Quality and Safety of Animal Feed in India

D. S. UPPAL, S. M. ILYAS & S. S. Sikka*

Central Institute of Post harvest Engineering & Technology (ICAR), Ludhiana (INDIA)

***Punjab Agricultural University, Ludhiana (INDIA)**

Feed quality

Feed quality has been defined as “any of the features that makes something what it is” and “ the degree of excellence which a thing possesses.” A quality feed would supply all nutrients in adequate quantity and high digestibility and ingestibility.

In India the quality control is regulated by to a statuary body Bureau of Indian Standards (BIS). It was established under BIS Act, 1986. Earlier , Indian standards Institute was regulating the quality control of various commodities. The objectives for the set up of BIS are as follows:

1. **Harmonious development of the activities for standardization of various feed commodities.**
2. **Marking**
3. **Quality certification of goods**
4. **Attending to the connected methods**

Bureau has set up subcommittees for the standardization of different types of commodities. A sub-committee on animal feeds called Animal Feeds Sectional Committee has been specifically set up to check the quality of animal feeds and feed ingredients.

The members of animal feeds sectional committee are the eminent nutritionist taken from the :

1. Indian Council of Agricultural Research (ICAR) institutes
2. State Agricultural Universities
3. Feed Industry
4. Government departments having specialization in Animal Nutrition
5. Feed Technologist concerned with Animal Husbandry Activities.

The objectives to constitute the sectional committees are:

- To describe the feeds accurately
- To lay down standards on feed ingredients
- To lay down standards for compounded feed formulations and mineral mixtures for cattle, poultry, pigs, laboratory animals, etc.

Development of Feed Industry in India

Feed industry came into existence in India in 1961 with the establishment of a feed plant in Ludhiana, India. Compound Livestock Feed Manufacturers Association (CLFMA) was formed. It is the sole, national, representative body of compound animal feed manufactures in India. It has about 115 members in the public, private and cooperative sectors with about 150 small, medium and large scale feed mills all over the country producing, nearly three million tones of compound feed per annum. The installed capacity of CLFMA members put together is around 6 million tones and capacity utilization is about 50 % (CLFMA), 1998). Compound feed also produced by other feed manufactures (Non members of CLFMA) and farmers directly and this comes to around four million tones.

Production of feed ingredients in India (2000-2001)

Commodity	Production Million tons	Remarks
Maize	10.2	Maize is an important cereal in animal feeds. About 4.7 million tonnes is used in animal feeds, 3.5 million tonnes in the starch industry and 2.5 million tonnes for human consumption.
Sorghum	9.3	
Rice bran, deoiled	2.95	
Soybean meal	3.86	Soybean meal is most popular for animal feed.
Peanut meal	2.65	
Rapeseed meal	3.7	
Sunflower meal	0.53	
Cottonseed cake	3.87	

Ingredients commonly used in animal feeds

Maize, Sorghum, Bajra (millet)	Soybean meal	Horse gram chuni
Rice bran, Wheat bran	Groundnut (Peanut) meal	Black gram chuni
Rice bran extractions	Rapeseed meal, Sesame meal	Pigeon Pea Chuni
Tapioca	Sunflower meal, Cottonseed meal	
Molasses	Copra meal, Guar meal	Di calcium phosphate (DCP)
	Meat meal, Meat-cum-bone meal	Bone origin
	Fish meal	Mineral based

Quality Control of feed ingredients

Ingredient Quality (Qualitative)	Physical characteristics (analyst's skills): Color, Texture, Odor and Taste, Particle size (screen analysis), shape, evidence of wetting, Adulteration, damage and deterioration, bulk density storage, pests, faecal material, hairs etc, spot chemical tests.,
Ingredient Quality (Quantitative)	**Chemical analysis:** Moisture, CP, CF, EE, NFE, ash, Acid insoluble ash (silica or sand), salts, free fatty acids, biogenic amins urea, and NPN, amino acids. Anti-nutritional factor: **Extrinsic (contaminants):** mycotoxins, weeds, insecticide, herbicides, fungicides **Intrinsic:** allergins, lectins, phytoestrogens, glucosinolates (rape seed), saponins, tannins, ricin, sinapine, gossypol, (cotton seed cake), lipoxygenase, trypsin inhibitor, urea. Decomposition and rancidity test: acid value, peroxide value, etc. **Protein quality:** protein solubility or dispersibility, Nitrogen solubility, mailard reaction product, dye binding, pepsin digestibility, amino acid digestibility.

Quality Evaluation of Feeds

The feeds are usually subject to following three types of tests

- Physical
- Chemical
- Biological

Physical Evaluation:

Colour : Any change in the colour of the feed ingredients gives an indication of the maturity of the grain, storage conditions, presence of toxins, contamination due to sand, possible use of insecticides/fungicides which gives dull and dusty appearance.

Size : Size of the grains govern its energy value due to the proportional decrease/ increase in seed and its coat. Smaller the grain lower will be the ME value.

Homogeneity: The presence of contaminants like other grains, husks broken grains, weed seeds, infested seeds.

Smell: Smell is the next best indicator

Taste: Each ingredient has a different taste, any change in the taste like bitterness in the grains, soya, sunflower oil meal and groundnut cake indicates the presence of mycotoxins.

Touch: Feeling the raw material will indicate the dryness and moisture content and clumpy ness.

Sound: Dry grains on pouring down or biting will produce sound of spilling coins.

Adulterant and Contaminants

Physical Methods to Detect Adulteration or Contamination

The Common contaminant or adulterant is husk or sand. Winnowing is the best method to detect husk in the feedstuff. Sieving can be done to differentiate contaminants based on particle size. To detect for the presence of sand a weighed quantity of the grain is soaked in water then by sieving with hand the grains can be separated. The remaining water if decanted the settled sand can be weighed and the level of contamination can be assessed.

Common Adulterants of Different Feed Ingredients.

Feed ingredient	Adulterant
Groundnut cake	Groundnut husk; urea, non-edible oil cakes
Mustard cake	*Argimona maxicana* seeds, fibrous feed ingredients, urea.
Soybean meal	Urea, raw soybean
Deoiled rice bran, wheat bran	Ground rice husk, saw dust.
Fish meal	Common salt, urea, sand
Mineral mixture	Common salt, marble powder, sand, lime stone
Molasses	Water
Maize	Cobs
Rice kani	Marble, grit

Chemical Evaluation

- An analytical laboratory for the precise estimation of nutrient contents and contaminants is of utmost importance.
- Analyse the feeds for proximate principles. This indicates possible constraints on usage due to the presence of excessive content of crude fiber, fat or total ash. Low CP and high CF of oil seed meals is indicative of adulteration with fibrous material. The high CF alone is indicative of adulteration with urea and or some inferior quality oil seed meals like mahua, castor or karanja cake.
- The amount of acid insoluble ash is a good guide to the amount of sand or other dirt which may be present. The fish meals are usually adulterated with sand during drying process.

Ingredient Specifications

Ingredient specifications are essential in a feed quality assurance program. Specifications serve as the basis from which purchasing agreements are written, feed/rations are formulated and ingredient inspections are performed. Ingredient description and general nutritional specifications may be found in BIS specifications for feeds and feed ingredients in India.

Mahua cake : To water extract of the test feed add conc. H_2SO_4: Violet or pink colour indicate the presence of mahua cake.

Argimona seeds: To water extract of test feed add conc. HNO_3. Appearance of **Brown-reddish** colour indicates the presence of argimona seeds.

Detection of caster cake in feedstuffs or edible oil cakes, BIS has specified the cake methods of analysis of castor cake, linseed meal, neem seed cake, cotton seed cake

- **Detection of Neem Seed Cake in feedstuff and edible oil cakes**
- **Detection of Linseed meal in Animal Feeds**
- **Detection of unextracted cotton seed cake in Animal Feeds**
- **Detection of common salt (Sodium Chloride)**
- **Detection of urea**

Measurement of Quality of Soybean Meal

Quality of Soybean meal is tested for the presence of two antinutritional factors trypsin inhibitors and haemagglutinins, which depress the utilization of proteins and for urease activity, an indicator of level of cooking or processing applied during the preparation of soybean meal. Both the urease enzyme and trypsin inhibitor are denatured at the same rate. Due to easier assay of urease enzyme it is accepted by the feed industry worldwide

Interpretation :

Visual Examination of Soybean Meal when Treated with Urea-phenol Red Solution*:

	Urease Activity	Approximate range of urease	Assessment
Not visible red colour	Inactive	0.00	overcooked
Few scattered red particles	Slightly active	0.05 - 0.10	properly cooked
Approximately 25% or red particles	Moderately active	0.20	properly cooked
Approximately 50% or more red particles	Very active	Above 0.20	Under cooked

***Urea - phenol red solution is made as follows. Dissolve 0.14g of phenol red in 7 ml 0.IN NaOH and 35 ml distilled water. Dissolve 21g of urea in 300 ml distilled water. Mix these two solutions together and titrate to amber colour with 0.IN H_2SO_4'**

Important mycotoxins in foods and feeds

The important mycotoxins in foods and feeds are as follows:

Mycotoxins	Nature of toxin
Aflatoxins* (Most ubiquitous) and Cyclopiazonic acid	(Hepatotoxins, Immunosuppression)
Ochratoxin* and Citrinin	(Nephrotoxins, Gout)
T-2 toxin* and Diacetoxyscripenol	(Mouth lesions, Loss of appetie, Skin and Gastro-intestinal irritation)
Fumonisins* and Moniliformin	(neurological disorder, Liver damage)
Vomitoxin* and Fusaric acid	(Feed refusal, Dermatotoxins)
Zearalenone*	(Estrogenic and Reproductive disorders)

***Mycotoxins to occur in feed stuffs significantly**

Important mycotoxins in forages		
Ergot alkaloids	Sporidesmin	Fescue toxin
Tremorgens	Patulin, Vomitoxin	Zearalenone

Maximum Permissible Levels of Aflatoxin as Stated by Different agencies

Food/Feed	Maximum level
USA	
Dairy feed, feed for immature animals	100 ppb
Feed for breeding cattle, swine or mature poultry	100 ppb
Feed for finishing swine	200 ppb
Feed for feedlot beef cattle	300 ppb
BIS	
Feeds for poultry	20 ppb
Feeds for ducks	3 ppb
ICAR, New Delhi	
Feeds for chicks	150 ppb
Feeds for broilers	400 ppb
Feeds for layers	900 ppb
Feeds for breeding stock	300 ppb

Effects on health and production performance

The physical or apparent effects of mycotoxins range from reduced feed intake and poor conversion ration to a general inability of an animal to thrive. Symptoms vary toxin to toxin as shown below:

Aflatoxin	Damages liver and causes growth suppression.
T-2 toxin	Oral lesions in poultry
Ochratoxins	Kidney damage Poultry and pigs are prone to ochratoxin, whereas dairy animals can tolerant it even at higher levels because of its biotransformation by ruminal microbes.
Vomitoxin (feed refusal factor)	Affect mainly pigs and other animal
Zearalenone	Affects the reproductive organs in pigs, dairy cattle and poultry
Fmonisins	Cause nervous disorders in horses
Ergot alkaloids	Produce nervous system disorders and necrosis of legs and tail in livestock

Control of mycotoxins

The most effective methods of neutralizing mycotoxins already in feed is by binding them to an inert compound before they can be absorbed from the intestines. The ‘ideal” features of a good mycotoxin binder are:

- § Ability to bind a wide range of mycotoxins
- § Low effective inclusion rate in feed
- § Rapid and uniform dispersion in the feed during mixing
- § Heat stability during pelleting, extrusion, and during storage
- § No affinity for vitamins, minerals or other nutrients
- § High stability over a wide pH range and
- § Bio-degradability after excretion

The most appropriate practices for mycotoxin control are:

1. Prevention of fungal growth on crops in the field, at harvest time, during storage of feedstuffs and processing of feed.
2. Not when production is at its lowest but at the time of purchase of raw materials, storage, etc., so that mycotoxin levels can be limited to a minimum
3. Good feed can become contaminated with mycotoxins in livestock and poultry sheds. This can be avoided with proper management practices.
4. Application of appropriate mycotoxins binder in order to achieve good productivity and economy.

Safe level of mycotoxins in foods and feeds

Strictly speaking, there is no safe level. The risk directly depends on the level of the major mycotoxins and also on the presence and levels of other mycotoxins in feeds. What is a safe level in one farm may not be safe in another because of difference in mange mental conditions and disease prevalence. Some factors that affect the mycotoxins toxicity are: interaction of mycotoxins with pathogens, genetic variability, environmental conditions (high temperature, humidity, ammonia, etc.), sex difference and nutritional status of the poultry and livestock.

Dioxins Contamination in Animal Feed

Dioxins are highly toxic. Even minute amounts of dioxin cause damage to the nervous system and liver, apart from causing cancer. They can cause birth defects as well as mimic hormones that disrupt reproduction and human development. Dioxins released into the environment reach the food chain and get accumulated in fat. By far the greatest exposure to dioxin (over 90%) is from food. These include fish meal, fish oil, recovered vegetable oil, grease and many byproducts from the food industry, bleaching earths and kaolintic clays, milk products. When these are included in animal rations dioxins get concentrated in animal products.

Microscopic Evaluation of Animal Feed

Feed microscopy is commonly used for confirming the adulteration and identifying the adulterants (AOAC, 1970). Feed ingredients, adulterants and contaminants must be studied under low and high magnification for distinguishing features whether coarsely or finely ground. At physical characteristics such as shape, color, and particle size, softness, hardness, and texture of the feeds are examined at low magnification of 8x to 50x. It is useful method to identify impurities/contaminants and evaluating the quality of feed ingredients. It also serves as a useful method for identifying missing ingredients in finished feed.

The plant cells and structural features of the feeds are observed at high magnification of 100xto 500x since there characters are retained after grinding or even after powdering the feed ingredients..

Precise characteristics on Microscopic Identification

- Crab Products
- Fish Products
- Shrimp Meal
- Squid Products
- Blood Meal
- Meat Meal and Meat and Bone Meal
- Soybean Meal
- Peanut Meal
- Sunflower Meal
- Rapeseed Meal
- Sesame Meal
- Cottonseed Meal
- Copra Meal

Detailed microscopic observations for fish meal and rice polish are given below:

FISH MEAL

a.	Muscle fiber:	Fiber bundles which separate under pressure, yellowish to brown colour and greasy.
b.	Scales :	Transparent, round with concentric rings, flat or curled.
c.	Sand[1]:	Granular, crystalline or bead, like. Light brown to translucent, do not break under pressure.
d.	Urea[1] :	Shiny, needle like crystalline appearance craks on pressure.
e.	Meat meal[1] :	Dark brown to black, chunky with bone pieces appearing as gray to white.
f.	Salt[1]:	When treated with 0.1N Silver nitrate solution it turns into white precipitate.
RICE POLISH:		
a.	Polishings :	Yellowish to light brown, greasy, curly, thin and small flakes
b.	Grain pieces :	White translucent
c.	Husk[1]:	Scaly with longituditional Striations and yellowish.

Improvement in the quality of feed

- Choosing the best quality raw materials available
- Fortifying the nutrient content of the diet with commercially available nutrients i.e. amino acids, mineral supplements, vitamins etc.
- Using additives to enhance the availability of the nutrients e.g enzymes

Suitability of stored and damaged cereals for livestock feeding:

In India the food grains produced are usually stored in bulk by the Govt. Agencies (FCI and CWC), and to some extent by the farmers. Food grains during storage undergo certain physical, chemical and biological changes due to the presence of enzymes and biochemicals itself and the enzymes produced by the insects pests and microbes or due to some other factors. These changes may deteriorate the quality of the grains. Usually the following changes occur in the food grains during harvesting, handling, transportation and storage:

A. Physical changes

B. Chemical changes

C. Biological changes

Physical changes :

The sound and healthy grains are shining with good luster and show hardness. The various physical changes the grains undergo during storage are, dull colour, musty odour, bores in grains, sprouting of seeds, damaged kernels due to bad weather conditions.

Chemical changes:

Cereals are characterized by relatively low protein and high carbohydrate contents contained in kernel. The germ is rich in proteins, fats, sugars and minerals whereas the endo-sperm 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 enzymes which are respon-sible for quantitative and qualitative changes in carbohydrates, proteins and fats of the cereals in addition to colour, flavour and texture

Carbohydrates

Proteins

Lipids

Carbohydrates:

In India, the temperature and relative humidity varried greatly (Temp: 6-45 C ; R.H: 22-100%) during storage which causes biochemical and physical changes in grains such as bursting and gelatinisation 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 above 12 % moisture increased sucrose, glucose,fructose and rafinose contents. The storage of cereals at high moisture content also produces sour odour due to the production of alcohols and acetic acid.

Proteins :

The high temperature and production of chemicals in grains during storage denature the proteins and make them less dispersable in water, deteriorates the gluten quality and increase the free amino acids contents.

The formation of certain sulphur containing amino acids impart bad odour. The free amino acids may also undergo maillard reaction combining with the reducing sugars giving browning of the grains. The type of deterioration is possible at temperature above 20^0 C and at RH between 60-70 percent.

Lipids :

Oxidation of lipids especially the unsaturated fatty acids results in typical rancid flavours, odour and taste. Hydrolysis of lipids also increase the fatty acid (FFA) contents which is considered as a sensitive index for the grain deterioration.

Biological changes : Infestation of weevils, insects, microbes and sprouting affect the nutrient composition of the cereals, through various metabolic reactions occurring in the seed by the enzymes produced.

Insecticides and pesticides Residues: To control the infestation of insects ,pests and rodents in the food grains, several insecticides, pesticides and rodenticides are used. The residues of these chemicals must be within the prescribed limits as per the Prevention of Food Adulteration (PFA) Act.

Contaminants: The food grains are usually contaminated with foreign material viz stones, chaffs, poisonous weeds, excreta of insects, pests, rodents etc. which gives poor look to the grains. The limits of weed presence, uric acid and insect excreta described by the Govt. Of India (FCI) for the stored food grains.

Categorization of food grains:

On the basis of damage to the kernels, infestation of insects, pests, FCI has given the following categories of different grains.

Category	Weevilled/germ wheat	eaten/touched Paddy*	grains % Maize
A	Up to 1	5	5
B	1-4	5-10	5-10
C	4-7	10-15	10-15
D	7-10	15-20	15-20

*Basis of categorization is same except the incorporating designation to indicate the intensity of slightly damaged/discoloured kernels and designation are represented as 1,2,3,&4

Use of damaged food grains for feed:

As per the quality control manual of FCI the damaged food grains are classified into five categories for their disposal which may be declared fit for consumption by the livestock/poultry birds.

Class	Sound/slightly damaged/touched & broken grains %	Category for which declared fit
Feed-1	70-85	Poultry
Feed-2	55-70	Cattle
Feed-3	30-55	Industrial
Manure	10-30	Manure
Dumping	4-10	Dumping

BIS specification for cattle feed

Characteristics	Cattle (type 1)	Cattle (type 2)	Calf Starter	Calf Grower
Moisture Max%	11	11	10	10
Crude Protein Min%	22	20	23-26	22-25
Ether Extract Min%	3.0	2.5	4.0	4.0
Crude Fiber Max%	7	12	7	10
AIA Max%	3	4	2.5	3.5
Salt max% (as NaCI)	2.0	2.0	-	-
Calcium Min% (as Ca)	0.5	0.5	-	-
Available Phosphorus	0.5	0.5	-	-
Vitamin A (IU/Kg)	5000	5000	-	-

Feed Requirement of Cow weighing 400kg and yielding 10kg of milk of 4.5% FAT

	DM (kg)	CP (kg)	TDN (kg)	ME (Mcal)	Ca (g)	P (g)
Maintenance	**12.5**	**0.32**	**3.10**	**12.01**	**16**	**11**
Production **96g CP/kg** **343 g TDN/kg** **1.32 Mcal/kg** **2.8g Ca/kg** **1.7 g P/kg**		**0.96**	**3.43**	**13.20**	**28**	**17**
Total	**12.5**	**1.28**	**6.53**	**25.21**	**44**	**28**

BIS specification for mineral mixture (BIS)

Characteristics	Cattle	Sheep & goat	Poultry
Moisture Max %	05	5	03
Calcium Max%	16	30	30
Phosphorus min%	09	14	9
Magnesium Min%	04	-	0.4
Sulpher Max%	1.4	0.13	-
Salt Min%	22	-	-
Zinc Min%	0.3	0.2	0.4
Iron Min%	0.3	0.55	2000 ppm
Iodine (as KI) Min%	0.02	0.35	0.01%
Copper Min%	0.078	0.03	500 ppm
Man ganese Min%	0.1	0.08	-
Cobalt Min%	0.009	0.008	-
Flourine Max%	0.05	0.03	0.05
Total Ash%	75.0-82.0	78-85	-
AIA%	3.0	3.0	3.0
Organic Impurities	Nil	Nil	Nil

Ration Schedule

Ingredients	Quantity		
	Miltch animals	Bullocks	Calves
Wheat Straw/paddy straw/grass hay/bagasse/pulse straw/oilseed straw/ground-husk (kg)	Upto 8	Upto 8	2-7
Local tree leaves or green leaves of sugarcane/neem/pipa/ acacia / bamboo /kachnar/pakar/ sheesham /banyan/ mango/ jaman (kg)	1	1	1/2
Concentrate mixture (kg)	1	12	1/4
Mineral mixture (g)	30	30	10-20
Urea (g)	30	30	10-20

Indian Standards of Poultry Feeds (IS: 1374: 1992)

- Types of feeds : 6

  Boilers starter feed, Finisher Feed, chick feed, Growing Chicken feed, Laying chicken feed, Breeder laying feed

- Description:The feed shall be free from rancidity, musty odor, toxic ingredients, adulterants, moulds and insects infestations

- Packaging: The feed shall be packed in clean, dry and sound, plain or polyethylene lines jute or laminated paper bags.

- Aflatoxins : The Aflatoxins content of poultry feed should not exceed 500ppb

- Marking: Each bag should suitably mark so as to give the all the information of the feed: name, type, net mass batch, manufacturing year and date etc.

BIS specification for poultry feed

Characteristics	Broiler Starter	Broiler Finisher Feed	Chick feed	Growing Chicken Feed	Laying chicken Feed	Breeder Layer Feed
Moisture Max%	11	11	11	11	11	11
Crude Protein Min%	23	20	20	16	18	18
Crude Fibre Max%	6	6	7	8	8	8
AIA Max%	3	3	4	4	4	4
Salt Max% as NaCI	0.6	0.6	0.6	0.6	0.6	0.6
Calcium Min% (as Ca)	1.2	1.2	1	1	3	3
Available P Min%	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin A (IU/kg)	6000	6000	6000	6000	8000	8000
ME Min% (Kcal/kg)	2800	2900	2600	2500	2600	2600

BIS specification for pig

	Pig feed		
Characteristics	**Starter**	**Growth**	**Breeding**
Moisture Max%	11	11	11
Crude Protein Min%	20	18	16
Crude Fibre Max%	5	6	8
AIA Max%	4	4	4
Ether extract Min%	2.0	2.0	2.0
Vitamin A (IU/kg)	1700	1300	1300
Calcium, g/Kg	6	6	6
Phosphorus, g/Kg	6	4	5

Proximate composition and nutritive value of Indian fodder commonly used

	CP	CF	NFE	EE	DCP	TDN	ASH	Ca	P
Berseem (Trifolium alexandrium)	16	26	36	2.4	13	59	20	1.7	0.33
Lucerne	20	30	35	1.8	16	58	14	2.0	0.32
Bajra (Penisetum typhoides)	7	32	49	1.5	4	59	11	-	-
Maize	7	36	47	2.1	4	68	8	0.52	0.28
Oat	10	27	51	2.2	7	70	11	-	-
Sorghum	8	32	50	1.7	4	54	9	-	-
Guinea Grass	8	38	37	1.2	6	65	16	0.51	0.39
Senji (Melilotus indica)	16	32	42	3.2	13	64	10	1.4	0.18
Rice straw	3	36	44	.9	00	42	17	0.3	0.11
Wheat straw	4	38	47	00	42	11	.8	0.15	
Sugarcane tops	6	37	50	1.5	00	46	6	0.41	0.20

Thanks