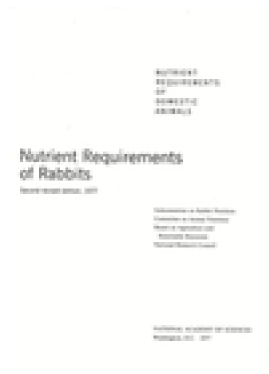

Nutrient Requirements of Rabbits, Second Revised Edition, 1977

Committee on Animal Nutrition, National Research Council

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NUTRIENT REQUIREMENTS OF DOMESTIC ANIMALS

Nutrient Requirements of Rabbits

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Subcommittee on Rabbit Nutrition
Committee on Animal Nutrition
Board on Agriculture and Renewable Resources
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1977

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Preface

This report is one of a series issued under the direction of the Committee on Animal Nutrition, Board on Agriculture and Renewable Resources, Commission on Natural Resources, National Research Council. It was prepared by the Subcommittee on Rabbit Nutrition and replaces the First Revised Edition of *Nutrient Requirements of Rabbits*, issued in 1966. The purpose of this report is to present available data on the nutrient requirements of domestic rabbits and to provide information on the application of the data to feeding these animals. Such information should be especially useful to rabbit producers, manufacturers of rabbit feeds, and scientists using rabbits in research.

The following items identify the general nature of the report:

- Data presented reflect, in most cases, new information that was not available for the previous report; however, many requirements for rabbits have not been determined.
- Nutrient requirements and signs of deficiency and toxicity, where known, are presented and discussed. Requirements for growth, maintenance, gestation, and lactation are presented in tabular form.
- Requirements for essential amino acids for growth are indicated, but requirements for other conditions are not known.
- A section on Diets and Feeding Practices includes information on Pelleted vs. Nonpelleted Feed, Particle Size and Crude Fiber, Purified and Experimental Diets, Diet Ingredients and Examples of Adequate Rations, Germ-Free Diets, and Antimicrobial Agents.
- The section on Composition of Feeds and the accompanying tables were prepared by the Subcommittee on Feed Composition from information supplied by the International Feedstuffs Institute.

The subcommittee is indebted to Philip Ross, Executive Secretary, and Selma P. Baron, Staff Assistant, of the Board on Agriculture and Renewable Resources for their assistance in the production of this report, and to William P. Flatt, Director, Agricultural Experiment Stations, University of Georgia, who served as liaison between the Committee on Animal Nutrition and the Board on Agriculture and Renewable Resources in the review of the report.

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Contents

Introduction

The domestic rabbit (*Oryctolagus cuniculus*) descended from the European wild rabbit originating in countries around the Mediterranean Sea and was introduced into England in the late eleventh or early twelfth century. The various breeds of modem domestic rabbits have been developed since the eighteenth century. There are now several hundred varieties throughout the world, varying in size, color, type of hair coat, and other characteristics. Thirty-eight breeds representing a wide range in size and other characteristics are now recognized by the American Rabbit Breeders Association. Rabbits are produced for meat, research, and wool and as pets or for a hobby. Meat production is the most important commercial aspect and will be emphasized in this report.

The New Zealand White and Californian breeds are marketed most extensively for meat. These are medium weight breeds (3.6-5.4 kg), providing a size of carcass to which the retail purchaser has become accustomed. Skins or pelts find some use in industry. Blood arid other organs and tissues used as specimens for biological and medical research are also important by-products from the large slaughtering units. Some slaughterhouse by-products may be used in pet foods. Production of wool from Angora breeds was popular at one time, but presently there is little commercial production of angora wool.

Official statistics are not available on the numbers of rabbits produced annually in the United States. It has been estimated that 4.5 to 5.4 million kg of rabbit meat is consumed annually, some of which is imported. Approximately 6 to 8 million rabbits are produced annually for all purposes. Peak production was reached in 1944, when it was estimated that about 24 million rabbits were produced. In times of national emergency, such as occurred during both world wars and in other times of food shortage, production of rabbits has traditionally increased. A growing phase of the rabbit industry is that of supplying animals for laboratory or research use. Current usage for this purpose is about 600 thousand annually.

The domestic rabbit is primarily herbivorous and will consume most types of grains, greens, and hay. Diets provided, whether home grown or commercially prepared, consist almost entirely of ingredients from plant sources. Although a few producers may still rely on homegrown feeds, a major portion of the rabbit feed presently used is commercial, pelleted feed. Since the rabbit can utilize a certain amount of forage, it has a place in food production by making use of some non-competitive feeds.

Rabbits habitually practice coprophagy, sometimes referred to as pseudorumination. This refers to the production of two kinds of fecal matter, one hard and one soft, the latter being consumed directly from the anus as it is excreted. This practice begins in rabbits shortly after they begin eating solid feed at about 3 to 4 weeks of age but is not practiced by germ-free rabbits. Fermentation in the large intestine and the practice of coprophagy probably provide the necessary amounts of most B vitamins, provide some bacterially synthesized protein, and may permit further digestion of *some* nutrients by multiple passage through the digestive tract. The high digestibility of forage protein in rabbits may be due partially to coprophagy.

The subcommittee considered the inclusion of Standard Reference Diets but found insufficient information on such diets that had been adequately tested in feeding trials. Specific requirements for many of the nutrients assumed to be needed by rabbits have not been established. The literature contains some information, and a number of significant reports have been published since the previous revision of this publication. The requirements summarized and presented in Table 1 reflect published data on intake levels reported to insure normal health and performance. A safety factor has not been added, and increased intakes may need to be considered under conditions of stress, variability in content, and availability of nutrients in the feed. Possible additional requirements under such conditions have not been evaluated, and no separate recommendations are made. Mature rabbits vary in size from 1 to 6 kg, so it is not possible to state requirements on a daily basis.

Nutrient Requirements And Signs Of Deficiency And Toxicity

ENERGY

The energy requirements for various productive functions (growth, lactation, gestation) have received little attention. Assuming that rabbits, like most animals, voluntarily adjust their feed intake to meet their energy needs, the lack of precise data on energy requirements is perhaps of less concern in rabbit diet formulation than the lack of data on requirements of most other nutrients.

Lebas (1975a) has studied the performance of growing rabbits fed diets differing in energy content. Approximately 9.5 kcal of digestible energy (DE) was required per g of body weight gain, regardless of energy content of the diet. The data suggest that a level of 2,500 kcal of DE per kg of diet will satisfy the energy needs for rapid growth, but, at energy levels lower than this, the rabbit may not be able to consume sufficient feed to meet its energy requirements for maximum growth.

Energy requirements for maintenance, gestation, and lactation of does and bucks have not been reported in detail. Lebas (1975b) has noted good reproductive performance of does fed diets of 2,500 to 2,900 kcal of DE per kg of diet. According to the results of Axelson and Erikson (1953), for an adult rabbit of 3 kg the daily metabolizable energy requirement is 200 kcal, a quantity easily provided with diets of 2,100 to 2,200 kcal of DE per kg.

Limited data on the DE content of feedstuffs for rabbits have been determined experimentally. Voris *et al*. (1940) reported digestibility coefficients for most common feedstuffs. These coefficients have been used, in conjunction with gross energy values (*NRC Atlas of Nutritional Data on United States and Canadian Feeds*), to obtain estimated DE contents of feeds. TDN values, based on the work of Voris *et al*. (1940), are also presented.

UTILIZATION OF ENERGY-PROVIDING NUTRIENTS

Carbohydrates

The fiber fraction of feeds corresponds to the structural carbohydrates of plant material. In the past, this was measured as crude fiber. In recent years, the terms "cell wall constituents" (CWC) and "acid-detergent fiber" (ADF) have become widely used. CWC consists of hemicellulose, cellulose, lignin, and silica, while ADF consists of cellulose, lignin, and silica. Few digestibility coefficients for ADF and CWC in rabbits are available. Cheeke (1974a) reported a value of 26.6 percent digestibility of barley ADF; there was a high degree of variability, with individual values ranging from 8.1 to 51.8 percent. Schurg *et al*. (1976) found digestibility coefficients of 25.0 and 36.7 percent for ADF and CWC, respectively, of whole plant corn pellets.

Because rabbits are herbivorous, it is widely assumed that they utilize plant fiber efficiently. Available data refute this assumption. Slade and Hintz (1969) report values of 18.1 percent digestibility for alfalfa crude fiber in the rabbit, whereas in the horse, pony, and guinea pig values of 34.7, 38.1, and 38.2 percent crude fiber digestibility were obtained. Fonnesbeck *et al.* (1974) reported values of 16.1 percent digestibility of cellulose and 24.7 percent digestibility of hemicellulose in the rabbit; comparable values for the rat were 20.7 and 25.9 percent. Maynard and Loosli (1969) cited an apparent digestion coefficient of 14 percent for crude fiber in the rabbit, as compared with values of 44, 41, 22, and 33 percent for cattle, horses, swine, and guinea pigs, respectively. It is apparent that the rabbit does not digest fiber efficiently.

In spite of the fact that crude fiber does not serve as an efficient energy source for rabbits, there is evidence that dietary fiber may have beneficial effects. As discussed later in this report (see chapter on Diets and Feeding Practices), nondigestible fiber may be necessary for normal functioning of the digestive tract. Davidson and Spreadbury (1975) reported that dietary fiber levels of less than 6 percent crude fiber may promote diarrhea. Lebas (1975b) has also noted that fiber levels lower than 12 percent may promote diarrhea.

Digestion of fiber in the rabbit would require the presence of cellulolytic bacteria or protozoa in the cecum and/or colon, since no mammal secretes cellulase. A few studies of the digestive tract flora of rabbits have been conducted. In contrast to the situation with many animals, the gut of the postweaning rabbit is almost devoid of

Escherichia coli and *Lactobacillus* (Smith, 1965). Compared to other animals studied, the rabbit is unique in that the flora of the large intestine is almost entirely bacteroides (Smith, 1965). Fuller and Moore (1971) also noted that bacteroide species were the dominant organism in rabbit large intestine. Gouet and Font), (1973) reported a similar finding. Many bacteroides are cellulose digesters (Hall, 1952; Hungate, 1966) so it is likely that the rabbit does have a population of cellulolytic organisms.

Hoover and Heitmann (1972) studied utilization of ADF by rabbits. Growth was significantly lower with a dietary level of 29.4 percent ADF than with 14.7 percent ADF. Lebas (1975a) obtained a similar growth rate with diets containing 10 and 18 percent crude fiber. Production of acetic, propionic, and butyric acids in the cecum was demonstrated. It was estimated that cecal fermentation produces an amount of volatile fatty. acids equivalent to 10 to 12 percent of the daily caloric requirement. Acetate is utilized by adipose tissue and mammary gland for fatty acid synthesis (Leung and Bauman, 1976; Perret *et al*., 1976).

Rabbits efficiently digest starch, the major carbohydrate in cereal grains. No special problems are encountered with the use of starch or sugars in the diet.

There is evidence that the use of grains by rabbits may be influenced by factors other than their energy content. Cheeke (1974b) found in preference trials that when given a choice, rabbits preferred barley or wheat to corn. This difference in palatability may be the explanation for the findings of Hall and Johnston (1976) that corn-based diets gave poorer growth responses than barley- or oat-based diets. In lactation diets, oats gave the best performance of four grains (wheat, oats, barley, and corn) as assessed by 3-week weights of the young (Hall and Johnston, 1976). The best performance with the lowest energy grain suggests that factors other than energy content, such as palatability, are involved.

Lipids

Thacker (1956) fed diets containing 5, 10, 15, 20, and 25 percent fat in the form of vegetable oils and found that gains of 4- to 5-week-old Dutch rabbits were greater with fat levels of 10 to 25 percent than with the 5 percent level. Arrington *et al.* (1974) also observed better performance with fat levels of 11 and 14 percent than with 2.4 and 3.6 percent. It appears that there are no special problems associated with feeding of fat to rabbits; level used in feeds is thus dictated by the prevailing *economic* relationship between fat sources and grains. Arrington *et al*. (1974) observed digestibility coefficients of 83.6 and 90.7 percent for the ether-extract fraction, largely consisting of corn oil. Inclusion of fat in the diet tends to improve palatability; Cheeke (1974) observed a preference by rabbits of a diet with 5 percent corn oil over one with no added fat; there was a distinct preference for a diet with 10 percent added corn oil over one with 20 percent oil added.

Essential fatty acid deficiency in rabbits has been demonstrated (Ahluwalia *et al*., 1967). Signs include reduced growth, loss of hair, and changes in the male reproductive system including degenerative changes in the seminiferous tubules, impaired sperm development, and decreased accessory gland weights.

PROTEIN AND AMINO ACIDS

The importance of protein quality in rabbit nutrition is well recognized. For rapid growth, rabbits are dependent upon adequate quantities of dietary essential amino acids. Bacterial protein synthesis in the cecum has been demonstrated, but this protein, obtained by means of coprophagy, apparently does not make a large contribution to the essential amino acid needs of the young rabbit. The inability of poor-quality proteins, such as zein and gelatin, to support a normal growth rate has been demonstrated by Cheeke (1971) and Kennedy and Hershberger (1974).

Dependence on dietary essential amino acids implies that nonprotein nitrogen sources would not be useful to rabbits. Numerous studies have indicated this to be true. Olcese and Pearson (1948) found that supplementation of a low-protein diet with urea did not allow for growth. King (1971) reported that substitution of part of the plant protein in a grower diet with urea resulted in decreased growth. Cheeke (1972) observed that neither urea, biuret, nor diammonium citrate improved growth when added to a low-protein diet. Lebas and Colin (1973) obtained no response by supplementing a low-protein diet with urea. These reports provide abundant evidence that nonprotein nitrogen sources cannot be employed usefully in grower diets.

Preliminary estimates of amino acid requirements of the rabbit for growth have been made. The first amino acid shown to be a dietary essential was arginine (McWard *et al*., 1967). Essentiality of arginine, methionine, and lysine was reported by Gaman and Fisher (1970) and Cheeke (1971). Adamson and Fisher (1973) reported the essentiality of numerous other amino acids. Quantitative estimates of requirements of the essential amino acids have been made, but these estimates will be subject to modification as more intensive studies are reported. For example, Adamson and Fisher (1976) have reported that the arginine requirement was overestimated in the initial studies (Cheeke, 1971; Adamson and Fisher, 1973) due to excesses of other amino acids, thus increasing the demand for arginine for urea cycle reactions. Adamson and Fisher (1973) and Davidson and Spreadbury (1975) have published estimates of requirements of all of the essential amino acids. In some of the experiments of Adamson and Fisher (1973), the growth rate of the animals was very low. Davidson and Spreadbury (1975) estimated requirements by measuring amino acid composition of diets that supported a rapid growth rate. This method may lead to considerable overestimation. In the case of lysine, methionine, and arginine requirements, more extensive studies have been conducted. These include those of Gaman and Fisher (1970), Cheeke (1971), Lebas (1973), Colin *et al*. (1973), Colin (1974, 1975a, 1975b), and Adamson and Fisher (1976). Based on these studies, there is general agreement for the following: arginine, 0.6 percent; lysine, 0.65 percent; and sulfur amino acids (methionine plus cystine), 0.6 percent of the diet on an as-fed basis. These levels will support a rapid rate of growth (35-40 g/day). Further refinements of these estimates, as well as those for other amino acids, will need to be concerned with breed and strain differences.

The value of various protein supplements for rabbits has been studied. Cheeke and Amberg (1972) found that, at equal protein levels, soybean meal or fish meal promoted growth rates of 34 g per day, while growth with cottonseed meal was 25 g per day. Supplementation of cottonseed meal with lysine and methionine increased growth rate to the level obtained with the other two supplements. Lebas (1973) found soybean meal supported a higher growth rate than obtained with sesame meal. Colin and Lebas (1976) have found rapeseed meal, horsebeans, and peas to be acceptable protein supplements after supplementation with methionine. Davidson and Spreadbury (1975) reported that fish meal, casein, and soybean meal supported greater growth than peanut meal, gelatin, and gluten when used as protein supplements. The various responses to different protein supplements are largely a consequence of their amino acid composition.

In contrast to other simple-stomached animals, such as swine and poultry, the rabbit is able to utilize efficiently the protein in forage plants. For example, in the pig the digestibility of the protein in alfalfa meal is less than 50 percent, while in the rabbit it is about 75 percent (Slade and Hintz, 1969). Thus, it is feasible to utilize considerable amounts of alfalfa in rabbit diets. Cheeke and Amberg (1972) found that a growth rate of 34 g per clay was maintained with dietary alfalfa levels between 10 and 60 percent, while with 90 percent alfalfa a growth rate of 23 g per day was observed. An isolated alfalfa protein concentrate, when substituted for soybean meal, maintained adequate growth (Cheeke, 1974); digestibility of the protein was 79 percent. This protein source had a digestibility of only 65 percent in rats. The ability of the rabbit to extract protein from fibrous forages, along with its willingness to consume these materials, suggests that greater use could be made of this animal in many protein deficient countries of the world.

The contribution of bacterial protein synthesized in the cecum and colon of the rabbit has not been evaluated quantitatively. As discussed previously, it does not appear to contribute significantly to the protein needs of growing rabbits. On the other hand, it may help to maintain nitrogen equilibrium in mature animals fed poor-quality proteins. Kennedy *et al*. (1970) demonstrated that amino acids can be absorbed rapidly from the rabbit cecum. Houpt (1963) hypothesized the secretion of urea from the blood into the cecum and colon. Mature rabbits allowed to engage in coprophagy maintained a positive nitrogen balance when fed gelatin but were in negative balance when coprophagy was prevented (Kennedy and Hershberger, 1974). Mature rabbits fed a low-protein (7 percent) diet showed a significant increase in nitrogen retention when urea was added, suggesting incorporation of urea nitrogen into protein (Slade and Robinson, 1970). Hoover and Heitmann (1975) have observed slight utilization of urea by rabbits nearing maturity.

Quantitative protein requirements depend in part on protein quality. Sufficient data have not been developed since the last revision of this report (1966) to recommend any changes in the protein requirements. Crude protein levels of 16, 12, 15, and 17 percent are recommended for growth, maintenance, pregnancy, and lactation, respectively. These values assume the use of protein of adequate quality to meet essential amino acid requirements.

MINERAL ELEMENTS

Calcium And Phosphorus

Calcium and phosphorus are major constituents of bone; in addition, calcium has metabolic roles in blood clotting, in controlling excitability of nerve and muscle tissue, and in the maintenance of acid-base equilibrium, while phosphorus is a component of such vital cellular constituents as ATP, DNA, RNA, and phospholipids.

The absorption of calcium is influenced by its level in the diet and the dietary. levels of phosphorus and vitamin D. The relative importance of these factors has not been studied critically in the rabbit. In other species, calcium absorption has been shown to be dependent on a carrier protein that transports calcium through the intestinal lining to the blood. The formation of this calcium-transporting protein is under the control of vitamin D.

The rabbit is unusual in that the serum calcium level reflects the dietary calcium level (Chapin and Smith, 1967a) rather than being homeostatically regulated to a narrow range as in other species. Another unusual concept of calcium metabolism in the rabbit is that the urine is a major route for calcium excretion (Kennedy, 1965; Besancon and Lebas, 1969; Cheeke and Amberg, 1973), while in most other animals biliary excretion is the major route. Because urinary excretion of calcium varies directly with the serum calcium level, the high urinary calcium excretion by the rabbit, especially when high calcium diets are fed (Cheeke and Amberg, 1973), is probably a reflection of the correlation between serum and dietary calcium levels in this species. Since a rise in serum calcium in most animals triggers secretion of calcitonin from the thyroid, the less efficient serum calcium homeostasis in the rabbit suggests that its calcitonin secretion rate may be low. Rabbits do respond to injected calcitonin, which will induce hypocalcemia (Lupulescu, 1974), although Salako *et al.* (1971) found hypocalcemia following calcitonin injection in the rat and mouse but not in the rabbit. Kennedy (1965) also suggests a possible role of vitamin D in stimulating the high urinary calcium excretion.

Dietary requirements for calcium and phosphorus for rabbits have been estimated. Mathieu and Smith (1961) estimated the phosphorus requirement for growth to be 0.22 percent of the diet. In an extensive study of calcium requirements, Chapin and Smith (1967a) determined that, with a dietary phosphorus level of 0.37 percent, maximum growth was achieved with 0.22 percent calcium in the diet, while 0.34 to 0.40 percent calcium was needed for maximum bone calcification. A predominantly grain diet with 15 percent good-quality alfalfa supplies enough calcium and phosphorus to allow maximum rate and efficiency of gain, while increasing the alfalfa level to 20 percent allows for maximum bone calcification as well. Chapin and Smith (1967b) reported that a diet with 0.37 percent phosphorus and 0.45 percent calcium was adequate for gestation and lactation. In view of the secretion of these elements into milk (Lebas *et al*., 1971), tentative requirements of 0.75 percent calcium and 0.5 percent phosphorus are recommended for lactation.

In nonruminant animals, phosphorus availability of plant sources is poor because of the presence of phytate phosphorus. In ruminants, bacterial phytase degrades the phytate complex, freeing the phosphorus for use by the animal. Although extensive phosphorus availability studies have not been conducted with rabbits, a reasonable assumption is that the bacterial action in the cecum and colon renders plant phosphorus available, and this has been confirmed in one report (Blanco and Gueguen, 1974).

Rabbits are tolerant of high dietary calcium levels. Chapin and Smith (1967b) found that diets containing as much as 4.5 percent calcium and a calcium: phosphorus ratio of 12:1 did not depress growth and resulted in normal bone ash. High (1 percent) levels of phosphorus are unpalatable, causing feed rejection (Chapin and Smith, 1967c).

Potassium

Hove and Herndon (1955) found that potassium deficiency in rabbits resulted in a severe and rapidly progressing muscular dystrophy. They estimated the potassium requirement for growth to be at least 0.6 percent of the diet. A deficiency is unlikely, except perhaps with prolonged feeding of a high-grain diet. Alfalfa and other forages are rich in potassium. It has been reported that high levels of potassium (0.8-1.0 percent) may induce nephritis in rabbits (Surdeau *et al*., 1976).

Sodium And Chlorine

Specific experimental data on salt requirements of rabbits are not available. Addition of 0.5 percent salt to the diet, or provision of salt blocks for free-choice consumption, are adequate means of providing these elements. Disadvantage of salt blocks include greater cost, greater labor requirements, and cage corrosion in moist climates.

Magnesium

Kunkel and Pearson (1948) characterized magnesium deficiency as causing poor growth and hyperexcitability with resulting convulsions. They estimated the magnesium requirement for growth as 30-40 mg per 100 g of diet. There is evidence that inadequate magnesium may result in fur chewing (Gaman *et al*., 1970). Woodward and Reed (1969) noted alopecia, blanching of the ears, and alteration of fur texture and luster in rabbits fed a diet containing 5.6 mg of magnesium per kg of diet. Cheeke and Amberg (1973) found that the major route for magnesium excretion in rabbits is the urine, a pattern which is similar to the unusually high urinary calcium excretion.

Iron

Iron deficiency in rabbits produces microcytic, hypochromic anemia (Smith *et al*., 1944). Specific data on iron requirements are not available.

At birth, rabbits have a very large iron reserve (Tarvydas *et al*., 1968), so the newborn are not dependent on a supply of iron in the milk. Rabbit liver has a high iron storage capacity. Iron from transferrins in the blood is incorporated into ferritin in the liver, which in the rabbit is the immediate precursor of hemosiderin (Underwood, 1971).

In view of the generous distribution of iron in feedstuffs, iron deficiency in rabbits is unlikely to be encountered under practical conditions. Because of the iron reserve at birth, the rabbit is not susceptible to iron-deficiency anemia in the preweaning phase.

Copper

A deficiency of copper results in anemia and graying of the hair (Figure 1) (Smith and Ellis, 1947). Bone abnormalities associated with copper deficiency have been reported (Hunt *et al*., 1970); the deficiency signs were accentuated by supplementation of the low copper diet with 1 percent ascorbic acid. A dietary level of 3 mg of copper per kg of diet has been suggested as approximately the requirement (Hunt and Carlton, 1965). King (1975) reported that 200 ppm added copper stimulated growth rate of young rabbits.

Selenium

The nutritional essentiality of selenium has been demonstrated for numerous species of animals. This element has been shown to be a constituent of the enzyme glutathione peroxidase, which is involved in the disposal of peroxides in tissues. The metabolism of selenium is inextricably

Figure 1 A copper-deficient rabbit, showing a graying of genetically black hair. There later develops a severe anemia (S. E. Smith, Cornell University).

involved with that of vitamin E, which functions in preventing peroxide formation. The rabbit appears to be unusual in its metabolism of these nutrients. Rabbits fed a Torula yeast diet develop muscular dystrophy; this is preventable only by vitamin E (Draper, 1957; Hove *et al*., 1958). In these studies selenium had neither protective nor "sparing effect." This is in marked contrast to the situation with rats, in which either selenium or vitamin E will prevent deficiency signs when a Torula yeast diet is fed. In rats, and most other species studied, selenium and vitamin E exert a sparing effect on each other. Jenkins *et al*. (1970) found that a low-selenium hay that induced nutritional muscular dystrophy in lambs and calves from dams fed the hay did not produce any deficiency signs when fed to young rabbits. The addition of 1 percent linoleic acid to the hay resulted in severe muscle degeneration that was not responsive to selenium. The results of these studies indicate that, in rabbits, selenium does not have a sparing effect on vitamin E and apparently does not have a role in disposal of peroxides. However, Cheeke and Whanger (1976) have found that rabbit tissues do have glutathione peroxidase activity with levels comparable to or higher than those of rat tissues. Although selenium has not been demonstrated to be a nutritional essential for the rabbit, further studies are needed to determine the significance of selenium in rabbit nutrition. On the basis of data presently available, protection against peroxide damage appears to be more dependent on vitamin E than on selenium in the rabbit.

Molybdenum

An excess of molybdenum induces copper deficiency, anemia, and other signs of toxicity (Arrington and Davis, 1953). Neither an excess nor deficiency of molybdenum in rabbits under practical conditions is likely.

Zinc

In young female rabbits fed a diet containing 0.2 ppm zinc, Shaw *et al.* (1972, 1974) observed the following deficiency signs: reduced feed consumption, lowered hematocrit, weight loss, graying of the dark hair, elevated zinc levels in the remaining dark hair, alopecia, dermatitis, and reproductive failure. Unreceptiveness to the male, apparent failure of ovulation, and a pale, inactive endometrium were factors in the lack of fertility. Since loss of appetite was pronounced, all of the above signs may be at least partially a result of reduced intake of other nutrients. In a similar study, Apgar (1971) noted sparse hair, dermatitis, weight loss, appetite depression, sores around the mouth, and wet matted hair on the lower jaw and ruff when female rabbits were fed a diet containing less than 3 ppm zinc. Quantitative data on zinc requirements for growth and reproduction have not been reported.

Cobalt

Cobalt is required for the synthesis of vitamin B_{12} by microorganisms in the digestive tract. Utilization of cobalt by the bacterial flora is much more efficient in the rabbit than in ruminants (Simnett and Spray, 1965a). After 51 weeks on a diet containing less than 0.03 ppm cobalt, no deficiency signs in rabbits were observed. Absorption of vitamin B_{12} is more efficient in the rabbit than in man, the rat, or sheep (Simnett and Spray, 1965b). In view of these results, cobalt deficiency in rabbits under natural conditions is extremely unlikely.

Manganese

Smith and Ellis (1947) have described the clinical signs of manganese deficiency in rabbits, which include maldevelopment of the skeletal system—crooked legs, brittle bones, and decreased weight, density, length, and ash content of the bones (Figure 2). Estimates of minimum manganese levels needed to prevent obvious deficiency signs are 2.5 and 8.5 mg of manganese per kg of diet for adults and growing animals, respectively. These estimates are derived from the studies of Smith and Ellis (1947).

Iodine

Iodine requirements of rabbits have not been studied. A sound management practice is the use of iodized salt, especially in low-iodine areas. Although the exact requirements are not known, diets should probably contain at least 0.2 mg of iodine per kg of diet. Excessive intakes have been observed to cause high mortality of the newborn, but amounts required to cause the toxic effects were much greater than would be present in diets without added iodine (Arrington *et al*., 1965).

Figure 2 A manganese-deficient rabbit showing crooked front legs, which reflect the generally abnormal bone development (S. E. Smith, Cornell University).

FAT-SOLUBLE VITAMINS

The qualitative need of rabbits for many of the known vitamins has been determined, but quantitative needs have been estimated for only a very few.

Vitamin A

Payne *et al*. (1972) found that 8 µg of vitamin A per kg of body weight per day was adequate for growth of female and breeding male rabbits. This corresponded to a level of 580 IU of vitamin A per kg of diet. However, reproducing females required somewhat more than the highest level fed, which was 14 µg per kg of weight, or 1,160 IU per kg of diet. They suggested that this requirement may approximate 20 µg. Normally rabbits obtain their vitamin A as pro-vitamin A, principally carotene. Phillips and Bohstedt (1938) showed that 50 µg of carotene per kg of body weight prevented symptoms of vitamin A deficiency and permitted normal growth and reproduction. Relatively large doses of carotene have been used by some (Mellanby, 1935; Mann *et al*., 1946) to effect a rapid recovery from the deficiency state. Unfortunately, the efficiency of the rabbit in converting carotene to vitamin A is unknown.

Signs of vitamin A deficiency in rabbits are similar to those described for other animals and include retarded growth, neural lesions, ataxia, spastic paralysis, xerophthalmia, and impaired reproduction (Nelson and Lamb, 1920; Mellanby, 1935; Phillips and Bohstedt, 1938; Lamming *et al*., 1954a, 1954b). In addition, Lamming *et al.* (1954b) demonstrated a high incidence of hydrocephalus with stenosis of the cerebral aqueduct among rabbits reared by females maintained on low-carotene diets for a period of 14 weeks prior to mating. Lack of appetite is characteristic of a vitamin A deficiency in rabbits (Saksena *et al*., 1971); these authors also noted abnormal elasticity of the lungs and aorta associated with a decreased elastin content.

Vitamin D

Although the quantitative requirement of vitamin D for the rabbit has not been determined, symptoms of rickets have been produced with diets that were deficient in this vitamin (Goldblatt and Moritz, 1925; Mellanby and Killick, 1926). Jarl (1948) fed rabbits a diet low in vitamin D with a narrow calcium:phosphorus ratio and demonstrated that interference with bone calcification was only temporary since by 8 to 12 weeks of age bone growth was equivalent to that of control rabbits fed supplemental vitamin D.

Ringler and Abrams (1970, 1971) observed probable vitamin D toxicity in rabbits fed a diet containing 23,000 IU of vitamin D per kg. The observed signs were high blood levels of both calcium and phosphorus and calcification of soft body tissues. Similar observations were noted in another case of hypervitaminosis D in a commercial rabbitry (Stevenson *et al*., 1976).

Vitamin E

Laboratory studies using semipurified diets are in good agreement that the daily vitamin E (α-tocopherol) requirement is about 1 mg per kg of body weight (Mackenzie and McCollum, 1940; Eppstein and Morgulis, 1941; Hove and Harris, 1947; Hove *et al*., 1957). However, Ringlet and Abrams (1970, 1971) encountered widespread signs of vitamin E deficiency in a commercial herd of rabbits fed a locally formulated natural diet that provided approximately 1 mg of α-tocopherol per kg of body weight (16.7 mg/kg of diet). In other species of animals it is known that the dietary vitamin E requirement is increased in diets containing autooxidizable substances, as polyunsaturated fatty acids, and very low levels of selenium. Thus, it appears wise to recommend a level of vitamin E for natural, commercial diets somewhat higher than 16.7 mg per kg of diet. There are insufficient data in the literature to permit a sound recommendation, and, in the meantime, a level of 40 mg per kg of diet is suggested.

Diehl (1960) and Diehl and Kistler (1961) observed a one-third decrease in body tocopherol levels in rabbits showing liver lesions due to coccidiosis infections when compared to noninfected controls. They suggested that, clue to the prevalence of this infection, many rabbits used in laboratory studies may be in a state of hypovitaminosis E.

Muscular dystrophy in rabbits, or cod-liver oil injury, as it is referred to in the early literature, is today recognized as being primarily caused by a vitamin E deficiency. Signs of this syndrome include degeneration of the skeletal and cardiac muscles, paralysis, and fatty liver (Bragdon and Levine, 1949). That muscular dystrophy may not be due to a simple deficiency of vitamin E is indicated by studies in which deficiencies of choline (Hove and Copeland, 1954) or potassium (Hove and Herndon, 1955) have been implicated. Proctor *et al.* (1961) produced this dystrophy in young rabbits fed a diet high in Torula yeast, and it was not prevented by supplements of either vitamin E or selenium. Still unexplained is the observation of Kaminura and Sasaki (1965) that the topical application of α-tocopherol significantly accelerates the growth of hair in rabbits. Ringler and Abrams (1971) reported on a vitamin E deficiency problem in a rabbit colony in which muscular dystrophy and death of neonates and infertility in breeding does was observed. The diet contained 16.7 mg of α-tocopherol per kg.

Vitamin K

Limited studies indicate that intestinal synthesis of vitamin K is sufficient for normal growth but that supplemental amounts may be needed for reproduction (Hogan and Hamilton, 1942; Moore *et al.*, 1942). Moore *et al.* (1942) fed a diet deficient in vitamin K to pregnant rabbits and observed placental hemorrhage and abortion of the young. A level of 2 ppm vitamin K in a purified diet is adequate to prevent hemorrhage and abortion (F. Lebas, unpublished data).

WATER-SOLUBLE VITAMINS

There is now good evidence that requirements for various members of the vitamin B complex are partially or even completely satisfied through the routine practice of coprophagy. In this manner a major portion of vitamins synthesized in the intestinal tract are recycled by coprophagy and made available to the animal.

Riboflavin And Pantothenic Acid

Olcese *et al*. (1948) found that rabbits grew normally when fed pantothenic acid-deficient and riboflavin-deficient diets, and, furthermore, these rabbits excreted amounts of these vitamins greatly in excess of dietary intakes. Owen *et al*. (1970) has reported contrary evidence insofar as riboflavin is concerned. In this study, rabbits were fed a riboflavin-deficient purified diet, and no riboflavin was detected in the cecum. The difference may have been due to the different diets used, i.e., natural vs. purified ingredients.

Niacin

Substantial synthesis of niacin occurs in the intestinal tract of rabbits fed niacin-deficient diets (Olcese *et al*., 1949; Kulwich *et al*., 1953), but such rabbits respond significantly in growth when fed additional niacin up to 11 mg per kg of body weight (Wooley and Sebrell, 1945; Wooley, 1947). As is true for other animals, niacin can be synthesized from tryptophan, and niacin-deficient rabbits have been shown to respond when fed this amino acid (Wooley, 1947; Kulwich *et al*., 1953). Dietary deficiencies of niacin have resulted in pronounced loss of appetite followed by emaciation and diarrhea (Wooley and Sebrell, 1945).

Thiamine

Reid *et al*. (1963) found that rabbits fed a thiamin-free diet averaged about 3 µg of thiamin per g of dry matter in the cecal contents and thus confirmed the intestinal synthesis of this vitamin. However, intestinal synthesis supplied inadequate amounts of this vitamin in that some rabbits developed a mild ataxia after prolonged feeding of the deficient diet. Reid *et al*. (1963) reported that rabbits fed a thiamin-free diet along with a thiamin antagonist (neopyrithamin) developed ataxia, flaccid paralysis, convulsions, coma, and death.

Pyridoxine

Pyridoxine deficiency, as reported by Hove and Herndon (1957a), is characterized by a decreased rate of growth and dermal and neurological signs that are similar to those observed in pyridoxine-deficient rats and pigs. These workers prevented the appearance of pyridoxine deficiency signs by feeding 39 µg of the vitamin per g of diet.

Choline

Choline deficiency signs were prevented when a level of 0.12 percent choline chloride was added to the diet (Hove *et al*., 1954, 1957). The choline deficiency syndrome in rabbits has been described as retarded growth, fatty and cirrhotic liver, and a necrosis of the kidney tubules (Hove *et al*., 1954, 1957). A progressive muscular dystrophy has been reported in rabbits fed a choline-deficient diet for more than 70 days (Hove and Copeland, 1954).

Vitamin B^{12}

Although common rabbit diets are practically devoid of vitamin B_{12}, a large urinary and fecal excretion of this vitamin has been demonstrated (Kulwich *et al*., 1953; Rosenthal and Cravitz, 1958). The amounts are such that the rabbit should not be dependent on a dietary source. Simnett and Spray (1961) have shown that vitamin B_{12} serum, fecal, and urinary levels are influenced by the nature of the diet, particularly its content of cobalt, which, of course, is required for the synthesis of the vitamin.

Ascorbic Acid (Vitamin C)

With respect to ascorbic acid requirements, the evidence indicates that the rabbit does not require a dietary source of vitamin C. Harris *et al.* (1956) demonstrated that young rabbits kept for periods up to 25 weeks on an ascorbic acid-free diet gained weight normally and continued to excrete considerable amounts of the vitamin in their urine. This confirms the earlier observations of Nelson *et al*. (1922) and Hogan and Ritchie (1934).

Biotin

A deficiency of biotin, characterized by loss of hair and dermatitis, occurs in those cases where raw egg white was fed over a period of time (Lease *et al.*, 1937).

Diets And Feeding Practices

PELLETED VS. NONPELLETED FEEDS

Observation of rabbits indicates that they prefer a pelleted diet to one in a meal form. They will adjust to a meal diet and accept it satisfactorily, but during the adjustment period intake may be very low and feed spillage excessive. Some individuals may refuse to consume a nonpelleted experimental diet. Unless fat or molasses is added to the diet, dustiness may be a problem with meal-type diets, further contributing to their lack of palatability.

Chapin (1965) compared performance of growing rabbits on a commercial pelleted diet (0.48 × 0.63 cm) with the same diet in the ground form. He also compared performance on a commercial meal-form diet with the same diet pelleted. In each case, growth rate and feed efficiency were significantly better with the pelleted diets. Lebas (1973) also observed improved growth performance with pelleted diets, and King (1974) reported similar findings.

PARTICLE SIZE AND CRUDE FIBER

Physical form and particle size of feed ingredients may be factors to be considered in rabbit diet formulation. Lebas (unpublished observations) has found that the particle size of alfalfa may influence the occurrence of enteritis. Fine grinding (more than 25 percent passing a 0.25-ram screen and 90 percent passing a 1.0-mm screen) tends to promote diarrhea, whereas coarsely ground material does not. The presence of undigestible fiber of large particle size in the cecum and colon may be necessary for maintenance of the epithelial tissue of these organs (Lebas, 1975b). Replacement of a poorly digested fiber source, such as alfalfa, with a well-digested fiber source, such as beet pulp, may provoke diarrhea (Lebas, unpublished observations). These observations, as well as undocumented statements of commercial rabbit producers, suggest that the presence of undigestible fiber of large particle size is necessary for normal functioning of the rabbit digestive tract, and that the absence of this material, either through fine grinding or the use of digestible sources of fiber (beet pulp), may result in changes in the cellular structure of the digestive tract lining and diarrhea. This aspect of feed preparation warrants considerably more study.

PURIFIED AND EXPERIMENTAL DIETS

Studies involving strictly purified diets for rabbits are few. In most cases, natural materials such as alfalfa or green feed have been included. Gaman *et at.* (1970) reported the composition of a purified diet that gave satisfactory results; rabbits were fed this diet for periods up to 2.5 yr during all stages of growth and reproduction. No problems were encountered; performance was similar to that of control animals fed a commercial diet. Composition of the diet is shown in Table 2. The vitamin mixture used may contain an excess of some of the vitamins, and it includes some vitamins (e.g., ascorbic acid) for which no dietary need has been demonstrated.

If possible, purified diets should be pelleted to increase their acceptability and to minimize waste. Diets should be kept under refrigeration to avoid rancidity, or an approved antioxidant may be added. Use of highly basic mineral mixtures should be avoided. Hove and Herndon (1955) found that potassium acetate or potassium carbonate in a mineral mixture led to rapid deterioration of the diet. Cheeke (1972) observed that Torula yeast has potent antioxidant activity and that inclusion of 2 percent Torula yeast in a diet will stabilize it. The use of lard or tallow in place of corn oil is also of assistance in preventing rancidity.

Acceptability of feeds by rabbits is a problem in nutrition research. Cheeke (1974) has examined feed preferences. While more extensive data are needed, this work suggests some dietary modifications that may be helpful if palatability is a problem. Adult Dutch male rabbits showed a marked preference for a barley-based diet containing sucrose over the same diet without sucrose, and preferred the plant proteins, soybean meal and cottonseed meal, over meat meal and fish meal. A diet with 5 percent corn oil was strongly preferred over a similar diet with no added corn oil, and a 10 percent level of corn oil was preferred over a 20 percent level. Further identification of preferences or dislikes of rabbits would aid in formulating acceptable diets.

DIET INGREDIENTS AND EXAMPLES OF ADEQUATE RATIONS

Rabbits consume many kinds of feeds satisfactorily. The feeds selected for use should be determined by relative costs and regional availability.

The following simple classification of feeds will guide the discussion of the merits of individual feed ingredients.

- Green or succulent feeds. Typically average 70-90 percent of H_2O. Growing pasture plants, root crops, cabbage, etc.
- Dry feeds. As fed will average only 10-15 percent of H_2O.
- Roughages. Those having high fiber content and relatively low digestibility and therefore low in energy value. Hay, etc.
- Concentrate feeds. Those having low fiber content and relatively high digestibility and therefore high in energy value.
- High carbohydrate concentrates. Those relatively high in the more digestible carbohydrates but low in protein content. The cereal grains (corn, wheat, oats, etc.) and their milled by-products as wheat bran, middlings, hominy feed, etc.
- Protein supplements. Those that are high in protein. Soybean meal, peanut meal, dried milk by-products, etc.

The green feeds are widely fed to rabbits, especially by small producers. They are generally succulent and highly palatable. However, the cost per unit of nutrients is too high for the commercial producer, and the high water content renders them bulky and too low in energy for efficient production of meat or for lactating females.

The dry roughages, primarily hay, normally make up about 40-80 percent of the diet for rabbits. While relatively low in energy value, the hays are economical sources of many nutrients, notably protein, some vitamins, and some mineral elements and furnish necessary amounts of fiber for a balanced diet. There are two principal classes of hay: legume (alfalfa, clovers, etc.) and grass (timothy, bluegrass, orchard grass, etc.). As a group the legume hays are superior to the grass hays in that they are generally more palatable, are significantly higher in protein and in calcium, and are preferred by the rabbit. In most sections of the country, alfalfa is generally used.

The high carbohydrate concentrate feeds are primarily rich sources of energy and, when added to the roughage, increase the energy density of the mixture to the point where it is adequate to meet the higher energy needs of producing rabbits—growth, meat production, and lactation. These concentrates may be fed as whole grains, ground and fed as a meal, or compressed into pellets. Some whole grains such as flint corn are so hard that grinding improves digestibility significantly.

Protein supplements are concentrate feeds that are high in protein, and they are used to increase the level of protein in the total diet to the recommended level. For the most part, protein supplements of most interest to rabbit growers are derived from plants rather than the more expensive animal protein supplements. The most widely used is soybean meal, though, in usual feed combinations, linseed meal, peanut meal, and sesame meal may also be used successfully. If cottonseed meal is used, it should be treated for removal of gossypol, and even then it should be limited to no more than about 5-7 percent of the diet.

Miscellaneous feeds include a wide variety of ingredients that are of little interest to commercial producers but may be of interest to small operators. Table wastes, except meat, fat, or spoiled foods, are acceptable. Milk and milk by-products are excellent but usually are too expensive. In some countries many weeds are used by small producers, and a summary of these is given by Aitken and Wilson (1962).

In practice, salt is generally added to a diet at a level of 0.5 percent or provided free choice as a salt block. The example diets in Table 3 are adequate in mineral elements so far as is known.

Since the great majority of rabbit breeders, including those raising rabbits in medical and biological laboratories, use commercially prepared pelleted feeds, the diets in Table 3 are formulated on the basis of suitability for pelleting. It should be stressed that many other feed combinations are possible.

Certain feeds are of interest because of their detrimental effects. There is evidence that cottonseed meal may have a cumulative toxic effect (Holley, 1955). This, in addition to the high sensitivity of rabbits to gossypol in untreated cottonseed meal, would suggest caution in its use until further research is done. It has been demonstrated by several workers that the feeding of large amounts of cabbage or rapeseed produces goiter in rabbits as well as in other species (Yamamoto, 1959; Fedelli-Avanzi and Janella, 1976). Other toxic feeds are listed by Aitken and Wilson (1962).

GERM-FREE DIETS

The nutrient requirements for germ-free rabbits have been subjected to only a few studies, but the requirements, except for B vitamins, do not appear to be fundamentally different from those of conventional rabbits. Some differences have been noted in the absorption of iron and copper (Reddy *et al*., 1965).

In the absence of intestinal flora, vitamins of the B complex must be present in the diet to supply those otherwise synthesized by conventional animals. Nutritionally adequate diets for germ-free rabbits have been described by Reddy *et al.* (1968).

ANTIMICROBIAL AGENTS

Antibiotics, sulfonamides, and nitrofurans added to the feed or drinking water have been evaluated for their effects upon growth or the control of coccidiosis and enteritis. In general, the antibiotics have not shown consistent beneficial effects upon growth, but in some cases they have aided in the control of enteritis. Sulfonamides are of value in the control of coccidiosis, and nitrofurans have had limited effect upon enteritis. The research with these agents and the practical aspects of their use have been reviewed by Hagen (1974). The use of antibiotics and other antimicrobial agents is controlled by federal regulations, and readers should consult the Food and Drug Administration (FDA) regarding the latest rulings on use of feed additives.

At present the following agents with amounts and indications for use are permitted in rabbit feeds. Oxytetracyclene at a level of 10 g per ton is permitted as an aid in stimulating growth and improving feed efficiency. Sulfaquinoxaline, 0.025 percent, continuously for 30 days, 0.025 percent intermittently for 2 days per week, or 0.1 percent for 2 weeks may be included as an aid in controlling coccidiosis due to *Eimeria stiedae*.

Lawrence and McGinnis (1952) reported no improvement in growth of rabbits fed Terramycin in amounts up to 50 mg per kg of diet. Chlortetracyclene (100 mg/kg of diet) and oxytetracyclene (50 mg/kg) had no effect upon growth except in the doe's first litter. The high levels of antibiotic reduced the incidence of enteritis and mortality due to enteritis but had no effect on the young once enteritis had appeared (Casady *et al*., 1964a). Zinc bacitracin (50 mg/kg of diet) likewise was found to have no effect upon growth but reduced evidence of enteritis (Casady *et al*., 1964b). No evidence of increased growth was observed by Huang *et al*. (1954) with Terramycin, Aureomycin, or Aureomycin plus vitamin B_{12}.

Studies in England have indicated beneficial effects of oxytetracyclene, chlortetracyclene, and virginiamycin upon growth, but no effect was noted with penicillin (King, 1962, 1966, 1967, 1974a, 1974b). Flavomycin was observed to decrease feed intake and improve feed efficiency but had no effect upon daily gain (Schlolaut and Lange, 1973).

Sulfamethazine (0.05 to 1.0 percent) in the feed, sulfamerazine (0.02 percent) in the drinking water, and sulfaquinoxaline (0.02 and 0.05 percent) in the drinking water controlled liver coccidiosis. Intestinal coccidiosis was successfully treated with 50 mg of sulfaguanidine per 100 g of diet daily for 2 weeks. Sulfamonomethoxine and sulfadimethoxine (75 mg/kg of body weight) were also effective. Limited studies with nitrofurans have indicated some effect upon growth and enteritis. Furazolidone (50 g/ton) increased weaning weight and reduced the incidence of enteritis. Nitrofurazone and furazolidone separately and in combination did not prevent liver lesions from coccidiosis, but the combination had some detrimental effect on the life cycle of coccidia (reports on sulfonamides and nitrofurans cited by Hagen, 1974).

TABLES

TABLE 1 Nutrient Requirements of Rabbits Fed Ad Libitum (Percentage or Amount per kg of Diet)

Nutrients[a]	Growth	Maintenance	Gestation	Lactation
Energy and protein				
Digestible energy (kcal)	2500	2100	2500	2500
TDN (%)	65	55	58	70
Crude fiber (%)	10-12[b]	14[b]	10-12[b]	10-12[b]
Fat (%)	2[b]	2[b]	2[b]	2[b]
Crude protein (%)	16	12	15	17
Inorganic nutrients				
Calcium (%)	0.4	-[c]	0.45[b]	0.75[b]
Phosphorus (%)	0.22	-[c]	0.37[b]	0.5
Magnesium (mg)	300-400	300-400	300-400	300-400
Potassium (%)	0.6	0.6	0.6	0.6
Sodium (%)	0.2[b,d]	0.2[b,d]	0.2[b,d]	0.2[b,d]
Chlorine (%)	0.3[b,d]	0.3[b,d]	0.3[b,d]	0.3[b,d]
Copper (mg)	3	3	3	3
Iodine (mg)	0.2[b]	0.2[b]	0.2[b]	0.2[b]
Iron	—[c]	—[c]	—[c]	—[c]
Manganese (mg)	8.5[e]	2.5[e]	2.5[e]	2.5[e]
Zinc	—[c]	—[c]	—[c]	—[c]
Vitamins				
Vitamin A (IU)	580	—[c]	>1160	—[c]
Vitamin A as carotene (mg)	0.83[b,e]	—[f]	0.83[b,e]	—[f]
Vitamin D	—[g]	—[g]	—[g]	—[g]
Vitamin E (mg)	40[h]	—[c]	40[h]	40[h]
Vitamin K (mg)	—[i]	—[i]	0.2[b]	—[i]
Niacin (mg)	180	—[j]	—[j]	—[j]
Pyridoxine (mg)	39	—[j]	—[j]	—[j]
Choline (g)	1.2[b]	—[j]	—[j]	—[j]
Amino acids (%)				
Lysine	0.65	—[g]	—[g]	—[g]
Methionine + cystine	0.6	—[g]	—[g]	—[g]
Arginine	0.6	—[g]	—[g]	—[g]
Histidine	0.3[b]	—[g]	—[g]	—[g]
Leucine	1.1[b]	—[g]	—[g]	—[g]
Isoleucine	0.6[b]	—[g]	—[g]	—[g]
Phenylalanine + tyrosine	1.1[b]	—[g]	—[g]	—[g]
Threonine	0.6[b]	—[g]	—[g]	—[g]
Tryptophan	0.2[b]	—[g]	—[g]	—[g]
Valine	0.7[b]	—[g]	—[g]	—[g]
Glycine	—[c]	—[g]	—[g]	—[g]

[a] Nutrients not listed indicate dietary need unknown or not demonstrated.
[b] May not be minimum but known to be adequate.
[c] Quantitative requirement not determined, but dietary need demonstrated.
[d] May be met with 0.5 percent NaCl.
[e] Converted from amount per rabbit per day using an air-dry feed intake of 60 g per day for a 1-kg rabbit.
[f] Quantitative requirement not determined.
[g] Probably required, amount unknown.
[h] Estimated.
[i] Intestinal synthesis probably adequate.
[j] Dietary need unknown.

TABLE 2 Purified Diet for Rabbits[a]

Ingredient	% of Diet
Isolated soy protein	20.0
Purified cellulose[b]	16.0
Corn oil	5.0
Mineral mixture[c]	6.6
Vitamin mixture[d]	0.2
Choline chloride (70%)	0.1
Antioxidant (Ethoxyquin)	0.025
DL-Methionine	0.2
α-Tocopherol acetate	50 IU/kg
Glucose monohydrate	15.0
Corn dextrin	5.0
Corn starch	27.4
Water (for pelleting)	5.0

[a] Gaman and Fisher (1970).
[b] Solka Floc, Brown Co., New York, N.Y.
[c] Composition (in mg/kg): $CoCl_2 \cdot 6H_2O$,3.5; $CuSO_4 \cdot 5H_2O$, 34.6; $MnSO_4 \cdot H_2O$, 81,1; $ZnSO_4$, 169; $FeC_6H_5O_4 \cdot 14H_2O$, 706.3; $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$, 22.7; (in g/kg): K_2HPO_4, 10; $KHCO_3$, 10; $NaHCO_3$, 8; NaCl, 5; $CaCO_3$, 12.5; $CaHPO_4$, 10.
[d] Composition (in mg/kg): thiamine-HCl, 25; riboflavin, 16; Ca pantothenate, 20; pyridoxine-HCl, 6; biotin, 0.6; folic acid, 4; menadione, 5; vitamin B_{12}, 0.02; ascorbic acid, 250; niacin, 150; vitamin A, 10,000 IU; vitamin D_3 600 IU; α-tocopherol acetate, 10 IU.

TABLE 3 Examples of Adequate Diets for Commercial Production

Kind of Animal	Ingredients	% of Total Diet[a]
Growth, 0.5 to 4 kg	Alfalfa hay	50
	Corn, grain	23.5
	Barley, grain	11
	Wheat bran	5
	Soybean meal	10
	Salt	0.5
Maintenance, does and bucks, avg. 4.5 kg	Clover hay	70
	Oats, grain	29.5
	Salt	0.5
Pregnant does, avg. 4.5 kg	Alfalfa hay	50
	Oats, grain	45.5
	Soybean meal	4
	Salt	0.5
Lactating does, avg. 4.5 kg	Alfalfa hay	40
	Wheat, grain	25
	Sorghum, grain	22.5
	Soybean meal	12
	Salt	0.5

[a] Composition given on an as-fed basis.

Composition of Feeds

Tables 4 and 5 give the composition of feeds commonly used in rabbit diets.* Two larger compilations are available.†

NOMENCLATURE

In previous NRC nutrient requirement reports, the names of the feeds gave considerable detail as to the way the feed was processed and the grade or quality designation. In this publication short names are used. A complete short feed name consists of as many as eight components. However, only the components needed to identify the feed are used. The components are as follows:

- Origin (or parent material)
- Species, variety, or kind
- Part eaten
- Process(es) and treatment(s) undergone before fed to animal
- Stage of maturity
- Cutting or crop
- Grade or quality designation
- Classification

Feeds of the same origin (and the same species, variety, or kind, if one of these is stated) are grouped into eight classes, each of which is designated by the "International Feed Number." The numbers and classes they designate are as follows:

1. Dry forages and roughages
2. Pasture, range plants, and forages fed green
3. Silages
4. Energy feeds
5. Protein supplements
6. Minerals
7. Vitamins
8. Additives

Feeds that in the dry state contain on the average more than 18 percent of crude fiber are classified as forages or roughages. Feeds that contain 20 percent or more of protein are classified as protein supplements. Products that contain less than 20 percent of protein and less than 18 percent etude fiber are classified as energy feeds.

Abbreviations have been devised for some of the terms in the short feed names (Tables 6 and 7).

A six-digit "International Feed Number" is listed in Tables 4 and 5 for each feed. The first digit is the class of the feed. This feed number may be used as the "numerical name" of a feed when making up a diet with electronic computers. This number is also listed after each "Legal Feed Definition" in the Association of American Feed Control Officials Handbook.*

A description of how the short names are made up is given in Table 7. When written out in linear form, the names in Table 7 would appear as follows, with a comma between each component.

Feed No. 1: Clover, red, hay, s-c
Feed No. 2: Soybean, seeds, meal solv extd 44% protein
Feed No. 3: Wheat, grain, soft white winter

* These tables were prepared by the Subcommittee on Feed Composition, Committee on Animal Nutrition, National Research Council: Charles W. Deyoe, *Chairman*, J. R. Aitken, Joe H. Conrad, Lorin E. Harris, Paul W. Moe, R. L. Preston, Peter J. Van Soest, and the International Feedstuffs Institute, Logan, Utah.

† Publication 1684, *United States-Canadian Tables of Feed Composition* , lists about 400 feeds. Publication 1919, *Atlas of Nutritional Data on United States and Canadian Feeds,* lists about 6,150 feeds. Both are published by the National Academy of Sciences, Washington, D.C.

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The names may vary slightly in each report because changes are made as more is known about a given feed or because the Association of American Feed Control Officials or the Canada Feeds Act may change the name or definition of a feed. However, if the feed is the same, the international feed number remains the same even though the name changes.

LOCATING NAMES IN THE TABLES

To locate the name of a feed in the table of feed composition, one must know the name of the parent material (e.g., the origin of the feed) and usually the variety or kind of parent material. Parent materials are of four types: plant, animal, poultry, and fish. For a feed derived from a plant, the origin term is the name of the plant (e.g., Alfalfa, Barley, Oats). For a feed derived from animals or poultry, the origin term is the name of the animal or bird (e.g., Cattle, Chicken, Whale). For a feed of fish origin, the original term is "Fish" followed by the species or variety (e.g., Fish, cod; Fish, menhaden).

When the specific origin of a feed derived from poultry or fish is not known, the origin term is "Poultry" or "Fish." When a specific origin of a feed derived from animals is not known, the origin term is the name of the animal product (i.e., Blood, meal). Molasses is listed under "Molasses."

DATA

Little data have been published on biological feed values for rabbits. In view of this, digestible energy (DE), digestible protein, and total digestible nutrients (TDN) were calculated from digestion coefficients of Voris *et al.* (1940).

Where digestion coefficients were not available, digestible energy and digestible protein were calculated for dry forages (class 1 feeds) and green forages (class 2 feeds) by formulas of Fonnesbeck and Harris.*

For legumes, DE (kcal/kg) = 4,340 - 68X and, for grasses, DE (kcal/kg) = 4,340 - 79X, where X equals crude fiber percentage on a dry basis.

Digestible protein (percent) = 0.85X - 2.5, where X equals protein percentage on a dry basis.

The analytical data are expressed in the metric system and are on an as-feed and dry basis. Analytical data may differ in the various NRC reports because the data are updated for each report. Individual feed samples may vary widely from averages in the tables of feed composition. Variations are influenced by factors such as crop, variety, climate, soil, and length of storage. Therefore, the values given should be used with judgment and related, if possible, to analyses about the feed on hand for critical nutrients.

See Table 8 for stages of maturity, Table 9 for weight-unit conversion factors, and Table 10 for weight equivalents.

* P. V. Fonnesbeck and L. E. Harris, 1976, unpublished data, International Feedstuffs Institute, Utah State University, Logan, Utah.

TABLE 4 Composition of Some Common Rabbit Feeds, Excluding Amino Acids

Line No.	Scientific Name / Short Name / American Feed Control Name (AAFCO) / Canada Feeds Act Name (CFA) / Other Names	International Feed No.[a]	As-Fed Basis and Dry Basis (Moisture Free)											
			Dry Matter (%)	DE (kcal/kg)	TDN (%)	Protein Total (%)	Protein Dig (%)	Crude Fiber (%)	Ether Extract (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Chlorine (%)	Copper (mg/kg)
1	ALFALFA. *Medicago sativa*													
2	—fresh	2-00-196	24	620	14	4.9	3.5	6.5	0.8	10.1	2.2	0.45	0.11	2.6
3			100	2540	57	19.9	14.4	26.5	3.2	41.3	9.1	1.87	0.48	10.9
4	—hay, s-c, early bloom	1-00-059	89	2200	50	17.7	12.9	24.9	2.4	37.3	8.1	1.33	—	19.3
5			100	2470	56	19.9	14.3	28.0	2.7	41.8	9.0	1.49	—	21.7
6	—hay, s-c, full bloom	1-00-068	88	1780	40	13.3	9.1	30.6	1.6	35.5	7.8	1.13	—	10.31
7			100	2000	45	15.0	10.3	34.4	1.9	40.0	8.9	1.29	—	11.72
8	—meal dehy, 17% protein	1-00-023	92	2350	53	17.4	12.2	23.9	2.7	38.1	9.8	1.32	0.48	8.99
9			100	2540	58	18.9	13.3	26.0	2.9	41.3	10.6	1.44	0.52	9.77
10	—meal dehy, 20% protein	1-00-024	92	2610	59	20.2	15.0	20.3	3.2	37.4	10.4	1.53	0.47	8.40
11			100	2830	64	22.1	16.3	22.2	3.5	40.9	11.3	1.68	0.51	9.20
12	BAKERY.													
13	—waste, dehy	4-00-466	92	4190	101	9.8	9.4	1.0	11.5	65.1	4.5	0.20	0.90	—
14	Dried Bakery Product (AAFCO)		100	4560	110	10.7	10.2	1.1	12.5	70.8	4.9	0.22	0.98	—
15	BARLEY. *Hordeum vulgare*													
16	—grain	4-00-549	89	3330	75	12.4	9.9	5.6	1.7	67.1	3.1	0.04	0.18	8.09
17			100	3740	84	13.9	11.1	6.3	1.9	75.2	3.5	0.05	0.20	9.09
18	—grain, Pacific Coast	4-07-939	89	3330	75	9.5	8.0	6.2	1.9	68.4	2.5	0.04	0.15	8.09
19			100	3740	84	10.7	9.0	7.0	2.2	76.9	2.8	0.05	0.17	9.09
20	BEET, SUGAR. *Beta saccharifera*													
21	—pulp, dehy	4-00-669	90	3080	70	8.6	4.1	18.3	0.5	58.4	4.7	0.65	0.04	12.38
22	Dried Beet Pulp (CFA)		100	3420	78	9.5	4.6	20.2	0.5	64.7	5.2	0.72	0.04	13.76
23	Dried Beet Pulp (AAFCO)													
24	BERMUDAGRASS. *Cynodon dactylon*													
25	—hay, s-c	1-00-703	91	1890	43	7.5	4.0	26.0	1.8	49.0	7.0	0.37	—	—
26			100	2080	47	8.2	4.5	28.6	2.0	53.9	7.7	0.41	—	—
27	BERMUDAGRASS, COASTAL. *Cynodon dactylon*													
28	—hay, s-c	1-00-716	91	1770	40	11.1	5.7	27.6	2.1	46.5	5.7	0.35	—	—
29			100	1940	44	12.3	6.2	30.4	2.3	51.1	6.3	0.38	—	—
30	CLOVER. *Trifolium pratense*													
31	—red, hay, s-c	1-01-415	87	2170	49	14.1	9.8	25.5	2.4	38.1	7.5	1.30	0.28	9.49
32			100	2390	54	15.9	11.0	28.7	2.8	44.0	8.5	1.49	0.32	10.91
33	CORN. *Zea mays*													
34	—gluten, meal	5-02-900	91	—	—	42.9	31.5	4.6	2.1	39.4	3.1	0.15	0.07	28.30
35	Corn Gluten Meal (CFA)		100	—	—	47.2	34.6	5.0	2.3	43.3	3.4	0.16	0.08	31.10
36	Corn Gluten Meal (AAFCO)													
37	—grain, dent yellow	4-02-935	89	3790	83	9.3	7.3	2.0	3.9	72.8	1.3	0.03	0.04	3.20
38			100	4260	93	10.5	8.3	2.2	4.4	82.1	1.5	0.03	0.05	3.60
39	COTTON. *Gossypium* spp.													
40	—seeds, meal solv extd, 41% protein	5-01-621	90	3090	67	40.7	34.5	12.6	2.1	31.8	6.2	0.17	0.05	20.48
41			100	3430	74	45.2	38.4	14.0	2.3	34.9	6.8	0.19	0.05	22.76
42	DICALCIUM PHOSPHATE.	6-01-080	97	0	0	0.0	0.0	0.0	0.0	0.0	79.2	23.00	—	6.01
43	Dicalcium phosphate (AAFCO)		100	0	0	0.0	0.0	0.0	0.0	0.0	81.4	23.70	—	6.20
44	FLAX. *Linum usitatissimum*													
45	—seeds, meal solv extd	5-02-048	90	3430	68	35.0	30.4	8.9	1.6	38.4	5.7	0.38	0.04	25.69
46	Solvent-Extracted Linseed Meal (CFA)		100	3810	75	38.9	33.9	9.9	1.8	42.8	6.4	0.43	0.04	28.54
47	Linseed Meal, Solvent Extracted (AAFCO)													
48	MILK.													
49	—dehy	5-01-167	96	5180	118	25.2	25.4	0.2	26.7	38.3	5.6	0.91	1.49	0.91
50	Dried whole milk, feed grade (AAFCO)		100	5380	123	26.3	26.4	0.2	27.8	39.7	5.8	0.95	1.55	0.94
51	—skimmed dehy	5-01-175	94	—	—	33.6	32.9	0.3	0.9	51.1	8.0	1.28	0.90	11.66
52	Dried skimmed milk, feed grade (AAFCO)		100	—	—	35.7	35.2	0.3	0.9	54.6	8.6	1.37	0.96	12.41

As-Fed Basis and Dry Basis (Moisture Free)

Line No.	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic Acid (mg/kg)	Niacin (mg/kg)	Pantothenic Acid (mg/kg)	Provitamin A (Carotene) (mg/kg)	Vitamin B_6 (mg/kg)	Riboflavin (mg/kg)	Thiamin (mg/kg)	Vitamin E (mg/kg)
1																		
2	—	0.012	0.05	15.1	0.06	0.05	0.10	4.2	0.12	373	—	11.8	8.7	46.6	1.60	3.2	1.4	146
3	—	0.049	0.20	62.9	0.25	0.19	0.41	17.6	0.49	1556	—	49.1	36.4	194.0	6.68	13.4	5.9	608
4	—	0.018	0.29	27.5	0.23	0.14	0.25	15.3	—	—	—	—	—	—	—	—	—	—
5	—	0.020	0.33	30.9	0.26	0.15	0.28	17.2	—	—	—	—	—	—	—	—	—	—
6	—	0.015	0.27	32.1	0.20	0.04	0.23	21.1	—	—	—	—	—	10.6	—	—	—	—
7	—	0.017	0.31	36.5	0.23	0.04	0.26	24.0	—	—	—	—	—	12.0	—	—	—	—
8	0.149	0.042	0.29	30.8	0.24	0.12	0.24	19.4	0.30	1401	2.07	39.3	29.3	120.6	8.00	13.3	3.4	124
9	0.161	0.046	0.32	33.5	0.26	0.13	0.26	21.1	0.33	1523	2.25	42.7	31.8	131.1	8.70	14.4	3.7	135
10	0.137	0.037	0.34	33.4	0.27	0.11	0.42	22.9	0.33	1446	2.64	49.1	35.3	151.3	9.30	14.3	5.3	145
11	0.150	0.040	0.37	36.5	0.30	0.12	0.46	25.0	0.36	1582	2.87	53.7	38.7	165.6	10.17	15.6	5.8	158
12																		
13	—	0.006	0.32	35.1	0.41	0.60	0.02	15.0	0.07	1165	0.15	26.2	21.5	4.6	30.99	1.1	1.5	219
14	—	0.007	0.35	38.2	0.44	0.66	0.02	16.4	0.08	1268	0.16	28.5	23.3	5.0	33.72	1.2	1.6	238
15																		
16	0.050	0.008	0.13	16.3	0.33	0.03	0.16	15.2	0.14	913	0.53	75.2	7.4	2.5	6.27	1.4	3.9	14
17	0.056	0.009	0.15	18.6	0.37	0.03	0.18	17.0	0.16	1026	0.60	84.5	8.3	2.8	7.04	1.6	4.4	16
18	—	0.011	0.12	16.2	0.34	0.02	0.15	15.2	0.15	991	0.50	47.4	7.9	—	2.90	1.5	4.2	21
19	—	0.012	0.13	18.3	0.38	0.02	0.17	17.1	0.17	1114	0.56	53.3	8.9	—	3.26	1.7	4.7	24
20																		
21	—	0.030	0.27	34.5	0.09	0.21	0.20	0.7	—	810	—	16.7	1.4	0.2	—	0.7	0.4	—
22	—	0.033	0.30	38.3	0.10	0.23	0.22	0.8	—	900	—	18.5	1.5	0.2	—	0.8	0.4	—
23																		
24																		
25	0.104	—	0.15	—	0.19	—	—	—	—	—	—	—	—	73.9	—	—	—	—
26	0.115	—	0.17	—	0.21	—	—	—	—	—	—	—	—	81.3	—	—	—	—
27																		
28	—	—	0.15	—	0.17	—	—	0.9	—	—	—	—	—	74.3	—	—	—	—
29	—	—	0.17	—	0.19	—	—	1.0	—	—	—	—	—	81.7	—	—	—	—
30																		
31	—	0.018	0.37	63.8	0.22	0.16	0.15	—	0.10	—	—	37.0	9.7	23.9	—	15.5	1.9	—
32	—	0.021	0.43	73.3	0.25	0.18	0.17	—	0.11	—	—	42.6	11.2	27.5	—	17.8	2.2	—
33																		
34	—	0.039	0.05	7.3	0.46	0.08	0.36	—	0.17	369	0.34	50.0	9.8	16.3	7.89	1.5	0.2	34
35	—	0.043	0.05	8.0	0.51	0.09	0.40	—	0.19	405	0.37	55.0	10.8	17.9	8.77	1.6	0.2	37
36																		
37	0.052	0.003	0.12	5.0	0.28	0.01	0.12	10.0	0.06	542	0.36	30.4	6.7	2.2	5.24	1.3	2.0	23
38	0.059	0.003	0.14	5.6	0.31	0.01	0.14	11.2	0.07	609	0.40	34.2	7.5	2.5	5.89	1.5	2.3	26
39																		
40	—	0.022	0.56	20.5	1.09	0.04	0.21	60.0	0.59	2752	2.79	40.6	13.9	—	6.29	4.8	6.2	14
41	—	0.024	0.62	22.8	1.21	0.05	0.23	66.0	0.66	3058	3.06	45.1	15.4	—	6.99	5.3	6.9	16
42	—	0.128	0.60	148.6	18.27	2.63	—	26.8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
43	—	0.132	0.62	153.2	18.84	2.71	—	27.6	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
44																		
45	—	0.032	0.60	37.5	0.81	0.14	0.40	—	—	1355	—	29.1	14.8	—	—	2.8	7.7	16
46	—	0.035	0.67	41.8	0.90	0.15	0.44	—	—	1506	—	32.4	16.4	—	—	3.1	8.6	18
47																		
48																		
49	—	0.017	—	0.5	0.73	0.36	—	—	0.38	—	—	8.4	22.8	7.1	4.74	19.8	3.7	—
50	—	0.018	—	0.5	0.76	0.38	—	—	0.40	—	—	8.8	23.8	7.4	4.94	20.6	3.9	—
51	—	0.005	0.12	2.2	1.02	0.35	0.32	41.0	0.33	1391	0.47	11.5	36.9	—	4.25	19.2	3.8	9
52	—	0.005	0.13	2.3	1.09	0.37	0.34	43.6	0.35	1480	0.50	12.2	39.3	—	4.52	20.4	4.0	10

Line No.	Scientific Name / Short Name / American Feed Control Name (AAFCO) / Canada Feeds Act Name (CFA) / Other Names	International Feed No.*	Dry Matter (%)	As-Fed Basis and Dry Basis (Moisture Free): DE (kcal/kg)	TDN (%)	Protein: Total (%)	Protein: Dig (%)	Crude Fiber (%)	Ether Extract (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Chlorine (%)	Copper (mg/kg)
53	MOLASSES.													
54	—sugarcane. *Saccharum officinarum*	4-04-696	75	—	—	3.9	2.0	—	0.1	63.7	7.4	0.79	2.78	60.38
55	Cane Molasses (AAFCO)		*100*	—	—	*5.2*	*2.7*	—	*0.1*	*84.9*	*9.8*	*1.05*	*3.71*	*80.51*
56	OATS. *Avena sativa*													
57	—grain	4-03-309	89	2950	65	12.1	9.2	10.6	4.5	58.7	3.4	0.06	0.11	6.3
58			*100*	*3310*	*73*	*13.6*	*10.4*	*11.9*	*5.1*	*66.0*	*3.8*	*0.07*	*0.12*	*7.15*
59	PEANUT. *Arachis hypogaea*													
60	—kernels, meal solv extd	5-03-650	92	4120	90	49.9	45.2	10.5	2.4	28.5	—	0.20	0.03	15.26
61	Solvent-Extracted Peanut Meal (AAFCO)		*100*	*4480*	*98*	*54.2*	*49.2*	*11.3*	*2.6*	*31.1*	—	*0.22*	*0.03*	*16.59*
62	PHOSPHATE.													
63	—defluorinated grnd	6-01-780	100	0	0	0.0	0.0	0.0	0.0	0.0	—	31.65	—	66.16
64	Phosphate, Defluorinated (AAFCO)		*100*	*0*	*0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	—	*31.65*	—	*66.16*
65,	RYE. *Secale cereale*													
66	—grain	4-04-047	88	3590	77	12.1	9.0	2.3	1.6	74.5	1.7	0.06	0.03	6.75
67			*100*	*4080*	*88*	*13.8*	*10.7*	*2.6*	*1.8*	*81.0*	*1.9*	*0.07*	*0.03*	*7.67*
68	SORGHUM. *Sorghum vulgare*													
69	—grain	4-04-383	89	3330	—	10.7	6.4	2.2	3.1	72.0	2.1	0.04	0.09	9.65
70			*100*	*3745*	—	*12.0*	*7.2*	*2.4*	*3.5*	*81.5*	*2.4*	*0.04*	*0.10*	*10.84*
71	SOYBEAN. *Glycine max*													
72	—seeds, meal solv extd	5-04-604	89	3770	82	46.1	41.4	5.8	1.0	30.8	5.9	0.28	0.03	27.30
73	Soybean Meal, Solvent Extracted (AAFCO)		*100*	*4240*	*92*	*51.8*	*46.5*	*6.5*	*1.1*	*34.6*	*6.6*	*0.31*	*0.03*	*30.67*
74	—seeds wo hulls, meal solv extd	5-04-612	90	—	—	50.2	45.0	3.0	0.9	30.4	5.8	0.24	0.05	21.70
75	Soybean Meal, Dehulled, Solvent Extracted		*100*	—	—	*55.6*	*49.8*	*3.3*	*1.0*	*33.7*	*6.4*	*0.27*	*0.05*	*24.15*
76	(AAFCO)													
77	SUNFLOWER. *Helianthus* spp.													
78	—seeds wo hulls, meal solv extd	5-04-739	93	—	—	46.3	41.2	11.0	2.9	24.8	7.7	0.38	0.10	3.50
79	Sunflower Meal, Dehulled, Solvent Extracted		*100*	—	—	*49.8*	*44.4*	*11.8*	*3.1*	*26.7*	*8.3*	*0.41*	*0.11*	*3.77*
80	(AAFCO)													
81	TIMOTHY. *Phleum pratense*													
82	—hay, s-c, midbloom	1-04-883	88	1420	32	8.4	4.9	30.0	2.2	40.0	6.0	0.36	—	4.46
83			*100*	*1600*	*36*	*9.5*	*5.6*	*34.1*	*2.5*	*45.4*	*6.9*	*0.41*	—	*5.07*
84	WHEAT. *Triticum* spp.													
85	—bran	4-05-190	89	2610	57	15.1	12.8	10.3	4.2	53.8	5.9	0.11	0.05	12.78
86	Bran (CFA)		*100*	*2930*	*64*	*17.0*	*14.4*	*11.7*	*4.8*	*60.7*	*6.7*	*0.12*	*0.06*	*14.36*
87	Wheat Bran (AAFCO)													
88	—grain, hard red spring	4-05-258	89	3680	79	15.6	9.2	2.6	2.0	69.1	1.7	0.04	0.08	6.39
89			*100*	*4130*	*89*	*17.5*	*10.3*	*3.0*	*2.3*	*77.7*	*1.9*	*0.04*	*0.09*	*7.18*
90	—grain, hard red winter	4-05-268	89	3680	84	12.8	9.0	2.4	2.0	69.4	1.7	0.04	0.05	4.79
91			*100*	*4130*	*94*	*14.4*	*10.2*	*2.7*	*2.3*	*78.2*	*1.9*	*0.05*	*0.06*	*5.38*
92	—grain, soft white winter	4-05-337	88	3680	79	9.8	8.6	2.7	1.7	71.2	2.0	0.05	0.08	6.90
93			*100*	*4130*	*90*	*11.1*	*9.8*	*3.0*	*2.0*	*81.1*	*2.3*	*0.06*	*0.09*	*7.84*

*The first digit is the feed class: (1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

As-Fed Basis and Dry Basis (Moisture Free)

Line No.	Iodine (mg/kg)	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Sodium (%)	Sulfur (%)	Zinc (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic Acid (mg/kg)	Niacin (mg/kg)	Pantothenic Acid (mg/kg)	Provitamin A (Carotene) (mg/kg)	Vitamin B_6 (mg/kg)	Riboflavin (mg/kg)	Thiamin (mg/kg)	Vitamin E (mg/kg)
53																		
54	—	0.020	0.35	42.8	0.08	0.16	0.34	22.5	0.70	744	0.11	40.6	39.2	—	6.50	2.8	0.9	5
55	—	*0.026*	*0.47*	*57.1*	*0.11*	*0.22*	*0.46*	*30.0*	*0.94*	*992*	*0.15*	*54.2*	*52.2*	—	*8.67*	*3.8*	*1.2*	*7*
56																		
57	—	0.008	0.12	37.4	0.33	0.16	0.21	—	0.24	1013	0.30	13.7	7.4	0.1	2.53	1.5	6.3	12
58	—	*0.009*	*0.14*	*42.0*	*0.37*	*0.18*	*0.23*	—	*0.27*	*1138*	*0.33*	*15.4*	*8.3*	*0.1*	*2.84*	*1.7*	*7.1*	*14*
59																		
60	—	—	0.04	26.9	0.63	0.41	—	32.8	0.32	1898	0.40	166.3	48.5	—	5.28	10.6	5.5	3
61	—	—	*0.04*	*29.2*	*0.69*	*0.45*	—	*35.6*	*0.36*	*2133*	*0.44*	*186.8*	*54.5*	—	*5.93*	*11.9*	*6.2*	*3*
62																		
63	—	0.709	0.27	696.4	13.70	0.19	0.13	74.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
64	—	*0.709*	*0.27*	*696.4*	*13.70*	*0.19*	*0.13*	*74.0*	*0.0*	*0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0*
65																		
66	—	0.006	0.36	55.0	0.32	0.03	0.15	31.8	0.33	—	0.62	20.5	9.0	10.2	2.59	1.6	3.0	15
67	—	*0.007*	*0.41*	*62.5*	*0.36*	*0.03*	*0.17*	*36.1*	*0.37*	—	*0.70*	*23.3*	*10.2*	*11.6*	*2.94*	*1.8*	*3.4*	*17*
68																		
69	—	0.004	0.18	15.4	0.29	0.03	0.14	14.3	0.41	622	0.20	40.8	11.2	1.2	4.62	1.2	4.2	11
70	—	*0.005*	*0.20*	*17.3*	*0.33*	*0.03*	*0.16*	*16.1*	*0.46*	*699*	*0.23*	*45.8*	*12.6*	*1.3*	*5.19*	*1.4*	*4.7*	*12*
71																		
72	—	0.012	0.27	28.4	0.62	0.28	0.43	42.6	0.23	2630	0.45	27.5	16.0	0.2	6.39	2.9	5.5	2
73	—	*0.013*	*0.30*	*31.9*	*0.70*	*0.31*	*0.48*	*47.9*	*0.36*	*2955*	*0.50*	*30.9*	*18.0*	*0.2*	*7.18*	*3.3*	*6.2*	*2*
74	—	—	—	27.8	0.62	0.26	0.43	45.3	0.32	2757	0.70	21.7	14.6	—	8.00	3.1	2.2	3
75	—	—	—	*30.8*	*0.69*	*0.28*	*0.48*	*50.1*	*0.36*	*3053*	*0.78*	*24.0*	*16.2*	—	*8.86*	*3.4*	*2.4*	*4*
76																		
77																		
78	—	0.003	0.73	14.4	1.05	1.21	—	—	—	3596	—	225.2	24.8	—	15.98	4.2	—	11
79	—	*0.004*	*0.78*	*15.5*	*1.13*	*1.30*	—	—	—	*3870*	—	*274.4*	*26.7*	—	*17.20*	*4.5*	—	*12*
80																		
81																		
82	—	0.012	0.14	40.7	0.17	0.16	0.11	—	—	—	—	—	—	47.0	—	—	—	—
83	—	*0.014*	*0.16*	*46.3*	*0.19*	*0.18*	*0.13*	—	—	—	—	—	—	*53.4*	—	—	—	—
84																		
85	0.074	0.011	0.52	110.6	1.26	0.04	0.22	109.8	0.57	1865	1.21	273.1	47.9	2.6	10.55	4.8	6.6	21
86	*0.083*	*0.012*	*0.58*	*124.3*	*1.42*	*0.04*	*0.25*	*123.9*	*0.64*	*2095*	*1.37*	*306.8*	*53.8*	*2.9*	*11.85*	*5.4*	*7.4*	*24*
87																		
88	—	0.006	0.16	37.4	0.38	0.03	—	26.3	0.12	854	0.41	57.8	10.1	10.3	5.14	1.4	4.3	12.8
89	—	*0.007*	*0.18*	*42.0*	*0.43*	*0.03*	—	*29.6*	*0.13*	*960*	*0.46*	*64.9*	*11.3*	*11.6*	*5.78*	*1.6*	*4.8*	*14.4*
90	—	0.004	0.10	29.3	0.38	0.02	0.15	30.6	0.11	1046	0.37	54.2	10.0	—	3.03	1.5	4.3	11.1
91	—	*0.004*	*0.12*	*32.9*	*0.43*	*0.02*	*0.17*	*34.5*	*0.12*	*1175*	*0.42*	*60.9*	*11.2*	—	*3.40*	*1.7*	*4.8*	*12.5*
92	—	0.004	0.10	38.1	0.32	0.03	—	27.8	0.11	967	0.36	35.4	11.1	—	4.07	1.2	4.7	13.7
93	—	*0.004*	*0.11*	*43.3*	*0.36*	*0.03*	—	*31.6*	*0.12*	*1099*	*0.41*	*60.2*	*12.6*	—	*4.62*	*1.4*	*5.3*	*15.6*

TABLE 5 Amino Acid Composition of Some Common Rabbit Feed Ingredients

Line No.	Scientific Name / Short Name / American Feed Control Name (AAFCO) / Canada Feeds Act Name (CFA) / Other Names	International Feed No.*	Dry Matter (%)	As-Fed Basis and Dry Basis (Moisture Free) Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
1	ALFALFA. *Medicago sativa*														
2	—fresh	2-00-196	24	—	—	—	—	—	—	—	—	—	—	—	—
3			*100*	—	—	—	—	—	—	—	—	—	—	—	—
4	—hay, s-c, early bloom	1-00-059	89	0.80	0.32	0.24	0.72	1.13	0.89	0.16	0.71	0.63	0.24	0.48	0.72
5			*100*	*0.90*	*0.36*	*0.28*	*0.81*	*1.27*	*1.00*	*0.18*	*0.80*	*0.71*	*0.27*	*0.54*	*0.81*
6	—hay, s-c, full bloom	1-00-068	88	0.62	0.03	0.26	0.66	0.89	0.54	0.09	—	0.62	0.09	—	0.62
7			*100*	*0.71*	*0.03*	*0.30*	*0.81*	*1.01*	*0.61*	*0.10*	—	*0.71*	*0.10*	—	*0.71*
8	—meal dehy, 17% protein	1-00-023	92	0.76	0.30	0.32	0.82	1.27	0.90	0.21	0.79	0.68	0.35	0.56	0.83
9			*100*	*0.82*	*0.32*	*0.34*	*0.89*	*1.37*	*0.97*	*0.23*	*0.85*	*0.74*	*0.38*	*0.60*	*0.90*
10	—meal dehy, 20% protein	1-00-024	92	0.95	0.31	0.34	0.87	1.37	0.90	0.32	0.86	0.74	0.43	0.61	0.97
11			*100*	*1.04*	*0.34*	*0.37*	*0.95*	*1.50*	*0.98*	*0.35*	*0.94*	*0.81*	*0.47*	*0.67*	*1.06*
12	BAKERY.														
13	—waste, dehy	4-00-466	92	0.51	0.18	0.15	0.36	0.70	0.32	0.17	0.40	0.44	0.10	0.30	0.40
14	Dried Bakery Product (AAFCO)		*100*	*0.55*	*0.19*	*0.16*	*0.39*	*0.76*	*0.35*	*0.19*	*0.44*	*0.48*	*0.11*	*0.33*	*0.44*
15	BARLEY. *Hordeum vulgare*														
16	—grain	4-00-549	89	0.55	0.21	0.26	0.51	0.82	0.46	0.18	0.61	0.38	0.16	0.36	0.62
17			*100*	*0.62*	*0.23*	*0.29*	*0.57*	*0.92*	*0.51*	*0.20*	*0.69*	*0.43*	*0.18*	*0.40*	*0.69*
18	—grain, Pacific Coast	4-07-939	89	0.44	0.20	0.21	0.40	0.60	0.27	0.14	0.48	0.29	0.12	—	0.46
19			*100*	*0.49*	*0.22*	*0.24*	*0.45*	*0.67*	*0.30*	*0.16*	*0.54*	*0.33*	*0.14*	—	*0.52*
20	BEET, SUGAR. *Beta saccharifera*														
21	—pulp, dehy	4-00-669	90	0.30	—	0.20	0.30	0.60	0.59	0.01	0.30	0.40	0.10	0.40	0.40
22	Dried Beet Pulp (CFA)		*100*	*0.33*	—	*0.22*	*0.33*	*0.66*	*0.66*	*0.01*	*0.33*	*0.44*	*0.11*	*0.44*	*0.44*
23	Dried Beet Pulp (AAFCO)														
24	BERMUDAGRASS. *Cynodon dactylon*														
25	—hay, s-c	1-00-703	91	—	—	—	—	—	—	—	—	—	—	—	—
26			*100*	—	—	—	—	—	—	—	—	—	—	—	—
27	BERMUDAGRASS, COASTAL. *Cynodon dactylon*														
28	—hay, s-c	1-00-716	91	—	—	—	—	—	—	—	—	—	—	—	—
29			*100*	—	—	—	—	—	—	—	—	—	—	—	—
30	CLOVER. *Trifolium pratense*														
31	—red, hay, s-c	1-01-415	87	—	—	—	—	—	—	—	—	—	—	—	—
32			*100*	—	—	—	—	—	—	—	—	—	—	—	—
33	CORN. *Zea mays*														
34	—gluten, meal	5-02-900	91	1.42	0.66	0.96	2.21	7.33	0.83	1.07	2.78	1.43	0.21	1.00	2.24
35	Corn Gluten Meal (CFA)		*100*	*1.56*	*0.73*	*1.06*	*2.43*	*8.05*	*0.91*	*1.18*	*3.06*	*1.57*	*0.23*	*1.10*	*2.46*
36	Corn Gluten Meal (AAFCO)														
37	—grain, dent yellow	4-02-935	89	0.50	0.13	0.20	0.40	1.10	0.20	0.13	0.50	0.40	0.09	0.44	0.38
38			*100*	*0.56*	*0.15*	*0.22*	*0.45*	*1.24*	*0.22*	*0.15*	*0.56*	*0.45*	*0.11*	*0.50*	*0.42*
39	COTTON. *Gossypium* spp.														
40	—seeds, meal solv extd, 41% protein	5-01-621	90	4.36	0.67	1.02	1.20	2.17	1.59	0.49	2.00	1.21	0.48	1.06	1.64
41			*100*	*4.79*	*0.73*	*1.12*	*1.32*	*2.38*	*1.74*	*0.54*	*2.20*	*1.33*	*0.53*	*1.16*	*1.80*
42	DICALCIUM PHOSPHATE.	6-01-080	97	—	—	—	—	—	—	—	—	—	—	—	—
43	Dicalcium phosphate (AAFCO)		*100*	—	—	—	—	—	—	—	—	—	—	—	—
44	FLAX. *Linum usitatissimum*														
45	—seeds, meal solv extd	5-02-048	90	3.05	0.62	0.68	1.74	2.16	1.20	0.57	1.58	1.29	0.53	—	1.82
46	Solvent-Extracted Linseed Meal (CFA)		*100*	*3.40*	*0.69*	*0.76*	*1.94*	*2.41*	*1.34*	*0.64*	*1.76*	*1.44*	*0.59*	—	*2.03*
47	Linseed Meal, Solvent Extracted (AAFCO)														
48	MILK.														
49	—dehy	5-01-167	96	0.92	—	0.72	1.34	2.57	2.26	0.62	1.34	1.03	0.41	1.34	1.75
50	Dried Whole Milk, Feed Grade (AAFCO)		*100*	*0.96*	—	*0.75*	*1.39*	*2.67*	*2.35*	*0.64*	*1.39*	*1.07*	*0.43*	*1.39*	*1.81*
51	—skimmed dehy	5-01-175	94	1.15	0.45	0.84	2.16	3.23	2.48	0.90	1.58	1.58	0.43	1.13	2.30
52	Dried Skimmed Milk, Feed Grade (AAFCO)		*100*	*1.23*	*0.48*	*0.90*	*2.31*	*3.46*	*2.66*	*0.96*	*1.69*	*1.69*	*0.46*	*1.21*	*2.45*

Line No.	Scientific Name Short Name American Feed Control Name (AAFCO) Canada Feeds Act Name (CFA) Other Names	International Feed No.[a]	Dry Matter (%)	As-Fed Basis and Dry Basis (Moisture Free) Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
53	MOLASSES.														
54	—sugarcane. *Saccharum officinarum*	4-04-696	75	—	—	—	—	—	—	—	—	—	—	—	—
55	Cane Molasses (AAFCO)		*100*	—	—	—	—	—	—	—	—	—	—	—	—
56	OATS. *Avena sativa*														
57	—grain	4-03-309	89	0.57	0.15	0.09	0.53	0.09	0.34	0.18	0.60	0.40	0.12	1.07	0.70
58			*100*	*0.64*	*0.17*	*0.10*	*0.60*	*0.10*	*0.38*	*0.20*	*0.67*	*0.45*	*0.14*	*1.20*	*0.79*
59	PEANUT. *Arachis hypogaea*														
60	—kernels, meal solv extd	5-03-650	92	5.90	—	1.20	2.00	3.70	2.30	0.40	2.70	1.50	0.50	1.80	2.80
61	Solvent-Extracted Peanut Meal (AAFCO)		*100*	*6.45*	—	*1.31*	*2.19*	*4.04*	*2.51*	*0.44*	*2.95*	*1.64*	*0.55*	*1.97*	*3.06*
62	PHOSPHATE.														
63	—defluorinated grnd	6-01-780	100	—	—	—	—	—	—	—	—	—	—	—	—
64	Phosphate, Defluorinated (AAFCO)		*100*	—	—	—	—	—	—	—	—	—	—	—	—
65	RYE. *Secale cereale*														
66	—grain	4-04-047	88	0.53	0.19	0.26	0.50	0.69	0.42	0.17	0.57	0.36	0.13	0.26	0.60
67			*100*	*0.60*	*0.22*	*0.30*	*0.56*	*0.78*	*0.48*	*0.19*	*0.64*	*0.41*	*0.14*	*0.30*	*0.68*
68	SORGHUM. *Sorghum vulgare*														
69	—grain	4-04-383	89	0.36	0.18	0.27	0.53	1.42	0.27	0.09	0.45	0.27	0.09	0.36	0.53
70			*100*	*0.40*	*0.20*	*0.30*	*0.60*	*1.60*	*0.30*	*0.10*	*0.50*	*0.30*	*0.10*	*0.40*	*0.60*
71	SOYBEAN. *Glycine max*														
72	—seeds, meal solv extd	5-04-604	89	3.25	0.67	1.14	2.44	3.49	2.92	0.60	2.26	1.78	0.65	1.24	2.36
73	Soybean Meal, Solvent Extracted (AAFCO)		*100*	*3.65*	*0.75*	*1.27*	*2.73*	*3.92*	*3.28*	*0.68*	*2.53*	*2.00*	*0.72*	*1.40*	*2.65*
74	—seeds wo hulls, meal solv extd	5-04-612	90	3.76	0.77	1.26	2.57	3.82	3.22	0.72	2.57	1.92	0.69	2.01	2.72
75	Soybean Meal, Dehulled, Solvent		*100*	*4.16*	*0.85*	*1.40*	*2.85*	*4.23*	*3.57*	*0.80*	*2.85*	*2.12*	*0.76*	*2.23*	*3.02*
76	Extracted (AAFCO)														
77	SUNFLOWER. *Helianthus* spp.														
78	—seeds wo hulls, meal solv extd	5-04-739	93	3.37	0.72	1.00	1.94	2.60	1.67	1.03	2.06	1.50	0.56	—	2.25
79	Sunflower Meal, Dehulled, Solvent		*100*	*3.62*	*0.78*	*1.08*	*2.09*	*2.80*	*1.79*	*1.10*	*2.22*	*1.61*	*0.60*	—	*2.43*
80	Extracted (AAFCO)														
81	TIMOTHY. *Phleum pratense*														
82	—hay, s-c, midbloom	1-04-883	88	—	—	—	—	—	—	—	—	—	—	—	—
83			*100*	—	—	—	—	—	—	—	—	—	—	—	—
84	WHEAT. *Triticum* spp.														
85	—bran	4-05-190	89	0.96	0.25	0.35	0.58	0.90	0.58	0.17	0.50	0.43	0.33	0.40	0.73
86	Bran (CFA)		*100*	*1.08*	*0.28*	*0.39*	*0.65*	*1.02*	*0.65*	*0.19*	*0.56*	*0.48*	*0.37*	*0.45*	*0.83*
87	Wheat Bran (AAFCO)														
88	—grain, hard red spring	4-05-258	89	0.59	0.24	0.24	0.59	0.90	0.36	0.19	0.68	0.37	0.14	0.57	0.59
89			*100*	*0.67*	*0.28*	*0.27*	*0.67*	*1.01*	*0.41*	*0.21*	*0.76*	*0.41*	*0.16*	*0.64*	*0.66*
90	—grain, hard red winter	4-05-268	89	0.57	0.25	0.22	0.57	0.87	0.38	0.23	0.65	0.39	0.18	0.50	0.56
91			*100*	*0.65*	*0.29*	*0.25*	*0.64*	*0.90*	*0.43*	*0.25*	*0.73*	*0.44*	*0.20*	*0.57*	*0.63*
92	—grain, soft white winter	4-05-337	88	0.40	0.27	0.20	0.42	0.59	0.32	0.17	0.45	0.32	0.12	0.39	0.44
93			*100*	*0.45*	*0.30*	*0.23*	*0.47*	*0.67*	*0.36*	*0.19*	*0.51*	*0.36*	*0.14*	*0.44*	*0.50*

[a] The first digit is the feed class: (1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

TABLE 6 Abbreviations for Terms Used in Tables 4 and 5

AAFCO	Association of American Feed Control Officials	mech	mechanical
		mech extd	mechanically extracted, expeller extracted, hydraulic extracted, or old process
CFA	Canada Feeds Act		
dehy	dehydrated	μg	microgram
extd	extracted	mg	milligram
extn	extraction	mt	more than
extn unspecified	extraction unspecified	s-c	suncured
g	gram(s)	solv extd	solvent extracted
gr	grade	spp	species
grad	ground	w	with
IU	International Units	wo	without
kcal	kilocalories		
kg	kilogram(s)		
It	less than		

TABLE 7 Description of How Short Names Are Formed

Components of Name	Feed No. 1	Feed No. 2	Feed No. 3
Origin (or parent material)	Clover	Soybean	Wheat
Species, variety, or kind	red		soft white winter
Part eaten	hay	seeds	grain
Process(es) and treatment(s) undergone before fed to animal	s-c	meal solv extd	
Grade or quality designations		44% protein	
Classification; first digit is international feed number (IFN)	(1) (dry forages and roughages)	(5) (protein supplements)	(4) (energy fees)
IFN	1-01-415	5-20-637	4-05-337

TABLE 8 International Stage of Maturity Terms (Revised 1973)

Preferred term	Definition	Comparable Terms
For Plants that Bloom		
Germinated	Stage in which the embryo in a seed resumes growth after a dormant period	Sprouted
Early vegetative	Stage at which the plant is vegetative and before the stems elongate	Fresh new growth, before heading out, before inflorescence emergence, immature prebud stage, very immature, young
Late vegetative	State at which stems are beginning to elongate to just before blooming; first bud to first flowers	Before bloom, bud stage, budding plants, heading to in bloom, heads just showing, jointing and boot (grasses), problem, preflowering, stems elongated
Early bloom	Stage between initiation of bloom and stage in which 1/10 of the plants are in bloom; some grass heads are in anthesis	Early anthesis, first flower, headed out in head, up to 1/10 bloom
Mid-bloom	Stage in which 1/10 to 2/3 of the plants are in bloom; most grass heads are in anthesis	Bloom, flowering, flowering plants, half bloom, in bloom, mid-anthesis
Full bloom	Stage in which 2/3 or more of the plants are in bloom	3/4 to full bloom, late anthesis
Late bloom	Stage in which blossoms begin to dry and fall and seeds begin to form	15 days after silking, before milk, in bloom to early pod, late to post anthesis
Milk stage	Stage in which seeds are well formed but soft and immature	After anthesis, early seed, fruiting, in tassel, late bloom to early seed, past bloom, pod stage, post anthesis, post bloom, seed developing, seed forming, soft immature
Dough stage	Stage in which the seeds are of dough-like consistency	Dough stage, nearly mature, seeds dough, seeds well developed, soft dent
Mature	Stage in which plants are normally harvested for seed	Dent, dough to glazing, fruiting, fruiting, fruiting plants, in seed, kernels ripe, ripe seed
Post ripe	Stage that follows maturity; some seeds cast and plants have begun to weather (applies mostly to range plants)	Late seed, over ripe, very mature
Stem cured	Stage in which plants are cured on the stem; seeds have been cast and weathering has taken place (applies mostly to range plants)	Dormant, mature and weathered, seeds cast
Regrowth early vegetative	Stage in which regrowth occurs without flowering activity; vegetative crop aftermath; regrowth in stubble (applies primarily to fall regrowth in temperate climates); early dry season regrowth	Vegetative recovery growth
Regrowth late vegetative	State in which stems begin to elongate to just before blooming; first bud to first flowers; regrowth in stubble with stem elongation (applies primarily to fall regrowth in temperate climates)	Recovery growth, stems elongating, jointing and boot (grasses)

TABLE 9 Weight-Unit Conversion Factors

Units Given	Units Wanted	For Conversion Multiply by
lb	g	453.6
lb	kg	0.4536
oz	g	28.35
kg	lb	2.2046
kg	mg	1,000,000.
kg	g	1,000.
g	mg	1,000.
g	μg	1,000,000
mg	μg	1,000.
mg/g	rag/lb	453.6
mg/kg	rag/lb	0.4536
μgj/kg	μgj/Ib	0.4536
Mcal	kcal	1,000.
kcal/kg	kcal/Ib	0.4536
kcal/Ib	kcal/kg	22.046
ppm	μg/g	1.
ppm	mg/kg	1.
ppm	mg/Ib	0.4536
mg/kg	%	0.0001
ppm	%	0.0001
mg/g	%	0.1
g/kg	%	0.1

TABLE 10 Weight Equivalents

1 lb = 453.6 g = 0.4536 kg = 16 oz
1 oz =28.35g
1 kg = 1,000 g = 2.2046 lb
lg = 1,000 mg
1 mg = 1,000 μg = 0.001 g
1 μg = 0.001 mg = 0.000001 g
1 μg per g or 1 mg per kg is the same as ppm

Bibliography

ANTIMICROBIAL AGENTS

Casady, R. B., K. W. Hagen, and K. Sittman. 1964a. Effects of high level antibiotic supplementation in the ration on growth and enteritis in young domestic rabbits. J. Anita. Sci. 23:477-489.
Casady, R. B., K. W. Hagen, J. E. Bertrand, and H. G. Thomas. 1964b. Effect of zinc bacitracin on the incidence of enteritis and growth in young rabbits. Clin. Med. 71:871-875.
Hagen, K. W. 1974. Colony husbandry. *In* Biology of the laboratory rabbit, S. H. Weisbroth, R. E. Flatt, and A. L. Kraus, eds. Academic Press, New York.
Huang, T. C., H. E. Ulrich, and C. M. McCay. 1954. Antibiotics, growth, food utilization and the use of chromic oxide in studies with rabbits. J. Nutr. 54:621-630.
King, J. O. L. 1962. The response of growing rabbits to the feeding of an antibiotic. Vet. Rec. 74:1411-1413.
King, J. O. L. 1966. The feeding of penicillin to rabbits. Br. Vet. J. 122:112-116.
King, J. O. L. 1967. The continuous feeding of two antibiotics to growing rabbits. Br. Vet. J. 123:453-456.
King, J. O. L. 1974a. Effects of feeding virginiamycin on the fertility of rabbit does and the development of young rabbits. Vet. Rec. 94:290-292.
King, J. O. L. 1974b. The effect of pelleting rations with and without an antibiotic on the growth rate of rabbits. Vet. Rec. 94:586-588.
Lawrence, J. M., and J. McGinnis. 1952. The effect of terramycin on the growth of rabbits. Arch. Biochem. Biophys. 37:164-166.
Schlolaut, W., and W. Lange. 1973. Effect of flavomycin on the fattening and slaughter characteristics of young rabbits for the meat industry. Arch. Gefluegelkd. 37:69-71.

ENERGY

Axelson, J., and S. Erikson. 1953. (Energy requirements for maintenance of domestic rabbits). K. Lantbrukshoegsk. Annaler 20:51-70.
Cheeke, P. R. 1974a. Evaluation of alfalfa protein concentrate as a protein source for rabbits. Nutr. Rep. Int. 9:267-272.
Cheeke, P. R. 1974b. Feed preferences of adult male Dutch rabbits. Lab. Anita. Sci. 24:601-604.
Davidson, J., and D. Spreadbury. 1975. Nutrition of the New Zealand White rabbit. Proc. Nutr. Soc. 34:75-83.
Fonnesbeck, P. V., L. E. Harris, and L. C. Kearl. 1974. Digestion of plant cell walls by animals. J. Anita. Sci. 39:182.
Fuller, R., and J. H. Moore. 1971. The effect on rabbit intestinal microflora of diets which influence serum cholesterol levels. Lab. Anim. 5:25-30.
Gouet, P., and G. Fonty. 1973. (Evolution of the intestinal microflora of conventional rabbits from birth to weaning). Ann. Biol. Anim. Biochim. Biophys. 13:733-735.
Hall, E. R. 1952. Investigation on the microbiology of cellulose utilization in domestic rabbits. J. Gen. Microbiol. 7:350-357.
Hall, K., and N. P. Johnston. 1976. Alfalfa quantity and grain source for the rabbit. Proc. West. Sect. Am. Soc. Anita. Sci. 27:146-147.
Hoover, W. H., and R. N. Heitmann. 1972. Effects of dietary fiber levels on weight gain, cecal volume and volatile fatty acid production in rabbits. J. Nutr. 102:375-380.
Hungate, R. E. 1966. The rumen and its microbes. Academic Press, New York.
Lebas, F. 1975a. (Influence of the dietary energy content on the growth performance of the rabbit). Ann. Zootech. 24:281-288.
Lebas, F. 1975b. (The meat rabbit: Nutritional requirements and feeding practices). Itavi, Paris. 50 pp.
Leung, T. T, and D. E. Bauman. 1976. *In vitro* studies of the pathways of fatty acid synthesis in the rabbit. Int. J. Biochem. 7:7-12.
Maynard, L. A., and J. K. Loosli. 1969. Animal nutrition. McGraw-Hill, New York.
Perret, J. P., A. Dorier, and C. Bacques. 1976. Triglycerides of rabbit milk during early lactation. 1st Int. Rabbit Congr., Dijon, France.
Schurg, W. A., D. L. Frei, P. R. Cheeke, and D. W. Holtan. 1976. Utilization of whole plant corn pellets by horses and rabbits. Proc. West. Sect. Am. Soc. Anim. Sci. 27:134-137.
Slade, L. M., and H. F. Hintz. 1969. Comparison of digestion in horses, ponies, rabbits and guinea pigs. J. Anita. Sci. 28:842-843.
Smith, H. W. 1965. Observations on the flora of the alimentary tract of animals and factors affecting its composition. J. Pathol. Bacteriol. 89:95-122.
Voris, L., L. F. Marcy, E. J. Thacker, and W. W. Wainio. 1940. Digestible nutrients of feeding stuffs for the domestic rabbit. J. Agric. Res. 61:673-684.

FEED COMPOSITION

Harris, L. E. 1963. Symposium on Feeds and Meats Technology. Ill. A system for naming and describing feedstuffs, energy technology and the use of such information in calculating diets. J. Anim. Sci. 22:535-547.

Harris, L. E., J. M. Asplund, and E. W. Crampton. 1968. An international feed nomenclature and method for summarizing and using feed data to calculate diets. Utah Agric. Exp. Stn. Bull. 479.

National Research Council. 1966. Biological energy interrelationships and glossary of energy terms. Publication No. 1411, National Academy of Sciences, Washington, D.C.

National Research Council. 1969. United States-Canadian tables of feed composition. Publication No. 1684. National Academy of Sciences, Washington, D.C.

Vanschoubroek, F., and G. Cloet. 1968. The feeding value of concentrates in the rabbit. World Rev. Anim. Prod. 4:70-76.

FEEDING PRACTICES

Aitken, F. C., and W. K. Wilson. 1962. Rabbit feeding for meat and fur. Tech. Comm. No. 12. Imp. Bur. Anita. Nutr., Scotland.

Chapin, R. E. 1965. Ph.D. Thesis, Cornell University.

Cheeke, P. R. 1972. Antioxidant activity of Torula yeast. Nutr. Rep. Int. 5:159-170.

Cheeke, P. R. 1974. Feed preferences of adult male Dutch rabbits. Lab. Anita. Sci. 24:601-604.

Fedelli-Avanzi, C., and G. G. Janella. 1976. Growth rate and thiocyanate level in blood and urine of rabbits fed with carrots, rape and cabbage. 1st Int. Rabbit Congr., Dijon, France. Communication 28.

Gaman, E., H. Fisher, and A. S. Fiegenbaum. 1970. An adequate purified diet for rabbits of all ages. Nutr. Rep. Int. 1:35-48.

Holley, K. T. 1955. Cottonseed meal in swine and rabbit rations. Ga. Agric. Exp. Stn. Mimeogr. Ser. N.S. 12.

Hove, E. L., and J. R. Hemdon. 1975. Growth of rabbits on purified diets. J. Nutr. 68:193-200.

King, J. O. L. 1974. The effects of pelleting rations with and without an antibiotic on the growth rate of rabbits. Vet. Rec. 94:586-588.

Lebas, F. 1975. (The meat rabbit: Nutritional requirements and pellets). Ann. Zootech. 22:249-251.

Lebas, F. 1975b. (The meat rabbit: nutritional requirements and feeding practices). Italy, Paris. 50 pp.

Reddy, B. S., J. R. Pleasants, D. R. Zimmerman, and B. S. Wostman. 1965. Iron and copper utilization in rabbits as affected by diet and germ-free status. J. Nutr. 87:189-196.

Reddy, B. S., B. S. Wostman, and J. R. Pleasants. 1968. Nutritionally adequate diets for germ free animals, pp. 87-111 . *In* The germ-free animal in research, M. E. Coates, ed. Academic Press, New York.

Yamamoto, Y. J. 1959. An experimental reproduction of congenital goiter in rabbits. Osaka City Med. J. 8:542-548.

LIPIDS

Ahluwalia, B., G. Pincus, and T. Holman. 1967. Essential fatty acid deficiency and its effects upon reproductive organs of male rabbits. J. Nutr. 92:205-214.

Arrington, L. R., J. K. Platt, and D. E. Franke. 1974. Fat utilization by rabbits. J. Anita. Sci. 38:76-80.

Cheeke, P. R. 1974. Feed preferences of adult male Dutch rabbits. Lab. Anita. Sci. 24:601-604.

Thacker, E. J. 1956. The dietary fat level in the nutrition of the rabbit. J. Nutr. 58:243-249.

MINERALS

Apgar, J. 1971. Effect of a low zinc diet during gestation on reproduction in the rabbit. J. Anim. Sci. 33:1255-1258.

Arrington, L. R., and G. K. Davis. 1953. Molybdenum toxicity in the rabbit. J. Nutr. 51:295-304.

Arrington, L. R., R. N. Taylor, C. B. Ammerman, and R. L. Shirley. 1965. Effects of excess dietary iodine upon rabbits, hamsters, rats and swine. J. Nutr. 87:394-398.

Besancon, P., and F. Lebas. 1969. (True digestive utilization and calcium retention in the growing rabbit receiving a calcium and phosphorus rich diet). Ann. Zootech. 18:437-443.

Blanco, A., and L. Gueguen. 1974. (Utilization of phosphorus from sunflower seed meal by the rabbit). Cuban J. Agric. Sci. 8:61-66.

Chapin, R. E., and S. E. Smith. 1967a. Calcium requirement of growing rabbits. J. Anita. Sci. 26:67-71.

Chapin, R. E., and S. E. Smith. 1967b. The calcium tolerance of growing and reproducing rabbits. Cornell Vet. 57:480-491.

Chapin, R. E., and S. E. Smith. 1967c. High phosphorus diets fed to growing rabbits. Cornell Vet. 57:492-500.

Cheeke, P. R, and J. W. Amberg. 1973. Comparative calcium excretion by rats and rabbits. J. Anita. Sci. 37:450-454.

Cheeke, P. R., and P. D. Whanger. 1976. Glutathione peroxidase activity of rabbit tissues. Nutr. Rep. Int. 13:287-290.

Draper, H. H. 1957. Ineffectiveness of selenium in the treatment of nutritional muscular dystrophy in the rabbit. Nature 180:1419.

Gaman, E., H. Fisher, and A. S. Fiegenbaum. 1970. An adequate purified diet for rabbits of all ages. Nutr. Rep. Int. 1:35-48.

Hove, E. L., and J. F. Herdon. 1955. Potassium deficiency in the rabbit as a cause of muscular dystrophy. J. Nutr. 55:363-374.

Hove, E. L, G. S. Fry, and K. Schwarz. 1958. Ineffectiveness of Factor 3 selenium compounds in muscular dystrophy of rabbits on vitamin E free diets. Proc. Soc. Exp. Biol. Med. 98:27-29.

Hunt, C. E., and W. W. Carlton. 1965. Cardiovascular lesions associated with experimental copper deficiency in the rabbit. J. Nutr. 87:385-393.

Hunt, C. E., W. W. Carlton, and P.M. Newberne. 1970. Interrelationships between copper deficiency and dietary ascorbic acid in the rabbit. Br. J. Nutr. 24:61-69.

Jenkins, K. J., M. Hidiroglou, R. R. MacKay, and J. G. Proulx. 1970. Influence of selenium and linoleic acid on the development of nutritional muscular dystrophy in beef calves, lambs and rabbits. Can. J. Anita. Sci. 50:137-146.

Kennedy, A. 1965. The urinary excretion of calcium by normal rabbits. J. Comp. Pathol. 75:69-74.

King, J. O. L. 1975. The feeding of copper sulfate to growing rabbits. Br. Vet. J. 131:70-75.

Kunkel, H. O., and P. B. Pearson. 1948. Magnesium in the nutrition of the rabbit. J. Nutr. 36:657.

Lebas, F., P. Besancon, and A. Abouyoub. 1971. (Mineral compositionof rabbits milk. Variations according to stage of lactation). Ann. Zootech. 210:487-495.

Lupulescu, A. 1974. Effect of synthetic salmon calcitonin on glucose, blood urea nitrogen and serum electrolytes in rabbits. J. Pharmacol. Exp. Ther. 188:318-323.

Mathieu, L. G., and S. E. Smith. 1961. Phosphorus requirements of growing rabbits. J. Anita. Sci. 20:510-513.

Salako, L. A., A. J. Smith, and R. N. Smith. 1971. The effects of porcine calcitonin on renal function in the rabbit. J. Endocrinol. 50:485-491.

Shaw, N. A., H. C. Dickey, H. H. Brugman, D. L. Blamberg, and J. F. Witter. 1972. Effects of zinc deficiency on female tan rabbits. J. Anita. Sci. 35:224.

Shaw, N. A, H. C. Dickey, H. H. Brugman, D. L. Blamberg, and J. F. Witter. 1974. Zinc deficiency in female rabbits. Lab. Anita. 8:1-7.
Simnett, K. E, and G. H. Spray. 1965a. The effect of a low-cobalt diet in rabbits. Br. J. Nutr. 19:119-123.
Simnett, K. E., and G. H. Spray. 1965b. The absorption and excretion of ^{58}Co cyanocobalamin by rabbits. Br. J. Nutr. 19:593-598.
Smith, S. E, and G. H. Ellis. 1947. Studies of the manganese *requirements* of rabbits. J. Nutr. 34:33-41.
Smith, S. E., M. Medlicott, and G. H. Ellis. 1944. The blood picture of iron and copper deficiency anemia in the rabbit. Am. J. Physiol. 142:179-181.
Surdeau, P, R. Henaff, and G. Perrier. 1976. (Dietary supplies and balances of Na, K, and Cl in the growing rabbit). 1st Int. Rabbit Congr., Dijon, France. Communication 21.
Tarvydas, H., S. M. Jordan, and E. H. Morgan. 1968. Iron metabolism during lactation in the rabbit. Br. J. Nutr. 22:565-573.
Underwood, E. J. 1971. Trace elements in human and animal nutrition. Academic Press, New York.
Woodward, D. L., and D. J. Reed. 1969. Effect of magnesium deficiency on electrolyte distribution in the rabbit. Am. J. Physiol. 217:1477-1482.

PROTEIN AND AMINO ACIDS

Adamson, I., and H. Fisher. 1973. The amino acid requirement of the growing rabbit: An estimate of the quantitative needs. J. Nutr. 103:1306-1310.
Adamson, I, and H. Fisher. 1976. Further studies on the arginine requirement of the rabbit. J. Nutr. 106:717-723.
Cheeke, P. R. 1971. Arginine, lysine and methionine needs of the growing rabbit. Nutr. Rep. Int. 3:123-128.
Cheeke, P. R. 1972. Nutrient requirements of the rabbit. Feedstuffs 44(48):28.
Cheeke, P. R. 1974. Evaluation of alfalfa protein concentrate as a protein source for rabbits. Nutr. Rep. Int. 9:267-272.
Cheeke, P. R., and J. W. Amberg. 1972. Protein nutrition of the rabbit. Nutr. Rep. Int. 5:259-266.
Colin, M. 1974. (Lysine supplementation of a sesame oil meal diet in the rabbit. Effects on growing performances and nitrogen balance estimated by means of two methods). Ann. Zootech. 23:119-132.
Colin, M. 1975a. (Effect on growth of the rabbit of supplementation of simplified diets with lysine and methionine). Ann. Zootech. 24:465-473.
Colin, M. 1975b. (Effect of dietary arginine level on growth and nitrogen of the rabbit: Relation to lysine content). Ann. Zootech. 24:629-638.
Colin, M, and F. Lebas. 1976. Utilization of rapeseed oil-meal, horsebeans and peas in the diet of growing rabbits. 1st Int. Rabbit Congress, Dijon, France.
Colin, M., G. Arkhurst, and F. Lebas. 1973. (Effect of methionine addition to the diet on growing performances in the rabbit). Ann. Zootech. 22:485-491.
Davidson, J., and D. Spreadbury. 1975. Nutrition of the New Zealand White rabbit. Proc. Nutr. Soc. 34:75-83.
Gaman, E, and H. Fisher. 1970. The essentiality of arginine, lysine and methionine for the growing rabbit. Nutr. Rep. Int. 1:57-64.
Hoover, W. H., and R. N. Heitmann. 1975. Cecal nitrogen metabolism and amino acid absorption in the rabbit. J. Nutr. 105:245-252.
Houpt, T. R. 1963. Urea utilization by rabbits fed a low protein ration. Am. J. Physiol. 205:1144-1150.
Kennedy, L. G., and T. V. Hershberger. 1974. Protein quality for the nonruminant herbivore. J. Anim. Sci. 39:506-511.
Kennedy, L. G., T. V. Hershberger, and R. D. McCarthy. 1970. Absorption of leucine from the nonruminant herbivore cecum. J. Anita. Sci. 31:204.
King, J. O. L. 1971. Urea as a protein supplement for growing rabbits. Br. Vet. J. 127:523-528.
Lebas, F. 1973. (Effect of amount of protein in diets based on soybean meal or sesame meal on growth of the rabbit). Ann. Zootech. 22:83-92.
Lebas, F., and M. Colin. 1973. (Effect of addition of urea to a diet poor in protein for growing rabbits). Ann. Zootech. 22:111-113.
McWard, G. W., L. B. Nicholson, and B. R. Poulton. 1967. Arginine requirement of the young rabbit. J. Nutr. 92:118-120.
Olcese, O., and P. B. Pearson. 1948. Value of urea in the diet of rabbits. Proc. Soc. Exp. Biol. Med. 69:377-379.
Slade, L. M, and H. F. Hintz. 1969. Comparison of digestion in horses, ponies, rabbits and guinea pigs. J. Anita. Sci. 28:842-843.
Slade, L. M., and D. W. Robinson. 1970. Nitrogen metabolism in rabbits and guinea pigs. J. Anim. Sci. 30:1044.

VITAMINS

Bragdon, J. H, and D. H. Levine. 1949. Myocarditis in vitamin E deficient rabbits. Am. J. Pathol. 25:265-271.
Diehl, J. F. 1960. Effect of hepatic coccidiosis infection in rabbits on tissue levels of vitamins A and E. J. Nutr. 71:322-325.
Diehl, J. F., and B. G. Kistler. 1961. Vitamin E saturation test in coccidioses-infected rabbits. J. Nutr. 74:495-499.
Eppstein, S. H., and S. Morgulis. 1941. The minimum requirement of rabbits for dl-α-tocopherol. J. Nutr. 22:415-424.
Goldblatt, H., and A. R. Moritz. 1925. Experimental rickets in rabbits. J. Exp. Med. 42:499-506.
Harris, L. J., B. J. Constable, A. N. Howard, and A. Leader. 1956. Vitamin C economy of rabbits. Br. J. Nutr. 10:373-382.
Hogan, A. G., and J. W. Hamilton. 1942. Adequacy of simplified diets for guinea pigs and rabbits. J. Nutr. 23:539-543.
Hogan, A. G., and W. S. Ritchie. 1934. Nutritional requirements of rabbits and guinea pigs. Mo. Agric. Exp. Stn. Bull. 219.
Hove, E. L., and D. H. Copeland. 1954. Progressive muscular dystrophy in rabbits as a result of chronic choline deficiency. J. Nutr. 53:391-405.
Hove, E. L., and P. L. Harris. 1947. Relative activity of the tocopherols in curing muscular dystrophy in rabbits. J. Nutr. 33:95-106.
Hove, E. L., and J. F. Herndon: 1955. Potassium deficiency in the rabbit as a cause of muscular dystrophy. J. Nutr. 55:363-374.
Hove, E. L., and J. F. Herndon. 1957a. Vitamin B_6 deficiency in rabbits. J. Nutr. 61:127-136.
Hove, E. L., and J. F. Herndon. 1957b. Growth of rabbits on purified diets. J. Nutr. 63:193-199.
Hove, E. L, D. H. Copeland, and W. D. Salmon. 1954. Choline deficiency in the rabbit. J. Nutr. 53:377-389.
Hove, E. L., D. H. Copeland, J. F. Herndon, and W. D. Salmon. 1957. Further studies on choline deficiency and muscular dystrophy in rabbits. J. Nutr. 63:289-300.
Jarl, F. 1948. Experiments with vitamin D and rabbits. Lantbruk-shoegsk. Husdjursfoersoeksanst. Medd. 29:1-40.
Kaminura, M., and N. Sasaki. 1965. Effect of topical application

of vitamin E on the hair growth of rabbits . J. Vitaminol. 11:1-8.
Kulwich, R., L. Struglia, and P. B. Pearson. 1953. The effect of coprophagy on the excretion of B-vitamins by the rabbit. J. Nutr. 49:639-645.
Lamming, E.G., G. W. Salisbury, R. L. Hays, and K. A. Kendall. 1954a. The effect of incipient vitamin A deficiency on reproduction in the rabbit. I. Decidua, ova and fertilization. 2. Embryonic and fetal development. J. Nutr. 52:217-226, 227-236.
Lamming, E. G., D. H. M. Wollan, and J. W. Millan. 1954b. Hydrocephalus in young rabbits associated with maternal vitamin A deficiency. Br. J. Nutr. 8:363-369.
Lease, J. G., H. T. Parsons, and E. Kelly. 1937. A comparison in five types of animals of the effect of dietary egg white and a specific factor given orally or parenterally. Biochem. J. 31:433-437.
Mackenzie, C. G., and E. V. McCollum. 1940. The cure of nutritional muscular dystrophy in the rabbit by alphatocopherol and its effect on creatine metabolism. J. Nutr. 19:345-362.
Mann, I., A. Pirie, K. Tansley, and C. Wood. 1946. Some effects of vitamin A deficiency on the eye of the rabbit. Am. J. Ophthalmol. 29:801-815.
Mellanby, E. 1935. Lesions of the central and peripheral nervous system in young rabbits by vitamin A deficiency and a high cereal intake. Brain 58:141-173.
Mellanby, E., and E. M. Killick. 1926. A preliminary study of factors influencing calcification processes in rabbits. Biochem. J. 20:902-926.
Moore, R. A., I. Bittenger, M. L. Miller, and L. M. Hellman. 1942. Abortion in rabbits fed a vitamin K deficient diet Am. J. Obstet. Gynecol. 43:1007-1012.
Nelson, V. E., and A. R. Lamb. 1920. The production of xerophthalmia in the rabbit. Am. J. Physiol. 51:530-535.
Nelson, V. E., A. R. Lamb, and V. G. Heller. 1922. The effect of vitamin deficiency on various species of animals. Am. J. Physiol. 59:335-342.
Olcese, O., P. B. Pearson, and B. S. Schweigert. 1948. The synthesis of certain B vitamins by the rabbit. J. Nutr. 35:577-590.
Olcese, O., P. B. Pearson, and P. Sparks. 1949. Intestinal synthesis of niacin and the metabolic interrelationship of tryptophan and niacin in the rabbit. J. Nutr. 39:93-105.
Owen, E. C., D. W. West, and M. E. Coates. 1970. Metabolism of riboflavin in germ-free and conventional rabbits. Br. J. Nuts. 24:259-267.
Payne, A. S., E. Donelet, and R. D. Baker. 1972. Effects of dietary vitamin A on growth and reproduction in rabbits. Can. J. Anita. Sci. 52:125-136.
Phillips, P. H., and G. Bohstedt. 1938. Studies on the effects of a bovine blindness-producing ration upon rabbits. J. Nuts. 15:309-319.
Procter, J. F., D. C. Maplesden, D. E. Hogue, and J. K. Loosli. 1961. Relation of selenium, vitamin E and other factors to muscular dystrophy in the rabbit. Proc. Soc. Exp. Biol. Med. 108:77-79.
Reid, J. M., E. L. Hove, P. F. Braucher, and O. Mickelsen. 1963. Thiamine deficiency in rabbits. J. Nuts. 80:381-385.
Ringlet, D. H., and G. D. Abrams. 1970. Nutritional muscular dystrophy and neonatal mortality in a rabbit breeding colony. J. Am. Vet. Med. Assoc. 157:1928-1934.
Ringler, D. H., and G. D. Abrams. 1971. Laboratory diagnosis of vitamin E deficiency in rabbits fed a faulty commercial ration. Lab. Anita. Sci. 21:363-388.
Rosenthal, H. L., and L. Cravitz. 1958. Organ, urine and feces vitamin B_{12} content of normal and starved rabbits. J. Nutr. 64:281-290.
Saksena, J. S., J. A. Mehta, and A. Naimark. 1971. The effect of vitamin A deficiency in rabbits on the elastic properties of the lung and thoracic aorta. Can J. Physiol. Pharmacol. 49:127-133.
Sirmnett, K. I., and G. H. Spray. 1961. The influence of diet on the vitamin B_{12} activity in the serum, urine and faces of rabbits. Br. J. Nuts. 15:555-566.
Stevenson, R. G., N. C. Palmer, and G. G. Finely. 1976. Hypervitaminosis D in rabbits. Can. Vet. J. 17:54-57.
Wooley, J. G. 1947. Niacin deficiency in rabbits and response to tryptophan and niacin. Proc. Soc. Exp. Biol. Med. 65:315-317.
Wooley, J. G., and W. H. Sebrell. 1945. Niacin (nicotinic acid), an essential growth factor for rabbits fed a purified diet. J. Nuts. 29:191-199.