

Barbara Rolls, PhD, discusses the role of energy density in weight control

## Energy Density and Nutrition in Weight Control Management

By Barbara Rolls, PhD

*In 1998, an evidence-based report of the National Heart, Lung and Blood Institute<sup>1</sup> concluded that low-fat diets are associated with spontaneous reduction of energy intake and body weight. The report further stated that reducing caloric intake confers additional benefits. The key question I consider in this presentation is: How do people who are trying to reduce their caloric intake avoid hunger and feel satisfied?*

### Here is Where Diet Composition Becomes Important

Low-fat diets are associated with weight loss because they have low energy density, defined as number of calories per portion. At an energy density of 9 kcal/g, fat has more than twice the number of the calories that carbohydrates or protein (each with 4 kcal/g) have.<sup>2,3</sup> In general, my colleagues and I have found that among foods most commonly consumed in the United States, the higher the fat content, the higher the energy density.<sup>4</sup> However, an even stronger relation exists between water content and energy density: The higher the water content of a food, the lower its energy density<sup>4</sup> (Table 1). Water adds weight and volume to foods without adding calories. Water-rich foods provide bigger, more satisfying portions than do dry foods. For example, a 100-calorie portion of grapes is eight times larger by weight than 100 calories of raisins (Figure 1).

The energy density of foods in-

fluences hunger, satiety, and food intake. My colleagues and I have studied how adding water to food (ie, decreasing energy density) affects satiety. One study<sup>5</sup> compared the effect of each of three first courses—a vegetable-and-rice casserole, the same casserole served alongside a ten-ounce glass of water, and a soup made by cooking the water and casserole together—on the quantity of lunch eaten a few minutes later. Compared with intake of the casserole alone, water consumed as a beverage with the casserole provided no additional reduction in lunch intake, whereas incorporating water into the casserole (to make soup) resulted in a 100-calorie reduction in later intake.<sup>5</sup>

Any number of possible explanations may account for the effect of energy density on satiety. In studies using direct intragastric infusion, my colleagues and I found that people are sensitive to the volume of stomach contents.<sup>6</sup> Some of the effect is cognitive and relates to portion size; some of the effect relates to the

sensory stimulation provided by a bigger portion.

Some studies<sup>4,7,8</sup> show that energy density—not fat content of foods—affects satiety and food intake. Studies showed also that subjects tended to eat a constant volume of food and that reduced energy density was associated with spontaneous decrease in daily energy intake without increased hunger.<sup>9,10</sup>

To help consumers use information about energy density to manage their weight, Robert Barnett and I wrote a book, *The Volumetrics Weight-Control Plan*,<sup>2,3</sup> in which foods are divided into four categories according to their energy density.

The first category consists of foods with very low energy density, ie, foods containing between 0.0 and 0.6 kcal/g. We encourage

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people to eat as much as they wish of these foods, which include soups, fruits, and vegetables.

The second category includes most foods that we eat daily: starchy fruits and vegetables, beans, and lean meat. Under the volumetrics concept, people may continue to consume relatively large portions of these foods. The energy density for this category is between 0.6 and 1.5 kcal/g.

The energy density of foods in the third category ranges from 1.5 to 4.0 kcal/g and includes a wide variety of foods, such as cheese, salad dressings, some snack foods, and desserts. Intake of these foods, particularly those with higher energy density, should be moderated.

The energy density of foods in the fourth category ranges from 4.0 to 9.0 kcal/g. These foods have the highest energy density and include chocolates, fatty foods (eg, nuts, chips, and other deep-fried foods), and candy. In-

**Table 1. Water content of foods**

Food	Water content
Soup	85-95%
Fruits and vegetables	80-95%
Hot cereal	85%
Egg, boiled	75%
Pasta	65%
Fish and seafood	60-85%
Meats	45-65%
Bread	35-40%
Cheese	35%
Nuts	2-5%
Oil	0%



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take of these foods requires careful portion control.

The volumetrics approach does not reinvent nutrition; the approach simply follows recommended dietary guidelines and leads to healthy food choices. Consuming an adequate balance of nutrients is particularly important for people who eat fewer calories, because these people are at greater risk for nutritional deficiency. What's new here is the advice to be more cautious about low-moisture-content foods, such as pretzels and crackers.

Several clinical trials using energy density to guide food choices are underway. Don Hensrud at the Mayo Clinic—the editor of a book on the subject<sup>11</sup>—has had success using energy density in a clinical trial. Michael Lowe and colleagues at Drexel University studied energy density in the weight maintenance phase of a weight-loss trial<sup>12</sup> and found that using energy density yielded better results than did traditional types of behavior therapy. My colleagues and I are also doing a clinical trial at The Pennsylvania State University.

## Conclusion

We urgently need action to combat obesity. The bad news is that the eating environment is at least partially driving the obesity epidemic; the good news is that the eating environment can be changed. We must give the food industry reasons to provide foods that promote satiety: lower-energy-density, good-tasting foods that don't cost more than less-healthy choices. Although consumers are responsible for what they put into their mouths, we can make it easier for them to make reasonable choices. ♦

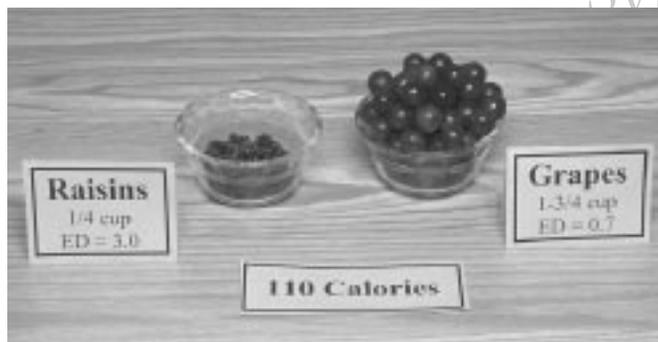


Figure 1. Water rich grapes provide bigger, more satisfying portions of less-energy-dense food than do dried raisins.

## After the presentation, Dr Rolls answered questions from the audience:

**The fast-food industry is showing signs of improvement. For instance, McDonald's® decided to reduce the amount of trans fat contained in foods that the company produces. Pepsico® also recently announced plans to reduce the fat content of snack products by 25% and to eliminate use of trans fat. Marketing data clearly show that public preferences are moving in this direction; we must support parallel movement in the food industry. How can this message—that the energy density of foods must be decreased—be translated into action by the food industry?**

The message about reducing energy density has two parts 1) Fat still counts, so reduce it—but not so much that you don't enjoy food; 2) Increase the water content of your food, primarily by adding fruits and vegetables.

Having energy density stated on food labels would be good. Even without this information, though, people can quickly assess energy density: If the number of calories per serving stated on the Nutri-

tion Facts label is lower than the number of grams, the food has low energy density. When the number of calories is close to twice the number of grams (or higher), the food is in an energy density category that requires the consumer to be more cautious about portion size. Beyond that, people know what highly energy-dense foods are: high-fat, low-water-content (ie, dry) foods.

**In clinical trials, how were subjects taught to do this calculation? Can this idea be translated into clinical practice?**

Michael Lowe used my book, *Volumetrics*, which is also being used in some National Institutes of Health (NIH) clinical trials and in the Pennsylvania public school system. The messages in *Volumetrics* could certainly be made more visual. For instance, you could have interactive computer programs where you could change portion sizes as energy density varies. My book could be made more fun with pictures, more examples, and simpler recipes—the book could be made very appealing to consumers. I'd love someone to develop a brochure based on the concepts discussed in the book.

**Can you comment on the difficulty people have reading**

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**nutrition labels and on how we might be able to get the food industry to give consumers better food labels?**

The food industry worked hard to introduce a standard label that contained a satisfactory amount of information; when you suggest yet another number to include, they're a little horrified. However, I think a simple number that people could understand more readily—a number stated in terms of energy density and portion size—would be great.

Incidentally, one concern is that once people understand energy density, they will simply eat more if they know they are eating foods that have lower energy density. We therefore studied the effect of adding information about energy density on the label and found that in a group of people who were trained about energy density, labels didn't affect eating behavior. At least, we found this result in a laboratory-based study.<sup>13</sup>

**Do you believe in daily consumption of five smaller meals (ie, consisting of 250 to 300 calories each) instead of**

### three larger meals a day? And do you think the protein recommendation (15% of daily caloric intake) is too low?

Frequency of eating is a difficult area of research. The evidence about whether frequency affects metabolism and body weight is controversial.

We can't justifiably say that one pattern will work for everybody. Part of the challenge is to identify meal patterns and types of foods that people can live with.

Animal and human studies indicate that of the macronutrients, protein has the most satiety value.<sup>14,15</sup> But has any really good study been done on protein and satiety? I don't think so; we clearly need to do more work. Protein comes with fat, too, and epidemiologic data indicate that, in general, people who eat more protein are heavier.

### One concern is that consumption of fruits and vegetables will be inadequately emphasized if we focus only on labeling. How do we keep fruits and vegetables in view?

First, we want to tell people that they can, in general, eat unlimited amounts of fruits and vegetables. The minimum five-a-day-fruit-and-vegetable message is very valid. Under the auspices of the Produce for Better Health Foundation and the Centers for Disease Control and Prevention (CDC), we are working on a review of the effect of fruits and vegetables on weight management.

However, problems with fruits and vegetables exist: Produce is often of poor quality, unavailable, or simply not consumed. Therefore,

although the government's job is not necessarily to increase public consumption of fruits and vegetables or to make them more affordable, the US Department of Agriculture (USDA) is actively rethinking the food stamp and Women, Infants and Children (WIC) programs as a way to increase intake of fruits and vegetables.

We must think both about each individual person's behavior and about population-level strategies—including food pricing—to reinforce what we're trying to achieve clinically.

### In my general pediatrics practice, I often see kids drinking juice from "sippy" cups or bottles. Excessive drinking of juice drinks—even drinks consisting of 100% juice—is an important issue.

Parents are in charge of what children are offered, and children can choose to eat it or not. The notion that children may consume as much juice as they want is really the wrong message.

Most studies show that, in general, sodas and alcoholic beverages add calories to food calories. Some early research also shows that whole fruit is more satiating than fruit juice. The more processed the food, the less satisfying it is for the same number of calories.

### Would you comment on Gary Taubes' article about dietary fat, "What if it's all a Big Fat Lie?,"<sup>16</sup> which appeared in the New York Times Magazine?

This field presents so many controversies that you can "tell the truth" simply by selectively including or excluding facts, as

Taubes appears to have done. However, scientists do agree that we should eat more fruits and vegetables and fewer refined carbohydrates and that protein sources should be lean. ❖

#### Acknowledgment

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