FEEDING AND NUTRITION OF LABORATORY ANIMALS

General Considerations for Feeding and Diet Formulation

A laboratory animal's nutritional status influences its ability to reach its genetic potential for growth, reproduction, and longevity and to respond to pathogens and other environmental stresses. A nutritionally balanced diet is important both for the welfare of laboratory animals and to ensure that experimental results are not biased by unintended nutritional factors. Laboratory animals require about 50 nutrients in appropriate dietary concentrations. Feed palatability and intake, nutrient absorption and utilization, and excretion can be affected by physicochemical characteristics of feeds such as physical form, sensory properties, naturally occurring refractory or anti-nutritive compounds, chemical contaminants, and conditions of storage. Many biological factors also affect nutrient requirements. In the rat and mouse, most of the microbial activity is in the colon, and many of the microbially produced nutrients are not available to the host unless feces are consumed, as is common for rats and other rodents.

DIET TYPES

It is common to classify diets for laboratory animals according to the degree of refinement of the ingredients.

Natural-Ingredient Diets

Diets formulated with agricultural products and by-products such as whole grains (e.g., ground corn, ground wheat), mill by-products (e.g., wheat bran, wheat middlings, corn gluten meal), high protein meals (e.g., soybean meal, fishmeal), mined or processed mineral sources (e.g., ground limestone, bonemeal), and other livestock feed ingredients (e.g. dried molasses, alfalfa meal) are often called natural-ingredient diets. This type of diet is relatively inexpensive to manufacture and, if appropriate attention is given to ingredient selection, is palatable for most laboratory animals. However, variation in the composition of the individual ingredients can produce changes in the nutrient concentrations of natural-ingredient diets. Soil and weather conditions, use of fertilizers and other agricultural chemicals, harvesting and storage procedures, and manufacturing or milling methods can all influence the composition of individual ingredients, with the result that no two production batches of feed are identical. The potential for contamination with pesticide residues, heavy metals, or other agents that might compromise experimental data is another disadvantage. Natural-ingredient diets are usually unsatisfactory for studies to determine micronutrient requirements, for toxicological studies that are sensitive to low concentrations of contaminants, or for immunological studies that may be influenced by antigens in diets.

Purified Diets

Diets that are formulated with a more refined and restricted set of ingredients are designated *purified diets.* Only relatively pure and invariant ingredients should be used in these formulations. Examples of such ingredients are casein and soybean protein isolate (as sources of protein), sugar and starch (as sources of carbohydrate), vegetable oil and lard (as sources of fat and essential fatty acids), a chemically extracted form of cellulose (as a source of fiber), and chemically pure inorganic salts and vitamins. The nutrient concentrations in a purified diet are less variable and more easily controlled via formulation than in a natural-ingredient diet. However, even these ingredients may contain variable amounts of trace nutrients, and experimental diets intended to produce specific deficiencies may need to be even more restrictive as to ingredient specifications. The potential for chemical contamination of these diets is also low. Purified diets are often used in studies of specific nutritional deficiencies and excesses. Unfortunately, they are not readily consumed by all species and are more expensive to produce than natural-ingredient diets.

Chemically Defined Diets

For studies in which strict control over nutrient concentrations and specific constituents is essential, diets have been made with the most elemental ingredients available, such as individual amino acids, specific sugars, chemically defined triglycerides, essential fatty acids, inorganic salts, and vitamins. Such diets are called *chemically defined diets*; they represent the highest degree of control over nutrient concentrations. Unfortunately, chemically defined diets are not readily consumed by most species of laboratory animals and are usually too expensive for general use. Although the nutrient concentrations in these diets are theoretically fixed at the time they are manufactured, the bioavailability of nutrients may be altered by oxidation or nutrient interactions during storage. Chemically defined diets that can be sterilized by filtration have been developed for use in germ-free and low-antigen studies.

Physical Form of Diets

Diets for laboratory animals can be provided in different physical forms. The most common form in use for laboratory animals is the pelleted diet, which is typically formed by adding water to the mixture of ground ingredients and then forcing it through a die. The size and shape of the holes in the die determine pellet shape and rotating blades control the length; the diet is then dried to firmness. Binders are sometimes used to improve pellet quality. Pelleted diets are easy to handle, store, and use; reduce dust in animal facilities; prevent animals from selecting choice ingredients; and tend to minimize wastage. It is not easy, however, to add test compounds or otherwise alter pelleted diets after manufacture.

Extruded diets are similar to pelleted diets except the meal is forced through a die under pressure and at high temperature after steam has been injected, so the product expands as it emerges from the die. Extruded diets are less dense than pelleted diets and are preferred by some animals (e.g., dogs, cats, and nonhuman primates). Extruded diets are not commonly used for laboratory rodents because of the increased wastage during feeding and higher production costs.

Diets in meal form are sometimes used because they permit incorporation of additives and test compounds after the diet has been manufactured. These diets are often inefficient, however, because large amounts may be wasted unless specially designed feeders are available. Also, meals cake under certain storage conditions. An additional problem is that dust generated from the feed may be hazardous if toxic compounds have been added. One solution to this problem is to add jelling agents and water to the meal to form a jelled mass that can be cut into cubes for feeding; however, the jelling agents may contain carbohydrate, amino acids, or minerals that must be accounted for in diet formulations. The gel diet requires refrigeration to retard microbial growth and must be fed daily or more frequently to maintain moisture content and thus food intake. Crumbled diets are prepared by crushing pelleted or extruded diets and screening particles to the most appropriate size for a particular age or size of laboratory animal, including fish and birds. Crumbled diets offer a method of presenting small particles of diet that, theoretically, contain all dietary ingredients present in pelleted diets. Crumbled diets offer the convenience, without the problems, of diets in meal form; they are not frequently used for rodents, however. Liquid diets have been developed to accommodate specific requirements such as filter sterilization. Liquid diets are often used in studies of the effects of alcohol on nutrient utilization and requirements. In some cases purified diets will take the form of a stable emulsion when blended with water. Neonatal animals are also fed liquid diets that are derived primarily from milk products. As with gel diets, care must be taken to store liquid diets properly to avoid microbial growth.