

Feeding Young Adult Dogs: Before Middle Age

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*"If you get to thinking you're a person of some influence,
try ordering somebody else's dog around."*

Will Rogers

INTRODUCTION

Depending on breed, dogs one through five to seven years of age are generally considered young adults. They are usually fully grown (about 12 months old for most breeds) but are not yet middle aged. In people, middle age is often considered to coincide with the third quarter of the average lifespan. Other than obesity and periodontal disease, this age range represents a relatively healthy period in a dog's life. Generally, many of the more common mortal diseases are more often diagnosed in middle-aged or older dogs.

The goals of nutritional management for young adult dogs are to maximize longevity and quality of life (disease prevention). A basic premise is that the foods fed should be nutritious; they should provide the recommended allowances of all known required nutrients. Most regulated commercial foods provide all the necessary nutrients in amounts that avoid deficiencies (Chapter 9). However, to meet the feeding goals described above, nutritional recommendations must exceed simply preventing diseases associated with nutrient deficiencies.

Nutritional recommendations for people living in affluent countries include nutrient and food recommendations that help prevent important diseases such as obesity, diabetes mellitus, cardiovascular disease, cancer, Alzheimer's disease and others. Thus, as in people, optimal feeding plans for pet dogs should include recommendations for specific nutrients and non-nutrient food ingredients (key nutritional factors) that influence

important canine diseases. **Table 13-1** lists the important health concerns that may be positively affected by proper nutritional management in this age group of dogs. To achieve these feeding goals, besides selecting the best food, the food needs to be properly fed (amounts and methods).

PATIENT ASSESSMENT

Patient assessment should be a structured process that includes: 1) obtaining accurate and detailed medical and nutritional histories, 2) reviewing the medical record, 3) conducting a physical examination and 4) evaluating results of laboratory and other diagnostic tests. During assessment, the feeding goals should be established and explained, risk factors for nutrition-related diseases considered and key nutritional factors identified.

History and Physical Examination

Often, in a typical busy clinical setting, the time available to obtain a dietary history and conduct a physical examination is limited. However, a minimum dietary database for all canine patients should be obtained and include: 1) the type of food fed (homemade, commercial, dry, moist, semi-moist, etc.), 2) recipes if homemade food represents the majority of the diet, 3) brand names of commercial foods, if known, 4) names of supplements, treats and snacks and 5) method of feeding (free

Table 13-1. Important diseases for adult dogs that have nutritional associations.*

Disease/ health concern	Incidence/prevalence/ mortality/pet owner concern
Dental disease	Most prevalent disease; numerous associated health risks (e.g.kidney disease)
Obesity	Approximate 30% prevalence; associated health risks (e.g., diabetes mellitus, musculoskeletal disease); major concern
Kidney disease	Second leading cause of non-accidental death; major concern
Arthritis	6% prevalence; primary concern
Cancer	Primary cause of death; primary concern
Skin/coat problems	Second most common cause of disease (26% prevalence); second most common health concern

*Adapted from DeBowes LJ, Mosier D, Logan EI. Association of periodontal disease and histologic lesions in multiple organs from 45 dogs. *Journal of Veterinary Dentistry* 1996; 13: 57-60. Egenvall A, Bonnet BN, Hedhammar A, et al. Mortality in over 350,000 insured Swedish dogs from 1995-2000: II. Breed-specific age and survival patterns and relative risk for causes of death. *Acta Veterinaria Scandinavica* 2005; 46(3): 121-136. Lund EM, Armstrong PJ, Kirk CA, et al. Health status and population characteristics of dogs and cats examined at private veterinary practices in the United States. *Journal of the American Veterinary Medical Association* 1999; 214: 1336-1341. Morris Animal Foundation Survey Results, August 12, 2005. Morris Animal Foundation Survey Results, 1998.

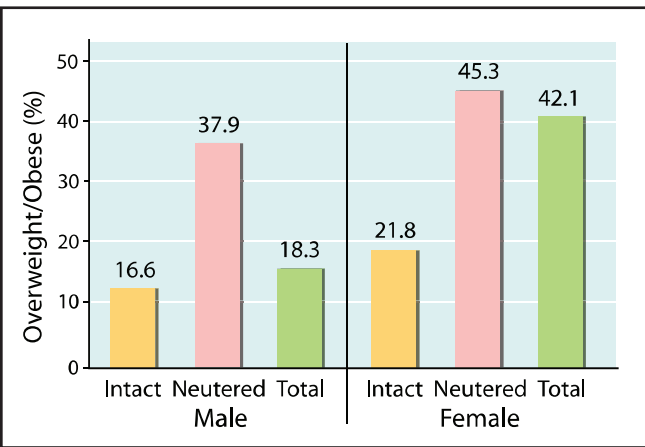


Figure 13-1. Percentage of overweight and obese dogs in intact, neutered and total female (3,828) and male (4,109) populations. (Adapted from Edney ATB, Smith PM. Study of obesity in dogs visiting veterinary practices in the United Kingdom. *Veterinary Record* 1986; 118: 391-396.)

choice, meal feeding, etc.). An extended dietary database includes: 6) quantities fed, 7) recent changes in food type, intake and preferences, 8) access to food for other pets or livestock, 9) who in the family buys food for the pet, 10) who in the family feeds the pet and 11) appetite changes with estimates of magnitude and duration. The general type and level of activity (e.g., house pet, confined to kennel, working dog, etc.) and neuter status should be noted because these factors are important determinants of energy requirements. The dietary history

should be expanded if nutrition-related problems such as obesity are identified in the initial evaluation of the patient.

Body weight, body condition score (BCS) (Chapter 1), oral health and overall appearance of the skin and coat of all adult dogs should be assessed and recorded in the medical record. These parameters are general indicators of nutritional adequacy. An otherwise healthy young adult dog with normal body weight, skin and coat and BCS (2.5/5 to 3.5/5) and no evidence of significant dental disease is unlikely to need further nutritional assessment. However, for purposes of disease prevention, nutritional intervention, such as switching to a food that matches the recommended levels of key nutritional factors, may be warranted. The health concerns listed in Table 13-1 are discussed in the risk factor review that follows.

Gender and Neuter Status

No controlled studies have been performed to delineate differences in nutritional requirements of intact male vs. intact female dogs. It may be presumed that, like other mammals, intact females require less caloric intake than intact males. If this assumption is true it is probably because of gender-related differences in lean body mass. Lean body mass accounts for nearly all of an animal's resting energy requirement (RER) (Blaxter, 1989). Women require fewer calories than men because of a lower relative amount of lean body mass than men (Pellett, 1990). One study showed that female dogs had an average of 16% more body fat than male dogs (Meyer and Stadtfeld, 1980). Surveys have found a much higher prevalence of overweight and obese conditions in female than male dogs (Figure 13-1) (Edney and Smith, 1986; Mason, 1970). These findings suggest that intact female dogs may need fewer calories than intact males.

Obesity occurs twice as often in neutered dogs than in reproductively intact dogs (Figure 13-1) (Edney and Smith, 1986). Very little is known, however, about the pathophysiology of this phenomenon. Neutering does not appear to have a marked impact on the resting energy expenditure of female dogs (Anantharaman-Barr, 1990); however, it may significantly increase food intake (Haupt et al, 1979). The increased food intake in neutered bitches is thought to be a consequence of a reduction of appetite-suppressing estrogen activity (Haupt et al, 1979; O'Farrell and Peachey, 1990). A decrease in physical activity is also assumed to occur in many dogs after neutering and may play a more important role in male dogs because of decreased roaming (Hopkins et al, 1976; Lewis, 1978). The daily energy intake should be limited to prevent rapid weight gain in neutered dogs; 1.6 x RER is a good starting point. For some breeds and individual dogs, it may be necessary to lower the energy intake of neutered dogs to 1.2 to 1.4 x RER (Chapters 1 and 5).

Breed

The breed classification should be determined in the initial assessment. Different breeds may be at risk for specific diseases or metabolic alterations that require nutritional management. As an example, certain canine breeds appear to be predisposed

to obesity (Chapter 27). In addition, daily energy requirement (DER) differences have been delineated among different breeds, possibly because of differences in lean body mass, temperament and activity level. As examples, Newfoundland dogs have energy requirements about 20% less than average (Kienzle and Rainbird, 1991), whereas Great Danes and Dalmatians may have energy requirements up to 60% higher than average (Rainbird and Kienzle, 1990; Kienzle and Rainbird, 1991; Zentek and Meyer, 1992; Männer, 1990). Careful attention to specific local lineage and personal clinical impressions of breed differences may prove useful in food recommendations.

Activity Level

Activity significantly influences the energy requirements of individual dogs and should be taken into account when estimating energy requirements. For example, standing requires 40% more energy than lying down (Meyer, 1983). DER may range from RER for sedentary dogs to almost 15 x RER for

endurance athletes under extreme conditions (Hinchcliff et al, 1997). A consistently higher level of physical activity probably would result in a relative increase in lean body mass, which would result in an increase in energy use, even at rest (Blaxter, 1989). However, because the activity of individual dogs often cannot be defined precisely, feeding recommendations should initially be conservative to avoid overfeeding and the risk of obesity. Food intake should be adapted as needed to maintain optimal body weight. Chapter 18 presents more information about the influence of specific nutrients on athletic performance (Box 13-1).

SEDENTARY DOGS

Estimations for DER include enough energy to support spontaneous activity, such as eating, sleeping, going outside and up to three hours of play and exercise per day. However, most pet dogs are minimally active (NRC, 2006). Approximately 19% of owners never play with their dogs and 22% take their

Box 13-1. Special Nutritional Considerations for Stressed Dogs.

STRESS

Police dogs, sentry dogs and other working dogs may refuse to eat, lose weight, develop diarrhea or become reluctant to work for inapparent reasons. Physiologically induced weight loss is most common in sentry dogs, in which a combination of mental stress, weather extremes and activity may result in loss of up to 10% of body weight during a six-hour tour of duty. Stress stimulates release of cortisol and induces a discharge of catecholamines. Besides stimulating alertness, catecholamines may depress food intake in stressed animals by activating the β -adrenergic and dopaminergic receptors in the lateral hypothalamus. This is obvious in highly stressed sentry dogs that may be reluctant to eat the volume of food they need to meet energy requirements. Dogs in various stressful situations demonstrate the same behavior. Some show dogs and racing greyhounds eat sparingly when the owner/handler prepares to depart to a show or a competition. A decrease in food intake, a slight increase in energy requirement and the catabolic effect of cortisol justify feeding a food with increased fat content (at least about 15% dry matter [DM]) and a protein level of about 25% DM. This recommendation does not compensate for energy spent for activity in addition to the stress (e.g., long-distance performances in which fat must be further increased to meet additional energy requirements).

Changing environments such as boarding or hospitalization may influence food intake due to stress. Dogs may develop diarrhea or refuse to eat when boarded. Practitioners commonly see dogs that refuse to eat in the hospital, but readily eat at home.

EFFECTS OF THE SHOW CIRCUIT

The success of a show dog is determined by genetics, general health, socialization, training and nutrition. Therefore, the preparation of a show dog starts with the correct choice of parents, sound breeding practices and correct rearing of puppies. Good nutrition allows for optimal expression of inherited qualities of a dog. Nutrition of a show dog involves feeding for correct development of skeleton and dentition, and maintenance of long-term health. More

specific to show dogs are the nutritional needs for optimal condition of skin and coat, and the support of stress.

Preparation for the show may require particular attention. Skin health and correct color, length and glossiness of hair are important for adult show dogs. The first requirement for a shiny coat is good overall health and nutrition throughout the year. See Chapter 32 for more information about the nutritional effects on skin and coat.

Some show dogs may be finicky eaters, so they may need to be fed a more concentrated, palatable food, containing 25 to 30% DM protein and $\geq 15\%$ DM fat. During a show, dogs don't spend much energy for physical activity; the primary increase is probably due to stress. Generally, a food that supports the health of skin and coat will provide all the nutrients needed to counteract stress.

EFFECTS OF MULTI-DOG HOUSEHOLDS

Individually housed dogs with limited exercise may have daily energy requirements (DER) as low as 90 to 95 kcal (375 to 400 kJ) metabolizable energy (ME)/BW_{kg}^{0.75}, or 1.3 x resting energy requirement (RER). When housed in kennels with other dogs in situations where much mutual interaction occurs, DER may increase to 130 to 140 kcal (545 to 585 kJ) ME/BW_{kg}^{0.75}, or 1.9 to 2.0 x RER or more.

In the U.S., more than a third of dog-owning families have more than one dog and many families own more than one species. Some dogs may increase their interest in food when a new pet is introduced to a household, whereas others may refuse to eat for a day or two. Jealousy may arise over food, bones or toys, or over space in the bed. Dogs may defend their food bowl and raise the hair on their crest, withers and back or growl. Free-choice feeding may have a quieting effect in kennels or multiple-dog households, and less dominant dogs may have a better chance to get their share of the food provided. In some cases, dogs need to be fed in separate places. However, those situations are often created by the owner's intervention in the pecking order.

The Bibliography for **Box 13-1** can be found at www.markmorris.org.

Table 13-2. Influence of age on daily energy requirements of active pet dogs.*

Age (years)	Typical DER ranges**		
	kcal ME/BW _{kg} ^{0.75}	kJ ME/BW _{kg} ^{0.75}	x RER
1-2	120-140	500-585	1.7-2.0
3-7	100-130	420-550	1.4-1.9
>7	80-120	335-500	1.1-1.7

Key: DER = daily energy requirement, ME = metabolizable energy, RER = resting energy requirement, kcal = kilocalories, kJ = kilojoules.

*Most pet dogs are minimally active and have a DER of approximately 95 kcal/BW_{kg}^{0.75} or 1.2 to 1.4 x RER.

**The energy requirements indicated in this table are only starting points and should be adapted for individual dogs.

dogs out for exercise fewer than three hours per week (Slater et al, 1995). Solitary dogs are less active than dogs housed as a group (Hubrecht et al, 1992). In one study, large dogs (Labrador retrievers) were active for half as many hours per day as small dogs (Manchester terriers) (Patil and Bisby, 2002). An association was also reported between increasing age and declining activity; older dogs spent less time running and more time walking (Head et al, 1997; Siwak et al, 2002).

ACTIVE AND SPORTING DOGS

Dogs and horses are often regarded as the elite athletes of domesticated mammals (Rose and Bloomberg, 1989). Greyhounds are sprint athletes and can reach average speeds of 56 to 60 km/hour (35 to 37.5 miles/hour) over typical race distances (Tompkins and Heasman, 1988). Sled dogs are endurance athletes and can maintain a trot of about 16 km/hour (10 miles/hour) for 10 to 14 hours per day for several consecutive days (Grandjean and Paragon, 1992). Energy requirements of dogs performing work between the two extremes (i.e., sedentary and sled dogs) need to be tailored to the individual. Chapter 18 describes how to feed active working and sporting dogs.

Age

Age-related changes occur between the onset of adulthood and five to seven years of age. The prevalence of dental disease, obesity, cancer, arthritis and kidney disease generally increases over this time span (Chapters 27, 30, 34, 37, 47). The cumulative effects of oxidative damage can result in beta-amyloid deposition in the brain as early as five to seven years of age, predisposing to cognitive dysfunction (Chapter 35). Furthermore, apart from reproduction and imposed activity during work or sport, age may be the single most important factor that influences the DER of most adult dogs (Table 13-2) (Finke, 1994).

Environment

The influence of the environment should not be neglected when evaluating energy and nutrient requirements. Temperature, humidity, type of housing, level of stress and the degree of acclimatization should be considered with respect to breed and lifestyle nutrient requirements of dogs (Box 13-1). Animal fac-

tors including insulative characteristics of skin and coat (i.e., subcutaneous fat, hair length and coat density) and differences in stature, behavior and activity interact and affect DER.

Dogs can tolerate extreme cold. Adult dogs can maintain normal body temperature in ambient temperatures as low as -46 to -50°C (-51 to -58°F) for four to 27 hours and six out of seven dogs maintained normal body temperatures at -75 to -79°C (-103 to -110°F) for three to five hours (Hume and Egdahl, 1959). One study found that an ambient temperature of -160°C (-256°F) was necessary to make a dog hypothermic after one hour (Giaja, 1938). When kept outside in cold weather, dogs may need 10 to 90% more energy than during optimal weather conditions (Meyer, 1983; Durrer and Hannon, 1962). Heat losses are minimal at a temperature called the lower critical temperature (Blaxter, 1989a). This is the environmental temperature at which dogs reach their minimum metabolic rate. It is breed specific and is lower when the thermic insulation (i.e., coat density and length) is greater (Zentek and Meyer, 1992; Meyer, 1983, 1990; Männer, 1991; Kleiber, 1975). The lower critical temperature is estimated at 15 to 20°C (59 to 68°F) for longhaired breeds, 20 to 25°C (68 to 77°F) for shorthaired breeds and may be as low as 10 to 15°C (50 to 59°F) for arctic breeds (Männer, 1990, 1991; Kleiber, 1975; Meyer, 1990).

Energy use by dogs in cold environments is similar to energy use during endurance exercise (Minaire et al, 1973). In part, skeletal muscle is involved in shivering and non-shivering thermogenesis (NRC, 2006). As with endurance exercise, muscle glycogen stores may limit the ability to withstand cold (Minaire et al, 1973). Thus, high-fat foods are probably well suited for cold-acclimatized dogs in a cold environment. No published studies currently exist about the influence of changing the relative proportions of the nutrient composition of a food for improved resistance to cold in dogs. But for long-term exposure to cold, the amount of food fed should be increased to ensure increased energy availability.

Compared to cold ambient temperatures, a relatively smaller amount of energy is expended to dissipate heat at temperatures above the thermoneutral zone; however, increased amounts of water are required (Box 13-2). Adult dogs tolerated high ambient temperatures up to 56°C (133°F) for three hours or more in dry air (Adolph, 1947) but became poikilothermic at 33°C (91°F) or higher in moist air after one hour (Lozinsky, 1924). The metabolic rate increased by 10% in adult dogs when ambient temperatures were 35°C (95°F) (Minaire et al, 1973).

Housing conditions may influence energy and water requirements by modifying the immediate environment. Many housing options are possible; however, any shelter with temperatures closer to the thermoneutral zone will decrease energy requirements in cold environments and water requirements in hot environments (i.e., protection from wind chill, excess sun, etc.). Conversely, housing that moves dogs farther away from the thermoneutral zone will have the opposite effects (e.g., closed spaces in hot humid conditions, damp shady shelters in cold weather). The number of dogs in a shel-

Box 13-2. Nutrients Used for Body Cooling.

When ambient temperature exceeds a dog's thermoneutral zone, water and energy are used for heat loss. The ability of dogs (and people) to withstand extremely high ambient temperatures is well demonstrated by a study conducted in 1775 by Blagden. It was reported that Blagden, and a dog in a basket (to protect its feet from being burned), entered a room kept at a 126°C (259°F) and remained there for 45 minutes. A steak he took with him was cooked; however, he and the dog were unaffected.

Bodies cool by radiation, conduction, convection and vaporization of water. As the ambient temperature increases, the conditions for heat loss by radiation, conduction and convection become increasingly unfavorable. When the ambient temperature exceeds the dog's body temperature, the dog's entire metabolic heat production and the heat received from the environment by conduction, convection and radiation must be removed by evaporation of water to maintain normal body temperature.

Vaporization of water can occur via insensible perspiration, respiration, panting and sweating. Dogs have few sweat glands and thus must pant to evaporate additional water for cooling. Panting is facilitated by the elastic properties of the thorax and respiratory system. Depending on the size of the dog, the respiratory apparatus

oscillates to a natural frequency (the resonant frequency of the chest is proportional to the square root of the body mass). The amount of cooling is regulated by the duration of panting. If not for resonant elasticity, the increased muscular effort of breathing would generate more heat than the total heat that could be dissipated by panting. As a result of these elastic properties, however, panting requires only a small amount of energy.

The amount of heat lost via vaporization of water is approximately 580 kcal (2,426 kJ)/kg water. In hot desert-like conditions, in which the heat gained from the environment can be 10 times the metabolic heat production, the water required for cooling a 15-kg dog may equal 2.5% of its body mass per hour. At this rate, if uncompensated for evaporative water loss, a dog could experience a 10% reduction of its total body water within 2.5 hours. Thus, from a nutritional perspective, dogs in hot environments may have a significant increase in water requirement with only a small increase in energy needs to maintain normal body temperature.

The Bibliography for **Box 13-2** can be found at www.markmorris.org.

ter may also affect the adequacy of the housing; increased numbers of dogs will increase the temperature in the local environment (Blaxter, 1989a; Kleiber, 1975).

Regarding environmental factors, and unrelated to the nutritional needs of dogs, pet food manufacturers develop products to address owner conveniences and concerns. This practice led to the development of specific pet food flavor varieties, kibble shapes, colors and sizes and packaging improvements. In the U.S., products have been introduced for pets that spend the majority of their lives indoors or in high population density urban settings. As an example, these products address the desire by pet owners for a very small stool volume, which makes cleanup easier. In addition, pets fed highly digestible, calorically dense foods eat less, resulting in less food carried home by the owner. Such trends, however, are not new to urban high population density countries such as Japan.

Laboratory and Other Clinical Information

Healthy young adult dogs require few laboratory and other diagnostic tests as part of routine assessment. The most common extended database includes a fecal examination for intestinal parasites, tests for heartworm infection and fundic examination. For dogs older than five years, a urinalysis performed on a fresh urine specimen collected after an all-night fast is added. A complete blood count, serum biochemistry profile and urinalysis should be obtained for ill dogs and those with suspected abnormal nutrition.

Key Nutritional Factors

Table 13-3 summarizes key nutritional factors for young adult

Table 13-3. Key nutritional factors for foods for young adult dogs.

Factors	Recommended food levels*	
	Normal weight and body condition	Inactive/obese prone
Water	Free access	Free access
Energy density (kcal ME/g)	3.5-4.5	3.0-3.5
Energy density (kJ ME/g)	14.6-18.8	12.5-14.6
Fat and essential fatty acids (%)	10-20	7-10
Crude fiber (%)**	≤5	≥10
Protein (%)	15-30	15-30
Phosphorus (%)	0.4-0.8	0.4-0.8
Sodium (%)	0.2-0.4	0.2-0.4
Chloride (%)	1.5 x Na	1.5 x Na
Antioxidants (amount/kg food)		
Vitamin E (IU)	≥400	≥400
Vitamin C (mg)	≥100	≥100
Selenium (mg)	0.5-1.3	0.5-1.3
Food texture (VOHC Seal of Acceptance)	Plaque	Plaque

Key: DM = dry matter, kcal = kilocalories, kJ = kilojoules, ME = metabolizable energy, VOHC = Veterinary Oral Health Council Seal of Acceptance (Chapter 47).

*Dry matter basis. Concentrations presume an energy density of 4.0 kcal/g. Levels should be corrected for foods with higher energy densities.

**Crude fiber measurements underestimate total dietary fiber levels in food.

dogs. The following section describes these key nutritional factors in more detail. Calcium is also a nutrient of concern for young adult dogs, especially when they are fed homemade foods (**Box 13-3**).

Box 13-3. Nutritional Factors of Concern for Homemade Foods Intended for Adult Dogs.

In addition to the key nutritional factors for commercial foods for adult dogs (See Key Nutritional Factors discussion.), calcium is also a nutritional factor of concern for homemade foods for adult dogs.

Commercial foods may contain inadequate, adequate and sometimes excessive amounts of calcium and/or phosphorus and; therefore, should not be supplemented. However, calcium is often deficient and phosphorus may be excessive in homemade foods, especially when most of the diet comes from meat and leftovers from the table (Table 12-5). Existing commercial multiple vitamin-mineral mixes (powders, tablets, etc.) are seldom designed to correct imbalances encountered in homemade foods. When formulating homemade foods, it is better to correct calcium-phosphorus imbalances by adding mineral sources such as calcium carbonate or dicalcium phosphate, both of which are usually available from drug stores (Chapter 10).

Water

Water accounts for approximately 56% of an adult dog's body weight (73% of lean body mass) (Stadtfield, 1978). The body has a limited capacity to store water, and although healthy dogs can replenish a water deficit of up to 8% of body weight in a few minutes (Anderson, 1982), water deprivation will result in death more quickly than withholding any other nutrient (NRC, 1985). Therefore, it can be argued that water is the most important nutrient.

Total water intake (i.e., drinking and water from food) is influenced by several factors such as environment, physiologic state, activity, disease processes and food composition. Total water intake increases almost linearly with increasing salt levels in food (Anderson, 1982; Burger et al, 1980). Switching from a moist to a dry food and vice versa markedly affects the amount of water taken with the food; however, dogs compensate well for this difference by changing the quantity of water they drink, thus keeping their total daily water intake constant (Burger et al, 1980). Generally, dogs self-regulate water intake according to physiologic need. Healthy adult dogs need roughly the equivalent of their energy requirement in kcal metabolizable energy (ME)/day, expressed in ml/day (Lewis et al, 1987). Dogs should be offered free access to water at rest and before, during and after exercise (NRC, 2006). During warm weather, enough water should be available to compensate for evaporation by panting (Anderson, 1982) **Box 13-2.**

Energy

Domestic canids are the most diverse mammalian species in body weight and size. Therefore, energy requirements are not linearly correlated with kg body weight, but are more closely related to metabolic weight ($BW_{kg}^{0.75}$) (Meyer, 1986; NRC, 2006). DER recommendations of adult, non-athletic, non-

reproducing dogs have varied from 85 kcal (355 kJ) $ME/BW_{kg}^{0.75}$ to more than 220 kcal (920 kJ) $ME/BW_{kg}^{0.75}$ (Zentek and Meyer, 1992; Männer et al, 1987; Heusner, 1991). This range may confuse dog owners, but it is not surprising considering that breed, neuter status, age, daily activity, environmental temperature and insulative characteristics of the integument markedly influence the DER of a particular dog (Rainbird and Kienzle, 1990; Kienzle and Rainbird, 1991; Männer, 1990, 1991; Meyer, 1983; NRC, 2006; Gesellschaft, 1989; Burger, 1994; Finke, 1991). Graphically, the DER for a population of dogs results in a bell-shaped curve; therefore, the energy intake of individual dogs may vary by about 50% above or below the average requirements, even within the same age group (Chapter 1). The RER, however, is not markedly influenced by these factors, and is similar for all dogs, independent of breed or age. RER is approximately 70 kcal (293 kJ)/ $BW_{kg}^{0.75}$ (NRC, 2006; Kleiber, 1975) (Chapter 1). A simple linear formula can also be used to estimate RER for dogs weighing more than two kg: RER_{kcal} is approximately $(30 \times BW_{kg}) + 70$ (Lewis et al, 1987). To convert from kcal to kJ, multiply kcal by 4.184. Table 5-2 provides RER values for dogs with body weights from 1.5 to 70 kg.

Because DER is the sum of RER plus all the above influences, it is better to use RER as the basis for calculating energy requirements of adult dogs and to assign different multipliers to account for differences in activity, age and environmental influences. When assigning multipliers to RER, it is important to account for neuter status because this variable can be an important factor in determining DER of household dogs. Neutered dogs may have a lower DER than intact counterparts. Surveys have shown that the prevalence of obesity increases progressively and peaks in middle-aged dogs (Armstrong and Lund, 1996; Kronfeld et al, 1991). Thus, prevention of obesity should be an important goal of feeding programs for young adult dogs. Animals benefit more from an appropriate weight-maintenance program than treatment for obesity (Chapter 27).

Three groups of adult dogs can be distinguished based on DER: 1) one to two years old, 2) three to seven years old and 3) more than seven years old (Table 13-2) (Rainbird and Kienzle, 1990; Kienzle and Rainbird, 1991; Finke, 1991, 1994). The differences in DER probably reflect an age-related decrease in activity and lean body mass.

Most pet dogs are minimally active and may have a DER that approaches their RER. Such dogs fed caloric intakes recommended for maintenance ($1.6 \times RER$) will be overfed and are likely to become overweight. A recommendation of 1.2 to $1.4 \times RER$ (85 to 98 kcal [355 to 410 kJ] $ME/BW_{kg}^{0.75}/day$) is a good starting point for feeding sedentary dogs (Männer, 1990, 1991; Männer et al, 1987; Heusner, 1991; NRC, 2006).

A good starting point for estimating the DER of more active adult dogs would be $1.6 \times RER$ (115 kcal [480 kJ] $ME/BW_{kg}^{0.75}$). Such dogs between two and seven years of age would probably have a DER between 1.4 to $1.9 \times RER$ (100 to 130 kcal [420 to 550 kJ] $ME/BW_{kg}^{0.75}$) with the higher number used in the lower age group and the lower number applied to the higher age group (Table 13-2). All initial estimates of

energy needs must subsequently be evaluated by body condition assessment and adjusted as needed for individual dogs. It has been estimated that sled dogs may require more than 10,000 kcal/day (41.8 MJ/day) (up to 15 x RER) to maintain body weight under racing conditions (Hinchcliff et al, 1997). Active young adult dogs should be fed a food with an energy density range of 3.5 to 4.5 kcal/g dry matter (DM). The energy density range of foods for inactive/obese prone dogs should be lower (3.0 to 3.5 kcal/g DM).

Fat and Essential Fatty Acids

Fats are an excellent source of energy, but the real requirement for fat is to supply essential fatty acids (EFAs). In addition, fat serves as a carrier for the absorption of fat-soluble vitamins (i.e., A, D, E and K). Linoleic and α -linolenic acids are considered essential because dogs lack the enzymes to synthesize them (Watkins, 1997). Linoleic acid (18:2n-6) is the parent fatty acid of the omega-6 (n-6 series), as is α -linolenic acid for the omega-3 (n-3) series. EFAs have structural functions in cell membranes and are precursors of eicosanoids such as prostaglandins, thromboxanes and leukotrienes (NRC, 1985a; Lands, 1991). Linoleic acid deficiency results in two primary skin defects: hyperproliferation and increased permeability to water (Ziboh and Miller, 1990). The epidermal water barrier consists of lamellae of lipids (sphingolipids) in the stratum corneum of the epidermis. Linoleic acid is incorporated into the ceramide-portion of sphingolipids where it provides the specific characteristics needed for barrier function (Ziboh and Miller, 1990). Additionally, linoleic acid plays a role in fertility (Lands, 1991). Ensuring an adequate intake of EFAs is key to maintaining normal skin and coat quality.

Whether omega-3 fatty acids are essential is less certain because of the inability of omega-3 fatty acids to support all of the physiologic functions that are supported by omega-6 fatty acids (Lands, 1991). Nevertheless, a source of dietary omega-3 fatty acids is recommended (Watkins, 1997). The minimum recommended allowance for dietary eicosapentaenoic plus docosahexaenoic acids is 0.044% DM (NRC, 2006). Omega-3 fatty acids may moderate excessively vigorous actions of omega-6-derived eicosanoids (Lands, 1991) and are of value in the management of certain diseases (Chapters 30, 32, 34, 37). The minimum recommended allowance for dietary fat in foods for normal, healthy adult dogs is 8.5%, with at least 1% of the food as linoleic acid (DM) (NRC, 2006). Depending on the type/source of fat, increasing the amount of fat in foods increases palatability and EFA levels; however, energy content also increases. The recommended range of fat for foods intended for young adult dogs is 10 to 20% (DM). Lower levels of dietary fat are recommended for obese-prone adult dogs (7 to 10% DM).

Fiber

The levels of dietary fat and fiber are important determinants of a food's energy density. Fat provides more than twice as much energy on a weight basis than carbohydrate or protein. High-fat foods have increased energy density; conversely, low-

fat foods have decreased energy density. Fiber is a poor source of energy for dogs; thus, as the fiber content of foods increases, energy density decreases. Dietary fiber reduces the energy density of the food and helps promote satiety (Chapters 5 and 27). Inclusion of fiber in foods may therefore help maintain ideal body weight in dogs fed free choice. In pet foods, fiber is listed as crude fiber, which is an imprecise measure because most soluble fiber is omitted. A better measure would be total dietary fiber; however, regulations only permit declaration of crude fiber because no method for determination of total dietary fiber is yet officially recognized for pet foods. It is difficult to determine the optimal concentration of crude fiber in a complete food for dogs; however, up to 5% DM seems adequate. Obese-prone dogs may benefit from at least 10% DM crude fiber and DM fat should be restricted to between 7 to 10%. Foods that are low in fat and high in fiber tend to have the lowest energy density and are recommended for obese-prone dogs.

Protein

The amount of protein in commercial foods for healthy dogs varies widely (15 to 60% DM). After the amino acid requirements are met for an individual animal, addition of more protein provides no known physiologic benefit. This fact often runs contrary to the popular belief that more protein is better. Also, the addition of extra protein in commercial dog foods is sometimes marketed as necessary for carnivores and misrepresents the fact that dogs are omnivores. Excess dietary protein, above the amino acid requirement, is not stored as protein, but rather is deaminated by the liver. Subsequently, the kidneys excrete the by-products of protein catabolism and the remaining keto acid analogues are used for energy or stored as fat, or as glycogen in some cases.

The subject of whether excess dietary protein contributes to the progression of subclinical kidney disease has yet to be resolved (Chapter 37). Studies in people suggest that protein restriction may help slow progression of kidney disease (Mitch et al, 1998; NKF, 1998). In addition to any potential aggravating effects excess dietary protein may have on subclinical kidney disease, foods high in protein also tend to contain high levels of phosphorus. As mentioned above, excess dietary phosphorus accelerates the progression of kidney disease in dogs. Minimum protein requirements for healthy adult dogs eating high-quality protein have been determined using nitrogen balance and endogenous nitrogen excretion. A more reliable estimate based on endogenous nitrogen excretion equates to a minimum requirement of 1.7 g metabolizable protein/BW_{kg}^{0.75} for an ideal protein (NRC, 1985a; Kendall et al, 1982; Schaeffer et al, 1989). When protein of average quality is used (biologic value of about 70), the minimum requirements are increased to 2.1 to 2.5 g digestible protein/BW_{kg}^{0.75} (Gesellschaft, 1989b).

The minimum crude protein content of food depends on digestibility and quality. For example, if the digestibility of an average quality protein is 75%, then about 12% DM crude protein is adequate. Foods containing less than 12% DM crude protein must be of higher biologic value. Biologic value becomes less important for healthy adult dogs if foods contain crude pro-

tein levels greater than 12%. A daily protein intake for adult maintenance of 4.3 to 5.0 g digestible protein/BW_{kg}^{0.75} (biologic value = 70) or 4.0 to 6.5 g digestible protein/100 kcal ME is recommended (Gesellschaft, 1989b). The minimum recommended allowance for DM crude protein is 10% for a commercial food with an energy density of 4 kcal/g DM (NRC, 2006). Foods formulated to meet the lower limits in crude protein must also have the recommended allowances for essential amino acids. Thus, the recommended range of DM crude protein for foods for young adult dogs is between 15 to 30%.

Phosphorus

Minimum requirements for phosphorus for adult dogs are not very different from those established for other mammals. Commercial foods contain adequate and sometimes excessive amounts of phosphorus and, therefore, should not be supplemented.

Based on endogenous losses, a daily intake of 75 mg phosphorus/kg body weight is adequate (Gesellschaft, 1989a). At an energy density of 3.5 kcal (14.6 kJ)/g DM this corresponds to an average content of about 0.4 to 0.6% DM phosphorus. These levels are adequate, but not excessive; daily intakes 20 to 30% less are still sufficient (Gesellschaft, 1989a). Therefore, it is unnecessary to feed foods with higher levels of phosphorus, or to add calcium-phosphorus supplements to commercial foods. Moreover, higher phosphorus levels are contraindicated for a substantial part of the dog population; up to 25% of the young adult dog population may already be affected by subclinical kidney disease (Oehlert and Oehlert, 1976; Rouse and Lewis, 1975; Shirota et al, 1979). One clinical study revealed that 22.4% of all dogs over five years of age examined at a European veterinary teaching hospital for a variety of reasons had abnormally elevated kidney function tests (Leibetseder and Neufeld, 1991). Excess dietary phosphorus can accelerate progression of chronic renal disease (Brown et al, 1991), whereas phosphorus restriction may slow the progression of chronic renal disease and improve long-term survival (Brown et al, 1991; Finco et al, 1992). It is therefore prudent to feed foods that contain adequate but not excessive amounts of phosphorus (Chapter 37 contains more information about how excess dietary phosphorus affects progression of kidney disease).

The minimum recommended allowance for phosphorus in foods for adult dogs is 0.3% (DM); this recommendation is appropriate for foods with an energy density of 4 kcal/g (DM) (NRC, 2006). The recommended range of phosphorus for foods intended for young adult dogs is 0.4 to 0.8% (DM) when the energy density ranges from 3.5 to 4.5 kcal/g DM.

Sodium and Chloride

Essential hypertension is not considered a common problem in dogs; therefore, higher intakes of dietary sodium and chloride have not been considered harmful in young, healthy dogs (Bodey and Mitchell, 1996; Bovée, 1990). However, one study suggested that up to 10% of apparently healthy dogs may have high blood pressure (Remillard et al, 1991).

High sodium and chloride intake is contraindicated in dogs

with certain diseases that may have a hypertensive component such as obesity, renal disease and some endocrinopathies (Anderson and Fisher, 1968; Cowgill and Kallet, 1986; Rocchini et al, 1987; Littman, 1990; Ross, 1992). Uncontrolled high blood pressure may lead to kidney, brain, eye, heart and cardiovascular damage (Cowgill and Kallet, 1986; Littman, 1990). Dietary sodium chloride restriction is the first step in, and an important part of, antihypertensive therapy (Cowgill and Kallet, 1986; Littman, 1990; Ross, 1992).

It is prudent to meet but not greatly exceed sodium and chloride requirements when selecting foods for adult dogs. The best estimate for a minimum requirement of sodium is about 4 mg/kg body weight/day (Morris et al, 1976). Generally, 25 to 50 mg/kg body weight/day (Gesellschaft, 1989a) is recommended for adult maintenance; these levels are six to 12 times more than the minimum. The minimum recommended allowance for sodium content of commercial foods is 0.08% (DM); this allowance is for foods with an energy density of 4 kcal/g (DM) (NRC, 2006). For risk factor management, the recommended range for dietary sodium is 0.2 to 0.4% (DM), which is more than adequate. Sodium levels in commercial foods for adult dogs range from 0.11 to 2.2% DM and are higher in moist foods than in dry foods. In the absence of studies establishing chloride requirements in dogs, a value 1.5 times the sodium requirement is recommended.

Antioxidants

The consequences of prolonged oxidative stress (i.e., free radical damage) to cell membranes, proteins and DNA may contribute to and/or exacerbate a wide variety of degenerative diseases. A partial list includes cancer, diabetes mellitus, kidney/urinary tract disease, heart disease, liver disease, inflammatory bowel disease and cognitive dysfunction (Ames et al, 1993; Kesavulu et al, 2000; Ha and Le, 2000; Thamilselvan et al, 2000; Freeman et al, 1999; Cheng et al, 1999; Center, 1999; Knight, 1999). The consequences of free radical damage to cells and tissues have also been associated with the effects of aging (Harman, 1956).

The body synthesizes many antioxidant enzyme systems and compounds but relies on food for others. Commonly supplemented food-source antioxidants include vitamins E and C, β -carotene and other carotenoids, selenium and thiols. Fruits and vegetables are good sources of flavonoids, polyphenols and anthocyanidins. The following discussion focuses on vitamins E and C and selenium as antioxidant key nutritional factors because: 1) they are biologically important, 2) they act synergistically (e.g., vitamin C regenerates vitamin E after it has reacted with a free radical), 3) they are safe and 4) information about inclusion levels in pet foods is usually available. For improved antioxidant performance, foods for mature dogs should contain at least 400 IU vitamin E/kg (DM) (Jewell et al, 2000), at least 100 mg vitamin C/kg (DM) and 0.5 to 1.3 mg selenium/kg (DM).

VITAMIN E

Vitamin E is the main lipid-soluble antioxidant present in

plasma, erythrocytes and tissues (NRC, 2006). It is transported in plasma proteins and partitions into membranes and fat storage sites where it is one of the most effective antioxidants for protecting polyunsaturated fatty acids from oxidation. It functions as a chain-breaking antioxidant that prevents propagation of free radical damage of biologic membranes. Vitamin E inhibits lipid peroxidation by scavenging lipid peroxyl radicals much faster than these radicals can react with adjacent fatty acids or with membrane proteins (Gutteridge and Halliwell, 1994). Vitamin E plays a dominant role in defending against oxidative damage in cells.

The requirement for vitamin E for foods (DM) for adult dogs is 30 mg/kg (NRC, 2006). Research indicates that a level of vitamin E much higher than the requirement confers specific biologic benefits. One antioxidant biomarker study in dogs indicated that for improved antioxidant performance, dog foods should contain at least 500 IU vitamin E/kg (DM) (Jewell et al, 2000). Besides helping to prevent chronic diseases associated with oxidative stress, increasing dietary intake of vitamin E up to 2,010 mg/kg food (DM) in older dogs improved immune function (Hayes et al, 1969; Hall et al, 2003; Meydani et al, 1998). Furthermore, increased vitamin E intake is also directly related to increased vitamin E content of skin in dogs (Jewell et al, 2002). The skin is uniquely challenged by oxidants due to its role as a barrier. It is exposed to air pollutants, ultraviolet radiation and oxidants released as a result of normal metabolism, parasites and aerobic microbes. An upper limit of 1,000 to 2,000 IU/kg food (DM) has been suggested for dogs (AAFCO, 2007; NRC, 1985). In one study that demonstrated improved immune function associated with ingestion of 2,010 IU vitamin E/kg food (DM) (Hall et al, 2003), dogs had no safety issues at this intake level for one year.^a A prudent recommendation is that foods for young adult dogs should contain at least 400 IU vitamin E/kg (DM).

VITAMIN C

Vitamin C is the most powerful reducing agent available to cells. As such, it is important for regenerating oxidized vitamin E. Besides regenerating vitamin E, vitamin C: 1) regenerates glutathione and flavonoids, 2) quenches free radicals both intra- and extracellularly, 3) protects against free radical-mediated protein inactivation associated with oxidative bursts of neutrophils, 4) maintains transition metals in reduced form and 5) may quench free radical intermediates of carcinogen metabolism.

Dogs can synthesize required amounts of vitamin C (Innes, 1931; Naismith, 1958; Chatterjee et al, 1975) and they can rapidly absorb supplemental vitamin C (Wang et al, 2001). However, in vitro studies indicated that dogs (and cats) have from one-quarter to one-tenth the ability to synthesize vitamin C as other mammals (Chatterjee et al, 1975). Whether or not this translates to a reduced ability in vivo is unknown. In conjunction with the recommended levels of vitamin E, above, for improved antioxidant performance, foods for adult dogs should contain at least 100 mg of vitamin C/kg (DM).

Excessive supplementation of vitamin C should be avoided. In people, high levels of oral vitamin C increased urine oxalate

excretion and stone risk (Massey et al, 2005). Vitamin C supplementation to cats resulted in a small, progressive reduction of urinary pH (Kienzel and Maiwald, 1998). However, moderate supplementation of foods for healthy adult cats with vitamin C (193 mg/kg of food, DM) did not increase the risk of oxalate production in urine (Yu and Gross, 2005).

SELENIUM

Glutathione peroxidase is a selenium-containing antioxidant enzyme that defends tissues against oxidative stress by catalyzing the reduction of H_2O_2 and organic hydroperoxides and by sparing vitamin E. The minimum requirements for selenium in foods for dogs and cats are 0.10 and 0.13 mg/kg (DM), respectively (Wedekind et al, 2002, 2003, 2003a). Animal studies and clinical intervention trials in people have shown selenium to be anticarcinogenic at levels much higher (five to 10 times) than human recommended allowances or minimal requirements (Combs, 2001; Neve, 2002). Several mechanisms have been proposed for this effect, including enhanced antioxidant activity via glutathione peroxidase (Neve, 2002). Therefore, for increased antioxidant benefits, the recommended range of selenium for adult dog foods is 0.5 to 1.3 mg/kg (DM). There are no data to base a safe upper limit of selenium for dogs, but for regulatory purposes, a maximum standard of 2.0 mg/kg (DM) has been set for dog foods in the U.S. (AAFCO, 2007).

Food Texture

Periodontal disease is the most common health problem of adult dogs (Harvey et al, 1994) and may predispose affected animals to systemic complications (DeBowes et al, 1996). Periodontal disease can be prevented in many dogs with routine veterinary care and frequent plaque control at home. Feeding recommendations for oral health commonly include feeding a dry pet food (Golden et al, 1982). However, typical dry dog foods contribute little dental cleansing and the general statement that dry foods provide significant oral cleansing should be regarded with skepticism. Research has demonstrated that maintenance dog foods with specific textural properties and processing techniques can significantly reduce plaque accumulation and maintain gingival health. If the labels of such foods carry the Veterinary Oral Health Council (VOHC) seal, they have been successfully tested according to specific protocols and shown to be clinically effective in reducing accumulation of plaque (Chapter 47).

FEEDING PLAN

Assess and Select the Food

After the nutritional status of the dog has been assessed and the key nutritional factors and their target levels determined, the adequacy of the food is assessed. The steps for assessing foods for normal adult dogs are to: 1) ensure that the nutritional adequacy of the food has been assured by a credible regulatory agency such as the Association of American Feed Control Officials (AAFCO) for foods sold in the U.S., 2) compare the

Table 13-4. Selected commercial foods for young to middle-aged adult dogs compared to recommended levels of key nutritional factors.*

Dry foods	Energy density (kcal/cup)**	Energy density (kcal ME/g)	Fat (%)	Fiber (%)	Protein (%)	P (%)	Na (%)	Vit E (IU/kg)	Vit C (mg/kg)	Se (mg/kg)	VOHC plaque (Yes/No)
Recommended levels (normal body condition)	-	3.5-4.5	10-20	≤5	15-30	0.4-0.8	0.2-0.4	≥400	≥100	0.5-1.3	-
Hill's Science Diet Lamb Meal & Rice Recipe	364	4.0	16.0	2.5	23.0	0.67	0.29	582	174	0.54	No
Hill's Science Diet Oral Care Adult	273	3.8	15.5	10.1	25.1	0.65	0.24	564	175	0.62	Yes
Iams Adult Lamb Meal & Rice Formula	330	4.0	14.2	4.2	25.1	1.6	0.65	123	52	0.37	No
Iams Chunks	381	4.4	17.8	2.9	29.8	1.1	0.6	103	43	0.27	No
Iams Eukanuba Medium Breed Adult	404	4.7	17.9	2.1	27.8	1.16	0.55	na	na	na	No
Iams ProActive Health Chunks	374	4.0	17.0	1.9	28.9	1.21	0.58	na	na	na	No
Medi-Cal Dental Formula	290	na	12.7	5.3	19.7	0.9	0.4	na	na	na	No
Medi-Cal Preventive Formula	340	na	16.3	2.7	23.9	0.8	0.4	na	na	na	No
Nutro Natural Choice Dental Care Lamb Meal and Rice	287	3.7	15.4	4.4	23.6	1.54	0.22	275	71	1.65	No
Nutro Natural Choice Lamb Meal and Rice	342	3.8	14.3	2.2	24.2	1.54	0.33	220	66	0.77	No
Purina Dog Chow	430	4.2	11.4	5.1	23.9	0.91	0.42	144	na	0.64	No
Purina ONE Total Nutrition Lamb & Rice Formula	451	4.7	20.1	1.8	30.5	1.09	0.52	na	na	na	No
Purina Pro Plan Chicken & Rice Formula	489	4.8	16.9	3.4	33.8	1.22	0.46	na	na	na	No
Royal Canin MINI Adult 27	352	4.3	17.4	1.6	29.3	0.87	0.43	717	326	0.22	No
Royal Canin MINI Dental Hygiene 24	320	4.2	15.4	1.8	26.4	0.77	0.33	659	330	0.21	No
Waltham Pedigree Small Crunchy Bites	290	3.8	13.7	2.0	26.0	1.55	0.65	256	80	na	No
Moist foods	Energy density (kcal/can)**	Energy density (kcal ME/g)	Fat (%)	Fiber (%)	Protein (%)	P (%)	Na (%)	Vit E (IU/kg)	Vit C (mg/kg)	Se (mg/kg)	VOHC plaque (Yes/No)
Recommended levels (normal body condition)	-	3.5-4.5	10-20	≤5	15-30	0.4-0.8	0.2-0.4	≥400	≥100	0.5-1.3	-
Hill's Science Diet Adult Advanced Savory Chicken Entrée	345/13 oz.	3.9	17.1	1.3	26.7	0.67	0.25	200	na	1.00	No
Medi-Cal Preventive Formula	435/396 g	na	20.1	3.3	23.8	0.7	0.3	na	na	na	No
Purina Pro Plan Adult Chicken & Rice Entrée Classic	426/13 oz.	4.9	36.6	0.9	40.4	1.36	0.47	na	na	na	No

food's key nutritional factor content with the recommended levels (Tables 13-3 and 13-4).

Whether or not commercial foods for healthy pets have been AAFCO approved can usually be determined from the nutritional adequacy statement on the product's label (Chapter 9). Although it is important to ensure nutritional adequacy, AAFCO approval does not ensure the food will be effective in preventing long-term health problems. Thus, in addition to having AAFCO approval, the food should be evaluated to ensure the key nutritional factors are at appropriate levels for delivering the feeding goal of promoting long-term health.

Table 13-4 compares the key nutritional factor recommendations for foods for young adult dogs to the key nutritional factor profiles of selected commercial foods sold in the U.S. and

Canada. The manufacturer should be contacted if the food in question cannot be found in Table 13-4. Manufacturers' addresses, websites and toll-free phone numbers are listed on pet food labels.

Comparing a food's key nutritional factor content with the key nutritional factor target levels will help identify any significant discrepancies in the food being fed. This comparison is fundamental to determining whether or not to feed a different food. The current food should be changed if significant differences are seen between the recommended key nutritional factor levels and those in the food currently fed.

Commercial treats, snacks and table food should also be included in the food assessment step because they are part of the total food intake of an animal and, if misused, may create

Table 13-4 (cont.) Selected commercial foods for young to middle-aged adult dogs compared to recommended levels of key nutritional factors.*

Dry foods	Energy density (kcal/cup)**	Energy density (kcal ME/g)	Fat (%)	Fiber (%)	Protein (%)	P (%)	Na (%)	Vit E (IU/kg)	Vit C (mg/kg)	Se (mg/kg)	VOHC plaque (Yes/No)
Recommended levels (inactive/obese prone)	-	3.0-3.5	7-10	≥10	15-30	0.4-0.8	0.2-0.4	≥400	≥100	0.5-1.3	-
Hill's Science Diet Light Adult	295	3.3	8.8	14.6	24.5	0.58	0.23	586	276	0.45	No
Iams Eukanuba Medium Breed Weight Control	275	4.2	10.5	1.9	21.3	0.76	0.50	206	42	0.34	No
Iams Weight Control	328	4.2	12.5	2.8	22.2	0.85	0.37	103	44	0.35	No
Medi-Cal Weight Control/Mature	320	na	8.5	4.0	19.5	0.8	0.2	na	na	na	No
Nutro Natural Choice Lite	244	3.4	7.2	4.4	16.7	1.22	0.33	161	67	0.44	No
Purina Pro Plan Chicken & Rice Weight Management	337	3.7	10.2	2.7	30.5	1.06	0.27	503	na	0.33	No
Royal Canin MINI Weight Care 30	326	3.8	12.0	6.2	32.6	0.82	0.33	652	326	0.16	No
Moist foods	Energy density (kcal/can)**	Energy density (kcal ME/g)	Fat (%)	Fiber (%)	Protein (%)	P (%)	Na (%)	Vit E (IU/kg)	Vit C (mg/kg)	Se (mg/kg)	VOHC plaque (Yes/No)
Recommended levels (inactive/obese prone)	-	3.0-3.5	7-10	≥10	15-30	0.4-0.8	0.2-0.4	≥400	≥100	0.5-1.3	-
Hill's Science Diet Light Adult	322 kcal/13 oz.	3.4	8.6	9.7	19.5	0.51	0.31	385	na	0.78	No
Medi-Cal Weight Control/Mature	370 kcal/396 g	na	10	5.5	21.5	0.6	0.3	na	na	na	No

Key: ME = metabolizable energy, Fiber = crude fiber, P = phosphorus, Na = sodium, Se = selenium, VOHC = Veterinary Oral Health Council, na = information not available from manufacturer, g = grams.

*From manufacturers' published information or calculated from manufacturers' published as-fed values; all values are on a dry matter basis unless otherwise stated.

**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup. To convert to kJ, multiply kcal by 4.184.

an imbalance in an otherwise balanced feeding plan. Excessive feeding of treats and snacks may markedly affect the cumulative nutritional profile (Box 13-4). The impact of snacks on daily nutrient intake depends on two factors: 1) the nutrient profile of the snack and 2) the number provided daily. Thus, if snacks are fed, it is prudent to recommend those that best match the nutritional profile recommended for a particular lifestage. However, meeting nutrient requirements is not the primary goal of feeding treats; consequently, many commercial treats are not complete and balanced. A few treats are complete and balanced and are approved by AAFCO, or some other credible regulatory agency. Similarly, most table foods are not nutritionally complete and balanced and may contain high levels of fat or minerals. If snacks are fed, it is simplest to recommend that they be commercial treats that, if possible, match the nutritional profile recommended for a particular lifestage (see product label). Generally, any snacks should not be fed excessively (<10% of the total diet on a volume, weight or calorie basis). Otherwise, the nutritional composition of the snack and food should be combined and assessed as the entire diet.

Assess and Determine the Feeding Method

The feeding method includes the amount fed and how it is fed (free choice vs. some type of restricted feeding). It may not

always be necessary to change the feeding method when managing healthy adult dogs in optimal body condition. However, a thorough evaluation includes verification that an appropriate feeding method is being used. In addition, current or future risk factors such as obesity should be considered when evaluating the current method. Current feeding methods should have been obtained when the history was taken.

Nutrient requirements of dogs and intake of appropriate levels of key nutritional factors are met, not only by the amount of nutrients in the food, but also by how much food is fed. If the dog in question has an ideal BCS (2.5/5 to 3.5/5), the amount being fed is probably appropriate. The amount fed can be estimated either by calculation (Chapter 1) or by referring to feeding guides on product labels. Such calculated amounts and feeding guides represent population averages and, likely, may need to be adjusted for individual dogs. If possible, owners should check the dog's body weight and/or be taught to regularly evaluate their dog's BCS. If these measurements indicate a trend of increasing or decreasing body weight or BCS, pet owners should be counseled to change the amount fed by 10% increments.

Besides establishing how much food is being fed, another part of feeding method assessment is to determine how the food is offered (i.e., when, where, by whom and how often). An

Box 13-4. Impact of Treats on Daily Nutrient Intake.

From 60 to 86% of owners regularly give their dogs commercial treats. If table foods are considered, 90% or more of dogs receive treats, snacks and biscuits as a supplement to their regular food. People like to give treats and snacks for emotional reasons, to change their pet's behavior or to improve and maintain oral health. Because several daily treats will have a marked effect on a dog's cumulative nutritional intake, specific questions about treats should be asked when taking the dietary history. Specific recommendations about treats should be provided when prescribing a food regimen for diseased or healthy dogs. This information is critical when managing specific problems such as developmental orthopedic disease in growing large- and giant-breed dogs, adverse reactions to food, obesity, urolithiasis, diabetes mellitus, heart failure and renal disease.

The impact of snacks on a dog's daily nutrient intake depends on two factors: 1) the nutrient profile of the treat and 2) the number of treats provided daily. It is best to recommend a treat that matches the nutritional profile preferred for a given lifestage or disease. Snacks provide energy; a handful of dog snacks, for example, can easily be equivalent to 40% of a small dog's daily energy requirement (DER) or 10% of a large-breed dog's DER. Therefore, the owner must compensate for the additional energy by feeding less of the dog's usual food. This recommendation is especially important for dogs in which a small snack can have a marked impact (i.e., toy- and small-breed dogs). The following two examples illustrate the impact of treats on daily nutrient intake.

A six-year-old, neutered male miniature pinscher weighing 4.5 kg is fed two commercial biscuit treats per day, in addition to its regular food. Each biscuit provides 15 kcal (62.8 kJ), so the dog receives a total of 30 kcal (125.5 kJ) per day from the treats. The dog's DER is about 330 kcal (1,381 kJ). Therefore, the treats provide almost 10% of the dog's DER. If the dog's DER is being met with the regular food, then the treats may contribute to long-term excess energy intake and obesity.

A five-month-old, 20-kg, female German shepherd dog is given a commercial treat marketed as a snack with "real marrow bone." Calcium is not declared on the guaranteed or typical analysis of the treat label. The owner gives the dog 10 treats daily as part of a training program. This number of treats is within the feeding guidelines on the label. However, analysis shows that each treat contains 426 mg of calcium. Consuming 10 treats daily increases the dog's daily calcium intake by more than 80% compared with feeding a commercial food formulated for large-breed puppies. This feeding practice increases the risk of developmental orthopedic disease (Chapter 33). To facilitate learning, dogs do not need to receive edible reinforcement every time and the pieces can be very small. If praise is paired with treats, praise alone will rapidly become sufficient reinforcement for the desired behavior.

The Bibliography for **Box 13-4** can be found at www.markmorris.org.

Table 13-5. Advantages and disadvantages of various feeding methods for dogs.

Method	Advantages	Disadvantages
Free-choice feeding	Less labor intensive Less knowledge required Quieting effect in a kennel Less dominant dogs have a better chance to get their share	Less control over food intake Predisposes to obesity Less monitoring of individual changes in food intake
Meal-restricted feeding	Better control of food dose Early detection of altered appetite Better control of body weight	Intermediate labor intensive Most knowledge required for food dose calculation
Time-restricted feeding	Intermediate control of food dose Some monitoring of appetite possible	Inaccurate control of food intake Risk of obesity similar to free choice Most labor intensive

important determinant of food intake in domestic dogs is the owner's and other family members' involvement because these factors usually control the amounts and types of food fed (Rabot, 1993; Mugford and Thorne, 1980; Houpt and Smith, 1981; Houpt, 1991). Studies show that owners typically feed their dogs one (26 to 77% of owners) to two (19 to 50% of owners) meals per day (Slater et al, 1995; Mugford and Thorne, 1980; Campbell, 1986). Often, pet owners overestimate needs and feed too much (Rabot, 1993). Furthermore, despite widespread concern about obesity among pet owners, most people do not recognize overweight/obesity in their own dog (Singh et

al, 2002). Pet dogs may eat several small meals daily when fed a commercial dry food free choice and still maintain an ideal body weight (Mugford and Thorne, 1980). However, relatively inactive dogs fed a highly palatable, energy-dense food free choice are at increased risk for obesity (Houpt, 1991). Most pet dogs are relatively inactive (NRC, 2006).

Both free choice and restricted feeding methods (time restricted or food restricted) have advantages and disadvantages. Although free-choice feeding is most popular, it can lead to the most problems. As an alternative, meal-restricted feeding is simple and more precise in delivering the required

Box 13-5. Alternative Eating Behaviors.**RESPONSE TO FOOD VARIETY**

Dogs may display preferences for specific types of foods according to taste and texture. However, the notion that dogs require a variety of flavors or taste in their meals is incorrect and may be detrimental in some instances. Dogs prefer novel foods or flavors to familiar foods; therefore, feeding a variety of novel foods free choice may lead to overeating and obesity. Dogs may correct for excessive energy intake by decreasing or refusing food intake the next day(s). Reduction of food intake to maintain weight following engorgement may erroneously be interpreted as a dislike of the current food instead of an auto-regulatory mechanism to achieve the previous set-point weight.

GARBAGE EATING

Garbage eating is probably normal behavior. Many dogs prefer food in an advanced stage of decomposition. However, garbage eating is oftentimes unhealthy. Ingestion of garbage may cause brief, mild gastroenteritis or more serious intoxication (Chapter 11). Because the etiology is complex and may involve bacterial toxins, mycotoxins and by-products from putrefaction or decomposition, the clinical signs vary widely from vomiting, diarrhea, abdominal pain, weakness, incoordination and dyspnea, to shock, coma and death. Scavenging dogs may eat less of their regular meal; therefore, garbage eating may be mistaken for anorexia at home.

Spraying garbage bags with a dog repellent usually will not stop the problem. Preventing access to garbage is the obvious best solution.

GRASS EATING

Owners often ask why dogs eat grass. Plant and grass eating is normal behavior. Herbivores are the natural prey for wolves and most other canids. The viscera of prey are often eaten first and contain partially digested vegetable material. Because dogs' ancestors and close relatives in the wild regularly ingest plant material, some investigators have suggested that domestic dogs must also eat grass. Probably the better explanation is that, to date, no one knows for sure why dogs eat plants or grass, but they may simply like the way plants taste or prefer the texture. Plant chlorophyll can bind mycotoxins, such as those found in moldy grains, decreasing their absorption.

BEGGING FOR FOOD

Begging for food may be fun when dogs sit up or perform other tricks; however, the behavior can become annoying when whining, barking, persistent nudging and scratching take over. Begging for food was one of the most common complaints addressed in a study involving more than 1,400 owners and was perceived as a problem in one-third of the dogs. Additionally, begging may encourage owners to feed more of the dog's regular food. Begging tends to increase with age and may indicate that most owners don't realize that they reinforce begging by continuing to offer tidbits to their begging pet. Treats reinforce begging. Also, the fact that begging for food is directly proportional to the num-

ber of people in the family may be related to an increase in the number of tidbits fed.

Treatment consists of ignoring behaviors such as begging, barking and whining. Owners should be prepared for a prolonged period of such behaviors before begging subsides completely. Intermittent reinforcement of begging when these behaviors become problematic can be more powerful than continuous rewarding, even though the owner may have refused to provide snacks in the interim. It may also help to keep the dog out of the kitchen and dining areas when preparing and eating food and to feed the dog before or after the family has eaten.

PICA

Pica is defined as perverted appetite with craving for and ingestion of non-food items. The etiology of true pica is unknown. Suggested causes include mineral deficiencies, permanent anxiety and psychological disturbances. A few cases of pica have been noted in relation to zinc intoxication and hepatic encephalopathy. Pica is common in dogs with exocrine pancreatic insufficiency, probably as a manifestation of polyphagia, and perhaps as a consequence of some specific nutritional deficiency. Sometimes, coprophagy and garbage eating are mistakenly considered forms of pica.

Pica can be treated with aversion therapy by offering a counter attraction at the moment the dog begins to eat foreign material and by punishment if there is no response. Outdoors, the dog should be kept on a leash or even muzzled. Most treatments for pica are unrewarding. Physically preventing the animal from engaging in pica is sometimes the only solution.

COPROPHAGY

Coprophagy is defined as eating feces and may involve consumption of the animal's own stools or the feces of other animals. Coprophagy is probably widespread among pet dogs and is probably more disturbing to owners than it is harmful to dogs. Bitches normally eat the feces of their puppies during the first three weeks of lactation. Feral dogs and dogs in rural areas have access to and consume large-animal feces, which is considered normal behavior. In many cases, however, coprophagy is a behavioral problem and the etiology is unknown. Coprophagy can also be related to certain diseases.

Table 1 lists behavioral and metabolic disorders that may be associated with coprophagy. The risk of transmitting parasitic diseases is probably the most important health reason for managing coprophagy; however, the associated halitosis is of primary concern to owners. The dog's motivation must be reduced to correct coprophagy. Several measures have been proposed.

Punishment may deter the dog's behavior, but may violate the confidence between owner and pet. Punishment may also aggravate the coprophagic behavior. Thus, a good balance has to be found. Walking the dog on a leash and keeping it away from feces after the dog defecates is helpful.

Box 13-5 continued

Repulsive substances can be used to create aversion for feces. Many different products have been recommended including spices (e.g., pepper, sambal, hot pepper sauce), quinine, strong perfumes and specific products such as cythioate, meat tenderizers and For-Bid.^a Adding repulsive substances to feces can be time-consuming and has questionable efficacy.

Food changes to deter coprophagy have been recommended; however, most of these recommendations lack substantiation. Using foods with increased fiber levels has been reported to help. Free-choice feeding has also been recommended, whereas a strict schedule of two meals per day and avoiding all tidbits or table foods has worked for others.

ENDNOTE

a. Alpar Laboratories Inc., La Grange, IL, USA.

The Bibliography for **Box 13-5** can be found at www.markmorris.org.

Table 1. Factors associated with coprophagy.

Behavior

Confinement in a kennel leading to stress or competitive behavior
Confinement leading to boredom with all exploratory effort focused on feces
Reaction to punishment during housetraining
Strong dominance or extreme submissive attitude towards the owner
To attract the owner's attention
Young animals with a natural interest in feces

Gastrointestinal disorders

Malassimilation
Parasitic infections
Polyphagia due to diabetes mellitus or Cushing's syndrome

Food

Overfeeding
Poorly digestible food

Table 13-6. Feeding plan summary for young adult dogs.

1. Select a food or foods with the best levels of key nutritional factors (**Table 13-4**); for foods not in **Table 13-4**, contact the manufacturer for key nutritional factor content.
2. The selected food should also be approved or meet requirements established by a credible regulatory agency (e.g., AAFCO).
3. Determine the preferred feeding method (**Table 13-5**); when the correct amount of food is fed, meal-restricted feeding is least likely to result in obesity.
4. For food-restricted meal feeding, estimate the initial quantity of food based on DER calculation ($DER \div \text{food energy density}$).
5. Body condition and other assessment criteria will determine the DER. DER is calculated by multiplying RER by an appropriate factor (**Table 5-2**). Remember, DER calculations should be used as guidelines, starting points and estimates for individual dogs and not as absolute requirements.
 $\text{Neutered adult} = 1.6 \times \text{RER}$
 $\text{Intact adult} = 1.8 \times \text{RER}$
 $\text{Inactive/obese-prone adult} = 1.2 \text{ to } 1.4 \times \text{RER}$ (Most pet dogs are relatively inactive)
 $\text{Working adult} = 2.0 \text{ to } 8.0 \times \text{RER}$ (**Chapter 18**)
6. Monitor body weight, body condition and general health. These parameters are used to refine the amount to feed.

Key: AAFCO = Association of American Feed Control Officials, DER = daily energy requirement, RER = resting energy requirement.

amount of food. Time-restricted feeding is less effective for controlling the amount of food consumed and is more labor intensive. **Table 13-5** provides a brief review of these feeding methods. See **Chapter 1** for a more in-depth discussion of feeding methods.

If a food change is in order and/or the amount fed needs to be modified, knowledge of the presence of other pets in the home, which family member is responsible for selecting and

purchasing the dog's food and who feeds the dog regularly are helpful for evaluating the feasibility of new dietary recommendations and improving compliance. Most healthy adult dogs adapt well to new foods. However, it is good practice to allow for a transition period to avoid digestive upsets. This is particularly true when switching from lower fat foods to higher fat foods or when changing forms of food (e.g., changing from dry to moist food). The new food should be increased and old food decreased in progressive amounts over a three- to seven-day period until the changeover is completed (Nott et al, 1993) (**Chapter 1**).

Dogs may eat an insufficient amount or completely refuse new food, especially if the new food is lower in palatability as may be required for health concerns (e.g., lower fat content). Investigation of food refusal may reveal problems with owner compliance rather than a finicky appetite. The following guidelines may be useful when a food change must be made: 1) Explain clearly to the owners why a change in food is necessary or preferable. 2) Justify your recommendation to the owners (i.e., food profile vs. specific needs of the dog). 3) As a general rule, start with one or two meals per day, always presented at the same time. Uneaten food should be removed after 15 to 20 minutes. 4) Don't give treats or table foods between meals for the first few days. If a small snack is given, it should be given immediately (i.e., within seconds) after the new food is eaten. Most dogs will accept the new food within a few days. **Table 13-6** summarizes the feeding plan recommendations discussed above.

Finally, owners are often concerned about alternative eating behaviors displayed by their dogs. In fact, these behaviors may be more offensive to the owner than detrimental to the dog. Alternative eating behaviors may be of nutritional or non-nutritional origin, and some may indicate underlying disease (**Box 13-5**).

REASSESSMENT

Owners should be encouraged to weigh their dog every month, and should be trained to observe their dog and adapt the food intake according to its needs. Dogs whose nutrition is well managed are usually alert, have an ideal BCS (2.5/5 to 3.5/5) with a stable, normal body weight and a healthy coat. Stools should be firm, well formed and medium to dark brown.

Reassessment by a veterinarian should take place regularly. Healthy dogs should be reassessed every six to 12 months. Because few if any homemade recipes have been tested according to prescribed feeding protocols, dogs should be reassessed more frequently if homemade food is a significant part of their caloric intake. Reassessment should take place immediately if clinical signs arise indicating that the current feeding regimen is inappropriate, or if the dog's needs change (e.g., reproduction

or change in activity).

If expected results are not obtained, the owner should also be questioned in detail about compliance with the feeding regimen or the possibility that the dog has access to other food sources.

ENDNOTE

a. Jewell DE. Hill's Science and Technology Center, Topeka, KS. Personal communication (data on file). March 30, 2007.

REFERENCES

The references for **Chapter 13** can be found at www.markmorris.org.

CASE 13-1

Feeding a Young Basset Hound after an Ovariohysterectomy

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Patient Assessment

A 12-month-old female basset hound was admitted for an ovariohysterectomy. The owners had observed no problems since purchasing the dog from a pet store eight months before. Physical examination revealed a normal 20-kg dog (body condition score [BCS] 3/5) except for excessive accumulation of waxy debris in both ears. Results of preanesthetic blood work were normal. The ovariohysterectomy was performed with no complications. The owners returned to pick up the dog the next day.

Assess the Food and Feeding Method

The dog was fed a commercial specialty brand growth formula (Science Diet Lamb Meal & Rice Formula Canine Growth^a) that the owners purchased from the pet store where they obtained the dog. The owners had been following the feeding directions on the pet food label. They were currently feeding one can of the growth formula in the morning (520 kcal, 2.18 MJ) and two cups (200 g) of the dry formulation of the same brand in the evening (780 kcal, 3.26 MJ). The dog's appetite had been good. The owners also gave the dog two commercial treats each day (Science Diet Canine Growth Treats^a) (19 kcal [79 kJ] per treat).

Questions

1. What are the key nutritional factors to consider in developing a feeding plan for this young neutered adult dog?
2. What response should be given when the owners ask whether the ovariohysterectomy will change the feeding recommendations for their dog?
3. Outline a specific feeding plan for this patient including an appropriate food and feeding method.

Answers and Discussion

1. Key nutritional factors for young adult dogs include water, energy, phosphorus, calcium, protein, sodium, chloride, fat and essential fatty acids, antioxidants and food texture. In general, water requirements are met by allowing free access to a source of potable water. Energy, fat and fiber are important because prevention of obesity is an important goal of feeding adult dogs. Phosphorus, calcium, sodium and chloride requirements should be met but not greatly exceeded. Essential fatty acids are important for maintenance of normal skin and coat, a primary concern of many dog owners. Food texture is important in controlling periodontal disease, the most common health problem of adult dogs. Antioxidants may help prevent certain diseases.
2. Gonadectomy increases the risk of obesity in dogs. Neutered female dogs are about twice as likely to be overweight as intact female dogs. A similar trend occurs in castrated male dogs. Gonadectomy predisposes dogs to weight gain and eventual obesity

for several reasons. Daily energy requirement (DER) may decrease because of metabolic changes associated with gonadectomy. Furthermore, studies have demonstrated that neutered female dogs eat more food and gain more weight than sham-operated females fed identical food. Thus, removal of the metabolic effects of estrogens and androgens by gonadectomy may lead to increased food consumption when the animal's energy requirement is simultaneously lower due to decreased metabolic rate and physical activity. These are important considerations when creating a feeding plan for young neutered adult dogs.

3. Basset hounds are predisposed to obesity. Gonadectomy and the breed predisposition to obesity make obesity prevention a primary goal in developing a feeding plan for this patient. This dog has also reached adulthood; therefore, the levels of nutrients found in growth-type formulas are unnecessary.

The food should be changed from a growth formula to an adult maintenance formula. In general, adult maintenance formulas of the same brand contain less energy, fat, phosphorus, calcium, sodium and chloride than growth formulas. These lower levels of nutrients exceed the minimum nutrient requirements of adult dogs while avoiding the higher nutrient levels found in growth or all-purpose type formulas. This dog's optimal BCS suggests that it is eating an appropriate amount of food. However, gonadectomy and other metabolic changes associated with maturity will probably decrease the DER. The estimated DER would be 1.4 to 1.6 x resting energy requirement (RER) (940 to 1,070 kcal, 3.93 to 4.48 MJ). The dog is currently consuming 1,300 kcal (5.44 MJ) or 2 x RER. The feeding method will be dictated somewhat by whether moist, dry, semi-moist or homemade foods are fed. The owners are currently meal feeding a combination of moist and dry foods; this feeding method can be continued with the new food.

Progress Notes

The dog was discharged to the owners' care with instructions to limit exercise for several days, examine the suture line daily for signs of swelling or inflammation and return for suture removal in 10 to 14 days. The owners were shown how to clean the ears and an otic cleaning solution was dispensed.

The owners were interested in continuing to feed a combination of moist and dry food. They were instructed to purchase the same brand adult maintenance food (Science Diet Lamb Meal & Rice Formula Canine Maintenance^a) and gradually mix the new food with the old food until the moist and dry growth formulas were completely gone. A combination of the adult maintenance food consisting of one large (418 g) can of moist food in the morning (420 kcal, 1.76 MJ) and 1 2/3 cups (165 g) of dry food in the evening (610 kcal, 2.59 MJ) would provide approximately 1.6 x RER for the dog's current weight of 20 kg. Two treats per day were also continued; however, the owners were encouraged to use the adult maintenance formula of the same treat (18 kcal [75 kJ] per treat).

Prevention of obesity was emphasized to the owners because of the risk factors discussed earlier. They were given an instruction sheet that outlined how to score the dog's body condition and encouraged to weigh the dog monthly. They were instructed to call the practice if the dog appeared to be gaining weight or if the dog's BCS increased. Periodontal disease, veterinary oral care and routine home oral care were also discussed.

Endnote

- a. Hill's Pet Nutrition, Inc., Topeka, KS, USA. Science Diet Lamb Meal & Rice Formula Canine Growth and Science Diet Lamb Meal & Rice Formula Canine Maintenance are currently marketed as Science Diet Lamb Meal & Rice Recipe Puppy and Science Diet Lamb Meal & Rice Recipe Adult.

Bibliography

Anantharaman-Barr G. The effect of ovariectomy on energy metabolism in dogs (research abstract). *Friskies Veterinary International* 1990; 2: 19-20.