



Low-Energy-Dense Foods and Weight Management: Cutting Calories While Controlling Hunger



Summary

Yes, calorie intake can be reduced while controlling hunger. This research brief investigates the impact of eating low-energy-dense foods on calories consumed, satiety, and body weight.

Achieving and maintaining a healthy body weight can be challenging. A person must sustain a careful balance between calories consumed and energy expended in order to maintain his or her recommended body weight and must consume fewer calories than expended in order to lose weight. To reverse the current U.S. trend toward overweight and obesity, many Americans need to consume fewer calories and be more active.

Americans have used many dietary strategies to consume fewer calories including limiting portion sizes, food groups, or certain macronutrients such as carbohydrates or fats. While these strategies can help moderate calorie intake, particularly during the short-term, they do have limitations. These approaches may compromise diet quality or cause feelings of hunger and dissatisfaction, which can limit their acceptability, sustainability, and long-term effectiveness. The research in this brief supports an alternative strategy for managing calorie intake based on encouraging people to eat more foods that are low in calories for a given measure—that is, are low in energy density (kcal/g).

Research shows that people eat a fairly consistent amount of food on a day-to-day basis (1-8). This finding holds true whether the amount of food contains many or few calories. Therefore, the number of calories in a particular amount or

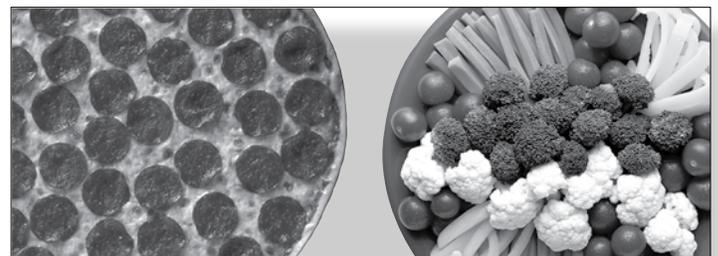
weight of food (i.e., the food's energy density) affects the total number of calories a person consumes.

This research brief:

- ❖ Provides an introduction to energy density.
- ❖ Examines the scientific evidence supporting the use of diets rich in low-energy-dense foods for managing weight.
- ❖ Provides practical approaches for practitioners to use when counseling people on lowering the energy density of the food they eat.

What is energy density?

Energy density is the amount of energy or calories in a particular weight of food and is generally presented as the number of calories in a gram (kcal/g). Foods with a lower energy density provide fewer calories per gram than foods with a higher energy density. For the same amount of calories, a person can consume a larger portion of a food lower in energy density than a food higher in energy density.

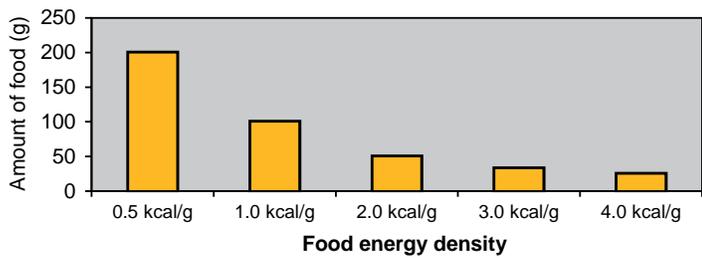


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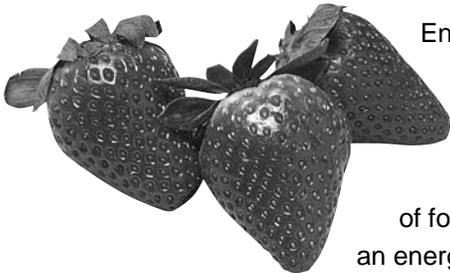
Figure 1. 100 kcal portions of foods differing in energy density



Examples: 1½ oranges ½ cup spaghetti with tomato sauce 1 fried egg ¼ cup raisins 3 large pretzel rods

Figure 1 shows the weight of different foods that contain 100 calories. As shown, 1½ oranges weighing 200 g yield 100 calories, whereas only 3 pretzel rods weighing 25 g with an energy density of 4.0 kcal/g yield 100 calories.

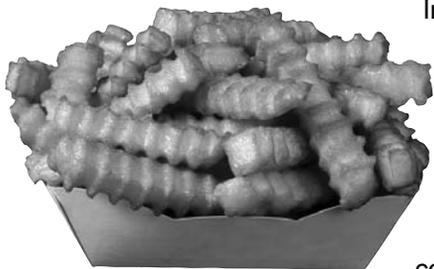
How does the composition of foods affect energy density?



Energy density values are influenced by the composition of foods. Water lowers the energy density of foods, because it has an energy density of 0 kcal/g and contributes weight but not

energy to foods. Fiber also has a relatively low energy density (1.5–2.5 kcal/g) and helps lower energy density.

On the opposite end of the energy density spectrum, fat (9 kcal/g) is the most energy dense component of food, providing more than twice as many calories per gram as carbohydrates or protein (4 kcal/g).



In general, foods with a lower energy density (i.e., fruits, vegetables, and broth-based soups) tend to be foods with either a high water content, lots of fiber, or little fat. While most high-

fat foods have a high energy density, increasing the water content lowers the energy density of all foods, even those high in fat. For example, adding water-rich vegetables, such as spinach, zucchini, celery, and carrots, to mixed dishes such as chili and casseroles lowers the energy density of these dishes.

Research Review: Eating a diet rich in low-energy-dense foods can help manage body weight.

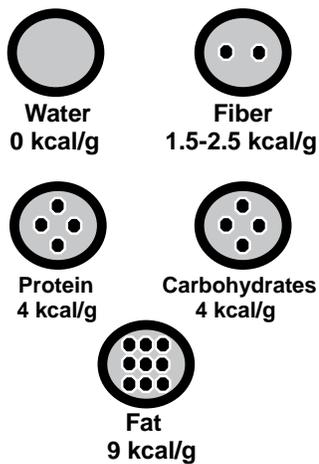
Low-energy-dense diets help people lower their caloric intake while maintaining feelings of satiety and controlling feelings of hunger.

Research studies indicate that consuming a low-energy-dense diet—one that is rich in fruits, vegetables, whole grains, lean meats, and low-fat dairy products—helps people lower their calorie intake. At the same time, eating low-energy-dense foods helps people control their hunger and maintain feelings of satiety, or the feeling of fullness and satisfaction experienced at the end of a meal. Satiety and hunger control are important for long-term satisfaction and compliance with an eating plan.

Observational studies focusing on the foods people typically eat have found that energy density is related to calorie intake and the amount of food consumed. A recent study by Ledikwe and colleagues found that among a nationally representative group of U.S. adults, men and women who reported eating a lower-energy-dense diet ate fewer calories yet consumed more food by weight than people who ate a higher energy dense diet (9). Other studies from countries around the world have reported similar findings (10-13). The results from these studies show that a diet low in energy density allows people to reduce their energy intake without necessarily decreasing the amount of food they consume.

Experimental studies in laboratories with dining facilities not only confirm that consuming foods lower in energy density is an effective strategy for reducing short-term calorie intake but also show that calorie intake can be reduced without increasing feelings of hunger. In these studies, the energy density of the foods served to study participants was carefully manipulated so that all the foods were equally palatable. The researchers then measured the participants' food intake and ratings of hunger and satiety. In one of these studies by Rolls and colleagues, participants were given a standard lunch on different occasions preceded each time with either a first-course salad of differing energy density or by no salad (14). Participants consumed fewer calories when the meal started with the lower-energy-dense salad and they reported feeling just as full as participants who had no first-course salad or had a salad that was higher in energy density.

Other types of foods that are low in energy density have also been found to help people decrease calorie intake



Water and fiber provide little, if any, energy to foods. Eating more water-rich and fiber-rich vegetables and fruit can decrease the energy density of the diet.

Protein and carbohydrates provide less than one-half the energy of fat per gram.

Fat has a high energy density. Reducing fat intake can decrease the energy density of the diet.

Figure 2. Energy density values vary from 0 to 9 kcal/g, as illustrated by the above ovals. Each oval represents 1 gram of a nutrient. The number of dots on each oval indicates how many calories are provided by each gram of that nutrient.

without increasing feelings of hunger. For example, in another study from the same laboratory, researchers found that consumption of a low-energy-dense soup as a first course in a meal maintained satiety while reducing energy intake (15).

Longer-term studies provide more evidence that reductions in energy density can significantly decrease calorie intake while maintaining fullness. These studies indicate that over the course of a few days, people generally consume a fairly consistent amount of food. Therefore, calorie intake is lower when research subjects eat foods low in energy density than when they eat foods higher in energy density.

In a study by Bell et al., normal weight women were provided with all of their meals over 2 days on three different occasions. On each occasion, the meals were modified by varying the amounts of vegetables offered (1) so that the 2-day diets differed in energy density. Although the participants could eat as much or as little as they liked, they ate similar amounts of food by weight during the 2 days. Consequently, reducing the energy density of the diet by adding extra vegetables led to a reduction in energy intake. Despite the reduced calorie intake, participants rated themselves equally full and satisfied.

In another study, Duncan and colleagues found that providing people with a reduced-fat diet that contained substantial amounts of fruits, vegetables, whole grains, and beans over 5 days led to the participants consuming fewer calories than when they were provided with a diet

containing large amounts of high-fat meats and desserts (2). Again, the participants consumed comparable weights of food during each 5-day session, and they reported that each diet satisfied their hunger similarly. In a study lasting 3 weeks, Shintani et al. provided participants with a traditional Hawaiian diet that was rich in fruits and vegetables (3, 4). This diet was substantially lower in energy density than the participants' habitual diet. Participants consumed a similar weight of food with both diets, which led to a reduction of their daily energy intake on the low-energy-dense traditional diet. Despite the reduced energy intake, which was sufficient to lead to weight loss during the 3 weeks, the subjects reported the diet to be moderately to highly satiating.



These (1-4) and other studies (5-8) indicate that over the course of a few days, the weight of food a person consumes is fairly consistent and is more consistent than energy intake. Therefore, encouraging people to eat more foods low in energy density and to substitute these foods for those higher in energy density helps them decrease their caloric intake while eating satisfying portions of food and controlling hunger.

Low-energy-dense diets may help manage body weight.

Many studies have confirmed that consuming a lower-energy-dense diet can be an effective strategy to control hunger while reducing calorie intake. An important question that follows is whether reductions in energy density can be successfully employed to manage body weight.

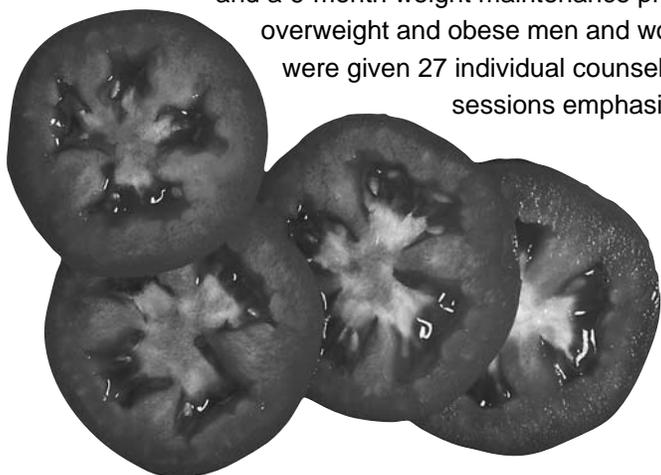
While the influence of dietary energy density on body weight has not been extensively investigated, several observational studies suggest that a relationship exists

between consuming an energy dense diet and obesity (9, 11, 16-18). For example, one study with a nationally representative group of adults found that normal weight individuals consumed diets that were lower in energy density than obese individuals (9). In a similar study, diets with higher energy density were found to be predictive of higher body mass index values (18). However, this type of cross-sectional data cannot determine causality.

Additional evidence supporting the use of diets rich in low-energy-dense foods comes from clinical interventions investigating the effectiveness of lower-energy-dense diets for weight loss and maintenance. Several trials, which did not specifically assess the energy of the diet, found that diets emphasizing foods low in energy density, such as fruits, vegetables, and other low-fat foods, as part of a reduced-energy diet were associated with weight loss (19-22).

In a study that provided participants with 18 individual and group counseling sessions over 7 months, Fitzwater and colleagues (19) encouraged overweight individuals to consume a reduced-energy diet emphasizing foods that were low in energy density, such as fruits, vegetables, whole grains, and beans. The participants lost an average of 7.3 kg. More than half (53%) of the subjects were able to maintain this weight loss over 2 years. While this study did not include a comparison group or the collection of detailed food intake information, it does suggest that advice to consume a diet rich in lower-energy-dense foods as part of an energy-restricted diet is an effective strategy for weight loss.

In another study, Rolls and colleagues (23) examined the effectiveness of incorporating either a low-energy-dense food (broth-based soup) or a high-energy-dense food (dry snack food) into a reduced-energy diet. During this year long clinical trial that included a 6-month weight loss phase and a 6-month weight maintenance phase, overweight and obese men and women were given 27 individual counseling sessions emphasizing



consumption of an energy-reduced diet. They were also provided with one of the following items to incorporate into their daily diet: one serving of soup, two servings of soup, two servings of a dry snack food, or no special food. Each soup and dry snack serving, which provided 100 kcal, was incorporated in the diet using an exchange-based system so that the diets prescribed to each group were similar in calories. When all intervention groups were combined, a mean loss of 7.6 kg occurred during the weight loss phase, followed by a mean gain of 1.1 kg during the weight maintenance phase. The researchers found that the strongest predictor of weight loss at 1 and 2 months was the overall decrease in the energy density of the diet. After participating in the intervention for 1 year, participants who consumed two servings per day of low-energy-dense soup experienced 50% greater weight loss than participants who consumed two servings per day of high-energy-dense dry snacks (7.2 kg vs. 4.8 kg).

In the previously discussed weight-loss trials, participants were encouraged to consume a reduced-energy diet. Ello-Martin and colleagues (24) took a novel approach to exploring the effect of reducing the energy density of the diet on weight loss. They tested two strategies to reduce the energy density of the diet without providing the subjects with specific calorie limits. The researchers provided counseling for one group of obese women in 38 individual and group sessions. The women were advised to decrease the energy density of their diets by increasing their consumption of water-rich foods, such as fruits and vegetables, and choosing reduced-fat foods. The other group was counseled only on reducing fat intakes. Both groups lowered the energy density of their diets, and both groups lost weight. However, after 12 months, the group counseled to eat more fruits and vegetables while also reducing fat intake experienced a greater reduction in the energy density of their diets and lost significantly more weight (7.9 kg vs. 6.4 kg) than the group told just to eat less fat. Even though they lost more weight, those participants eating the lower-energy-dense diet reported consuming more food by weight and experiencing less hunger.

These limited studies (19, 23, 24) suggest that dietary advice to reduce the energy density of the diet may be an effective strategy for weight loss. This finding was demonstrated even when obese individuals were not instructed specifically to reduce their calorie intake, which suggests that following this type of eating pattern can lead to a concomitant decrease in calorie intake. Additional studies are needed to confirm these positive findings. A benefit of this type of eating plan is that it allows people to eat

Figure 3: To calculate the energy density from the Nutrition Facts Panel of a food label, divide the calories by the weight.

This is the Nutrition Facts Panel on a package of fat-free chocolate pudding.

Nutrition Facts	
Serving Size 1 container (110 g)	
Servings Per Container 1	
Amount Per Serving	
Calories	100

$$\text{Energy Density} = \frac{100 \text{ Calories/serving}}{110 \text{ Grams/serving}}$$

The energy density is 0.9 kcal/g.

An extra large bar of chocolate, which has a much higher energy density because of less moisture and more fat, provides more than twice as many calories per serving than fat-free chocolate pudding. It is important to note that many foods, such as this extra large candy bar, contain more than one serving in a package.

Nutrition Facts	
Serving Size 1 bar (45 g)	
Servings Per Container 2	
Amount Per Serving	
Calories	230

$$\text{Energy Density} = \frac{230 \text{ Calories/serving}}{45 \text{ Grams/serving}}$$

The energy density is 5.1 kcal/g.

The low-energy-dense pudding, which weighs twice as much as the candy bar, would provide a more filling, lower-calorie snack. While high-energy-dense foods, such as chocolate do not need to be completely eliminated from the diet, choosing a smaller portion is a good strategy to control the calorie content. A full-sized chocolate bar and a miniature bar of chocolate both have the same energy density and therefore provide the same number of calories per gram, but the smaller bar contains fewer total calories.

satisfying amounts of food while restricting their energy intake. Furthermore, this type of eating plan uses positive messages (i.e., eat satisfying portions of low-energy-dense foods), which has been shown to result in greater dietary changes than restrictive messages (i.e., eat small portions of all foods) (20).

Diets low in energy density can be nutritionally sound.

Some people may think that consuming a diet low in energy density decreases the nutritional value of the diet. On the contrary, diets low in energy density can be nutritionally sound. While a decrease in body weight is a primary goal of a weight-loss diet, nutritional quality is equally important. People who limit their caloric intake and do not eat a variety of nutrient-rich, low-energy-dense foods may have inadequate micronutrient intakes (25, 26).

Getting adequate micronutrients is important for maintaining health. Data from a nationally representative survey of

U.S. adults (27) indicate that people consuming a lower-energy-dense diet eat a balanced diet by making specific choices within each food group, generally choosing foods that are low fat, are dense in micronutrients, or have high water content (28). These choices have led to higher intakes of fiber, vitamin A, vitamin C, and folate than with foods consumed in a higher-energy-dense diet. Therefore, a lower-energy-dense diet can be consistent with a healthy diet based on the Dietary Guidelines for Americans (29).

From Research to Practice: Practical approaches to lowering the energy density of the diet.

Calculating energy density

People can reduce caloric intake without strictly limiting food portions by consuming a diet low in energy density. The energy density of packaged food can be calculated easily by using information that is readily available on the Nutrition Facts Panel of food labels.

Creating a diet low in energy density

People can follow several steps in order to create a diet low in energy density:

1) Try to incorporate a large portion of fruits and vegetables into meals. Choose spinach, cruciferous vegetable, tomatoes, citrus fruits, and melons, just to name a few. Broth-based soups, which are also low in energy density, are filling, low-calorie food choices. Also choose these foods as snacks and appetizers.

2) Round out meals by adding starchy fruits and vegetables, whole grains, legumes, lean meats, and low-fat dairy food. These foods are important for creating a healthy, balanced diet.

3) Pay attention to portion sizes of fried foods, including vegetables; non-whole grains; dairy foods that are not reduced in fat; and fatty cuts of meat. These foods can be part of a healthy diet when consumed occasionally in small portions.

4) Consume infrequently, with particular attention to portion size, foods with little moisture, such as crackers, cookies, and chips as well as high-fat foods like croissants, margarine, and bacon. These foods provide a large number of calories relative to their weight and can easily be over-consumed. Foods such as nuts and olives, which have a relatively high amount of polyunsaturated and monounsaturated fatty acids, can be part of one's diet as long as they are consumed in moderate portions.

Strategies to lower energy density

A brochure, "*Eat More, Weigh Less*" has been developed in conjunction with this brief for practitioners to use with their patients and clients. Another research brief and brochure in this Research to Practice Series—*Can Eating Fruits and Vegetables Help People to Manage Their Weight?*—provide information on substituting fruits and vegetables for higher-energy-dense foods.

Several practical strategies that people can use to lower the energy density of their diet are as follows:

- **Start with what is already on the plate.** Palatability and food preferences play critical roles in food selection. Helping people modify the energy density of their existing diet may increase the likelihood of achieving lasting changes. When providing guidance for decreasing dietary

energy density, the main goals should be to increase fruit and vegetable intake while limiting intake of foods high in fats and oils. Keep total fat intake between 20% and 35% of calories, with most fats deriving from sources of polyunsaturated and monounsaturated fatty acids, such as fish, nuts, and vegetable oils.

- **Lower the energy density of frequently consumed foods.** The energy density of many foods can be lowered with slight modifications that are unlikely to compromise palatability. While energy density can be lowered by reducing the amount of fat or increasing the amount of water-rich foods, the most substantial reductions in energy density are achieved when both of these strategies are used simultaneously.

Example: Main dishes

The energy density of many main dishes can be reduced by adding extra vegetables or by reducing the amount of added fat. Many different vegetables (e.g., chopped spinach, shredded carrots, diced green pepper, shredded zucchini, broccoli, or mushrooms) can be added to omelets, lasagna, pizza, chili, soups, and other hot dishes. Using lower fat meat and cheese or simply using less of the higher fat ingredients can reduce the fat content.

Example: Dessert

Instead of having 1 cup of ice cream for dessert, have ½ cup of reduced-fat ice cream topped with ½ cup of fruit.

- **Substitute foods lower in energy density for items higher in energy density.** Encourage people to identify some of the foods they consume that are high in energy density and help them come up with acceptable alternatives that are lower in energy density.



Example: Lunch at a fast food restaurant

Compared to a fried chicken sandwich, a grilled chicken salad with lettuce, tomatoes, and a low-fat dressing can provide a tasty alternative with more water-rich vegetables, less fat, and fewer calories.



- **Avoid large portions of foods that are high in energy density—BUT encourage foods low in energy density to be consumed in portions that are appropriate for calorie needs.**



Along with energy density, food portion size has been shown to affect calorie intake (14, 30-35). Recent studies have shown that when either the energy density or the portion size of foods is increased, calorie intake increases. Given how common large portions of energy dense foods are in today's society, this may be a problem for weight management.

However, recent studies have shown that even modest reductions in the energy density and portion size of popular foods could have a significant beneficial impact on energy intake (14, 30, 31). In one study (31), participants were provided with a variety of popular, commercially available foods over 2 consecutive days on four occasions and allowed to eat as much as they wanted. The foods were varied in energy density and presented in two portion sizes. Participants consumed the least amount of energy when provided with the smaller portions of the lower-energy-dense foods and the greatest amount of energy when provided with the larger portions of the higher-energy-dense foods. Specifically, the researchers found that a 25% decrease in energy density led to a 24% decrease in energy intake and that a 25% decrease in portion size led to a 10% decrease in energy intake. Over the 2 days, this led to a reduction of 1,625 kcal when both portion size and energy density were decreased.

Foods low in energy density, such as vegetables, fruits, and broth-based soups, can aid in weight management by providing satisfying portions that are appropriate for calorie needs. While energy dense foods do not need to be completely eliminated from the diet, they should be consumed in moderate portions along with foods that are predominantly low in energy density in order to create a balanced eating plan. Understanding how energy density and portion size work together can lead to more effective nutrition education messages than simply encouraging people to eat less. People should be encouraged to meet their calorie needs by eating satisfying portions of foods with a low energy density.

- **Prepare fruits, vegetables, and other foods without excess fat and sugar.** Frying vegetables or

covering them in butter or cream sauce will increase their energy density. The same holds true for fruits with added sugar, syrup, or fat.

- **Choose meats and cheeses that are lower in fat.** When selecting and preparing meat, poultry, dry beans, and milk or milk products, make choices that are lean, low fat, or fat-free.
- **Consume an appetizer low in energy density.** A practical approach to help moderate calorie intake is to consume a low-energy-dense food, such as a 100-kcal serving of a broth-based soup or a green salad, at the start of a meal. If a person pays attention to satiety cues, this practice may help reduce his or her overall calorie intake at the meal.
- **Have plenty of foods low in energy density readily available.** Making food more readily available can increase consumption. Having plenty of low-energy-dense food at home and at the office makes it easier to choose these foods over higher-energy-dense options. Frozen and canned fruits and vegetables are good options when fresh produce is not available or affordable. However, choose items without added sugar, syrup, or fat.

- **Choose water and other low-calorie beverages to quench thirst.** Most beverages have a low energy density, even beverages that are relatively high in calories. While increased consumption of water-rich foods such as fruits, vegetables, and broth-based soups can help control hunger while moderating calorie intake, increased beverage consumption is not likely to promote satiety. When Rolls and colleagues (15) gave study participants either a chicken-rice casserole with a glass of water or a chicken-rice soup prepared by adding water to the ingredients used

in the casserole, they found that eating the soup significantly increased the feeling of fullness and reduced the participants' hunger and calorie intake at the meal. Drinking a glass of water with the casserole had no additional effect on total calories consumed or on ratings of fullness than eating the casserole alone. Drinking beverages may reduce thirst, but they will most likely not contribute to feeling full (satiety). Choosing water and other low-calorie beverages can help moderate calorie intake and reduce thirst, but they will most likely not contribute to feeling full (satiety).



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