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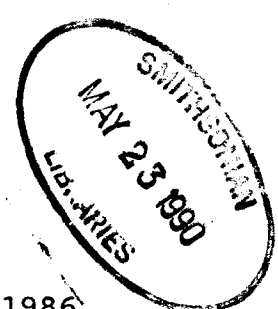

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SPECIFICATIONS FOR FEEDS USED IN ZOO ANIMAL DIETS

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INTRODUCTION

As the feeding of zoo animals becomes more scientific and more objective, some of the techniques and methods used in formulating feeds for lab animals, pets and livestock can be applied to zoo animal diets. The purpose of this paper is to acquaint the reader with types of feed formulations and their applicability to zoo animal diets. The appendix contains two examples of formulations; Appendix A is an example of an open formula herbivore diet and Appendix B is an example of a closed formula primate diet. These diets have been used at the National Zoo since 1984. They are given as examples only and, for many reasons, may not represent appropriate formulations for feeding programs in other zoos.

ADVANTAGES AND DISADVANTAGES OF COMPETITIVE BIDDING

A contract award system involving competitive bidding is a common method for the purchasing of feeds. One advantage is that objective criteria are specified. Feeds are purchased under contract according to certain ingredient or nutrient specifications. This means that a shipment of feed can be rejected if the specifications are not satisfied. Under the worst circumstances, such specifications also protect the rights of the purchaser, should legal recourse be required to settle differences. Feeds are more likely to be uniform and consistent if feed specification criteria are carefully written than if specifications are vague or non-existent.

This system was also designed to avoid favoritism in the award process. Some zoo feed contracts involve hundreds of thousands of dollars. A competitive, lowest bid system helps assure impartiality in

the award of contracts to individuals or companies. The system also helps the zoo to avoid high food costs. Expenses and profit margins must be carefully calculated by the feed supplier so that the bid submitted actually reflects a reasonable estimate. Bidding is competitive and companies are therefore less likely to inflate estimated costs of production and shipping, since each wishes to secure the contract.

A main disadvantage in this system of feed purchasing relates to the necessity of developing objective criteria. If you don't know or can't specify what you need, you probably won't get what you want. Writing specifications requires knowledge of nutrition, feeds, feed manufacturing and feed distribution. Most zoos don't have anyone on staff who is knowledgeable in these areas. Professional nutritionists in industry, in academia or in other zoos may be able to assist zoo staff in writing feed specifications. In some cases, nutritionists in feed companies will assist in developing specifications. However, this is likely only when the company has a high probability of being awarded the contract.

The main disadvantage of the system, however, relates to the difficulty in rewarding favorites. Good working relationships between zoo staff and feed manufacturers can be mutually beneficial. It is to the advantage of the zoo to deal with companies that provide good service and have responsive employees, yet the contract award system has no simple mechanism to reward such service. A supplier who consistently provides good quality fish or hay and who acts responsively if quality is questioned is an asset to a zoo commissary manager. Such relationships are rare and difficult to establish, yet they can be of great benefit in terms of food quality and consistency. In the case of manufactured feeds, company representatives may invest considerable time and effort in helping to develop feeds, yet that company may not be awarded the contract in subsequent years, even though expertise was contributed in initial product development.

In some instances, certain manufacturers can be excluded from bidding if justification for the exclusion is warranted. Justification could include a lack of response to complaints, late delivery of

feeds or provision of feeds that do not meet specifications.

Feed specifications must be written in such a way to assure that feeds of inconsistent or inferior quality are not supplied. Amounts and types of feed ingredients that make up a formulated feed can be specified exactly (see Open Formula Feeds). If specifications are written too vaguely, the manufacturer may make substitutions in order to reduce manufacturing costs. For some feeds, ingredient substitutions may be acceptable, but should only be made with the knowledge of the zoo staff. For example, some substitutions may be necessary in response to scarcity or exorbitant cost of specific ingredients, due to poor growing conditions. Substitution of ingredients, such as including corn gluten meal instead of soybean meal, or animal fat instead of vegetable oil, may change the color, flavor or texture of a feed. This may lead to feed refusals with negative consequences for animal performance, behavior and management.

In some zoos, specifications have been written to justify using certain products. For example, information about a product may be taken from the label or from company-furnished information. Specifications can then be written so narrowly that other manufacturers are unable to bid. Zoo staff may feel this is a good way to assure consistency in feeds, by restricting the "bidding"to one company, but it is not legitimate since it defeats the purpose of the bid system.

DIET FORMULATION

Development of Nutrient, Ingredient and Quality Standards

The impetus for writing feed specifications may be a desire to improve the feeds used in zoo animal diets. For a variety of reasons, many commercially available dairy, beef, swine, poultry and horse diets are not suitable for use in zoo animal diets. The purchaser usually can obtain very limited information about the ingredients and nutrient levels in such diets. The limited information on feed tags and labels is usually insufficient to allow decisions about product adequacy, especially with regard to

ingredient composition and micronutrient concentrations.

The nutrient levels specified in domestic animal diets are based upon known or estimated nutrient requirements. By contrast, the nutrient requirements of zoo animals are not well established. A nutritionist must therefore make assumptions and judgments about appropriate nutrient concentrations to include in feed formulations. Nutrient standards should be based on knowledge of animals' natural feeding habits and food selection in the wild, on gastrointestinal tract anatomy and physiology, and on desired performance objectives such as growth, lactation or maintenance. For example, a nutritionist may set minimum standards for protein, calcium, and phosphorus and maximum standards for iron, copper and sodium. It is not uncommon to specify that unusually high concentrations of some vitamins be included since some vitamins are labile. A level of 2,000 ppm of vitamin C in a dry primate diet may seem excessive, but since vitamin C may be destroyed under typical storage conditions, high levels of this nutrient should be included at the time of manufacture. A feed manufacturer must agree, if awarded the contract, that the product will comply with these standards.

Specifications may include the types of feed ingredients, such as alfalfa meal, soybean hulls and corn grain, as well as types of vitamin, mineral or amino acid supplements. A list of acceptable feed ingredients from which the diet can be made may be provided to the manufacturer. The quality of the ingredients may also be specified. For example, if soybean meal is to be used in the production of a pelleted feed, the manufacturer can be restricted to using soybean meal with a 48% protein content. The specifications may also state that contamination of the feed ingredients with foreign material (other grains, chaff or weed seeds) will be restricted to 2 to 3%, and that contamination due to mold, insect or rodent infestation will not be permitted.

The form of manufactured product, such as pellet, extruded biscuit or semi-moist cake, must also be included in the specifications. The physical dimensions of the product, such as the size of pellet or kibble, can also be specified. In addition, it is

usually common to require the manufacturer to date the bag or feed shipment and provide some identification as to lot or production number. This information is important in establishing product shelf life and in tracking information about a product should a problem arise.

Closed Formula Diets

A closed formula diet is one in which the formula is 'closed' to the public, i.e. it is maintained as a trade secret by the manufacturer. The actual ingredient composition of the diet is not provided to the purchaser. Such formulations are developed by manufacturers to meet certain standards, established by animal nutritionists, but the actual quantities and ratios of ingredients used are not released. The specifications for closed formula products may state the exact quantities (or minimum/maximum levels) of some or many nutrients, but the way in which the manufacturer meets these nutrient standards is not predetermined. In such cases a list of acceptable feed ingredients may be specified by the purchaser. The producer may then select from among the listed ingredients in formulating the product. In practice, seasonal or regional restrictions on the availability of ingredients may restrict the manufacturer to a subset of the listed ingredients.

The evaluation of zoo animal diets requires knowledge of the characteristics of all feed items that are included in the diets. When commercial, closed formula products are included in zoo animal diets, there are usually many unknown nutrient values since specific concentrations of most nutrients will be unavailable. Detailed information concerning product specifications is considered to be proprietary by most companies. Such a policy is understandable because feed companies must compete for a share of the market. Revealing 'secret formulations' may mean giving away information that could ultimately end up in a competitor's feed mill. Some manufacturers may reveal information on a specific nutrient or ingredient in response to justifiable health concerns, but will rarely make available lists of all vitamins or minerals. Feed companies that handle small orders or that will make special order custom feeds are usually more willing to provide information

on closed formula diets, although this varies considerably among companies.

One way to evaluate closed formula products is to have nutrient levels analyzed in a university or commercial laboratory. A quality control program can be established in which closed formula (and open formula) feeds are routinely screened for specific nutrients. However this is apt to be expensive ($40 to $60 per sample for proximate analysis, fiber fractions and some minerals; $60 to $120 per sample for some vitamins). Laboratory analysis of feeds on a routine basis will increase costs in the short term but is justified as an insurance against inadvertent use of products that do not contain appropriate or expected nutrient concentrations.

Open Formula Diets

An open formula diet is one in which the particular ingredients and ingredient amounts are specified, i.e. the formula is not a trade secret. Nutrient concentrations (or minimum/maximum values) are usually specified as well. Ingredient quality and amounts of acceptable foreign material are also of concern in open formula specifications.

Open formula diets are typically more expensive than closed formula diets since the manufacturer is not allowed to adjust freely the types or amounts of ingredients based on price or availability. However, there are usually minimal advertising or promotional costs for the manufacturer. Occasionally specifications are written to allow a limited number of substitutions, mainly to keep costs down. In open formula diets a nutritionist will usually include specifications for vitamin and mineral premixes to be certain that the product conforms to nutrient standards. The use of custom premixes may also add to costs. Periodic laboratory analysis of open formula feeds is important to verify that feeds contain the specified nutrient concentrations.

Knowledge of price and availability of feed ingredients and of various aspects of the milling process is essential for the successful formulation of open formula feeds. The production costs of such diets may become excessive if the specifications are unrealistic. For example, locally available feed

ingredients should be used whenever possible to avoid high transportation costs associated with shipping ingredients over long distances. A formulation that may be inexpensive for a zoo in Illinois may be prohibitive for a zoo in Florida, due to the feed ingredients used for manufacture. It is also important to take into account the pelleting or extruding properties of feed ingredients. A successful product must have appropriate physical characteristics (e.g. pellet size and hardness), must withstand shipping and must be palatable to the animals to be fed.

Among the benefits of open formula diets are product consistency from batch to batch, known levels of individual ingredients, and clearly specified nutrient additions and/or nutrient concentrations. Even if the contract for a specific feed is awarded to a different manufacturer, product composition and consistency should not differ greatly. Another advantage is that modifications to the formulation can be made easily if a nutritionist believes that specific ingredients or nutrient amounts should be raised or lowered.

In general, open formula diets are cost effective when large quantities can be ordered, such as in zoos with large ungulate or bird collections. Most large feed mills are equipped to run batches of 2 tons or more at a time, and some require even larger orders. It is therefore impractical or impossible to have small batches of custom diets manufactured on a regular basis. Specifications can be written for feeds used in small amounts but for practical reasons these are usually of a closed formula type.Some specialty feed manufacturers have the capability and are willing to run small batches of custom (open formula) feeds (500 lbs. or less), but production costs are usually very high per pound of feed, such that the products become expensive.

CONCLUSION

There are many instances where commercially available pet and livestock feeds are inappropriate for use in zoo animal diets. 'Making do' with feeds best suited for domestic animals may be less expensive but may also represent an unnecessary risk to some animal species. Zoo animals are unique, and many are rare and irreplaceable. Whether open or

closed formula diets are used depends on the nature of the collection, food budget and long-range objectives of a zoo's breeding program

The reasons for writing feed specifications for zoo animal diets should be obvious. Feed manufacturers and their nutritionists are usually willing to help in feed formulations and can represent a valuable resource in planning a zoo feeding program.

APPENDIX A

Open Formula Diet

SPECIFICATIONS FOR DRY FEEDS

National Zoological Park
Washington, DC 20008

A. Herbivore Breeder Diet (Open Formula)

1. This product shall be an open formula pelleted ration for use in feeding zoo herbivores, including monogastric and other nonruminant herbivores.

2. Ingredients: The manufacturer will be restricted to the following ingredients which will be incorporated into the product in the exact proportions specified:

International Feed No.	Ingredient	Percentage by weight
4-02-935	Corn, yellow, grain	32.4
1-00-023	Alfalfa meal, dehydrated (17% crude protein)	32.0
5-04-612	Soybean meal, dehulled (48% crude protein)	12.0
4-05-205	Wheat middlings	10.0
4-04-695	Molasses, cane, dried	10.0
4-07-983	Soybean oil	1.5
6-01-083	Mono-dicalcium phosphate (16% Ca, 21% P)	0.9
	Sodium chloride	0.5
	Vitamin and mineral premixes	0.5
	Sodium or calcium propionate	0.2

Supplemental vitamins and trace minerals shall be added to the ration via separate vitamin and mineral premixes. These premixes shall be formulated such that a minimum of one pound of each premix is required per ton of finished product. These supplemental premixes shall provide the following levels of fortification:

I. Vitamin premix

Vitamin	Fortification level per ton (2,000 lbs) of product	Source
Vitamin A	5,450,000 IU	Stabilized vitamin A palmitate or acetate
Vitamin D_3	454,000 IU	D activated animal sterol
Vitamin E	118,000 IU	d,l-alpha-tocopheryl acetate
Vitamin K	1.8 g	menadione activity
Thiamine	4.5 g	thiamine mononitrate
Riboflavin	3.6 g	riboflavin supplement
Niacin	36.3 g	niacin
Pyridoxine	5.5 g	pyridoxine hydrochloride
Biotin	0.18 g	biotin
Pantothenic acid	23.0 g	d-calcium pantothenate
Folic acid	2.7 g	folic acid
Vitamin B_{12}	30.0 mg	vitamin B_{12} supplement
Choline	700.0 g	choline chloride

II. Mineral premix

Element	Amount per Ton (of element, not compound)	Source
Iron	91.0 g	ferrous sulfate
Copper	6.4 g	copper oxide or sulfate
Zinc	74.0 g	zinc oxide or sulfate
Manganese	36.3 g	manganous oxide or carbonate
Iodine	0.64 g	penta-calcium ortho periodate or potassium iodate
Selenium	180 mg	sodium selenite
Cobalt	91 mg	cobalt carbonate or cobalt sulfate
Magnesium	360 g	magnesium oxide

3. Ingredient standards: Ingredients used in the manufacture of this ration will not be contaminated with any more than 3% of foreign materials such as other grains, weed seeds, chaff, etc. Nor will any mold, must or insect/rodent infestation be allowed. The average minimum nutrient concentrations of ingredients used in the manufacture of this product shall be equal to the values published in the National Academy of Sciences Publication 1684, "United States-Canadian Tables of Feed Composition". Contractors may be requested to provide a significant amount of data to show an effective ingredient quality control program is being followed.

4. Nutrient contents: The total calculated concentration of nutrients in the finished product from ingredients and from the fortifications at the time of manufacture should be as follows:

Crude protein	15.5%	Minimum
Crude fat	3.0%	"
Crude fiber	16.0%	Maximum
Calcium	0.6%	Minimum
Phosphorus	0.4%	"
Magnesium	0.2%	"
Potassium	0.8%	"
Sodium chloride	0.5%	"
Iron	100 ppm	"
Copper	7 ppm	"
Zinc	80 ppm	"
Manganese	40 ppm	"
Iodine	0.7 ppm	"
Selenium	0.2 ppm	"
Cobalt	0.1 ppm	"
Vitamin A	6,000 IU/kg	"
Vitamin D_3	500 IU/kg	"
Vitamin E	130 IU/kg	"
Vitamin K	2.0 ppm	"
Thiamine	5.0 ppm	"
Riboflavin	4.0 ppm	"
Niacin	40.0 ppm	"
Pyridoxine	6.0 ppm	"
Pantothenic acid	25.0 ppm	"
Biotin	0.2 ppm	"
Folic acid	3.0 ppm	"
Vitamin B_{12}	0.03 ppm	"
Choline	1,000 ppm	"

5. Form: The finished product shall be furnished in firmly pressed cylindrical pellets, 3/16" or 1/2" in diameter (as per directions of the National Zoological Park at the time of ordering), and packaged in 50 lb. double-walled bags that are clearly labeled with the name of the product, the name of the manufacturer, the net weight, the ingredients, the guaranteed analysis of the contents, the date of manufacturing, and the batch number under which it was processed. Codes or coding will not be acceptable for any markings specified herein.

6. Nutritional analysis: A sample of the initial and one subsequent batch (as requested by NZP) will be sent by the manufacturer to an independent laboratory for analysis of the following constituents: dry matter, crude fat, crude protein, crude fiber, ash, calcium and phosphorus. The results will be sent directly to the nutritionist at NZP, but the manufacturer will pay for these analyses.

Appendix B

Closed Formula Diet

SPECIFICATIONS FOR DRY FEEDS

National Zoological Park
Washington, DC 20008

B. Primate Feed (High Protein)

1. This product shall consist of extruded biscuits designed to be fed to both New World and Old World primates.

2. Ingredients: The manufacturer will be restricted to select ingredients from the following list for the formulation of this ration; however there is no intent to require the manufacturer to use all the ingredients that are listed:

Dried skim milk, Dehydrated alfalfa meal, Soybean meal, Ground yellow corn, Corn gluten meal, Fish meal, Animal liver meal, Oat groats, Ground wheat, Dried beet pulp, Dried bakery product, Wheat germ meal, Sugar (sucrose), Animal fat (preserved with BHA), Soybean oil, Brewers dried yeast, Irradiated dried yeast, D-activated animal sterol, Vitamin A palmitate, Vitamin A supplement, Vitamin B_{12} supplement, Vitamin E supplement, Menadione sodium bisulfite, Riboflavin supplement, Niacin, Calcium pantothenate, Folic acid, Choline chloride, Thiamine, Ascorbic acid, Pyridoxine hydrochloride, Steamed bone meal, Calcium carbonate, Dicalcium phosphate, Defluorinated phosphate, Salt, Iodized salt, Manganous oxide, Copper sulfate, Iron oxide, Iron carbonate, Manganese sulfate, Calcium iodate, Potassium iodate, Cobalt sulfate, Cobalt carbonate, Zinc oxide, Ethylene diamine dihydroiodide.

The manufacturer shall determine the amount of each ingredient used in the formulation of this ration that will ensure the nutrient contents specified in section 4, below, and that will be a palatable ration for primates.

3. Ingredient standards: Ingredients used in the manufacture of this ration will not be contaminated with any more than 3% of foreign materials such as other grains, weed seeds, chaff, etc. Nor will any mold, must, or insect/rodent infestation be allowed. Manufacturers may be required to provide a significant amount of data to show an effective ingredient quality control program is being followed.

4. Nutrient standards: The finished product at the time of manufacture shall conform to the following calculated standards:

Crude protein	24.00%	Minimum
Crude fat	5.00%	"
Crude fiber	4.00%	Maximum
Ash	6.75%	"
Amino Acids, % of Total Diet		
Arginine	1.50%	Minimum
Glycine	1.10%	"
Lysine	1.20%	"
Methionine	0.35%	"
Tryptophan	0.25%	"
Cystine	0.30%	"
Histidine	0.50%	"
Leucine	2.25%	"
Isoleucine	1.20%	"
Phenylalanine	1.20%	"
Threonine	0.85%	"
Valine	1.30%	"
Tyrosine	0.75%	"
Calcium	0.95%	"
Phosphorus	0.55%	"
Magnesium	0.10%	"
Potassium	0.90%	"
Sodium	0.34%	"
Chlorine	0.40%	"
Iron	275 ppm	"
Copper	13 ppm	"
Zinc	20 ppm	"
Manganese	40 ppm	"
Iodine	1.6 ppm	"
Cobalt	2.0 ppm	"
Vitamin A	20,000 IU/kg	"
Vitamin D_3	5,000 IU/kg	"
Vitamin E	100 IU/kg	"
Vitamin C	2,000 ppm	"
Thiamine	15 ppm	"

Riboflavin	10 ppm	"
Niacin	80 ppm	"
Pyridoxine	12 ppm	"
Pantothenic acid	40 ppm	"
Biotin	0.2 ppm	"
Folic acid	10 ppm	"
Vitamin B_{12}	0.03 ppm	"
Choline	1,500 ppm	"

5. Form: The finished product shall be furnished in extruded biscuits, 5/16" to 1/2" thick, 1"$\pm$1/4" wide, and 1 1/2" - 2" long. This product will be bagged in quantities of uniform weight and clearly labeled with the name of the product, the name of the manufacturer, the net weight, the ingredients, the guaranteed analysis of the contents, the date of manufacturing, and the batch number under which it was processed. Codes or coding will not be acceptable for any markings specified herein.