Obesity

AND FOOD TECHNOLOGY

American Council on Science and Health

OBESITY AND AND FOOD TECHNOLOGY

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EXECUTIVE SUMMARY

- **Obesity is one of today's leading health concerns for both adults and children. It is responsible for at least 100,000 deaths per year in the United States, placing it second only to cigarette smoking as an underlying cause of death.**

  Obesity increases the risk of multiple health problems, including heart disease, diabetes, several types of cancer, stroke, liver disease, osteoarthritis, chronic kidney disease, some gastrointestinal disorders, sleep apnea, asthma, and reproductive problems.

- The use of food technology to solve public health problems has a long and impressive history. Three important examples are the pasteurization of milk, the fortification of foods to prevent nutritional deficiencies, and the use of irradiation to enhance microbiological safety and to kill pests in foods.

- Research has shown that foods that are low in energy density (calories per unit weight) can be helpful in weight control by providing fewer calories without making people feel deprived or unsatisfied. The use of reduced portion sizes can also be helpful.

- Although innovations from food technology have contributed to the increased availability of abundant and tasty foods (that makes over consumption of food easier), the food industry is not the cause of obesity and its creativity may contribute to solving the obesity problem.

- In conjunction with dietary change, increased physical activity, behavioral changes, and education, food technology can contribute in the fight against obesity by providing consumers with an increased variety of tasty, appealing foods that are lower in energy density and/or portion size than standard products.

- Technological innovations that may be used in the creation of lower-energy-density and/or controlled-portion-size products include sugar substitutes, fat replacers, addition of fiber, use of chemical additives produced by biotechnology, new production methods, and different food packaging strategies. Designing foods that promote satiety or suppress appetite are active areas of research. For example, insulin-type fructans, added to foods, have been shown to affect blood levels of appetite signaling hormones thereby helping to suppress appetite. Some novel fat emulsions and types of dietary fiber induce a feeling of fullness and may reduce food consumption.

- Many food products with reduced energy density or controlled portion size are already being marketed successfully. Whether additional, newer products of these types will be commercially successful depends on several factors, including economic issues, government regulations, and the knowledge and attitudes of the public, the food industry, and health professionals.

The Importance of Obesity as a Public Health Problem

Obesity is one of today's leading health concerns for both adults and children.

Approximately one-third of all American adults are obese, as compared to only 15% in the 1970s (1). Another one-third of adults are overweight. In American children and adolescents, obesity rates have more than doubled in the past 30 years]]] — a very serious issue because obesity in childhood often persists into adulthood, leading to long-term health problems, such as heart disease, diabetes, and liver disease (2).

Approximately one-third of all American adults are obese, as compared to only 15% in the 1970s.

Experts estimate that obesity is responsible for about 112,000 excess deaths per year in the United States (3), placing it second only to cigarette smoking as an underlying cause of death. In terms of health care expenditures, obesity and cigarette smoking may actually be tied for first place (4). Obese people have higher-than-average rates of a variety of diseases that can cause ongoing health impairment and require long-term treatment, such as diabetes, asthma, and osteoarthritis. Obesity is also associated with increases in cardiovascular risk factors, including high blood pressure and abnormal levels of blood lipids. An individual's likelihood of dying of cardiovascular disease can be reduced if these risk factors are identified and treated, but diagnosis and treatment involve substantial costs for physician visits, diagnostic tests, and medicines. Most types of health care expenditures are affected by obesity, but the highest relative increases involve outpatient services, such as prescription medications and office visits (5, 6).

When people think of health problems associated with obesity, they usually think of heart disease and diabetes — and they're right; both of these diseases are linked to obesity. Many people do not know, however, that obesity is also associated with an increased risk of a variety of other health problems, including the following:

- Several types of cancer, including cancers of the endometrium (lining of the uterus), colon and rectum, esophagus, breast, kidney, and gallbladder, and aggressive or fatal prostate cancers (obesity may not be associated with prostate cancer in general) (7, 8, 9)
- Strokes, especially those resulting from blockage of a blood vessel (10, 11)
- Liver disease (obesity, along with alcohol abuse and viral hepatitis, is one of the three leading causes of serious liver diseases) (12, 13)
- Osteoarthritis, particularly involving the knees (14)
- Chronic kidney disease (15, 16)
- Several diseases of the gastrointestinal tract, including gastroesophageal reflux disease (GERD), gallstones, and pancreatitis (17, 18, 19, 20)
- Asthma in adults and children (21)
- Sleep apnea (a condition in which people repeatedly stop breathing during sleep and must at least partially arouse themselves to resume breathing; it is associated with daytime sleepiness and an increased risk of motor vehicle crashes) (22)
- Carpal tunnel syndrome (23, 24)
- Erectile dysfunction (25, 26)
- Difficulty conceiving, complications of pregnancy, urinary incontinence, and polycystic ovary syndrome (27, 28, 29)

One promising recent development is an increased awareness on the part of the American public of obesity as an important health problem. Prior to 2005, surveys by the International Food Information Council found that the top health concerns for consumers were cardiovascular disease and cancer, with concerns about obesity a distant third. However, weight is now the number two concern, behind cardiovascular disease and ahead of cancer, with about one-third of consumers mentioning weight as a health concern in surveys conducted in 2005 and 2007 (30).

Sound Approaches to Fighting Obesity

Sound ideas about how to fight obesity include dietary changes, increased physical activity, and education to promote changes in behavior leading to more desirable eating and exercise habits.

For some obese people, drugs and/or surgery may also be options in treating their individual problems. And, as later sections of this report will discuss in detail, food technology can also play a useful role in fighting obesity.

Exercise is an important component of any weight loss strategy, not only because it burns calories consumed in food but also because it helps to prevent the decrease in basal metabolic rate (BMR) that sometimes accompanies dieting. When caloric intake is cut, the body responds by reducing BMR as a means of preserving calories during a time of perceived starvation. Regular exercise also appears to help regulate appetite (31). Many studies have shown that a combination of diet and exercise result in a greater loss of weight than either strategy alone (32).

The National Institutes of Health has issued a set of recommendations for health professionals that outlines the methods of treatment for obesity that are supported by sound scientific evidence (33). The recommendations include the following key points:

1. A low-calorie diet, preferably one individually planned to provide 500 to 1,000 calories per day less than the individual would need for weight maintenance, will aid in reducing weight by 1 to 2 pounds per week.
2. Increased physical activity is recommended, with the eventual goal of accumulating at least 30 minutes or more of moderate-intensity activity on most days of the week for a minimum of 150 min/week.
3. As an adjunct to diet and exercise, behavior modification may help people make long-term changes in their patterns of eating and physical activity.
4. After successful weight loss, a weight maintenance program consisting of dietary therapy, physical activity, and behavior change needs to be continued indefinitely to prevent weight regain.
5. For some patients (those with a body mass index [BMI] of 30 or more or with a BMI of 27 or more accompanied by obesity-related health problems such as hypertension, diabetes, and dyslipidemia), the use of weight-loss drugs may be appropriate in conjunction with (not as a substitute for) diet and exercise, but careful monitoring of the patient for side effects is needed.
6. Weight-loss surgery is an option for severely obese patients (those with BMIs of 40 or over or those with BMIs of 35 or over in combination with obesity-related health problems) for whom more conservative forms of therapy have failed and who are at high risk for obesity-related health problems.

Another government agency with a strong interest in obesity is the FDA. A working group at the FDA has issued a report on obesity that focused on the importance of caloric balance (34). Because obesity, at the most fundamental level, is a result of an imbalance between energy (calorie) intake and output, the FDA report emphasized the importance of focusing educational messages on the basic concept that "calories count." The report also noted, though, that there is evidence that many people misperceive their own weight status and that of their children, and that those who incorrectly believe that they or their children are not overweight or obese are unlikely to pay attention to educational messages aimed at fighting obesity (34).

The Nutrition Facts label on food products is one of the FDA's principal educational tools. However, recent research indicates that many people are not using these labels effectively to achieve an appropriate calorie intake. Recent surveys indicated that a large proportion of the respondents did not make use of the information on Nutrition Facts labels that is most crucial to weight management — calorie content and serving size (35). Moreover, even if they had this information, a substantial minority of the study participants would not have known how to interpret it. Only 33% could describe an appropriate daily calorie intake, even when a very broad definition of an appropriate intake (anywhere between 1,500 and

2,500 calories/day) was used (35). Other research has shown that the literacy and numeracy levels of some consumers are too low to enable them to use the information on Nutrition Facts labels correctly (36).

Food technology can play a role in the fight against obesity by providing consumers with choices that may help them with their weight control efforts.

Clearly, education is critical in efforts to decrease the problem of obesity. People need to be better informed about how to judge their own weight status, achieve and maintain a healthful weight, and evaluate information concerning the calorie content and serving size of foods. Other approaches, however, can complement educational efforts. Some of these approaches involve applications of food technology.

In saying that food technology can play a role in fighting obesity, the American Council on Science and Health (ACSH) does not mean to imply that the food industry is at fault in causing obesity or that it is the responsibility of food manufacturers to solve the obesity problem. Obesity is a multifactorial condition of great complexity; no single factor is responsible for its increased prevalence. People want to be able to buy good, inexpensive food — and manufacturers and businesses provide the goods and services that people want to buy. This is how a free economy works. Nevertheless, food technology can play a role in the fight against obesity by providing consumers with choices that may help them with their weight control efforts. In most instances, this involves using technology to create foods that are tasty, appealing, and affordable, yet lower in calories than similar products currently on the market.

Food Technology Provides Solutions for Public Health Problems

The use of food technology to solve public health problems has a long and impressive history.

Three important examples are the pasteurization of milk to prevent the transmission of infectious diseases, the judicious fortification of foods to prevent nutritional deficiencies, and the use of irradiation to enhance microbiological safety and to kill pests in foods.

Pasteurization of Milk

In the late nineteenth century and early twentieth century, milk was a vehicle for transmission of many infectious diseases, including typhoid fever, tuberculosis, diphtheria, severe streptococcal infections such as scarlet fever, and potentially fatal diarrheal diseases (37). This public health threat was eliminated by the development and near-universal adoption in the United States of a technique now called pasteurization — the heating of milk to specific temperatures below the boiling point for strictly prescribed time periods to kill disease-causing microorganisms. This process, combined with aseptic packaging techniques to prevent handling and recontamination after heating, renders milk safe to drink without causing major changes in flavor or nutritional content. Pasteurization was first applied to milk in the 1870s, and the process was performed on a commercial scale in Denmark and Sweden as early as 1885 and in several US cities before 1900 (38). It was not until several decades later, however, that its use became nearly universal.

Today, federal law requires that all milk sold in interstate commerce in the United States be pasteurized. However, 25 states allow raw (unpasteurized) milk to be produced and sold within their borders. From 1998 to May 2005, the Centers for Disease Control and Prevention identified 45 outbreaks, involving more than 1000 cases, more than 100 hospitalizations, and two deaths, attributable to unpasteurized milk or cheese made from it (39).

Fortification

Fortification is the addition of specific nutrients to food, usually a staple food that people consume on a daily basis, that may correct or prevent a nutritional deficiency. It can be very effective because it does not require people to change their habits by taking a dietary supplement or choosing different foods.

One of the first examples of food fortification was the addition of iodine to salt in the United States to prevent goiter and other manifestations of iodine deficiency. In the early 1900s, iodine deficiency was common in parts of the United States far from the oceans, where soils, and the foods grown in them, are low in iodine. In 1924, iodized salt (salt containing added sodium iodide) was first introduced in Michigan, leading to a decrease in the prevalence of goiter from 38.6% to 9%. By the 1930s, iodized salt was in use throughout the United States, and iodine deficiency was almost completely eliminated as a public health problem (40).

Other successful fortification programs include the addition of vitamin D to milk, beginning in the early 1930s, to prevent rickets and the enrichment of flours and breads starting in 1938 (made mandatory in 1943) to prevent deficiencies of thiamin, niacin, riboflavin, and iron. A more recent example of fortification is the addition of the B vitamin folic acid to grain products to reduce the occurrence of neural tube birth defects (anencephaly and spina bifida), which became mandatory in 1998 (41).

Irradiation

Irradiation is the process of exposing foods to gamma irradiation, electron beams, or x-rays at approved doses that do not cause deterioration of food components. Irradiating foods in excess of the approved levels can produce lipid oxidation products and some undesirable tastes, particularly in high fat foods. Irradiation kills harmful bacteria, eliminates insect

infestation, and inhibits sprouting of certain vegetables (42). Bacterial spores and foodborne viruses, however, are resistant to irradiation levels used in most foods (43).

The safety of irradiation has been studied more extensively than that of any other food preservation process. Extensive scientific data indicate that irradiated foods are safe, wholesome, and nutritious. Irradiated foods are not radioactive. Irradiation can play the same role as pasteurization in ensuring food safety by destroying disease-causing microorganisms without changing the essential nature of a food (44). One of the best-established uses of irradiation is to ensure the hygienic quality of spices, herbs, and dried vegetable seasonings so that they do not add excessive quantities of bacteria to the foods in which they are used. Irradiation has been used for this purpose since the 1980s, and globally, about 260,000 pounds of irradiated spices are produced each year.

Another important commercial application of irradiation is the treatment of ground beef to eliminate *E. coli* O157:H7 and other bacteria. Although thorough cooking of ground beef kills bacteria, pathogenic bacteria can survive in the center of “rare” hamburgers. Following several high-profile disease outbreaks traced to fresh greens from California, in August, 2008, FDA approved the use of ionizing radiation to kill pathogenic bacteria on fresh iceberg lettuce and fresh spinach. (21CFR 179) Irradiation is also being used to treat tropical fruits to prevent introduction of pests from one part of the world into other areas.

Although substantial quantities of irradiated foods are sold each year (worldwide, an estimated 300,000 tons of irradiated food entered commercial channels in 2005), irradiation is still underutilized. Some applications of irradiation already approved by the FDA, such as the irradiation of raw poultry to kill *Campylobacter* and other disease-causing bacteria, are infrequently used. Many consumers remain skeptical of the safety of this process, concerned about possible negative effects (45).

USING FOOD TECHNOLOGY TO DECREASE CALORIE LEVELS IN FOOD

Scientific Rationale

Before discussing how lower-calorie foods can be created, it's worth asking whether this is desirable.

Some people may question — quite reasonably — if it is worth the effort. After all, if people eat lower-calorie foods, won't they still be hungry after they finish eating them? And won't they simply eat more food to compensate? Will intense sweeteners increase the appetite for sweet foods and promote overeating?

A substantial body of scientific evidence indicates that external cues, rather than the body's internal sensations of hunger or fullness, play a major role in determining how much food people actually eat.

The answer to these questions turns out to be "not necessarily." A substantial body of scientific evidence indicates that external cues, rather than the body's internal sensations of hunger or fullness, play a major role in determining how much food people actually eat. Under both controlled experimental conditions and free-living conditions, subjective hunger ratings are only moderately or weakly associated with energy intake (46). Apparently, people are easily influenced by environmental factors. For example:

- Atmosphere matters. People stay longer in a restaurant and are more likely to order a dessert or extra drink if the lighting is dim and/or the music is soft and pleasant, as is often the case in fine dining establishments. On the other hand, harsh or bright lighting and/or loud, fast music or loud ambient noise can prompt diners to finish their meals quickly, which can also lead to overeating because the diners do not take the time to monitor their own feelings of fullness (47).
- People eat more when they eat with others, and the greater the number of companions, the greater the effect. In one study, meals eaten in large groups were more than 75% larger than those eaten when alone (48).
- Increased visibility and availability of food lead to increased consumption. People working in an office eat more candies if the container is kept on their desks rather than several steps away and if the jar is clear rather than opaque (49).
- Variety increases consumption — even if it's only visual variety rather than flavor variety. In one study, people given a bowl of M&M candies in ten colors ate 43% more than those given a bowl containing the same candies in seven colors (50).
- People apparently use vision-based rules of thumb, such as "I will eat until I have finished all (or half, or some other proportion) of the contents of this bowl," to make consumption decisions. In one study, people were served tomato soup in bowls that were slowly refilled through concealed tubing. People who ate from these special bowls consumed 73% more soup than those eating from normal bowls, but they did not believe that they had eaten more and they did not preceive themselves to be more satisfied (51).
- Larger packages, portions, plates, bowls, and drinking glasses all lead to increased consumption, presumably by suggesting that it is appropriate to consume larger amounts (47). Many studies in laboratory and natural settings have shown that giving people larger portions of food leads to greater food (or calorie) intakes (52). For example, adults served 1000-g portions of macaroni and cheese consumed 30% more calories than those served 500-g portions (53). It is well documented that typical food portion sizes in the United States have increased in recent decades. In one study, data from successive surveys of foods consumed by nationally representative samples of the U.S. population between 1977 and 1996 showed that portion sizes increased over the time period studied for all of the foods except pizza. (54). Data on food provided in restaurants indicated that portion sizes began to grow in the 1970s, increased sharply in the 1980s, and have continued to increase since then (55).

- Stress affects amounts and types of foods eaten. Increased daily hassles, such as those related to work and interpersonal relations in natural settings, have been found to increase consumption of high fat/sugar snacks and decrease consumption of vegetables and main meals (56).
- Costs of foods matter, particularly to lower income consumers. Persons with limited incomes often purchase less food, a reduced variety of foods, and generally less healthy foods. Foods containing refined grains, added sugars, and added fats are less expensive than nutrient-dense foods such as lean meats, vegetables, and fruits (57).

Individuals respond differently to these environmental factors. Evidence from a number of studies indicates that nearly all people respond to normative cues of what or how much to eat (such as plate or portion size). While people generally eat more of foods they consider good-tasting or palatable, obese and dieting individuals respond more strongly to sensory cues of palatability, such as smell, appearance, and texture. These sensory cues may overide the effects of normative cues leading to consumption of more food than might be deemed appropriate (58). Obese individuals are also more likely to consume unhealthy snacks in response to stress (56).

The fact that people eat more when offered larger portions or more attractive foods might be of little importance if they compensated for their greater consumption on one occasion by decreasing their food intake at subsequent meals, but the scientific evidence indicates that they do not, at least over a period of a few days. This was observed in a study in which the participants ate all their meals in a controlled setting for two consecutive days in each of three weeks. The smallest portion sizes of all foods were served during one two-day period, the middle portion sizes during another week, and the largest portion sizes during the remaining week. People consistently ate more throughout the two-day periods when given larger servings of food, and calorie intake on the second day of each test period did not differ from that on the first day (59). Although people reported feeling more full after consuming larger portions, they did not compensate by eating less food at subsequent meals.

USING FOOD TECHNOLOGY TO DECREASE CALORIE LEVELS IN FOOD

Energy Density

Dietary prescriptions for weight loss usually emphasize eating less food (reducing portion size) and/or eating less of certain foods (deserts, fried foods) and more of other foods (fruits, vegetables, whole grain breads). The less desirable foods are energy (or calorie) dense while the recommended foods are less energy dense.

Energy density refers to the amount of energy or kilocalories (kcal) contained in a quantity of food, expressed as a function of weight (kcal/gram) or volume (kcal/cup or tablespoon). The energy density of a particular food depends on the proportions of its major components — fat, protein, carbohydrate, water — and their energy density. Of these components, fat has the highest energy density: 9 kcal/g. Protein and carbohydrate each provide 4 kcal/g, and water provides 0 kcal/g. Insoluble fiber also provides 0 kcal/g because it is not digested.

Water has the greatest impact on energy density because it adds substantial weight to a food without adding calories. The foods that are lowest in energy density are those that are highest in water: vegetables, fruits, and broth-based soups. It is important to note that some foods that are low in water may be high in energy density even if they contain little or no fat.

Because fat has a higher energy density than any other nutrient, the amount of fat in a food or meal also has a substantial impact on energy density. For example, fatty meats have a higher energy density than lean meats, and the energy density of full-fat dairy products is higher than that of low-fat or nonfat dairy products.

Energy density is important because research has shown that people tend to eat a consistent weight (or volume) of food from day to day, rather than a consistent amount of energy (calories) (60). If the energy density of foods is lowered without making the food unpalatable, people will usually still eat the same amount and report a similar level of fullness as they did when they consumed the higher-energy-density food (61).

In studies in which adults were given entrées of varying energy density and allowed to choose how much of the entrée to eat, they consumed similar amounts of the entrée despite differences in its energy density and therefore had lower total calorie intakes when consuming entrées lower in energy density (61). In another study women ate three apples (0.63 kcal/g), three pears (0.64 kcal/g), or three oat cookies (3.7 kcal/g) each day in addition to their regular diet over a 10 week period. Energy density of the total diet declined by 1.23-1.29 kcal/g for the apple and pear groups and daily energy intake also decreased significantly as compared to the oat cookie group (62). Similar results have been obtained in studies in children (63, 64).

Energy density is important because research has shown that people tend to eat a consistent weight (or volume) of food from day to day

Varying both energy density and portion size has a greater effect on total food intake than could be achieved by manipulating just one of these two variables. In a study in adults, reducing the energy density of the overall diet by 25% for two days led to a 24% decrease in calorie intake. Reducing portion size by 25% led to a 10% decrease in calorie intake while reducing both factors by 25% led to a 32% decrease. These findings indicate that the effects of energy density and portion size are approximately additive, at least for these relatively small degrees of modification. People did not compensate for changes in intake at one meal by eating different amounts at subsequent meals, at least over a two-day period (65). Similar combined effects of energy density and portion size have been demonstrated in children in a single-meal study (63). In these studies, participants found changes in energy density to be less noticeable than changes in portion size. Thus, to help people reduce energy intake without making a dish or meal seem unsatisfying, changes in portion size may need to be small. But more substantial changes can be made in energy density, if it can be accomplished without compromising palatability (66).

Since foods of low energy density tend to be low in fat, it may be that the participants in those studies were responding primarily to changes in the fat content of their meals, rather than changes in energy density. In another

study in which fat content and energy density were manipulated independently of one another, energy density influenced energy intake, but fat content did not (67). Thus, a high- (or low-) fat diet appears to be a marker for a high- (or low-) energy-density diet, rather than the other way around.

Specific ways of incorporating low-energy-density foods into meals may be particularly effective in decreasing calorie intake. For example, consuming a low-energy-density first course can decrease total calorie intake at a meal, presumably by enhancing feelings of satiety. This has been demonstrated both for low-energy-density first-course salads (68) and soups (69).

Energy density is also important in long-term, real-life situations. A survey of a representative sample of the U.S. population showed that both men and women whose self-chosen diets were low in energy density consumed more food (by weight) than those with high-energy-density diets, but their total calorie intakes were lower. Normal-weight individuals in this survey had diets with lower energy density than obese individuals (70). A study of people from five different ethnic groups in Hawaii also showed a relationship between energy density of the diet and body weight; in each of the five ethnic groups and in both sexes. Those who consumed diets of higher energy density had higher BMI values (71).

Several studies of people on weight-loss diets have indicated that a reduction in the energy density of the diet is associated with greater success in weight loss. An analysis of data from participants in a trial of non-pharmacological therapies for high blood pressure, participants who decreased the energy density of their diets the most lost the greatest amounts of weight (72). In another study, people on standard weight-loss diets were randomly assigned to consume two different types of snacks, with equal numbers of calories, as part of their meal plans; one group consumed two snacks of high energy density, while the other consumed two servings of low-energy-density soup (73). Those who consumed two servings daily of low-energy-density soup had a 50% greater weight loss than those who consumed the same number of calories daily as high-energy-density snack foods. In another study, obese women were counseled either to reduce their fat intake or to both reduce their fat intake and increase their intake of water-rich foods, particularly fruits and vegetables, as part of a weight-loss diet (74). After a year, the women who were advised to make both of the dietary changes had lower dietary energy density and lost more weight, despite eating a greater weight of food; they also reported experiencing less hunger.

Innovations from Food Technology: Overview

Although most overweight people realize that they are consuming too many calories, it can be very difficult to change eating habits for the long term and give up favorite foods that are high in energy density.

Food choices are not only a matter of habit, of course, but also of culture, availability, and cost. Food technologists have been working for over 30 years to devise palatable, low energy density versions of some foods. A variety of approaches have been used to reduce the caloric density of foods . Lessening energy density of a food can be accomplished either by removing some or all of the fat or sugar in a food, thereby decreasing its caloric content, or by adding substances with few or no calories to the food to increase volume and weight. Other strategies may include innovations in plant and animal breeding, changes in processing and production methods, and alterations in structures of foods. However, foods are very complex mixtures of many ingredients with specific tastes, textures, and mouthfeel. Therefore, formulation of "light" and "nonfat" foods, with reduced levels of sugars and/or fats, that still taste very similar to standard foods, is not a simple matter.

Low-calorie products are a relatively recent invention, and are only popular in developed countries. A 2007 survey of a nationally representative sample of the U.S. population aged 18 and over, conducted for the Calorie Control Council, a trade organization of manufacturers of low-calorie and reduced-fat foods and beverages, showed that 86% of all survey respondents reported the usage of low-calorie, reduced-sugar, or sugar-free foods or beverages — the highest level ever reported (75). Usage was higher among women than men, and the product category with the highest level of acceptance was non-carbonated sugar-free soft drinks, exceeding diet carbonated soft drinks for the first time. In addition to these beverages, other popular low-calorie items were reduced-sugar frozen desserts, sugar substitutes, and sugar-free gum. Frequency of consumption of low-calorie products was highest among those aged 18 to 34 years and among those who reported being on a weight-loss diet. Eighty-seven percent of low-calorie product users reported being interested in being offered additional products of this type. Only 14% of all survey respondents did not use any low-calorie, reduced-sugar, or sugar-free products. The primary reason non-users gave for not using the products was "don't like the taste." Some people can detect an undesirable aftertaste from sugar substitutes while others are not sensitive to this taste.

A 2008 report from Credit Suisse, "Obesity and Investment Implications," forecasts that the market for obesity fighting staple foods could reach a value of $1.4 trillion by 2012 as consumers around the world continue to gain weight. There are particularly good opportunities for producers of healthier snack foods and beverages (76). Various approaches for manufacturing such foods are described in the following sections.

Alteration of Sugar Content

Sweetness is an important primary taste that signaled our ancestors that fruits were ripe and ready for eating. In modern times, people in developed countries have access to a plethora of sweet foods that contribute a substantial number of calories to the daily diet.

Results of a survey by the Calorie Control Council indicate that many of the most popular low-calorie products involve the use of sugar substitutes that lower the product's calorie count.

Creating good-tasting foods and beverages using sugar substitutes is as much an art as a science. Even in beverages, much effort goes into formulation to make products with a flavor sufficiently similar to that of sugar to please consumers. In foods where sugar performs other crucial functions besides providing sweetness, the use of sugar substitutes is even more challenging. Such products include confections, where sugar may provide nearly 100% of the product bulk; baked goods, where sugar contributes bulk, provides food for yeast, and contributes to browning; and frozen desserts, where sugar plays a key role in determining the freezing point and creating a smooth and pleasant texture (77).

Use of non-caloric sweeteners in beverages such as diet sodas can decrease energy density from 0.44 kcal/g to nearly 0 kcal/g. This can significantly reduce daily caloric intake for people who consume a lot of sweetened drinks. However, some concern has been expressed that the different metabolic fates of sugar and non-caloric sweeteners may affect the body's ability to accurately assess energy intake and therefore these sweeteners may not aid in weight control over an extended period of time. Data on long term weight gain and consumption of artificially sweetened beverages by participants in the San Antonio Heart Study demonstrated a significant positive dose-response relationship between the two measures over a 7-8 year period. The researchers caution that this does not prove causality. Rather consumption of artificially sweetened beverages may simply be a marker for those individuals already gaining weight. Nevertheless, the researchers found it troubling that these low calorie beverages were apparently not assisting in weight loss for many people (78). In some rodent experiments, animals fed diets sweetened with saccharin, rather than glucose, increased their caloric intake resulting in increased body weight and adiposity (79).

Experiments with female volunteers showed that sucrose and the sweetener, sucralose, stimulate the same taste receptors on the tongue but magnetic resonance imaging demonstrated that they elicited different responses in some brain regions and only sucrose engaged the dopaminergic midbrain areas associated with the pleasantness response to foods. (80) As yet, there are no definitive, consistent data from human studies that indicate that non-caloric sweeteners interfere with homeostatic physiological processes and cause consumption of more energy dense foods and weight gain (81, 82).

The use of sugar substitutes may actually help to make weight control easier by providing palatable low-energy-density food and beverage options. This concept is supported by a study in which overweight women who participated in a weight-reduction program were divided into two groups, one of which was encour--aged to consume aspartame-sweetened products, while the other group was asked to avoid them. The two groups of women lost similar amounts of weight during the program, but those who were encouraged to use aspartame-sweetened products maintained their weight loss more successfully during the three years after the program ended (83). More recently, overweight children in families that were asked to replace 100 calories of sugar per day from their typical diets with sucralose and to increase physical activity were more likely to maintain or reduce their BMI than children in families not asked to make these changes (84). The effects of the two interventions (physical activity and the use of the sugar substitute) could not be evaluated separately, but the findings suggest that the use of sugar substitutes may be helpful in conjunction with other efforts at weight control.

Reduction in Added Sugar

One approach to reducing sugar content is simply to decrease the amount of sugar in a product, such as cereals. The food may be less sweet but still acceptable to consumers. However, a reduction in sugar content does not necessarily translate directly into a reduction in energy density. One brand name peanut butter "with no sugar added" has more calories per serving than another peanut butter with sugar listed as its second ingredient because the first peanut butter contains more fat.

Sugar Substitutes

Certain compounds with a very intense sweet taste can be used in small amounts to replace the sweetness of a much larger amount of sugar, while adding negligible or zero calories to the product. Five sweeteners of this type are currently approved for use in foods and beverages in the United States: acesulfame-K (Sunett and other brand names), aspartame (NutraSweet and other brand names), neotame, saccharin (Sweet'n Low and other brand names), and sucralose (Splenda). Sweetening power, as compared to sucrose, ranges from 100-200 (acesulfame-K, aspartame) to 300-400 (saccharin), 600 (sucralose) and 7,000-13,000 (neotame). Other sugar substitutes, including alitame, cyclamate, and compounds derived from the Stevia plant, are approved as food ingredients in other countries and are now being evaluated for GRAS (generally recognized as safe) status in the United States.

Sugar substitutes vary in their chemical structures and properties such as stability during heating and this affects their potential uses in foods. One important characteristic of sugar substitutes is that they replace only the sweetness of sugar, not its bulk or texture. Thus, these sugar substitutes have found their greatest use in products where sweetness is the main property contributed by sugar: beverages, powdered sweeteners added to foods or beverages at the table, and foods where something other than sugar provides the bulk of the product, such as gelatin desserts, puddings, and flavored yogurts.

A strategic business report on artificial sweeteners indicates that the worldwide market for these compounds is worth $3.5 billion of which the U.S. and Europe account for 65%. Beverages, dairy products, salad dressings and snack foods are the fastest expanding markets for these compounds (85). Consumers are also driving the market towards more "natural" food ingredients. The U.S. market for sweeteners is predicted to grow at 4% per year and a company that offered a natural sweetener could do particularly well.

Kraft Original Barbecue Sauce: 50 calories/ 2 TBS
Kraft Light Barbecue Sauce: 20 calories/2 TBS
Uses: Sucralose and Asulfame-K

Intensely sweet compounds from plants are currently the focus of much research and development (86). Extracts from leaves of the South American herb, *Stevia rebaudiana*, have up to 300 times the sweetness of sugar. Stevia compounds can now be marketed in the U. S. as "dietary supplements" but not as "food additives." A sweetener called Truvia, derived from Stevia, is now available as a table-top sweetener and labeled as a supplement. Stevia sweeteners have not yet been approved for use in foods. In 2008, FDA received two requests for GRAS approval for rebaudioside A for use in "foods in general" and in "beverages and cereals." Coca-Cola has announced plans to add a *Stevia* compound, Rebiana, to some of its products for sale in countries where this sweetener is approved.

Several other natural compounds with intensely sweet tastes are being used in some products in other countries and new applications are being developed. Several sweet proteins have been isolated from tropical plants including thaumatin, monellin, mabinlin, and brazzein. One problem in using these compounds in large-scale industrial production is obtaining enough plant material. Extraction of the sweet compounds may also require complex chemical processes. Therefore, efforts are underway to utilize biotechnology to transfer genes coding for these proteins into yeast, bacteria, or easily cultivated plants, thereby increasing production and decreasing processing costs (86).

In the past, safety concerns have been raised about some sugar substitutes, especially aspartame and saccharin. All of these safety issues appear to have been resolved (81), although a recent animal cancer study testing aspartame has again raised questions (87). Regulators in the U.S. and Europe said they will review this study but the FDA noted that these results are not consistent with five previously conducted negative carcinogenicity studies. They are also not consistent with some large epidemiological studies that found no link between aspartame consumption and several types of cancer (88, 89).

Sugar Replacers

In foods where the bulk of the product consists of sugar itself or where sugar makes a crucial contribution to texture, sugar substitutes cannot be used — at least not alone — as substitutes for sugar. When bulk is important, such as in chewing gums, candies, ice cream, cookies, and fruit spreads, a second type of sweetener, a

sugar replacer, may be used. Most of these compounds are sugar alcohols (polyols). Examples are: sorbitol, mannitol, xylitol, isomalt, erythritol, lactitol, maltitol, hydrogenated starch hydrolysates, and hydrogenated glucose syrups. Two substances that are actually sugars but that have chemical properties more similar to those of polyols, trehalose and tagatose, are also used as sugar replacers. These sweeteners usually replace sugar on a one-to-one basis (that is, one ounce of a polyol substitutes for one ounce of sugar).

Polyols are lower in calories than sugar, usually by about half, because they are incompletely digested. Thus, they can be used to create products that are substantially lower in calories than similar products made with sugar. Since some polyols are not as sweet as sugar, a sugar substitute of the type described above may also be included in the product to provide additional sweetness. Replacing all of the sucrose in a product with a sugar replacer may yield products with an inferior taste. Panelists rated cookies with half the sugar replaced by tagatose as comparable to the all sugar cookies. But they disliked cookies with 100% of the sucrose replaced by tagatose (90).

Because polyols are incompletely digested, they can cause gastrointestinal disturbances such as loose stools and flatulence if consumed in large quantities. Non-effective doses, that is doses that do not induce diarrhea and abdominal discomfort, have been determined to be 0.42 g/kg body weight for xylitol, 0.34 g/kg for lactitol, and 0.68 g/kg for erythritol for females. Non-effective doses were lower for males (91). Some polyols, such as lactitol, are more readily fermented than others and cause more gas formation. In some cases, symptoms of diarrhea subside after several days as the microflora in the colon adapt to this new food source. Nevertheless, regular ingestion of high levels of polyols can cause chronic diarrhea, abdominal pain and severe weight loss as observed in a woman consuming 20g of sorbitol/day and a man consuming 30g sorbitol/day (92). Therefore, polyols can only be used in modest amounts.

Sweetness Enhancers

A third category of compounds with the potential to replace some or all of the sugar in foods includes compounds that are not sweet themselves but have the capacity to modify the taste of acidic foods and drinks so that they are perceived as sweet. For example, when added to lemon juice, they make it taste like lemonade. Two such proteins, from tropical plants known in their native countries for many years, are miraculin and neoculin. Miraculin has no taste when consumed alone while neoculin is a sweet tasting compound. In the presence of acid, both compounds are altered in shape so that they can react with sweet taste receptors on the tongue (93, 94). There is a great deal of interest in these taste-modifying compounds and genes coding for these proteins have been cloned into a food-grade fungus, *Aspergillus oryzae*, and into some other plants including lettuce and tomatoes (86). As yet, these compounds are not being used in processed foods although fruits of these tropical plants are consumed.

USING FOOD TECHNOLOGY TO DECREASE CALORIE LEVELS IN FOOD

Alteration of Fat Content

Reduction in Added Fat

Because fat has a higher energy density (9 kcal/g) than any other food component, removing it or replacing it with lower energy-density ingredients offers great potential for reducing energy density of a food. However, replacing fat in foods is even more difficult than replacing sugar because fat performs a wide variety of functions in food.

One potential strategy for decreasing the fat content in foods, without the need for replacement, is reducing the fat absorbed by foods during frying. Several procedures have been described to achieve this goal.

Different cooking methods can reduce exposure to and uptake of fat while producing a familiar and acceptable product. Super heated steam at 200ºC circulating in a closed environment can substitute for the second frying step for French fries and other snacks without sacrificing crispiness, color, aroma, or flavor. Fat content is halved (95). Air drying of noodles, rather than frying them, can reduce fat content by 60-80% (96). A new method for cooking chicken using radiant heat called "alternative roasting with their own fat" was reported to produce chickens with high scores for characteristic fried flavor and overall acceptability and approximately half the fat of deep fried chicken (97).

A new appliance for deep frying foods will shortly be introduced to consumers. It consists of a fryer that, after frying is completed, spins the food at a high rate which substanitally reduces the amount of oil adhering to the fried product.

Microparticulated fiber from soybean hulls was added to batter for doughnuts by coating coarse flour particles with the soybean-derived material. Doughnuts that contained the soybean-hull fiber absorbed 11-36% less fat during deep-fat frying than conventional doughnuts, and therefore had fewer calories. Taste-testers found their flavor, appearance, and crispness to be just as acceptable as those of doughnuts produced in the usual manner (98). In a similar fashion, a beta-glucan-rich preparation from oats added to batter used for deep fat frying reduced uptake of oil by as much as 40% (99).

Researchers have developed a genetically enhanced potato that absorbs less oil when fried (Council for Biotechnology Information). It was created by inserting an inactive form of a gene for NAD-dependent malic enzyme into the potatoes that increases the conversion of sugar into starch. These new potatoes could be used to reduce the fat, and thus the calories, of french fries and potato chips; they are not currently in commercial production, however (100).

Fat Replacers: Overview

Consumer interest in using reduced-fat foods has been high for more than 15 years even as obesity rates continued to climb. Surveys conducted during the early 1990s showed that consumers were interested in using such products provided that there was credible assurance of their safety and that their flavor was good (101, 102). Products with partial fat reduction have become popular, perhaps because their taste is closer to that of the full-fat versions (102). Surveys conducted by the Calorie Control Council in 2004 and previous years have shown that the vast majority of U.S. adults (88%) use some low-fat, reduced-fat, or fat-free products, with the highest levels of usage among women, those who use low-calorie products, and dieters (103). The most popular low-fat, reduced-fat, or fat-free products are milk, dairy products, and salad dressings/sauces/mayonnaise.

Fat has profound effects on the overall sensory experience of eating food. It contributes to aroma and flavor both in itself and as a carrier for fat-soluble substances that contribute to flavor and aroma. Fat makes high-temperature cooking processes (frying) possible, and these cooking processes create flavorful compounds important for characteristic tastes of foods (104). Fat also influences palatability, flakiness, creaminess, and crisp-

ness which contribute to the texture or mouthfeel of a food. For most consumers, these characteristics are as important as taste in determining whether they like a food. Removing the fat from food, without providing an adequate replacement, usually creates products that people find unacceptable. For example, cooked fruits, such as applesauce, can be used to replace some of the fat in home baked goods. But if too much fat is replaced with applesauce, the texture and taste of the baked goods is impaired (105). Avocado puree has also been used successfully to replace up to 50% of the fat in oatmeal cookies. Total fat content was reduced by 35% because avocado does contain some fat. However, fat in avocadoes is predominantly monounsaturated which is considered healthier than the saturated fat in butter (106).

When food manufacturers remove fat from foods to produce a reduced-fat or no-fat food, they replace it with other ingredient(s) that perform the important functions of fat in that food to create a product that people will be willing to eat. These ingredients that take the place of fat and perform some of its functions are collectively called "fat replacers." Some replacers provide energy, but it is usually less than the energy provided by fat. Other ingredients, such as sugar, may be added to low-fat foods to make them more palatable. For this reason, some reduced-fat foods are not substantially lower in calories than their full-fat counterparts. It is important for consumers to read food labels to check the calorie counts of reduced-fat products.

No one substance can perform all the functions of fats and finding adequate fat replacers for different foods poses unique challenges. Fat in ice cream provides creaminess and carries flavor compounds and also affects melting characteristics and ice crystal formation. Mayonnaise traditionally contains 70-80% fat which provides a smooth mouthfeel. An effective fat replacer needs to provide this texture in a product that doesn't separate over time. So food technologists must consider stability, effects of high and low temperatures during storage, and rheology in addition to sensory characteristics in devising appropriate fat replacers for different foods. Often more than one replacer is used in order to produce low-fat products that are tasty and have a similar texture to full-fat counterparts. For example, Cargill reports that it has produced a "carbohydrate-based fat replacement system" that can reduce the fat content in pound cakes by 25% and the fat in luxury breads by 50% (107).

Some carbohydrates and proteins can provide texture, volume/bulk, and lubrication to foods. Since these compounds contain 4 kcal/g, they reduce the overall energy density of a food. These compounds are sometimes called "fat mimetics." Some fat mimetics are produced as microparticulates with diameters <30 micormeters. Particle sizes larger than this evoke a gritty sensation in the mouth (108). There are also numerous fat-based substitutes that provide fewer or no calories because they are indigestible or incompletely digested. These compounds are often stable at cooking temperatures (104).

It is important to note that many fat replacers, unlike many sugar substitutes are not special ingredients used only to replace a more caloric component of foods. Fat replacers are often ordinary food ingredients that have long been used for other purposes. The presence of tapioca, whey protein, or pectin in a processed food does not necessarily signal that these ingredients are being used to replace fat, just as the presence of applesauce in a recipe for a homemade baked product does not necessarily signal that the applesauce is being used as a fat replacer. Also, unlike sugar substitutes like aspartame and sucralose, many fat replacers, because of their long history of safe use for other purposes, do not require approval from the FDA before being used. Like applesauce, they are already part of the food supply. They're just being used for a new purpose.

Carbohydrate-Based Fat Mimetics

Carbohydrate fat replacers could provide 4 kcal/g to foods but, in fact, they usually contribute much less than that because they are incompletely digested. These compounds absorb water, expand, and form gels and are used primarily as thickeners and stabilizers that impart a texture and mouthfeel similar to fats. Oatrim, consisting of soluble beta-glucan and amylodextrins from oat flour, becomes a gel with an energy density of 1 kcal/g when hydrated with water. Because oatrim gel is heat stable, it has been used as a fat replacer in baking and produces acceptable cookies at a substitution rate up to 50% (106).

Some carbohydrate-based fat mimetics, such as gums, inulin, pectins, and carrageenan, are naturally present in some foods. Gums are thickeners that provide a creamy mouthfeel. They pass through the body almost completely unmetabolized and therefore contribute essentially no calories. Carrageenan and alginates are extracted from seaweed and are used as emulsifiers, stabilizers, and thickeners. They can replace part of the fat in some meat, cheese, and dessert products. Pectin, found in apple and citrus fruit peel, forms a gel that

imparts a mouthfeel and melting sensation similar to fat. Pectin is used in soups, sauces, gravies, cakes, cookies, dressings, spreads, frozen desserts, and frostings. Other carbohydrate mimetics are derived from natural compounds. These include: modified starches, polydextrose, maltodextrins from hydrolyzed cornstarch, and cellulose fiber that is ground into microparticles.

Hellman's Regular Mayonnaise: 90 calories/TBS
Low Fat Mayonnaise: 15 calories/TBS
Uses Maltodextrin

Pectin gels can be microparticulated by chopping and then shearing of the coarse particles into non-spherical microparticles that consist of 97-98% water and have a smooth organoleptic character similar to an oil emulsion like mayonnaise (109). Z-Trim, developed by the U.S. Department of Agriculture (USDA), consists of dietary fiber from oat hulls, soybeans, peas, and rice or bran from corn or wheat, processed into microscopic fragments, purified, and dried and milled into a powder. When the fragments absorb water, they swell to provide a smooth mouthfeel. This zero-calorie fiber-based fat replacer can be used to partially replace the fat in a variety of foods, including baked goods and ground beef (110). When Consumers Union used Z-Trim to partially replace the fat in recipes for salad dressing, cake, tuna salad, and a vegetable omelet, they found that tasters could not tell the difference between the modified products and their full-fat equivalents (111). Replacing all the fat in a recipe with Z-Trim is not recommended, however.

New types of fat replacers are being developed all the time. For example, recently a company in the United Kingdom introduced an ingredient made from tapioca that can replace much of the butter in cakes, breads, and pastries (112).

Protein-Based Fat Mimetics

Protein fat replacers are generally made from egg or whey proteins. (Whey is the liquid that remains after a curd forms in cheesemaking.) Proteins are digestible and have an energy density of 4 kcal/g. However, microparticulated proteins often absorb water and can be used in lower amounts than fat. In some applications, 1g microparticulated protein can replace 3g fat (104). Protein mimetics often develop undesirable flavors when subjected to high heat, so they are not suitable for fried foods. However, modified whey proteins and microparticulated proteins are widely used in low-fat and no-fat dairy products deserts, sauces, and some baked goods.

Microparticulated proteins provide creaminess and richness but not the flavor of fat. Like very fine sand, microparticulated protein particles convey a feeling of fluidity because of their very small size. Microparticulates are formed by high shear homogenization of proteins, sometimes mixed with carbohydrates, to form very small spheres less than 3 micrometers in diameter. Evaporative cooking processes increase interactions between carbohydrates and proteins to form gels. Microparticulates of sucrose and proteins have been used in low fat ice creams and candies (113).

Protein-based mimetics and carbohydrate-based mimetics may be used together to more faithfully replicate the characteristics of a full fat product. For example, xanthan gum and whey protein complexes were produced under controlled acidic conditions to yield particles <40 micrometers diameter, a particle size that is perceived as creamy and smooth. This fat replacer was used successfully to replace 50-75% of the fat in cake frostings and sandwich cookie fillings (114). Many other preparations of carbohydrates and proteins are being tested for suitability as fat replacers.

Fat-Based Fat Substitutes

Fat substitutes are ingredients that resemble conventional fats and oils and can replace them on a gram-for-gram basis. Fat substitutes are a particularly useful type of fat replacer because they can replace all of the functions of fat and may be stable even at the high temperatures used in baking or frying. They provide fewer calories per gram than fat because they are not fully absorbed or metabolized in the body. Ordinary fats are triglycerides (compounds consisting of three fatty acids linked to an alcohol called glycerol). Some triglyceride fat substitutes contain fatty acids of shorter or longer chain length that provide fewer calories or are more poorly absorbed than the fatty acids usually present in triglycerides. One example is salatrim (Benefat®) which has been used to substitute for fat in chocolate cake (115). Salatrim is estimated to have an energy density of 5-6 kcal/g.

New fats and oils with altered structures and nutritional properties have been produced using lipases and other enzymes (116). For example, fat-based substitutes known as diacylglycerols contain only two fatty acids. Japanese scientists have developed a cooking oil that contains more than 80% diacylglycerols. This product, called Enova®, contains a similar energy density as triglycerides and is digested by the same enzymes, but diacylglycerols are oxidized more rapidly and cannot be stored as efficiently by the body. In a year-long trial in which overweight participants used either the diacylglycerol oil or a control triacylglycerol oil for their normal cooking oil (117), those who consumed the diacylglycerol oil lost more weight. A recent meta-analysis of randomized

controlled clinical trials concluded that diacyglycerols do cause a significant reduction in body weight as compared to common triacylglycerols (118).

Another type of fat substitute is sucrose polyester, also known as olestra (trade name Olean), which looks, tastes, and feels like fat but passes through the body unabsorbed. It was approved by the FDA in 1996 for use in certain snack foods. Because olestra was truly new, it had to go through the extensive safety studies required of all new food additives. At the time of olestra's original approval, the FDA required a label statement on products containing it saying that olestra may cause abdominal cramping and loose stools (119). Such effects are not unique to olestra; they can occur when any food component that is not fully digested is consumed (for example, foods high in dietary fiber).

Lays Original Potato Chips: 150 calories/oz
Lays Light: 75 calories/oz
Uses Olestra

In the years after olestra was approved, "real-life" consumption studies of products containing olestra showed that it only infrequently caused mild gastrointestinal effects. Among other evidence, a 6-week study of more than 3,000 people showed that a group consuming only olestra-containing chips experienced just a minor increase in bowel movement frequency compared to people who consumed only full-fat chips. Because of the new scientific evidence, in 2003 the FDA dropped the requirement for a special statement about gastrointestinal side effects on the labels of products containing olestra (120). Currently (2008), olestra is only approved for use in snack foods such as potato chips and crackers but there is a request pending before the FDA to approve GRAS status for olestra to be used in cookies.

Meanwhile, in an entirely different approach, researchers from the University of Massachusetts, Amherst, have been working to develop fats encapsulated in layers of dietary fiber, in the hope that the encapsulated fats would retain many of their contributions to the texture, taste, and aroma of foods but would provide fewer calories because the surrounding fiber would prevent the fat from being digested (121).

USING FOOD TECHNOLOGY TO DECREASE CALORIE LEVELS IN FOOD

Addition of Non-Caloric Substances

Water

Water was one of the first additives used to decrease energy density of foods. While the standard of identity for margarine requires at least 80% fat, reduced fat and light spreads can contain 40-60% fat. Water is added along with fat replacers, such as whey protein, to make these low calorie spreads. Light versions of mayonnaise and lunch meats also contain more water than the full fat versions. Stabilizers and/or emulsifiers must be included in the formulation of these products so that the water doesn't separate out during storage.

Air and Other Gases

In addition to other major components, some foods also contain significant amounts of air. Air does not contribute either energy (calories) or weight to foods but it does increase the volume. People's feelings of satisfaction with the amount of food consumed may have as much to do with the volume of the food as with its weight. Whipped margarines have fewer calories per serving because air has been added. In a study in which the volume of a yogurt shake was modified by varying the amount of air in the shake, men who consumed shakes that were higher in volume but identical to lower-volume shakes in both weight and energy content had significantly lower energy intakes at a subsequent meal (122). In another study, participants were allowed to consume as much as they wanted of a snack food (cheese puffs) with different levels of air incorporated into it; those who were given the more-aerated cheese puffs consumed 21% less of the snack in terms of both weight and energy (calories), even though they consumed a greater volume of cheese puffs (123). It has been suggested that the effects of modifying volume by incorporating air could also be applied to other categories of food such as bakery products and extruded breakfast cereals (124).

New aerated products are appearing in grocery stores, some with novelty value such as bubble-included chocolate. A recent report described results of adding bubbles of different gases (carbon dioxide, nitrogen, nitrous oxide, and argon) on bubble size and sensory qualities of chocolate. Chocolates made with nitrogen and argon had smaller bubbles and were judged to be creamier and more tasty (125).

However, adding air to increase volume may not be helpful in all instances; in one study in which the volume of loaves of white bread was altered without changing the nutrient content, study participants found the denser (lower volume) breads to be more satisfying than the less dense versions (126). Thus, the effects of incorporating more air into foods may vary for different types of food.

Fiber

Since insoluble fiber does not contribute calories, increasing the proportion of insoluble fiber in a food can reduce its energy density. Soluble dietary fiber is digested by bacteria in the colon to produce some short chain fatty acids and other compounds. Some of these compounds may be absorbed into the body thereby contributing to caloric intake. An increase in dietary fiber may have the helpful effect of enhancing feelings of fullness and decreasing subsequent hunger, leading to decreased food intake (127). Some of the fat replacers discussed above, such as Z-Trim, are fiber-based. However, fiber is also added to foods for reasons other than as a fat replacer.

One type of fiber that may find increased use as a food ingredient is purified powdered cellulose, which can be derived from soy or oat hulls, wheat stalks, or wood (128). Not only does powdered cellulose contribute no calories to food itself, its inclusion in food formulations allows more water to be added to the food than with other types of fiber. Thus, both the water and the cellulose itself can contribute to lowering energy density. Powdered cellulose can be used to replace some of the flour in breads, pizza crust, flour tortillas, and dry pasta, among other products, decreasing their energy density and increasing their fiber content. Other types of fiber, including resistant starches, from many vegetable sources are being added to a variety of foods.

Other Technological Approaches

Enzyme Inhibitors

A new product called Starchlite has been developed for addition to starchy foods to reduce digestion and absorption of this macronutrient (http://www.starchlite.com/). It contains an inhibitor of the alpha amylase enzyme that breaks down starch. This inhibitor has been isolated from white beans and has been approved by the FDA. Use on this inhibitor could inhibit digestion of starch and absorption of some calories from starchy foods.

Microparticulation

Sometimes, creating a reduced-calorie food product that is as appealing to consumers as higher-calorie versions is a matter of production technique rather than special ingredients. Several carbohydrate- and protein-based fat mimetics, described in previous sections, are subjected to shear forces to produce microparticles with a creamier texture. Successful examples of a recently improved foods with microparticles are new varieties of low calorie ice cream, where special techniques — double churning, slow churning or cold churning — are used to create the creamy texture characteristic of full-fat ice creams in a lower-fat, lower-calorie product. These processes utilize one or more low temperature extrusion processes that significantly reduce the size of the fat globules in the ice cream and stabilize them at -25ºC. The smaller particles impart a creamier texture to the ice cream allowing a reduction in fat content. Both Edy's and Breyers have had impressive success with ice cream products produced using new churning techniques (129).

One issue that arises with lower fat ice creams is the tendency for large ice crystals to form and erode the creamy texture. Ice structuring proteins from cold acclimated winter wheat grass and from Antarctic fish have been incorporated into these light ice creams to preserve creaminess. Since isolating these proteins from fish is not economical, biotechnology was used to transfer the genes coding for these proteins into a food-grade yeast. The yeast produces large amounts of these proteins. However, there have been some complaints by those opposing any genetic engineering (130, 131).

Texture and mouthfeel are crucial characteristics of chocolate products. Reduced-fat, reduced-calorie chocolate does not melt in the mouth as readily as regular chocolate does, and consumers often describe the products as being too hard and too difficult to swallow. New technology for optimizing the particle size distribution in reduced-fat chocolate may help to solve these problems without requiring a change in the products' ingredients (108). In model systems, the new process has been shown to increase melting rate and decrease hardness — important characteristics in creating a reduced-fat chocolate product that is acceptable to consumers.

Packaging: Reduced Portion Sizes and Reduced Calorie Density

In 2004, Kraft launched a product line that featured reduced serving sizes as well as reduced energy density, Nabisco's 100-Calorie Packs of snack foods. Many products in this line consist of reduced-energy-density baked-crisp versions of well-known Nabisco cookies and crackers, packaged in single, 100-calorie servings, although the product line has recently been extended to include other items such as candies and Jello fat-free puddings (http://www.nabiscoworld.com/100caloriepacks/#/home/). In some cases, such as cinnamon Teddy grahams, the 100 calorie pack simply contains a small portion of the standard product. In other cases, such as the "Ritz snack mix, 100 calories" contains crackers that have about half the fat content and more fiber than standard Ritz crackers. The product line was an immediate success, leading to $100 million in sales in less than a year (66). Other companies, such as

Kelloggs, Frito-Lay, Hostess, and Good Humor–Breyers, are now marketing either standard or modified versions of some of their most popular products in portion-controlled 100-calorie packages as well (132, 133). Similarly, some soft drink companies are now marketing small (8-ounce) cans of their products as alternatives to larger cans or bottles.

Sales of portion-controlled foods have been increasing rapidly, with a 42% increase reported between September 2006 and September 2007 (134). Some people within the food industry have speculated that the highly successful 100-calorie single-serve packages may have set a new 100-calorie standard in the consumer's mind for the acceptability of healthy snacks. (135). However, a recent report suggests that attractive, smaller, portion-controlled packages might not effectively reduce consumption in all cases. Smaller temptations may fly under the radar while larger packages may cause people to consider more fully what they are eating (136).

Substituting Lower-Calorie Foods

Calorie content of meals containing potatoes could be reduced by replacing the potato with a vegetable called chayote, originally grown in the jungles of Guatemala. Chayote is actually a squash but has the taste and texture of potatoes and is much lower in calories. An Israeli agronomist has been tinkering with the genetics of chayote to enable it to be grown in climates other than tropical jungles and has succeeded in creating a hardy version suitable for cultivation in a variety of terrains and climates. Efforts to market the new low-calorie potato alternative are expected to begin in 2009 (137).

Biotechnology and Genetically Modified Foods

Techniques of biotechnology are being used to alter the genetic makeup of some crop plants so they are more resistant to insects and viral or fungal diseases or are more drought-tolerant or herbicide-resistant. Genes coding for intensely sweet proteins from plants and "antifreeze" proteins in plants and Antarctic fish have been inserted into bacteria, yeast, fungi, and easily-grown plants to enhance their production and availability. (86,130,131) These techniques may have other future applications in producing foods with reduced energy density.

Whether American consumers will accept products such as these remains to be seen. as Some research indicates that [[[CALL OUT OR BOX:most American consumers have few concerns about the use of biotechnology in plant food production and 33% believe that applied food biotechnology will provide benefits for themselves and their families]]] in the next five years, especially in the area of nutrition and health. Only 2.5% say that they would alter their food purchasing behavior because of concerns about plant biotechnology. However,consumers are less sure about the safety and desirability of biotechnology in animal production. (138). Acceptance of a new technology depends on consumers' estimates of benefits and risks in a broad sense that may include animal welfare and environmental issues as well as food safety and nutritional issues (139).

Multiple Techniques

In some instances, production of a lower-energy-density product may involve the application of several different techniques simultaneously. A good example is the meat industry's response to consumer demand for leaner meats in recent decades. This demand has been met through a combination of approaches — ranging from the selective breeding of animals that produce leaner meat to the modification of the animals' feed to closer trimming of meat cuts at the retail level. As a result of these combined approaches, today's meats are leaner (lower in fat and calories) than those sold in the past. For example, a 2006 analysis by the USDA found that eight of nine retail cuts of pork were leaner than the same cuts had been in 1991, with no decrease in protein. The data for pork in the U.S. government's official nutrient database have been revised to reflect this new information (140).

Enhancing Satiety

One concept currently on the frontiers of food technology research is the creation of food products or ingredients that enhance feelings of satiety or act as antagonists to appetite-stimulating substances, thus decreasing food intake. The system that controls energy regulation in the human body is exceedingly complex, involving multiple signals that control when meals occur and when they end. Some of these signals are external, such as visual, olfactory, and taste sensations, and social cues, while others involve hormones secreted in the gastrointestinal tract and the brain. The potential use of foods to trigger satiety signals and thus reduce meal size is under intensive investigation. The possibility that particular nutrients in the bloodstream influence food intake is also being investigated, as is the difference in the impact on satiety of solid versus liquid foods (141). Most of this research is now in the preliminary stages.

Fiber is being added to foods and processing methods are being adapted to preserve more of the fiber naturally present in foods. Fiber in foods may be helpful

in weight management in two different ways. There is evidence that several types of fiber, including cellulose, pea fiber, psyllium, oligosaccharides, soy polysaccharide, sugar beet fiber, and wheat bran, among others, may decrease energy intake, apparently by promoting satiety (134). Fiber also decreases the energy density of foods, as discussed earlier, and this may also reduce caloric intake.

Marketing

Sometimes, creating new, lower-calorie foods does not require any special technology at all; it just requires tasty food and good marketing. An example here is the Fresco-style line of menu items that Taco Bell has been promoting recently. These modified versions of some of the restaurant chain's most popular items contain a flavorful fresh salsa in place of higher-fat, higher-calorie cheese and sauce. Several of the Fresco-style items are substantially lower in calories than their regular counterparts, despite being the same size. For example, as indicated in Taco Bell's online information (http://www.yum.com/nutrition/documents/tb_nutrition.pdf), the Fresco version of the ranchero chicken soft taco is 37% lower in calories than the regular version (170 calories vs. 270).

DISCUSSION

Foods with reduced energy density and/or controlled portion size have great potential as part of overall weight management efforts.

Some such products are already being successfully marketed and are used by a large proportion of the population. However, these reduced fat foods have not as yet been effective in reducing obesity rates. New technology is providing many additional options.

Some reduced-energy-density food products are well established in the United States. According to food industry sources interviewed by ACSH for this report, there are at least 10,000 products on the market that have been modified in some way to reduce calories.

Perhaps the best example of a product category where reduced-energy products have become mainstream is fluid milk. The traditional product that is highest in fat content and energy density, whole milk, no longer dominates the fluid milk market. In 1980, whole, 2% fat, 1% fat, and nonfat milks accounted for 59%, 23%, 7%, and 5% of total fluid milk sales, respectively, but by 2006, sales of these different fluid milk categories were 30%, 32%, 12%, and 15%, respectively (142).

Another well-established product category is that of sugar substitutes and products such as diet beverages. These products have been popular since the 1960s, when a noncaloric sweetener with a highly acceptable taste, cyclamate, came into widespread use. By 1977, products containing noncaloric sweeteners were so much a part of mainstream American culture that when the FDA proposed to ban saccharin, there was a huge public outcry against this action, not because the scientific evidence against the sweetener was very limited (although it certainly was), but rather because banning saccharin, then the only available noncaloric sweetener, would mean that entire categories of popular products, such as diet sodas, would be taken off the market (143).

For several reasons, however, newer types of low-energy density products — as well as foods naturally low in energy density — may have more difficulty becoming accepted as part of the mainstream food supply. One of these reasons is economic. One of the difficulties in recommending diets of low energy density is that such diets are more expensive than high-energy-density diets. Some food components highest in energy density, such as refined grains, fats, and sugar, are also among those that cost the least, while foods naturally high in water content and therefore lower in energy density, such as vegetables and fruits, are much more expensive (57, 60). Some processed products with decreased energy density or controlled portion size are also more expensive than their conventional counterparts. For example, the popular 100-calorie, single-serving packages of various snack foods are more expensive, ounce for ounce, than the same snacks sold in large, multiple-serving packages. Similarly, the recently introduced single-serving packages of frozen vegetables, which could help to encourage vegetable consumption because they are quick-cooking, convenient, and well-suited for those who live or eat alone, cost more per serving than larger packages of vegetables do.

Another obstacle is the lack of an FDA-approved health claim, related to obesity, that can be displayed on package labels. A food manufacturer who produces a product that is substantially lower in both fat and calories than the standard product can place a health claim on the product label about dietary fat and cancer risk but cannot claim that foods lower in calories can help to prevent or ameliorate obesity because there is no authorized health claim. The FDA panel that initiated the “Calories Count” educational campaign proposed that the FDA consider allowing a health claim related to calories and obesity (144), such as “Diets low in calories may reduce the risk of obesity, which is associated with type 2 diabetes, heart disease, and certain cancers.” However, the process for approving a new health claim is lengthy and no final action has been taken. Food companies interested in obtaining permission for an FDA-approved health claim related to obesity could aid their cause by funding independent research that would demonstrate effects of consuming lower-energy-density foods over a period of several years.

Even label statements that a food is reduced in calories (nutrient content claims) may not be optimally helpful to manufacturers trying to market new products with lowered energy density. For such a label claim to be permitted, the food must have a calorie count per serving 25% lower than that of a reference product (145). For some types of foods, it may not be possible to reduce calories to this extent and still have an acceptable product. A smaller reduction in calories might be achievable without compromising the quality and could be meaningful in terms of the energy density of the overall diet. But if manufacturers cannot announce it on labels, they have little incentive to attempt it.

Food marketing responds to consumer interests and demands.

One potentially valuable label change proposed in the FDA's Calories Count is the use of a larger font for calories and the expression of calories in terms of a percentage of a Daily Value (probably 2000 calories/day), as is done for most nutrients (144). This might make consumers more aware of the importance of calories and of roughly how many calories per day people should consume.

Some types of lower-calorie products have met with mixed reactions from nutritionists, health professionals, and consumer advocates. News articles about 100-calorie packages of snack foods usually include a quote from someone who regrets their availability because they encourage the easier switch from a high-calorie package of cookies or salty snacks to a smaller, portion-controlled package rather than the more desirable switch to a snack that makes a greater positive nutritional contribution to the diet, such as fresh fruit or carrot sticks. Similar objections would likely be raised if such products as lower-calorie french fries made from new strains of potatoes or lower-calorie doughnuts made with soybean-hull fiber reach the market. The counterargument here is that eating habits are hard to change, and people want to eat the foods that they like. Consumers are more likely to respond to opportunities to control calories within the context of their current eating habits than to change those habits drastically. The change from a large serving of cookies to a 100-calorie snack pack may not be the optimal nutritional choice, but it does represent an improvement..

Some of the approaches to lowering the energy density of foods discussed earlier in this report, such as the use of biotechnology or of synthetic fat substitutes, may be opposed by those segments of society that have negative attitudes toward advanced technology, the corporations that develop it, and "big industry" in general. Such attitudes have likely played a role in the extremely negative attitudes sometimes displayed against aspartame, olestra, and other products of technology that are not regarded as "natural." It would be unfortunate, in ACSH's view, if such attitudes were to limit the public's access to as wide a variety as possible of good-tasting, high-quality reduced-calorie foods.

Despite the FDA's efforts to promote its "Calories Count" message, calories are not high on the list of issues that people currently mention when asked about food. Susan Borra, president of the International Food Information Council, which conducts extensive survey research on consumer attitudes and concerns about food, told ACSH in a telephone interview that consumers don't have a good relationship with calories; they give the impression that they don't want to count calories or even be aware of them. This may be particularly true for foods eaten away from home; Borra noted that more than 90% of consumers do not ask for reduced-calorie foods when eating in restaurants.

Food marketing responds to consumer interests and demands. For example, when the low-carbohydrate craze swept the country several years ago, food companies responded quickly by drawing attention to already-existing products that would fit well into a low-carohydrate diet and by creating and marketing new low-carbohydrate products. If consumers are not asking for lower-energy-density foods, the food industry is not likely to emphasize them in product development or marketing unless they also meet other consumer demands and therefore can be successfully marketed in other ways.

For example, a major quick-service restaurant chain successfully introduced lower-calorie sandwiches a few years ago. The initial marketing of these sandwiches focused not on their low calorie counts but on their low fat content — an issue of greater interest to the public at the time (66).

In other instances, lower-calorie products have been successfully marketed using currently popular concepts such as "fresh" or "natural," which may serve as code words for "lower in calories." This type of marketing (a sort of "stealth" marketing) has helped to ensure the success of some lower-energy-density products, but unfortunately it does not help to increase the public's awareness of the importance of calories, and it can cause confusion because the code words also have well-established meanings of their own. For example, although it may be perfectly accurate to describe the guacomole made in your favorite Mexican restaurant as "fresh" and "natural," it is by its very nature far more energy-dense than the same restaurant's equally "fresh" and "natural" fresh-tomato salsa. Emphasizing the "fresh," "natural" nature of these menu items does not help calorie-conscious diners realize that one is a better choice for them than the other. Also, terms such as "fresh" and "natural"

may not be applicable to products where energy density has been reduced by the application of sophisticated technology, yet such products may be highly acceptable in terms of taste and texture, as well as having lower calorie counts.

Another type of "stealth" marketing involves changing the default choices in restaurant menus to lower-calorie options. One example involves Starbucks, which has changed the type of milk used in its drinks when the customer does not make a specific request from whole milk to 2% (146). Such approaches may generate favorable publicity for restaurants that try them, and they may place those restaurants ahead of the curve if consumer awareness of the importance of calories in the fight against obesity increases in the future. Other restaurants are placing themselves ahead by including at least a few menu items that meet some consumers' desires for "natural" and "fresh" products and are also relatively low in energy density; the main-dish salads sold at McDonald's are a good example here, as is Taco Bell's Fresco menu.

Concerns have been raised that marketing products based on lower calorie counts — or even providing information about calories — could be counterproductive in some settings because some consumers interpret "lower-calorie" as meaning "doesn't taste as good" or "less satisfying" and therefore would be less likely to choose products identified in that way. This may be particularly applicable to the restaurant industry, where one of the concerns about providing calorie labeling on menus is that it might have the unintended consequence of decreasing the number of customers who choose the lowest-calorie menu items and meals (66).

In conclusion, the full use of food technology as a tool against obesity may have to await societal developments that will place calories, and their relationship to obesity, in their appropriate place near the top of consumer priorities in food selection. When the public is ready, however, food technology will be able to provide an increased variety of tasty, good-quality, lower-calorie foods that can play important roles in the fight against obesity. The use of food technology, along with other sound approaches to weight management, offers a far better approach to fighting obesity than dubious approaches to solving the problem of obesity, such as banning soft drinks in schools, placing a special tax on soft drinks and/or "junk foods," requiring calorie counts on menu boards at chain restaurants, demonizing high-fructose corn syrup, using zoning laws to restrict fast-food restaurants in specific neighborhoods, putting children's body mass indexes on their report cards, and taking dietary supplements to promote weight loss.

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Examples of Ingredients In Reduced Calorie Foods and Beverages

Pasta, Sandwiches, "Meats," Beans

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Chef Boyardee Beef Ravioli ***Beef Ravioli 98% Fat free***	Modified corn starch, textured soy protein	240 cal/cup	170 cal/cup
B & M Baked Beans, regular & 98% fat free	Extra molasses & brown sugar	180 cal/1/2cup	170 cal/1/2 cup
Loma Linda Vegan Big Franks ***Low Fat Vegan Big Franks***	Water	110 cal each	80 cal each
Oscar Meyer Beef franks ***Low fat beef franks***	Modified corn starch	130 cal each	90 cal each
Jimmy Dean Croissant Sandwiches: Sausage, Egg, Cheese on a Croissant ***D-Light Croissant: Turkey Sausage, Egg White and Cheese on a Croissant***	Mono/ diglycerides Cellulose gum Carrageenan Dextrose (carb) Turkey, egg white	430 cal/sandwich (128 grams)	300 cal/sandwich (136 grams)

Spreads, Condiments, Sauces

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Fleischmann's Original Margarine ***Fleischmann's Light***	Water, mono- and diglycerides Soy lecithin	70 cal/TBS	40 cal/TBS
Benecol Regular spread ***Benecol Light Spread***	Water, mono- and diglycerides	70 cal/TBS	50 cal/TBS
I Can't Believe It's Not Butter Original Spread ***Light Stick***	Water, mono- and diglycerides Soy lecithin	80 cal/TBS	50 cal/TBS
Land O' Lakes Salted Butter ***Land O'Lakes Light Butter Salted***	Water Tapioca maltodextrin Mono-and diglycerides Xanthan gum Modified food starch	100 cal/TBS	50 cal/TBS
Smart Balance Original and Light	Water	80 cal/TBS	50 cal/TBS
Smucker's Strawberry Preserves: regular, sugar free	Water, locust bean gum, polydextrose, maltodextrin, sucralose	50 cal/TBS	10 cal/TBS
Kraft Original Barbecue Sauce ***Light Barbecue Sauce***	Acesulfame-K Sucralose Additional Water	50 cal/TBS	20 cal/TBS

Salad Dressing

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Wish-Bone Italian Dressing ***Wish-Bone Fat Free Italian***	Water, Xanthan gum	45 cal/TBS	10 cal/TBS
Ken's Caesar ***Lite Caesar***	Proplyene glycol, alginate, xanthan guml	85 cal/TBS	35 cal/TBS

Beverages

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Jones root beer ***Sugar –free root beer***	Sucralose	180 cal/12 oz	0 cal/12 oz
Pepsi ***Diet Pepsi***	Aspartame	100 cal/8 oz	0 cal/8 oz
Mug Root Beer ***Diet Mug Root Beer***	Aspartame	100 cal/8 oz	0 cal/8 oz
Sierra Mist ***Sierra Mist Free***	Aspartame Acesulfame-K	100 cal/8 oz	0 cal/8 oz
AMP Energy ***AMP Energy- Sugar Free***	Sucralose Acesulfame-K	110 cal/8 oz	0 cal/8 oz
No Fear ***No Fear Sugar Free***	Sucralose Acesulfame-K	130 cal/8 oz	10 cal/8 oz
Tropicana Fruit Punch ***Tropicana Sugar Free Fruit Punch***	Aspartame Acesulfame-K	110 cal/8 oz	0 cal/8 oz
Frappuccino Mocha ***Frappuccino Mocha Light***	Sucralose Acesulfame-K	150 cal/8 oz	85 cal/8 oz
Lipton White Tea with Raspberry ***Lipton Diet White Tea with Raspberry***	Aspartame Acesulfame-K	60 cal/8oz	0 cal/8 oz
Starbucks DoubleShot Coffee Drink ***Starbucks DoubleShot Light Coffee Drink***	Sucralose Acesulfame-K	170 cal/8 oz	90 cal/8 oz
Lipton Iced Tea with Lemon ***Lipton Diet Iced Tea with Lemon***	Sucralose Acesulfame-K	60 cal/8 oz	0 cal/8 oz
SoBe Green Tea ***SoBe Lean Diet Green Tea***	Pectin Sucralose Acesulfame-K	100 cal/8 oz	5 cal/8 oz
Tropicana Orange Juice some pulp ***Tropicana Light 'n Healthy some pulp***	Sucralose Acesulfame-K	110 cal/8 oz	50 cal/8 oz
Minute Maid Lemonade ***Minute Maid Light Lemonade***	Aspartame Acesulfame-K Sucralose	100 cal/8 oz	5 cal/8 oz

Waffles and Syrup

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Eggo Syrup ***Eggo Syrup Light***	Cellulose Gum	240 cal/1/4 cup	110 cal/1/4 cup
Eggo Nutri-Grain Waffles Whole Wheat ***Eggo Nutri-Grain Low Fat Whole Wheat Waffles***	Guar Gum Modified corn starch, whey protein, Soy lecithin	68 cal/oz	57 cal/oz

Cookies

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Oreo Sandwich Cookies ***Oreo: reduced Fat*** ***Sugar free***	Maltitol, inulin, whey protein concentrate, sucralose, Acesulfame-K	160 cal/3 cookies (34 grams)	150 cal/3 cookies (34 grams) 100 cal/2 cookies (24 grams)
Murray Old Fashioned Ginger Snaps ***Murray Sugar Free Gingersnaps***	Polydextrose / Maltodextrin Acesulfame-K Sucralose Sorbitol Lactitil Maltitol	140 cal/5 cookies (30 gm)	130 cal/7 cookies (31 gm)

Chips, Snacks

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Ruffles potato Chips ***Original Light***	Olestra	160 cal/oz	70 cal/oz
Lays original potato chips ***Baked Light***	Olestra	150 cal/oz	120 cal/oz 75 cal/oz
Hunt's Vanilla pudding snack pack ***Sugar free***	Water, maltitol, erythritol, carrageenan, milk protein isolate, sucralose, Acesulfame-K	120 cal/cup	60 cal/cup

Sauces / Condiments

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Kraft Tartar Sauce ***Kraft Tartar Sauce Fat Free***	Cellulose gum Xanthan gum	55 cal/oz	66 cal/oz
Hellman's Mayonnaise-Lo Fat	Maltodextrin	66 cal/TBS	15 calTBS
Miracle Whip Dressing ***Miracle Whip Light*** ***Miracle Whip Non Fat***	**Light**: Cellulose gum Xanthan gum Sucralose Acesulfame-K **Fat Free:** Xanthan gum Cellulose gum	66 cal/oz	**Light:** 35 cal/oz **Fat Free:** 27 cal/oz
Heinz ketchup Reduced sugar	Sucralose	15 calTBS	5 calTBS

Cheese & Dairy Foods

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Cracker Barrel Cheese sticks Extra sharp Cheddar ***Cracker barrel Cheese sticks extra sharp cheddar 2% milk Reduced Fat***	Part Skim Milk	90 cal/oz	50 cal/oz
Deli Deluxe Cheese American Slices ***Deli Deluxe Cheese American 2% Milk Slices***	2% milk	101 cal/oz	90 cal/oz
Kraft Singles American Slices ***Kraft Singles American Fat Free Slices***	Cellulose Gum, Carrageenan Milk protein concentrate	95 cal/oz	41 cal/oz
Natural Cheese Monterey Jack ***Natural Cheese Monterey Jack 2% Mild Reduced Fat***	2% milk	101 cal/oz	81 cal/oz

Cheese & Dairy Foods (continued)

PRODUCTS	CALORIE-REDUCING INGREDIENTS	CALORIES ORIGINAL	CALORIES: REDUCED VERSION
Polly O Ricotta ***Polly O Part Skim Ricotta***	Guar Gum Xanthan gum Nonfat milk	50 cal/oz	41 cal/oz
Breakstone Cottage Cheese Small Curd 4% ***Breakstone Cottage Cheese Small Curd Fat Free***	Maltodextrin Mono-and diglycerides guar gum xanthan gum	27 cal/oz	18 cal/oz
Breakstone Sour Cream Traditional ***Breakstone Sour Cream Fat Free***	Xanthan gum Maltodextrin	60 cal/2TBS	29 cal/2 TBS
Philadelphia Cream Cheese Original ***Philadelphia Cream Cheese Fat Free***	Xanthan gum Carob Bean gum Nonfat milk Sugar, nonfat milk	100 cal/ oz	30 cal/ oz
Activia Vanilla Yogurt ***Activia Light Vanilla***	Sucralose Inulin, Modified Cornstartch	110 cal/4 oz	70 cal/4 oz
Colombo plain yogurt Low Fat	Pectin	65 cal/4 oz	50 cal/4 oz
Yoplait Original 99% Fat Free- Banana Crème ***Yoplait Light Fat Free- Apple Turnover***	Aspartame, Acesulfame-K	170 cal/6 oz	100 cal/6 oz.
Edy's vanilla bean ice cream ***Edy's slow churned vanilla bean***	Whey protein Tapioca malto-dextrin	140 cal/1/2 cup	100 cal/1/2 cup
Cool Whip- Whipped topping Regular ***Cool Whip-Sugar Free***	Sugar Free: Guar gums Aspartame Acesulfame-K	25 cal/2 TBS	20 cal/2 TBS

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