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Storage and quality assessment of ingredients and formulated feeds

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Appropriate storage of ingredients and feeds is an important aspect in feed manufacturing process. Good storage is essential because the value of the feed presented to fish depends on it. Feed spoils during storage and the extend of deterioration depends very largely on the storage conditions. Since fish feeds usually contain relatively high amounts of fish meal and/or fish oil, they are very much susceptible to rancidity. In addition, loss of certain nutrients occurs during prolonged periods of storage. For these reasons, fish feeds should not be stored for longer periods (not more than 3 months). Ingredients and feeds should be stored in a cool, dry place away from direct sunlight.

Factors which affect the quality of ingredients and feeds during storage

(i) Physical loss-due to human theft, fire and the consumption of scavenging animals, such as rats and birds

(ii) Insect damage- various species of moths, weevils and beetles consume the feed and cause damage through weight loss and expose the feed to microbes (fungi, bacteria) for further contamination and oxidation. They grow well at normal temperatures (26-37 °C) in feed stores and can reach epidemic proportions. Insects thrive better on ground materials. Therefore, oil cakes and whole cereals can be stored for longer period than meals made from them.

(iii) Fungal damage- In general, fungi grow at relative humidity above 65%, moisture contents generally above 15% and temperatures above 25° C which are specific to the fungal species. Higher temperatures and moisture levels favour increased growth. Even though most fungi are killed during the processing of ingredients, their spores are resistant and have the potential to re-infect the material later if the environmental conditions become favourable for their development.

Fungal growth causes weight loss, increases in temperature and moisture, staleness (off-flavour), discolouration and, production of mycotoxins. Mycotoxins such as 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 particularly prone to contamination with mycotoxins.

(iv) Chemical changes- changes in the chemical quality of the feeds occur due to enzymatic actions, loss of vitamin potency and the development of oxidative rancidity. The free fatty acids which develop due to lipid break down make the feeds more prone to the development of rancidity. High lipid ingredients and materials with high levels of poly-unsaturated fatty acids are more prone to the development of rancidity than others. Ingredients such as expeller vegetable oil cakes, fish meals, and rice bran are mostly vulnerable. Rancid fats present in feeds reduce its palatability and contain toxic metabolites which may depress growth. The fermentation of carbohydrates produces alcohols and volatile fatty acids.

The availability of amino acids in the feed proteins may be reduced during long term storage due to the development and interaction of certain chemicals and due to increase in temperature. The potency of vitamins (particularly vitamins C and B1) decreases

significantly during storage (and processing). Naturally occurring vitamins in feed-stuffs also deteriorate on storage.

(v) Environmental factors- Several factors such as moisture (feed moisture content and relative humidity), temperature, light, and oxygen influence deteriorative changes and losses in feedstuffs. Temperature increases sufficient to cause fire. 'Spontaneous combustion' can occur in stacked feeds and if they are constantly full of fine atmospheric dust from grinding processes within the store or adjacent areas. Heat is also generated by the growth of fungi and insects.

Storage plan of feeds and ingredients

The prepared feeds should be treated in the same way as dry ingredients but should not be stored for a long time. Formulated feeds are more susceptible to quality deterioration than individual ingredients. This is because of interactions between different ingredients and due to cross contamination with insects and fungi. The potency of vitamins in feed declines during storage. This is because many of these organic compounds are highly reactive/unstable and can be easily denatured by oxygen, heat, moisture and ultraviolet light. Therefore, direct exposure of feed to sunlight and moisture should be avoided.

The lipids (fish oil, sunflower oil, lecithin etc.) should be kept in sealed, preferably plastic, containers, in a cool dark place. Ensure that antioxidants are added to them while manufacture.

Table 1. Average vitamin stability in stored feeds (Source: Coelho, 1991)

Vitamin	Ingredient Source	% Vitamin retention at months		
		<u>1</u>	<u>3</u>	<u>6</u>
A	Beadlet	83	69	43
D3	Beadlet	88	78	55
E	Acetate	96	92	88
K	MSBC 1	75	52	32
	MPB 2	76	54	37
Thiamin	Hydrochloride	86	65	47
	Mononitrate	97	83	65
Riboflavin	Riboflavin	93	88	82
Pyridoxine	Hydrochloride	91	84	76
B12	Cyanocobalamin	97	95	92
Pantothenic Acid	Calcium d-Pantothenate	97	95	92
Folic Acid	Folic Acid	97	83	65
Biotin	Biotin	90	82	74
Niacin	Nicotinic Acid	88	80	72
Vitamin C	Ascorbic Acid	64	31	7
	Fat Coated Ascorbic	95	82	50
	Ascorbyl Phosphate	98	90	80
Choline	Chloride	99	98	97

1 MSBC = Menadione Sodium Bisulfite Complex
 2MPB = Menadione Dimethyl PyrimidinolBisulfate

General recommendations/ guidelines for storage

- Provide a building for storage which is secure, with proper roofing, water proof and can be adequately locked
- Provide it with ventilation points. Ventilation entry points should preferably be low on the side facing the prevailing wind and high on the opposite side
- All entry points must be meshed to avoid entry by birds, rats, other pests etc.
- Raw materials which are visibly damp or mouldy or which are obviously infested with insects should not be accepted
- Ingredients should be stored for a minimum period as possible and compounded feeds used quickly, especially in tropical conditions
- Make small stacks. Even though large stacks of sacks lessen insect damage, which occurs mainly at the surface, but cause heat generation, with other consequential damage
- The feed/ ingredient sacks should be raised off the ground by stacking them on wooden pallets (platforms)
- Ensure that ingredients are clearly labelled
- Avoid walking on the stacks of compounded feeds unnecessarily to avoid the breakage of pellets and the production of wasteful fines (dust)
- Don't keep the sacks to rest against the outer walls of the store. Leave a space between the stacks and the wall to facilitate air circulation
- Don't allow staff to sleep, eat or smoke in the feed store
- Always keep the store clean. Floors and walls should be regularly swept
- Arrange the store in such a way that new deliveries are not put in front of old stocks so that the oldest materials can be used first
- As a general rule, don't keep materials longer than the following guidelines (Source: FAO):

Table 2. Shelf life of feed ingredients

Material	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

Quality evaluation of ingredients and feeds

(i) Physical

The physical indices include colour, texture, odour, particle size, shape, damage and deterioration, pest infestation, fecal material contamination, hair, bulk density, water stability, leaching, pellet hardness, durability, settling velocity measurement, presence of adulterants etc.

(ii) Chemical

The chemical evaluation includes proximate composition, pepsin digestibility, pesticide estimation, elemental analysis, estimation of Trimethyl amine (TMA) and Total Volatile Base Nitrogen (TVBN), biogenic amines, urea, NPN, peroxide value, free fatty acid value, iodine number, anisidine value, saponification number, TBARS value, antibiotics and antioxidants estimation, protein solubility etc.

(iii) Microbiological

Ingredients and feeds may be contaminated during processing, storage or transport, which may cause disease when consumed.

Therefore, it is necessary to establish surveillance programs for microbiological feed hazards. Some microorganisms introduced

during storage such as moulds, can negatively affect feed quality including reducing dry matter and nutrients, causing musty or sour odours, and producing toxins. The microbiological indices of feed quality include Total plate count (TPC), yeast and mould count, *Escherichia coli* count, coliformes, *Enterobacteriaceae* count etc.

Table 3. Common adulterants of feed ingredients

Feed ingredient	Adulterant
Fish meal	Common salt, urea, sand
De-oiled rice bran, wheat bran	Saw dust, ground rice husk
Soy bean meal	Urea, raw soy bean
Maize	cobs
Mineral mixture	Limestone, common salt, marble powder, sand
Ground nut cake	Ground nut husk, urea, non-edible oil cakes
Mustard cake	<i>Argimona mexicana</i> seeds, urea, fibrous feed ingredients

References

Coelho, M. B. (1991). Feed Management. 42:10, 24-35.

