., canned food).
  - Prepared feeds: one week after end of experiment or 8 weeks post mixing (whichever is shorter).
  - Ground grain: One month after milling unless stabilized.
  - Fats and oils:
    - ✓ Opened container: One month
    - ✓ Un-opened or stabilized: One year post mixing.
  - Vitamin mixtures: 6 months after preparation (exceptions of up to one year if stabilized with ethoxyquin). Vitamin C hydrolyses more rapidly.
  - Whole grain or seeds: One year after harvest
  - Fat-free ingredients, protein meals, minerals: No specific expiration date as long as feeds remain dry and free from obvious contaminants (These items should carry an acquisition date).

### Grain storage and handling

- Grain based rations typically contain more than 80% cereal grains on a dry matter basis. This means infrastructure associated with grain handling, storage and processing is a dominant component of the feed preparation facility.
- Feedlots with on-site feed processing require bulk storage and grain handling. Feedlots using commercial pre-mixed feed will also need on site bulk storage. The storage and handling of grains requires systems that are compatible with each grain type and grain characteristic. Consideration should be given to whether the grains to be handled are whole grains, ground grains or processed grains.



Figure 1: On-site grain storage facility

### Silage storage and management

- The silage making process, design and management of storage are critical to ensure the highest quality product, while minimising losses during storage and feeding. Good quality silage, correctly harvested and stored, maintains its quality for a long time. Where the local environment or feed processing equipment is not suited to growing and/or handling silage, a feedlot may feed hay instead.

### Storage and handling of liquid feedstuffs

- When liquid feeds are used in rations that are prepared on site, these need special equipment. This includes tanks and pumps designed to handle liquids.

(Peter *et al.*, 2016)

### Hay and straw storage and management

- Hay or straw is best fed in a chopped form when mixed with the grain and other commodities to ensure even intake of the concentrate and roughage. In an on-site feed processing facility, the relatively high percentage of roughage in a typical ration requires significant amounts of hay (and/or silage) to be stored on site.



Silage bunks



Hay storage in open-sided shed



Liquid supplement storage and dispensing

**\*CODE OF PRACTICE ON GOOD ANIMAL FEEDING****CAC/RCP 54-2004****SECTION 5. PRODUCTION, PROCESSING, STORAGE, TRANSPORT AND DISTRIBUTION OF FEED AND FEED INGREDIENTS****5.2 Receiving, storage and transportation****(Points 34-39)**

34. Chemical fertilizers, pesticides and other materials not intended for use in feed and feed ingredients should be stored separately from feed and feed ingredients to avoid the potential for manufacturing errors and contamination of feed and feed ingredients.

35. Processed feed and feed ingredients should be stored separately from unprocessed feed ingredients and appropriate packaging materials should be used. Feed and feed ingredients should be received, stored and transported in such a way so as to minimize the potential for any cross-contamination to occur at a level likely to have a negative impact on food safety.

36. The presence of undesirable substances in feed and feed ingredients should be monitored and controlled.

37. Feed and feed ingredients should be delivered and used as soon as possible. All feed and feed ingredients should be stored and transported in a manner which minimizes deterioration and contamination and enables the correct feed to be sent to the right animal group.

38. Care should be taken to minimize deterioration and spoilage at all stages of handling, storage and transport of feed and feed ingredients. Special precautions should be taken to limit fungal and bacterial growth in moist and semi-moist feed. Condensation should be minimized in feed and feed ingredient manufacturing and processing facilities. Dry feed and feed ingredients should be kept dry in order to limit fungal and bacterial growth.

39. Waste feed and feed ingredients and other material containing unsafe levels of undesirable substances or any other hazards should not be used as feed, but should be disposed of in an appropriate manner including compliance with any applicable statutory requirements.

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