

## DEPARTMENT OF GRAIN SCIENCE AND INDUSTRY

# Evaluating Feed Components and Finished Feeds

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Ingredient quality is the foundation upon which an animal ration is built. Therefore, establishing an ingredient quality evaluation program is an essential component of a successful feed processing operation. Routine evaluation of finished feed quality will help ensure that proper ingredient storage, proportioning, grinding, and mixing were performed.

This bulletin contains information pertaining to ingredient specifications, suggestions on which feed ingredient and finished feed properties should be analyzed, types of assays to perform, and how to interpret lab results.

The first step in evaluating ingredients and finished feed quality involves collecting a representative sample as described in the bulletin, *Sampling: Procedures for Feed* (Herrman 2001).

## Ingredient Specifications

Ingredient specifications are essential to a quality assurance program. Specifications serve as the basis from which purchasing agreements are written, feed rations are formulated, and ingredient inspections are performed. Ingredient descriptions and general nutritional specifications may be found in the following publications: *AFIA Feed Ingredient Guide II* (American Feed Industry Association (AFIA), 1992), the Association of American Feed Control Officials (AAFCO) *Official Publication* (2000), and the *Feedstuffs Reference Issue* (2001).

A partial list of nutritional properties of these ingredients are in Table 1.

## Sensory and Physical Properties

Sensory property evaluation, including inspection of ingredient color, odor, texture, moisture, temperature, and a visual inspection for physical purity (absence of foreign material and insect infestation) enables one to

quickly assess whether the ingredient should be rejected. It also enables the person responsible for receiving the ingredient to confirm product identity (same as recorded on the bill of lading). The inspection process should be accompanied by a reference sample for comparison.

Physical property evaluation usually involves testing incoming grain and feed ingredients for bulk density, purity, and texture. All of these

properties will determine how the material unloads, conveys into and out of bins, stores, and performs during processes.

**Bulk density** of a material represents the mass per unit volume. This characteristic is commonly expressed as pounds per cubic foot (lb/ft<sup>3</sup>) or kilograms per cubic meter (kg/m<sup>3</sup>). The bulk density of a material is measured by weighing the amount of material that fills a one-cubic-foot box. Bulk density can vary significantly for the same ingredient due to differences in particle size, moisture content, or compaction. Bulk density of a feed ingredient is important for inventory control purposes and will determine how the ingredient will perform during batching and blending. When a feed ration requires blending ingredients that differ widely in bulk density, the feed processor should ensure that the particle size of the feed ingredients is similar, use a binding agent (fat or molasses), and load the mixer using an ingredient sequence that optimizes the blending action of the mixer. For example, high-density ingredients should be added early to vertical mixers and late in the batching sequence for horizontal mixers.

**Test weight** is a bulk density measurement applied to grain, and the value represents the weight (expressed as pounds) in a Winchester bushel (2150.42 cubic inches). Specifications for test weights of different

**Table 1. Ingredient Profile**

| Ingredient                       | Protein     | Fat        | Fiber      | Ash         | Moisture   | Calcium | Phosphorus | Magnesium | Pepsin Digest | % Brix |
|----------------------------------|-------------|------------|------------|-------------|------------|---------|------------|-----------|---------------|--------|
| Alfalfa                          |             |            |            |             |            |         |            |           |               |        |
| Sun-cured (13%)                  | 13.2        | 1.9        | 33.0       | 7.5         | 11.0       |         |            |           |               |        |
| Sun-cured (15%)                  | 15.2        | 1.9        | 30.0       | 7.2         | 11.0       |         |            |           |               |        |
| Dehydrated (15%)                 | 15.2        | 2.3        | 30.0       |             | 7.5        |         |            |           |               |        |
| Dehydrated (22%)                 | 22.2        | 3.0        | 20.0       |             | 7.5        |         |            |           |               |        |
| Corn                             |             |            |            |             |            |         |            |           |               |        |
| Corn Gluten Feed                 | 18.0 - 24.0 | 0.5 - 1.0  | 6.2 - 7.8  | 7.3         | 11.0       |         |            |           |               |        |
| Corn Gluten Meal                 | 41.0 - 43.0 | 1.0 - 2.5  | 4.0 - 6.0  |             | 11.0       |         |            |           |               |        |
|                                  | 60.0 - 65.0 | 1.0 - 5.0  | 0.5 - 2.5  | 1.8         | 13.0       |         |            |           |               |        |
| Cottonseed Meal                  | 41.0        | 0.9 - 3.3  | 9.2 - 13.4 |             | 8.0 - 10.0 |         |            |           |               |        |
| Fat                              |             |            |            |             |            |         |            |           |               |        |
| Feathermeal                      | 80.0 - 85.0 | 2.5        | 1.5        | 3.0         | 10.0       |         | 0.75       |           | 75.0          |        |
| Limestone                        |             |            |            | 98.0        |            | 38.0    |            | 1.0       |               |        |
| Methaden Fish Meal               | 60.0        | 11.0       |            |             | 7.0 - 11.0 |         |            |           | 92.0          |        |
| Meat/Bone Meal                   | 50.4        | 10.4       | 2.4        | 31.5        | 7.0        | 9.0     | 4.1        |           | 86.0          |        |
| Middlings                        | 15.5 - 17.5 | 3.5 - 4.5  | 8.0 - 9.0  |             |            |         |            |           |               |        |
| Molasses                         | 9.0         |            |            | 9.0         | 23.0       |         |            |           |               | 79.5   |
| Rice Mill Feed                   | 7.4         | 6.7        | 26.0       | 19.0        | 8.0        | 0.6     | 0.6        |           |               |        |
| Peanut Meal <sup>1</sup>         | 47.0        | 1.0        | 7.0        | 6.0         | 10.0       |         |            |           |               |        |
| Peanut Meal & Hulls <sup>1</sup> | 45.0        | 2.0        | 15.0       | 6.0         | 10.0 - 8.0 |         |            |           |               |        |
| Poultry Meal                     | 55.0 - 65.0 | 8.0 - 12.0 | 2.0 - 4.0  | 12.0 - 18.0 | 6.0 - 10.0 | 8.0     | 4.0        |           | 88.0          |        |
| Sorghum                          | 8.9         |            | 2.0        |             |            |         |            |           |               |        |
| Soybean Meal <sup>2</sup>        |             |            |            |             |            |         |            |           |               |        |
| w/ Hulls                         | 44.0        | 1.0        | 7.0        | 6.0         | 12.0       |         |            |           |               |        |
| Dehulled                         | 48.0 - 50.0 | 1.0        | 3.5        | 6.0         | 12.0       |         |            |           |               |        |
| Sunflower Meal                   |             |            |            |             |            |         |            |           |               |        |
| Dehulled                         | 46.1        | 1.6        | 13.1       |             | 10.0       |         |            |           |               |        |
| w/ Hulls                         | 32.1        | 1.6        | 23.7       |             | 10.0       |         |            |           |               |        |

<sup>1</sup> Solvent extraction of oil.

<sup>2</sup> Based on solvent extraction of the oil. Mechanical extraction will have 4% fat.

grains and grades are presented in the bulletin *Grain Grading Standards in Feed Manufacturing* (Herrman and Kuhl, 1997). The procedure for measuring test weight is included in separate bulletins listing the grains' name (e.g., *Corn: Grading Procedures, 2000*).

Ingredient **purity** refers to the absence of contaminants. The source of these contaminants may be physical (e.g., glass), chemical (e.g., seed treatment), and microbial (e.g., mycotoxin). The use of hand sieves to inspect for physical contaminants enables rapid evaluation of material. For example, the use of two sieves (12/64-inch round-holed sieve placed on top of a 5/64-inch round hole sieve) separates dockage (non-wheat material) from wheat. The material on the top sieve and the pan underneath the bottom sieve contain dockage. Visual inspection is then performed on the dockage-free wheat (wheat on top of the 5/64-inch sieve) to identify non-wheat material which is referred to as foreign material. Chemical and microbial contaminants can be performed by laboratories listed at the

back of this bulletin (Tables 2 and 3). Further details on analyses for microbial contaminants and their effect on animal performance are presented in the following bulletins: *Mycotoxins in Feed Grains and Ingredients* (Trigo-Stockli and Herrman, 2000) and *Quality Management for Feed Related Disease Prevention* (Herrman and Stokka, 2001).

**Texture** of an ingredient is measured visually and with sieves. Soybean meal texture is described visually as "homogeneous, free-flowing, without coarse particles or excessive fines" (AFIA, 1992). Soybean meal texture measured by sieve analysis is described as "95 to 100 percent through U.S. Standard Sieve No. 10; 40 to 60 percent through U.S. Standard Sieve No. 20; and a maximum 6 percent through U.S. Standard Sieve No. 80" (AFIA, 1992). For further information about sieves and particle-size analysis, refer to the bulletin titled *Evaluating Particle Size* (Herrman, 2001).

## Nutritional Properties

Nutritional properties of feed ingredients require laboratory analysis; this usually entails expensive analytical equipment operated by professional chemists. Many feed companies use commercial labs for these analyses (Table 1). Most analysis techniques involve the use of procedures tested and approved by scientific organizations such as the Association of Official Analytical Chemists' (AOAC, 2000) *Official Methods of Analysis* and the American Association of Cereal Chemists' (AACC, 1995) *Approved Methods of Analysis*.

### Moisture

Moisture content affects an ingredient's nutritional content and its performance during handling, storage, and processing. Both direct and indirect measures of ingredient and finished feed moisture are approved for feed industry use. Direct methods include oven drying and distillation while indirect methods include near infrared (NIR) spectral analysis, conductance, and water activity.

The oven drying method involves the removal of free water from a sample through heating and measurement of weight loss. This procedure is based on the principle that the boiling point of pure water is 212° F (100° C) at sea level. The likelihood that a compound will decompose or volatilize (turn from solid to vapor) determines the type of oven used (convection, forced draft, or vacuum oven). A vacuum oven lowers the boiling point of water and allows the oven drying procedure to be performed at a lower temperature, thus reducing loss of dry matter through volatilization.

Calculation of moisture content and total solids is performed as follows:

$$\% \text{ Moisture (wt/wt)} = \frac{\text{wt H}_2\text{O in sample}}{\text{wt of wet sample}} \times 100$$

where: wt H<sub>2</sub>O in sample = wet wt – dry wt

$$\% \text{ Total Solids} = \frac{\text{wt of dry sample}}{\text{wt of wet sample}} \times 100$$

In the case of semi-moist products (e.g., dog food) the Karl Fischer method is preferred. Water is extracted with methanol from pet food that contains other volatile components, and an aliquot is titrated with

Karl Fischer reagent. This test is good for products containing between 20 to 30 percent moisture (AOAC Official Method 991.02).

Moisture content in heat-sensitive feed ingredients is measured using the distillation method. In this technique, the ingredient is boiled in a solvent and water is driven off from the sample, condensed, and measured (AOAC Official Method 925.04).

Indirect moisture measurement for feed grains involves the use of an electrical moisture meter (AACC Method 44-11). Another indirect moisture measurement can be performed using a beam of light in the near infrared (NIR) frequency with a spectrophotometer. This method works well for feed grains, feed ingredients, and finished feeds.

### Protein

Proteins are comprised of amino acids which are the building blocks of protein. When formulating a complete feed, the nutritionist creates a feed ration with a complete balance of amino acids. A shortage of one amino acid in a complete ration can cause animals to experience depressed growth rate, poor feed conversion, and reduced reproductive performance. Most protein tests evaluate the nitrogen (N) content of the sample; nitrogen is present in protein molecules at about 16 percent. The combustible nitrogen analyzer has grown in popularity as the preferred method for measuring N. This technique is reliable, quick, does not involve the use of highly corrosive acids and bases, and its cost is fairly reasonable. Additionally, the use of optical measurement of protein content using NIR technology works well for cereal grains, oilseeds, and finished feed.

Assaying feed for individual amino acids is expensive and is seldom performed by a feed company. Thus, nutritionists use standard values for amino acid content in feed ingredients based on the National Research Council publications (NRC, 2001).

### Fat

Crude fat content is measured by extracting fat with an ethyl ether solvent and then weighing the extracted fat in a vessel after the solvent has been evaporated. Crude fat is a term that refers to both fats and oils or a mixture of the two and all other organic soluble compounds. The melting point of most fats is such that they are solid at ordinary room temperature, while oils have lower melting points and are liquids at room temperatures. Fats are high-energy ingredients containing about 2.25 times the amount of energy as other nutrients. Fat analyses should include moisture, impuri-

ties, unsaponifiable materials (M.I.U.), and free fatty acids (FFA). FFA content should not exceed 15 percent.

Additionally, NIR technology works well for measuring oil content in oilseed crops (e.g., soybeans), corn, and on complete feeds.

### Fiber

Crude fiber includes the materials that are indigestible to humans and non-ruminant animals. It is defined as the material that is insoluble in dilute acid and dilute alkali under specified conditions. Crude fiber is used as an index of an ingredient's feeding value since materials high in fiber are typically low in nutritional value.

### Minerals

Mineral analysis procedures are described in the National Feed Ingredient Association's (NFIA, 1991) Laboratory Methods Compendium, Volume I.

Calcium constitutes about 2 percent of the body weight and is important for bones, teeth, and muscle contraction and relaxation, especially the heartbeat; has a role in the transmission of nerve impulses; is necessary for blood clotting; and activates a number of enzymes.

Phosphorus is closely associated with calcium, thus, a deficiency or overabundance of one will interfere with the utilization of the other. Phosphorus is involved with bone formation and maintenance, teeth development, milk secretion, and building muscle tissue; it is an essential element in genetic material, metabolic functions, and osmotic and acid-base balance.

Magnesium interacts with calcium and phosphorus. If extremely low, magnesium will cause calcium to be deposited in soft tissues forming calcified lesions. An excess of magnesium upsets calcium and phosphorus metabolism.

Sodium helps control the osmotic pressure and acid-base balance in body fluids (upon which depends the transfer of nutrients to the cells and removal of waste material from cells). Sodium is associated with muscle contraction and nerve function.

### Pepsin Digest

Pepsin digest is a procedure used to determine the protein digestibility of animal by-product meals. Animal by-product meal is processed under extreme temperature conditions that can cause the proteins to become denatured and indigestible. Results of a pepsin digest analysis are usually reported as a percentage of pepsin indigestible residue or percent of crude protein

that is pepsin indigestible. The AFIA *Feed Ingredient Guide II* lists the following recommendations for animal by-product meals:

- **Poultry Feathers.** Not less than 75 percent of crude protein should be pepsin digestible.
- **Meat Meal.** Not more than 14 percent indigestible residue and not more than 11 percent of crude protein should be pepsin indigestible.
- **Meat and Bone Meal.** Not more than 14 percent indigestible residue and not more than 11 percent of crude protein should be pepsin indigestible.

### Urease

Urease is an enzyme (present in soybeans) that acts on urea to produce carbon dioxide and ammonia. Urease is controlled by heating to denature the enzyme, and as such, is analyzed in soybean meal to assess if it has been properly processed.

### Microscopic

All microscopic identification is based upon relating the items seen to known material. Through the use of low magnification (8 to 50 times) materials are examined and identified based on physical characteristics such as shape, color, particle size, softness, hardness, and texture. Feed microscopy is a useful method for identifying impurities/contaminants and evaluating the quality of incoming ingredients. It also serves as a useful method for identifying missing ingredients in finished feed.

### M.I.U.

M.I.U. stands for moisture, impurities, and unsaponifiable material. Fat sources should be evaluated for these components and should not exceed the following levels: moisture less than or equal to 1 percent, impurities less than or equal to .5 percent, unsaponifiable material less than or equal to 1 percent.

### Brix

Brix is a term commonly used to indicate the sugar (sucrose) content of molasses. This analysis is performed based on the optical properties of the molasses using a refractometer. Brix is expressed in degrees and is closely related to percent sucrose. The AFIA *Feed Ingredient Guide II* specifies a Brix reading of 79.5 degrees.

## Laboratories

When selecting a laboratory, price should not be the only consideration. It is important to find out which professional association laboratory personnel belong to and analytical techniques used. Official methods are tested and approved by members of these professional organizations: i.e., Association of Official Analytical Chemists (AOAC) or American Association of Cereal Chemists (AACC).

Some membership affiliations to look for include: AOAC, AACC, American Chemical Society, American Oil Chemists Society, National Oilseed Processors Association, American Fats and Oils Association, National Institute of Oilseed Products, and NFIA. Also check to see if the lab participates in check sample programs provided by the Association of American Feed Control Officials (AAFCO), American Feed Ingredients Association, and other professional organizations.

Table 2 presents a partial list of labs and mailing address, phone number, and web address where services and prices are listed. Laboratories and services appearing in this publication are used for identification only. No endorsement is intended, nor is criticism implied of laboratories not mentioned.

Most labs will analyze for individual components as well as offer special rates for grouped analyses. One such common group analysis is proximate analysis. Proximate analysis consists of moisture, crude protein, crude fat, crude fiber, ash, and nitrogen-free extract.

## Analytical Variation (AV)

AAFCO has established analytical variation (AV) guidelines in order to assist control officials in making decisions regarding marginally acceptable products (AAFCO, 2000). These variances are intended to allow for inherent variability in sampling and laboratory analyses. They are not intended to allow for deficiencies or excesses in a product or poor analytical techniques. Table 3 shows the analytical variances for some of the common ingredients. If the assay indicates that the ingredient is outside the analytical variance, the feed does not conform to label requirements.

The concentration range indicates for what inclusion rate (level) the Analytical Variation Percentages (AV%) apply; e.g., moisture AV% applies to feed containing between 3 and 40 percent moisture.

The AV% can be calculated using the following steps:

**Step 1:** Multiply the expected or guaranteed value by the value derived from the formula in Table 3 in the AV% column. Convert the AV% value to the decimal equivalent (move the decimal two places to the right).

**Step 2:** Add and subtract the value obtained in Step 1 to the expected or guaranteed value.

### Example:

*Suppose a sample of soybean meal was submitted for protein analysis. If the expected or guaranteed protein content was 44%, the acceptable range would be 42.9-45.1.*

$$\text{Step 1: } 44 \times \{(20 \div 44 + 2) \div 100\} = 1.08$$

$$\text{Step 2: } 44 - 1.08 = 42.9$$

$$44 + 1.08 = 45.1$$

## Drug Analysis

The FDA's Current Good Manufacturing Practices (CGMPs) stipulate that periodic assays of medicated feeds for drug components shall be performed as a means of monitoring the manufacturing process. Each category II Type A drug must be sampled and assayed three times each year. For medications containing a combination of drugs, perform the assay on only one drug each time and rotate the drugs analyzed.

If the results of these assays are outside the permissible limits listed in Tables 4 and 5 (Feed Additive Compendium, 2001), an investigation and corrective action must be implemented. The CGMPs also stipulate that "corrective action shall include provisions for discontinuing distribution where the medicated feed fails to meet the labeled drug potency. Distribution and subsequent production of the particular feed shall not begin until it has been determined that proper control procedures have been established."

Many commercial feed mills and on-farm feed processors are not required by law to conduct drug assays since they are not registered (for further information, refer to Kansas State University Extension bulletins MF-2042 and MF-2043 by Herrman et al., 2000). However, routine inspection of finished feed for drug potency is a good business practice.

Unfortunately, the CGMPs do not provide advice on how to investigate high or low drug potency. Typical sources (or reasons) for out-of-tolerance assays include the following:

- the medicated article has lost its drug potency,
- incorrect weighing of the medicated article,
- poor mixing of the medicated article into the feed,
- poor sampling technique.

One way to perform drug assays on medicated feed is to use the same sampling technique used to conduct mixer performance tests. A complete description of this procedure is listed in the bulletin titled *Testing Mixer Performance* (Herrman and Behnke, 2001). The procedure involves collecting samples from 10 representative locations in the mixer. Combine the samples to form a single composite sample for the drug assay. One half of the composite sample should be retained for a minimum of three months, in the event the first sample is out of tolerance. Also, collect and retain a sample of the medicated article. If the feed is out of tolerance, submit a sample of the medicated article and the retained portion of the feed sample for drug analysis. *Note: similar procedures may be followed for identifying the source of variation of other ingredients in complete feed.*

The CGMPs also specify methods to avoid cross-contamination of feed when using medicated articles to produce medicated feed. These methods include flushing, sequencing, and equipment clean-out. Procedures to avoid drug cross-contamination are discussed in detail in MF-2055.

### Utilizing Assay Results

After investing considerable time and capital to collect a representative sample and have it analyzed, the feed processor must manage the information. Correct information management will assist in:

- detecting ingredient/product variation,
- evaluating suppliers,
- determining the discount for substandard product,
- fine-tuning feed rations,
- explaining animal performance problems,
- meeting FDA CGMPs (if feed mill is licensed).

A simple way to utilize information involves recording lab results in table form (either by hand or on a computer spreadsheet program). Columns in the table should include the date material was received, lab number assigned to the sample, ingredient supplier, and assay results (e.g., protein, moisture). Separate data sheets should be kept for each ingredient type (e.g., grain, protein, drug). These results should be regularly compared with contract specifications to ensure suppliers are shipping ingredients that meet or exceed quality criteria. Summarize data by month and supplier to detect noticeable trends.

The use of Statistical Process Control (SPC) to evaluate assay data provides an additional management tool from which to control variability in finished feed, thus improving product quality and profitability. For

further information, read the bulletin titled *Statistical Process Control: Techniques for Feed Manufacturing* (Herrman, 2001).

### Summary

Feed ingredients should be routinely evaluated to ensure they are safe, they contain the correct amount of the specified nutrient, and to ensure the finished feed quality will optimize animal performance. A list of ingredients, their important nutritional components, where they can be tested, and how to interpret this information is provided in this bulletin.

Permitted analytical variation (PAV) guidelines are included to explain how to identify deficiencies or excesses of an ingredient in a product. If the assay indicates the ingredient is outside the PAV, the feed does not conform to label requirements. Techniques for identifying the source of variation and corrective actions are discussed.

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**Table 3. Feed Ingredient Analytical Variations**

| Ingredient                | Method <sup>a</sup>            | AV%        | Range                   |
|---------------------------|--------------------------------|------------|-------------------------|
| <b>PROXIMATE ANALYSIS</b> |                                |            |                         |
| Moisture                  | 934.01 930.15 935.29           | 12         | 3 - 40%                 |
| Protein                   | 954.01 976.05 976.06<br>984.13 | (20/X + 2) | 10 - 85%                |
| Lysine                    | 975.44                         | 20         | 0.5-4%                  |
| Fat                       | 920.39 954.02 932.02           | 10         | 3 - 20%                 |
| Fiber                     | 962.09                         | (30/X + 6) | 2 - 30%                 |
| Ash                       | 942.05                         | (45/X + 3) | 2 - 88%                 |
| Pepsin Digest             | 971.09                         | 13         |                         |
| Total Sugar as Invert     | 925.05                         | 12         | 24 - 37%                |
| NPN Protein               | 941.04 967.07                  | (80/X + 3) | 7 - 60%                 |
| <b>MINERALS</b>           |                                |            |                         |
| Calcium                   | 927.02                         | (14/X + 6) | .5 - 25%                |
| "                         | 968.08                         | 10         | 10 - 25%                |
| "                         |                                | 12         | < 10%                   |
| Phosphorus                | 964.06 965.17                  | (3/X + 8)  | .5 - 20%                |
| Salt                      | 969.10                         | (7/X + 5)  | .5 - 14%                |
| "                         | 943.01                         | (15/X + 9) | .5 - 14%                |
| Fluorine                  | 975.08                         | 40         | ppm                     |
| Cobalt                    | 968.08                         | 25         | .01 - .16%              |
| Iodine                    | 934.02 935.14 925.56           | 40         | ppm                     |
| Copper                    | 968.08                         | 25         | .03 - 1%                |
| "                         |                                | 30         | < .03%                  |
| Magnesium                 | 968.08                         | 20         | .01 - 15%               |
| Iron                      | 968.08                         | 25         | .01 - 5%                |
| Manganese                 | 968.08                         | 30         | .01 - 17%               |
| Potassium                 | 975.03 925.01                  | 15         | .04 - 8%                |
| Zinc                      | 968.08                         | 20         | .002 - 6%               |
| Selenium                  | 969.06                         | 25         | ppm                     |
| Sodium                    | a.a.                           | 20         | .2 - 4%                 |
|                           | ICP                            | 15         | .2 - 4%                 |
| <b>VITAMINS</b>           |                                |            |                         |
| Vitamin A                 | 974.29                         | 30         | 1200 - 218,000<br>IU/lb |
| Vitamin B <sub>12</sub>   | 952.20                         | 45         |                         |
| Riboflavin                | 970.65 940.33                  | 30         | 1 - 1500 mg/lb          |
| Niacin                    | 961.14 944.13                  | 25         | 3 - 500 mg/lb           |
| Pantothenic Acid          | 945.74                         | 25         | 4 - 190 mg/lb           |

<sup>a</sup> Method References are from 17th Edition, AOAC Official Methods of Analysis.

**Table 2. Laboratories Performing Feed Ingredient and Finished Feed Analyses**

Midwest Laboratories, Inc.  
13611 B Street  
Omaha, NE 68144-3693  
(402) 334-7770  
www.midwestlabs.com

AT Laboratory  
P.O. Box 752027  
Memphis, TN 38175  
(901) 363-2354

SDK Laboratories, Inc.  
1000 Cory Rd.  
Hutchinson, KS 67501  
(620) 665-5661  
www.sdklabs.com

CIH Laboratory Inc.  
10835 Ambassador Drive  
Kansas City, MO 64153  
(816) 891-7337  
www.ciisvc@ciilab.com

Servi-Tech  
1816 East Wyatt Earp  
P.O. Box 1397  
Dodge City, KS 67801  
(620) 227-7123  
(800) 468-5411  
www.servi-techinc.com

Servi-Tech  
1602 Park West Drive  
P.O. Box 169  
Hastings, NE 68902  
(402) 463-3522  
www.servi-techinc.com

Doty Laboratories  
2100 L and A Road  
Metaria, LA 70001  
(504) 833-9119  
(877) 493-3349

Barrow-Agee Laboratories  
1555 Three Place  
Memphis, TN 38116  
(901) 332-1590  
www.balabs@aol.com

Woodson-Tenent Laboratories  
313 East Helena  
Dayton, OH 45404  
(937) 222-4179  
www.wtlabs.com

Woodson-Tenent Laboratories  
3507 Delaware  
Des Moines, IA 50313  
(515) 265-1461  
www.wtlabs.com

Ralston Analytical Laboratories  
824 Gratiot Dr.  
St. Louis, MO 63102  
1-800-423-6832  
1-314-982-1310  
www.purina.com

A&L Analytical Lab, Inc.  
411 N. 3rd St.  
Memphis, TN 38105  
(800) 264-4522  
(901) 527-2780  
www.al-labs.com

Colorado Analytical Laboratory  
P.O. Box Drawer 507  
Brighton, CO 80601  
(303) 659-2313

Iowa Testing Lab  
Highway 17 North  
P.O. Box 188  
Eagle Grove, IA 50533  
(515) 448-4741  
www.iowatestinglabs.com

Livestock Nutrition Laboratory  
Services  
P.O. Box 1655  
Columbia, MO 65205  
(573) 445-4476

Romer  
1301 Style Master Dr.  
Union, MO 63084-1156  
(636) 583-8600  
(636) 583-6553 FAX  
www.romerlabs.com

**Table 4. Category I**

| Drug                              | Assay Limits                | Assay Limits  |
|-----------------------------------|-----------------------------|---|
|                                   | Type A Percent <sup>1</sup> | (Percent of Labeled Amount)<br>Type B/C <sup>2</sup>  |
| Aklomide                          | 90 - 110                    | 86- 120   |
| Amprolium with ethopabate         | 94 - 114                    | 80 - 120  |
| Bacitracin methylene disalicylate | 85 - 115                    | 70 - 130  |
| Bacitracinzinc                    | 84 - 115                    | 70 - 130  |
| Bambermycins                      | 90 - 110                    | 80 - 120 / 70 - 130   |
| Buquinolate                       | 90 - 110                    | 80 - 120  |
| Chlortetracycline                 | 85 - 115                    | 80 - 115 / 70 - 130   |
| Coumaphos                         | 95 - 115                    | 80 - 120  |
| Decoquinolate                     | 90 - 105                    | 80 - 120  |
| Dichlorvos                        | 100 - 115                   | 90 - 120 / 80 - 130   |
| Diclazuril                        | 90-110                      | 75-120  |
| Erthromycin (thiocyanate salt)    | 85 - 115                    | < 20 g/ton 70 - 115 / 50 - 150<br>> 20 g ton 75 - 125   |
| Iodinated casein                  | 85 - 115                    | 75 - 125  |
| Laidlomycin propionate            | 90 - 110                    | 90 - 115 / 85 - 115   |
| Lasalocid                         | 95 - 115                    | Type B (Cattle & Sheep):<br>80 - 120;<br>Type C (All): 75 - 125   |
| Lincomycin                        | 90 - 115                    | 80 - 130  |
| Melengestrol acetate              | 90 - 110                    | 70 - 20   |
| Monensin                          | 85 - 115                    | Chickens: 75 - 125;<br>Cattle: 510 g/ton 80 - 120;<br>Cattle: 10-30 g/ton 85-115;<br>Goats: 20 g/ton 85 - 115;<br>Liq. feed: 80 - 120 |
| Narasin                           | 90 - 110                    | 85 - 115 or 75 - 125  |
| Nequinolate                       | 95 - 112                    | 80 - 120  |
| Niclosamide                       | 85 - 20                     | 80 - 120  |
| Nystatin                          | 85 - 125                    | 75 - 125  |
| Oleandomycin                      | 85 - 120                    | < 11.25 g/ton 70 - 130<br>> 11.25 g/ton 75 - 125  |
| Oxytetracycline                   | 90 - 120                    | 75 - 125 or 65 - 135  |
| Penicillin                        | 80 - 120                    | 65 - 135  |
| Poloxalene                        | 90 - 115                    | Liq. Feed: 85 - 115   |
| Salinomycin                       | 95 - 115                    | 80 - 120  |
| Semduramicin                      | 90-115                      | 80-110  |
| Tiamulin                          | 90 -115                     | 90 - 115 or 70 - 130  |
| Tylosin                           | 80 - 120                    | 75 - 125  |
| Virginiamycin                     | 85 - 115                    | 70 - 130  |
| Zoalene                           | 98 - 104                    | 85 - 115  |

<sup>1</sup> Percent of labeled amount.<sup>2</sup> Values given represent ranges for either Type B or Type C medicated feeds. For those drugs that have two range limits, the first set is for a Type B medicated feed and the second set is for a Type C medicated feed. These values (ranges) have been assigned in order to provide for the possibility of dilution of a Type B medicated feed with lower assay limits to make a Type C medicated feed.



Table 5. Category II

| Drug                              | Assay Limits                | Assay Limits   |
|-----------------------------------|-----------------------------|--|
|                                   | Type A Percent <sup>1</sup> | (Percent of Labeled Amount)<br>Type B/C <sup>2</sup> |
| Amprolium                         | 94 - 114                    | 80 - 120   |
| Apramycin                         | 88 - 112                    | 80 - 120   |
| Arsanilate sodium                 | 90-110                      | 85-115 / 75-125                                      |
| Arsanilic acid                    | 90 - 110                    | 85 - 115 / 75 - 125                                  |
| Carbadox                          | 90 - 110                    | 75 - 125   |
| Clopidol                          | 94 - 106                    | 90 - 115 / 80 - 120                                  |
| Famphur                           | 100 - 110                   | 90 - 115 / 80 - 120                                  |
| Fenbendazole                      | 93 - 113                    | 75 - 125   |
| Halofuginone hydrobromide         | 90 - 115                    | 75 - 125   |
| Hygromycin B                      | 90 - 110                    | 75 - 125   |
| Ivermectin                        | 95 - 105                    | 80 - 110   |
| Levamisole                        | 85 - 120                    | 85 - 125   |
| Maduramicin ammonium              | 90 - 110                    | 80 - 120   |
| Morantel tartrate                 | 90 - 110                    | 85 - 115   |
| Neomycin                          | 80 - 120                    | 70 - 125   |
| Neomycin                          | 80 - 120                    | 70 - 125   |
| Oxytetracycline                   | 80 - 120                    | 65 - 135   |
| Nicarbazin (P) <sup>3</sup>       | 98 - 106                    | 85 - 115 / 80 - 120                                  |
| Nicarbazin (G) <sup>3</sup>       | 90 - 110                    | 85 - 115 / 75 - 125                                  |
| Narasin                           | 90 - 110                    | 85 - 115 / 75 - 125                                  |
| Nitarsons                         | 90 - 110                    | 85 - 120   |
| Nitromide                         | 90 - 110                    | 80 - 120   |
| Sulfanitran                       | 85 - 115                    | 75 - 125   |
| Nitromide                         | 90 - 110                    | 85 - 115   |
| Sulfanitran                       | 85 - 115                    | 75 - 125   |
| Novobiocin                        | 85 - 115                    | 80 - 120   |
| Pyrantel tartrate                 | 90 - 110                    | 80 - 120   |
| Robenidine                        | 95 - 115                    | 80 - 120   |
| Ronnel                            | 85 - 115                    | 80 - 120   |
| Roxarsone                         | 90 - 110                    | 85 - 120   |
| Roxarsone                         | 90 - 110                    | 85 - 120   |
| Aklomide                          | 90 - 110                    | 85 - 120   |
| Roxarsone                         | 90 - 110                    | 85 - 120   |
| Clopidol                          | 94 - 106                    | 80 - 120   |
| Bacitracin methylene disalicylate | 85 - 115                    | 70 - 130   |
| Roxarsone                         | 90 - 110                    | 85 - 120   |
| Monensin                          | 90 - 110                    | 75 - 125   |
| Sulfadimethoxine                  | 95 - 110                    | 85 - 115 / 75 - 125                                  |
| Ormetoprim (5:3)                  | 95 - 110                    | 85 - 115   |
| Ormetoprim (5:1)                  | 95 - 110                    | 85 - 115   |
| Sulfaethoxyipyridazine            | 95 - 105                    | 85 - 115   |
| Sulfamerazine                     | 85 - 115                    | 85 - 115   |
| Sulfamethazine                    | 85 - 115                    | 80 - 120   |
| Chlortetracycline                 | 85 - 115                    | 85 - 125 or 70 - 130                                 |
| Penicillin                        | 85 - 115                    | 85 - 125 or 70 - 130                                 |
| Sulfamethazine                    | 85 - 115                    | 80 - 120   |
| Chlortetracycline                 | 85 - 115                    | 85 - 125 or 70 - 130                                 |
| Sulfamethazine                    | 85 - 115                    | 80 - 120   |
| Tylosin                           | 80 - 120                    | 75 - 125   |
| Sulfanitran                       | 85 - 115                    | 75 - 125   |
| Aklomide                          | 90 - 110                    | 85 - 120   |
| Sulfanitran                       | 85 - 115                    | 75 - 125   |
| Aklomide                          | 90 - 110                    | 85 - 120   |
| Roxarsone                         | 90 - 110                    | 85 - 120   |
| Sulfanitran                       | 85 - 115                    | 75 - 125   |
| Aklomide                          | 90 - 110                    | 85 - 120   |
| Roxarsone                         | 90 - 110                    | 85 - 120   |
| Sulfaquinoxaline                  | 98 - 106                    | 85 - 115   |
| Sulfathiazole                     | 85 - 115                    | 80 - 120   |
| Chlortetracycline                 | 85 - 125                    | 70 - 130   |
| Penicillin                        | 80 - 120                    | 70 - 130   |
| Tilmicosin                        | 90-110                      | 85-115   |
| Thiabendazole                     | 94-106                      | >2/3 7% 85-115                                       |
|                                   | 94 - 106                    | <1/3 7% 90 - 110                                     |

<sup>1</sup> Percent of labeled amount.<sup>2</sup> Values given represent ranges for either Type B or Type C medicated feeds. For those drugs that have two range limits, the first set is for a Type B medicated feed and the second set is for a Type C medicated feed. These values (ranges) have been assigned in order to provide for the possibility of dilution of a Type B medicated feed with lower assay limits to make a Type C medicated feed.<sup>3</sup> P = powder; G = granular.

## *Notes*

## *Notes*

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