Satiety Reduces Adiposity in Dogs*

Dennis E. Jewell, PhD, Diplomate, ACAN
Philip W. Toll, DVM, MS
Bruce J. Novotny, DVM

Hill's Science and Technology Center
PO Box 1658
Topeka, KS 66601-1658

Heli os Communications, LLC
5826 Park Circle
Shawnee, KS 66216-4905

ABSTRACT

The study reported here investigated the effect of satiety on body composition. Twelve beagle dogs were fed either a low-fiber (<2%) or a high-fiber (~20%) food that had previously been shown to cause differences in satiety. After 3 weeks the groups were fed the opposite food. Dogs were fed all they would voluntarily consume during one 45-minute meal per day. Each dog served as its own control. Although dogs consumed approximately equal amounts of food on a weight basis, they voluntarily ate significantly fewer calories (27% less) when fed the high-fiber food. Dogs lost four times as much fat mass when fed the high-fiber food versus when fed the low-fiber food. Therefore this study indicates that foods enhanced with fiber increase satiety and reduce adiposity.

INTRODUCTION

Obesity is often defined as body weight 15% to 20% greater than optimal (i.e., 35% to 40% body fat, a level associated with health problems in humans and likely in other species).1-3 According to a large epidemiologic study, 25% of the dogs and cats seen by veterinarians in the United States are either overweight (body condition score [BCS] 4/5) or obese (BCS 5/5).4 In 1996, the American Veterinary Medical Association (AVMA) estimated the pet population in the United States at 52.9 million dogs and 59.1 million cats.5 Combining the conclusions of the epidemiologic study with the total United States pet population suggests that 28 million dogs and cats are overweight or obese and therefore are candidates for weight loss. Again, from AVMA information, 33,352 veterinarians were employed in small and mixed animal private practice in 1998, a figure that when combined with the number of overweight/obese dogs and cats suggests there are almost 840 overweight/obese dogs/cats per veterinarian in private practice in the United States. Although some pets never see a veterinarian, the implications are obvious: obese/overweight conditions are rampant in dogs and cats and a tremendous opportunity exists for veterinarians to improve the health of these animals.

Obesity is a health problem of appreciable magnitude because it is a risk factor for various
diseases and is associated with increased mortality. Scarlett and Donoghue found that obesity increases the risk of death in middle-aged cats to nearly three times that of lean cats. Overweight cats were nearly four times more likely to develop diabetes mellitus, three times more likely to become lame, and had an increased incidence of nonallergic skin disease. Obesity is also a risk factor for hepatic lipodosis in cats. Dogs also have associated health impairments resulting from obesity. Obese dogs have an increased incidence of traumatic and degenerative orthopedic disorders, neoplasia, cardiovascular and respiratory disease, hypertension, diabetes mellitus, dermatopathies, and possibly less tolerance to weather extremes, anesthesia, and surgical procedures.

Obesity warrants treatment because the condition has the potential to cause harm, effective treatments exist, and the risks of the condition outweigh the hazards of therapy. Treatment would seem to be a simple matter: owners of overweight pets merely have to reduce caloric intake below energy expenditure for their pet to lose weight. In practice, however, treatment of obesity is often frustrating because fat resists change and success depends on long-term pet owner commitment and compliance and, often, a radical change in eating and exercising habits.

In humans, rodent models, and probably other animal species (i.e., dogs and cats), a weight plateau and body composition set point develops in which body fat is maintained and any attempt to lose weight is resisted by a powerful drive to return to the weight plateau. Adipocytes form an elastic energy reservoir that expands and contracts to accommodate an animal's energy balance. Fat is clearly not a passive triglyceride receptacle as was once thought. Investigators have shown that adipocytes increase secretion of a hormone called leptin as they enlarge and decrease secretion when they become depleted. Levels of this hormone increase with satiation (i.e., the process that brings eating to a close) and decrease with fasting and starvation. An animal may sense the extent to which adipose cells fill with triglycerides, thus regulating adipose tissue mass. Weight increase during refeeding seems to continue until fat cells have returned to their original size. Some investigators have suggested that adipose tissue thereby exerts a regulatory function on energy intake and energy balance.

Various feedback mechanisms exist to control eating and body weight. Short-term feedback mechanisms are activated by eating food. Long-term feedback mechanisms are produced by adipose tissue. Much research is currently being conducted to elucidate genetic predisposition to obesity and the role of feedback mechanisms. Long-range signals of satiety may be related to fat mass.

Satiety is the lack of desire to eat and usually results from the consequences of ingestion. Satiety is difficult to measure in dogs and cats, but a sense of fullness can be inferred by a decrease in food-seeking activities and reduced consumption of foods when meals are offered. In an earlier study, the authors showed that the amount of dietary fiber influenced food consumption. In that study, commercial foods containing 12% and 21% crude fiber on an as-fed basis increased satiety and voluntary reduction of energy consumption compared with commercial foods containing less than 2% crude fiber (as-fed basis). Foods with low levels of crude fiber (i.e., 2% or less) apparently do not sufficiently affect satiety to influence daily caloric intake; therefore, increasing dietary fiber in canine foods significantly decreases voluntary food intake, strengthens satiety, and reduces energy intake.

The study reported here was conducted to determine if foods that caused different levels of satiety, as determined in the previous study, had any effect on food intake and body composition in dogs.
MATERIALS AND METHODS

Subjects

Twelve neutered female beagle dogs in good health, between 1 and 7 years of age, with an average weight of 15.4 ± 0.15 kg, participated in this study. Investigators allocated dogs to one of two treatment groups based on body weight. The subjects were individually housed in 16-square-foot cages. Water was available ad libitum. The temperature was controlled between 20°C and 22°C.

Study Design

A crossover study was conducted to compare the effects of two foods on body composition. Six dogs were fed a low-fiber food and six were fed a high-fiber food for 21 days (Figure 1, weeks 1–3). Average body weight for dogs receiving the low-fiber food was 15.1 ± 0.15 kg; dogs receiving the high-fiber food had an average body weight of 15.2 ± 0.15 kg. At the end of 21 days, dogs were fed the opposite food for 21 more days (Figure 1, weeks 3–6). Both foods were commercially available at the time of the study. Table 1 lists the nutrient profiles of the two foods. Energy values were obtained from manufacturer’s published data.

Meals were fed at the same time each day. Subjects were allowed one 45-minute meal daily. Dogs were offered more food than they chose to eat within the 45-minute feeding interval. Amounts eaten were recorded daily. Body weights were recorded weekly. Each dog’s body composition was assessed using dual energy x-ray absorptiometry at the beginning of the study and at the end of each 21-day feeding segment (i.e., at the end of the high-fiber and the low-fiber feeding periods).

Statistical Methods

The effect of treatment was statistically evaluated using a general linear model containing time (period), animal, and treatment. Each animal served as its own control for evaluation of differences. Differences with P values ≤0.05 were considered significant.

ANALYSIS

All subjects remained in good health throughout the 42-day study. Both foods were readily accepted by all subjects. At the end of the feeding period, dogs in the low-fiber group had an average body weight of 15.0 ± 0.10 kg;
similarly, dogs in the high-fiber group had an average body weight of 14.7 ± 0.10 kg. Dogs fed the high-fiber food had a higher daily intake of food on a gram basis; however, the increase was not statistically significant (281.2 g/day when fed the high-fiber food versus 247.8 g/day when fed the low-fiber food). On an energy basis, dogs fed the high-fiber food consumed 660.8 kcal/day versus 904.3 kcal/day when fed the low-fiber food. This 27% reduction in calories consumed was statistically significant (*P < 0.05; Figure 2). Figure 3 shows the effect of satiety on body composition. When fed the low-fiber food, dogs lost 0.91 g lean body mass/day versus a gain of 3 g lean body mass/day when they were fed the high-fiber food. These changes were not significant. When fed the low-fiber food, dogs lost 118.9 g fat over the 21-day feeding period (5.67 g fat lost/day) versus 488.8 g fat lost over the 21-day period in which they were fed the high-fiber food (23.28 g fat lost/day). The high-fiber product caused a significant loss in body fat (*P < 0.05), whereas the low-fiber product did not result in a significant change. Expressed another way, dogs had 37.4% body fat before they were fed the low-fiber food. Body fat percent decreased to 37.0% at the end of the 21-day period during which they were fed the low-fiber food (Table 2). Dogs had 37.6% body fat before they were fed the high-fiber food. The percent body fat decreased to 35.2% at the end of the 21-day period during which the dogs were fed the high-fiber food. This change in body fat percent and the difference in final fat percent of the dogs showed that the high-fiber group was losing body fat, whereas the low-fiber group was not (Table 2).

Although this study could have analyzed soluble fiber, analysis of crude fiber is well recognized in the industry and by AAFCO as the current standard. Until more pet food companies provide analyses of soluble fiber, the crude fiber standard will persist in favor of the more
The data provided in this article about foods are chemical compositions.

**DISCUSSION**

The fundamental cause of obesity is the sustained imbalance between energy intake and expenditure. Yet, the amount of energy retained during the development of obesity is small compared with the daily energy turnover. When averaged over long periods, the imbalance between energy intake and expenditure often is less than one percentage point. Consider this example: the yearly change in weight among men between 20 and 60 years of age has been estimated at 0.5 lb/year. The energy used to deposit this weight is about 1,560 kcal; however, an average male eats about 900,000 kcal/year. Therefore, the amount of energy used to gain the 0.5 lb/year represents less than 0.2% of the energy eaten over the course of the year. This observation can be used to prove that set-point mechanisms exist to maintain body weight. This observation also suggests that even small differences in metabolic efficiency can help prevent or treat obesity.

**TABLE 2. Change in Body Composition of Beagle Dogs When Fed Foods Containing Low (1.7% As Fed) or High Fiber (19.4% As Fed)**

<table>
<thead>
<tr>
<th>Foods</th>
<th>Initial Fat (%)</th>
<th>Final Fat (%)</th>
<th>Change in Fat (%)</th>
<th>Initial Lean (%)</th>
<th>Final Lean (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-fiber food*</td>
<td>37.4</td>
<td>37.0</td>
<td>-0.4</td>
<td>61.0</td>
<td>61.3</td>
</tr>
<tr>
<td>High-fiber food†</td>
<td>37.6</td>
<td>35.2</td>
<td>-2.3</td>
<td>60.8</td>
<td>63.1</td>
</tr>
</tbody>
</table>

*Eukanuba® Restricted-Calorie Formula®, The Iams Company, Dayton, OH.
†Prescription Diet® Canine r/d® dry, Hill’s Pet Nutrition, Inc., Topeka, KS.
The first law of thermodynamics applies to obese, overweight, ideal weight, and thin individuals. When the energy provided by food intake exceeds energy output, the excess is stored primarily as fat. Correspondingly, weight loss will occur if absorbed energy falls sufficiently below energy usage. Treatment of obesity may include starvation, dietary modifications, exercise, behavior/psychological intervention, and drugs. Starvation is generally unsatisfactory in dogs because both fat and lean body mass are lost. Lean body mass is difficult to regain, especially in older animals. Exercise and dietary changes are most useful in veterinary medicine.

In general, dietary recommendations include moderate caloric restriction and modification of foods that clients select and how they feed dogs. Various methods of caloric restriction have been advocated for weight loss and will not be described here. Feeding an animal a low-energy food is the typical means of reducing dietary energy.

To be successful, a weight-loss program must influence the patient's current set point. Some foods accomplish this goal more effectively than others. Increased dietary fiber dilutes the caloric content of food and thus offers an attractive solution to treating obesity and aiding in the prevention of weight gain. As the authors showed in a previous study, fiber-enhanced foods induce satiety and reduce voluntary intake of energy. Those results have subsequently been corroborated by other studies. These results are not surprising in that Pappas and others demonstrated that gastric distention was a physiologic satiety signal in dogs. Both of the foods used in this study are weight-control products, although neither was fed to promote weight loss (i.e., dogs were fed all they would eat during one daily 45-minute meal). The foods had small differences in protein, fat, moisture, and ash. The greatest difference was the fiber content (1.7% for the low-fiber food versus 19.4% for the high-fiber food, both on an as-fed basis; Table 1). As mentioned, these two foods were previously studied and shown to have different effects on satiety and energy intake.

The study reported here shows the benefit of tailoring food composition to the needs of the animal. Dogs fed the high-fiber food voluntarily decreased energy consumption by 27% (implying satiety) and consequently lost more than four times the fat mass as dogs fed the low-fiber food. When fed the high-fiber food, dogs lost 0.77% body fat per week, which falls within the generally accepted range of weight loss for dogs and cats (i.e., 0.5% to 2.0% per week) on a weight-loss program, despite the fact that the dogs in this study were not fed to achieve weight loss. When animals lose weight in a weight-loss program or through voluntary reduction in energy intake, as occurred here, they must mobilize body fat to make up for the dietary caloric deficit. According to the results of this study, the satiety benefit of enhanced fiber intake affects body composition in this way. The relationship between energy intake and energy use was balanced by energy (i.e., fat) mobilization in dogs in this study. If energy intake and energy mobilization are summed, then 100% of the predicted energy requirement of dogs in this study can be accounted for.

Although the change in lean body mass was not statistically significant when dogs were fed the two foods, preservation of muscle mass is important in weight-reduction programs because muscle is much more metabolically active than fat. This fact probably takes on more significance with client-owned dogs that have greater opportunity for exercise than the subjects used in this study. Skeletal muscle increases energy expenditure during physical exertion and lean body mass is the body
compartment that can most readily burn fatty acids, especially during aerobic exercise.

Both foods fed in this study were highly acceptable to the study subjects. Diet palatability is an important consideration for client-owned pets on a weight-loss program. Foods used must be acceptable to the overweight pet for prolonged intervals. The manufacturers of the foods used in this study have subsequently re-formulated both products. The high-fiber food now contains L-carnitine, which has been reported to help obese dogs achieve rapid weight loss (2.5% of initial body weight/week) over 12 weeks to reach ideal percent body fat when supplemented in the food at 300 parts per million. These same dogs had a 7.1% increase in lean body mass.20

**CONCLUSION**

Weight loss requires negative energy balance. The dogs in this study were fed either a high-fiber or a low-fiber food free choice during a 45-minute daily feeding interval. When fed the high-fiber food, dogs voluntarily consumed 27% fewer calories, which created a negative energy balance and led to loss of body fat. Dogs lost more than four times the fat mass when fed the fiber-enhanced food versus the low-fiber food. Food composition not only influenced satiety, but also body composition.

**REFERENCES**