

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.
 - a. Known shelf life of some products is marked on container (e.g., canned food).
 - b. Prepared feeds: one week after end of experiment or 8 weeks post mixing (whichever is shorter).
 - c. Ground grain: One month after milling unless stabilized.
 - d. Fats and oils:
 - Opened container: One month
 - Un-opened or stabilized: One year post mixing.
 - e. Vitamin mixtures: 6 months after preparation (exceptions of up to one year if stabilized with ethoxyquin). Vitamin C hydrolyzes more rapidly.
 - f. Whole grain or seeds: One year after harvest
 - g. 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).

Justification

Captive animals depend on caretakers for a diet that supplies adequate amounts of nutrients required for good health. Some nutrients are subject to destruction by chemical action or light. Moisture, heat, and, in some cases, light accelerate destruction of nutrients in feed ingredients. Proper preparation of feeds and appropriate storage conditions can prolong the shelf-life of feeds and ingredients, but not indefinitely. Therefore, all containers of feed and most ingredients must have an accepted expiration date. Feed should be discarded on or before this date.

How Nutrients are Destroyed:

1. Oxidation by oxygen in air or by hydroperoxides. Nutrients so destroyed include unsaturated fats, essential fatty acids, vitamins A, C, D, and biotin, and the amino acid lysine.
2. Chemical destruction catalyzed by minerals or promoted by high or low pH. This is accelerated with increasing moisture. Vitamin C and thiamine are destroyed at alkaline pH.
3. Interaction of aldehydes of carbohydrates (e.g., glucose) or oxidized fats with amino groups. This can occur at room temperature and at usual moisture content in feeds.
4. Cleavage of thiamine by sulfite. Destruction of riboflavin by light.
5. Fungal growth, nutrient destruction or production of mycotoxins. This can occur when local spots within feed or ingredients develop pockets of moisture of about 16%, usually at

the edges of the container where moisture has migrated as the temperature fluctuated.

6. Bacterial growth will develop if moisture and temperature are favorable. Nutrient degradation and production of toxins occurs readily.
7. Insect damage. Grain and grain products are easily contaminated by larvae and beetles that typically grow in grains.
8. Rodents eat and contaminate grains and feeds.

Prevention or Reduction of Damage to Feed and Ingredients

1. Grains and Grain Products:

- a. Obtain clean, insect-free grain (or treat grain with a USDA-approved insecticide). Have an effective, safe rodent control program in place.
- b. Store feed in a cool, dry location, free from conditions where condensate may form.
- c. Store large quantities of feed in tight paper containers or in ventilated cloth or papersacks or in bulk. These containers allow moisture to migrate and escape rather than condense, which allows mold growth.

Smaller quantities of feed, as present in feed mixing rooms, should be stored in closed plastic containers to prevent entry of insects, rodents, and moisture. The initial moisture content of the feed should be less than 14 %.
- d. Grind corn and other grains shortly before use. Grinding, flaking, or crimping releases the oil in the germ of the seed. This oil contains polyunsaturated fats and a limited amount of natural antioxidants. Therefore, rancidity will occur within days or weeks after grinding.

2. Protein Sources:

- a. Low-fat (<1%), dry (<12 % moisture) protein sources (e.g., casein, isolated soy protein, solvent extracted meals of soybean, peanut, etc., may be kept indefinitely). However, they should be labeled with an acquisition date.
- b. Meals with fat, usually > 2% (e.g., cottonseed meal , sunflower seed meal, meat meals, meat and bone meals, poultry meals, fish meal) have a limited shelf life that may be extended to about 6 months if an appropriate antioxidant (e.g., ethoxyquin, TBHQ, BHA-BHT) has been added. These meals should be stored in a cool location (ideally <77° F, although this may not be possible under summer conditions at the field labs). In summer, use these ingredients within 2 months of milling.
- c. Whole seeds (soybeans, cottonseed, sunflower, etc.) will keep for at least one year in a cool location. Their oil is contained in oil glands along with a natural antioxidant.

3. Fats and Oils:

- a. Unopened containers of vegetable oil should keep for one year only. However, once opened and exposed to air, the oil begins to oxidize. The oil may be stabilized by adding ethoxyquin (Santoquin from Novus, Inc., St. Louis, MO), or TBHQ (Eastman Organic Chemicals) at levels such that the total amount of these preservatives in the final feed does not exceed 0.0125% of the diet (125 mg/kg

- feed).
- b. "Stripped" oils or fats are used in some studies. They have been stripped of all antioxidants by the process of molecular distillation. These products are stored in a nitrogen atmosphere or at very low temperatures. They are mixed into diets shortly before use, and the diets prepared fresh at least once/week or more frequently, unless an antioxidant is added to the feed.
 - c. Vitamin E or naturally occurring tocopherols are not as good antioxidants as are the synthetic ethoxyquin or tertiary butyl hydroquinone (TBHQ). The acetate derivative of vitamin E (d,l-alpha tocopherol acetate) is not an antioxidant in feed. It is a stable vitamin E source. The acetate is hydrolyzed in the intestines so that the tocopherol becomes a good antioxidant in tissues. Ethoxyquin is absorbed from the gut and is an antioxidant in tissues. Exceeding the recommended dietary level of 125 mg ethoxyquin/kg of diet could have pharmacological effects.
4. Mixed Feeds:
- a. The moisture content of feed should be <12%. Store feed in closed bags in a cool dry place. Prevent rodent and insect exposure.
 - b. Add an antioxidant to the feed (or with the added fat) at time of preparation
 - c. If no antioxidant is added, store feed in a cool location for a limited period of time.
 - d. If glucose monohydrate (dextrose, cerelose) is used as a feed ingredient, consider that glucose will react with the free amino groups of protein and added amino acids within hours to days.
 - e. Vitamin C (ascorbic acid) is stable for only days, not weeks. Ascorbic acid phosphate is a commercially available, stable form of vitamin C. It is required in diets for primates, guinea pigs, fish, and probably lizards and some other types of animals.
 - f. Add vitamin premixes to diets to provide all the vitamins at concentrations 4 to 5 times required level stated in the National Research Council publications on nutrient requirements of Animals (Government Printing Office, Constitution Ave., Washington, DC), except when the experimental protocol requires otherwise.
5. Vitamin and Mineral Premixes:
- a. Vitamin premixes usually contain some ethoxyquin, and the vitamins A and E are added as the stable acetate derivatives.
 - b. Vitamin C is usually not added to vitamin premixes but rather is added separately just before mixing. However, ascorbic acid phosphate is a stable form of vitamin C, albeit more expensive.
 - c. **DO NOT MIX VITAMINS AND MINERALS TOGETHER IN A PREMIX!** This is done by some commercial mills, even done successfully using special preparations, but it is not a good, general recommendation.
 - d. **MINERAL** premixes are usually stable indefinitely. The carrier is usually limestone or calcium carbonate; the trace minerals are the sulfate salts (less or non-hygroscopic) (biologically available). However, zinc carbonate, zinc oxide, and manganous oxide are biologically available. (The oxides of iron, copper and the carbonates of iron, copper, and manganese are not biologically available).

- e. Calcium iodate (CaIO_3) is a stable, biologically available form of iodine. Potassium iodide (KI) is unstable, especially in mineral premixes.
- f. Selenium is usually added to the diet as sodium selenite. Selenite may be added to the vitamin mix or may be added as a separate premix, usually with limestone or calcium carbonate as the carrier. Selenium is not very stable in mineral premixes. SELENIUM is toxic and should normally not exceed 3 times the NRC recommended level. At 10 X toxic signs appear.
- g. Other inorganic mineral sources (calcium phosphates, sodium, potassium, magnesium, and calcium salts) are stable indefinitely.