OLESTRA: CHARACTERISTICS AND IMPACT ON NUTRIENT COMPOSITION OF FOODS

Carolyn M. Bergholz

The Procter & Gamble Company
Winton Hill Technical Center
Cincinnati, Ohio

There is a consensus among nutritionists and health professionals that diet plays a major role in risk of a number of chronic diseases. The Surgeon General's Report on Nutrition and Health in 1988 and the National Research Council Report on Diet and Health in 1989 compiled the scientific evidence supporting this assessment. These reports also recommended specific guidelines and dietary changes that could contribute to long-term health. Nutrition education and motivation of the general public are essential if we are to realize the public health benefits of achieving the dietary recommendations. Another important part of the equation is innovation. Innovation is needed on a variety of fronts, among them, education, behavior modification, food preparation and recipes, agriculture, and food technology.

The Federal government has recognized that the food industry must play a major role. The NIH Consensus Development Conference (1) concluded that "The food industry should be encouraged to continue and intensify efforts to develop and market foods that will make it easier for individuals to adhere to the recommended diets...". Similarly, the Surgeon General's Report (2) stated, "Industry can contribute to improving the quality of the American diet by increasing the availability of palatable, easily prepared food products that will help people follow dietary guidelines."

One of the most challenging guidelines is the recommendation to reduce consumption of fat, especially saturated fat. The food industry has responded with the introduction of many new food products that are reduced in fat and calories. The goal is to make these foods as appealing as the full fat, full calorie option. This has been a challenge because it is often the fat in a food that carries flavors and provides the desirable texture, moistness or sensation of richness in the mouth.

Fat replacement technologies are not new, but there are a number of innovations that have resulted in improved products and new possibilities. As shown in Table 1, water has replaced fat in some dairy products, spreads like margarine and in salad dressings. Starches and gums are used to reduce the amount of fat by stabilizing the water and oil emulsions and simulating the mouthfeel of fat. These technologies have been used with increasing effectiveness in mayonnaise-like spreads, dairy products like yogurt, sour cream and frozen desserts, and are now being used to decrease the amount of fat in retail baked goods. A more recent innovation is the development by Nutrasweet and Kraft of hydrated microparticulated proteins. This technology can be used for the same types of foods applications as starches and gums. None of these fat replacement technologies, however, can be used to replace the fat used in cooking, frying or home baking. Engineered fats are an innovation that will meet this need.

Olestra is an example of an engineered fat. It is made by esterifying sucrose, with 6, 7, or 8 long-chain fatty acids from vegetable oils like soybean or cotton seed oil. Technically olestra is defined as a mixture of hexa-, hepta- and octaesters of sucrose with long-chain fatty acids. Figure 1 shows the structure of the octaester of sucrose and for comparison, a triglyceride molecule. The physical properties of olestra are comparable to those of conventional fat because it is composed mostly of fatty acids. The degree of unsaturation and chain length of the fatty acids determine whether the olestra is a liquid or a solid, just as for a triglyceride. The heating stability, smoke and flash points of olestra are comparable to a conventional fat. Because it is just like a fat in its physical characteristics, it provides the same flavor, texture and mouthfeel when used to replace fat.

The unique characteristic of olestra is that it is non-caloric. This is because it is too large to be broken down by digestive enzymes (3). Therefore it is not absorbed from the gastrointestinal tract and never enters the bloodstream (4). It also is not metabolized by microorganisms in the colon, so it is excreted with other nondigested fecal material (5). In the environment it absorbs to sludge and is completely degraded by aerobic soil bacteria.

Olestra and the Evolution of Edible Oils

Although olestra can technically be used to replace fat in a wide variety of foods such as ice cream, margarine, salad dressings and processed meat and cheese, the first use planned is to replace fat used for cooking and frying. This use fills a niche for which there is no other fat replacement technology available. It is also a natural extension of Procter & Gamble's edible oil and snack food businesses. All vegetable shortening was the first of a number of major innovations in fats and oil that have occurred in the twentieth century. Before then butter and lard were essentially the only cooking fats available. Now shortening, margarine and vegetable oils are staples in the American diet. The trend has been toward processing and source oils that reduce the amount of saturated fat in the finished product. Olestra is the latest step in this series of innovations in healthier edible oils.

Food Additive Petition

Although olestra is made from sugar and vegetable oil, it is a new food ingredient. Therefore its use in food must be approved by the Food and Drug Administration through the Food Additive Petition process. The petition filed requested approval to blend olestra with vegetable oil, with a 35% replacement for shortening and oil to be used at home and up to 75% replacement in deep-fat frying in restaurants and in commercial production of savory snacks like potato and corn chips. The initial olestra foods to reach the marketplace will come from these food categories. The Food Additive Petition process will have to be repeated for broader usages.

The Food Additive Petition is comprised largely of reports of extensive animal and clinical research that establish the safety of olestra for food use. The data from this research show that olestra is not absorbed by the body, is not toxic or mutagenic and does not cause cancer or reproductive effects (6-9). Other research in animals and humans shows that olestra does not affect gastric emptying (10), secretion of pancreatic enzymes (11), total transit time, bile acid physiology or morphology of the gastrointestinal tract (7, 12). Nutrition research and estimates of possible consumption levels are other elements of the Food Additive Petition that are important to assure the safety of olestra for use in food.

Effect of Olestra on Nutrient Composition of Food

The greatest reduction in fat through use of olestra will occur for those foods that derive most of their fat from the fat in which they are prepared. For example, potatoes have very little fat until they are turned into ever-popular potato chips, which have 57% of calories from fat. As shown in Table 2, by using 100% olestra for making potato chips, the nutrient composition of 1 oz. of potato chips changes from 9.8 g of fat to zero, while the grams of protein and carbohydrate are unchanged (13). This means that the percent of calories from carbohydrate, for example, increase from 38% to 88%. Olestra-fried potato chips still have nutrients, only fewer calories and no fat.

The fat and calorie composition of foods deep-fried in a restaurant in a fat with 75% olestra would change similarly, as illustrated in Figure 2. If olestra is in shortening and oils used in the home, fat can be decreased by a few grams across a wide variety of foods. As shown in Figure 3, a 35% substitution with olestra gives a modest reduction in fat and calories for any single food, but these grams can add up. Again a decrease in fat is the only change in nutrient composition.

Results of extensive research demonstrate that olestra does not affect utilization of carbohydrate, protein or fat in the diet. Indirect evidence comes from long-term feeding studies conducted in rats, monkeys, and dogs and a multi-generation reproduction study in rats (7, 8). In these studies growth and development and all measures of health status were normal. Other animal and also clinical studies were conducted specifically to investigate the potential for olestra to affect absorption of each macronutrient. For example, studies among type II diabetics showed no effect of olestra on fasting blood glucose levels (14) and measurement of fecal lipid showed no difference in the percent of ingested triglyceride that was absorbed (5).

Olestra would not be expected to affect mineral absorption, since minerals are not lipid soluble. Additionally, since olestra is not hydrolyzed to free fatty acids, it does not bind divalent cations. Animal and clinical data show no change in minerals analyzed in serum chemistries and no increase in amounts of fecal calcium or magnesium. The clinical research has involved consumption of over 90 g of olestra per day for six weeks and several studies with intake of 18 - 27 g/d for 16 weeks (14, 15).

The most important nutrition research has centered on the potential for olestra to affect absorption of fat-soluble vitamins. It was demonstrated very early that olestra decreased the absorption of cholesterol (5). Further research confirmed that highly fat-soluble material has the potential to partition into olestra where a portion of it may stay dissolved and be carried from the body (12). These effects are small and can be eliminated by supplementing olestra foods with modest levels of vitamins.

Use of Nutrient Data Bases for Estimating Olestra Intake

As discussed above, the only effect of olestra on nutrient composition of a food is a decrease in grams of fat. Determining the amount of this decrease is not always straight forward. This is an important and complicating element of estimating the amount of olestra that would be consumed through a proposed use. Estimates of olestra intake are an important part of the Food Additive Petition. The first step in the process of estimating olestra intake from use in shortening and oil is to determine the amount of fat in a food that is derived from shortening, oil, margarine or lard, either added as an ingredient or used as a cooking medium. The problem is that the grams of fat or percent fat in foods listed in data bases is not necessarily equal to the grams or percent of fat from the shortening, oil, margarine or lard, since some fat may come from other sources, such as eggs, nuts or meat, a dairy product or the cooking fat. Finally, the amount of fat used for frying or sauteing a food is not the same as the amount consumed.

The amount of olestra in foods that could contain olestra was calculated using data from a number of sources, among them USDA Handbook No. 8, Pennington and Church's Food Values of Portions Commonly Used (13), and recipes in a number of major cookbooks and USDA ARS No. 13. For deep-fried foods like fried chicken, the amount of olestra was measured by analytical methods. The equations used to calculate the grams of olestra in a specific food are shown below. Intake estimates assumed olestra shortening (S) or oil (O) could also be used in place of margarine (M) or lard (L).

1) % Olestra = % Fat x % Fat from S, O, M, or L x % Olestra Substitution

2) Olestra (g) = Portion Size (g) x % Olestra

The average portion size is based on data from the USDA Nationwide Food Consumption Survey. MRCA Information Services 14-day diary data are used to determine for each individual all olestra foods eaten and the frequency of eating of each food in a single day. The intake from all potential olestra containing foods eaten on a specific day are summed to compute the total single-day intake. The estimate of chronic intake is determined by an average of intake over 14 days. Estimates for single-day consumption are also generated and the data are broken out for various age groups and subpopulations, such as dieters. This method of estimating intake was developed by the National Academy of Sciences and is the accepted by the FDA. These estimates are corroborated by estimates made using data from NHANES II and the USDA Continuing Survey of Intake by Individuals. For perspective, the estimated chronic intake for all ages from the proposed savory snack uses is about 6 g/day at the mean and 10 g/day at the 90th percentile.

Potential Impact of Olestra on Dietary Fat Intake

Obviously the limited uses of olestra proposed will not achieve the recommended guideline of <30% of calories from fat. There is need for other innovations in fat replacement and expanded uses, as well as appropriate changes in food selection and methods of preparation. Studies are underway to learn more about how olestra will affect total caloric intake and nutrient composition of the diet. Preliminary placebo-controlled, double-blind studies looking at caloric compensation indicate that over a 24-hour period lean adults compensate for the calories replaced by olestra, but they do not compensate with just fat. The net outcome is a decrease in calories from fat. Since children are very good at regulating their energy needs, olestra is not expected to affect their total energy intake. Other preliminary research suggests that obese adults may not compensate completely (20).

The future also holds the opportunity for research to explore the impact of changes in eating behavior on nutrient intake. In the interim we have used the existing data bases to model changes in eating behavior and calculate the impact on our intake estimates. For example, you can assume a 70% increase in potato chip eating occasions. The result is a modest increase in chronic intake estimates. In the future, food consumption surveys and nutrient data banks will be important for monitoring the impact of fat replacements on macro- and micronutrient intake.

Nutrition education and motivation will be important to help people understand how to appropriately incorporate foods made with olestra into the diet. By providing to the public more foods that are lower in fat but meet the need for eating pleasure, it is hoped that everyone will be able to achieve a healthier diet that they can live with for a long life time.

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TABLE 1. FAT REPLACEMENT TECHNOLOGIES

	APPLICATIONS				
Fat Replacer	Dairy	Spreads	Salad Dressings	Baking	Frying
Water	X	X	X		
Starches	X	X	X	X	
Gums	X	X	X	X	
Microparticulated Protein	X	X	X		
Engineered Fats	X	X	X	X	X

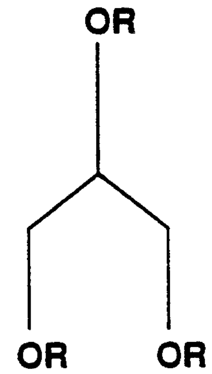
TABLE 2. EFFECT OF OLESTRA ON NUTRIENT COMPOSITION OF A REGULAR ORDER OF FRENCH FRIES*

	CURRENT	WITH 75% OLESTRA
Protein (g)	3.0 g	3.0 g
Carbohydrate (g)	26.1 g	26.1 g
Fat (g)	11.5 g	2.9 g
Total kcal	220 kcal	143 kcal
% Protein kcal	6%	8%
% Carbohydrate kcal	47%	74%
% Fat kcal	47%	18%

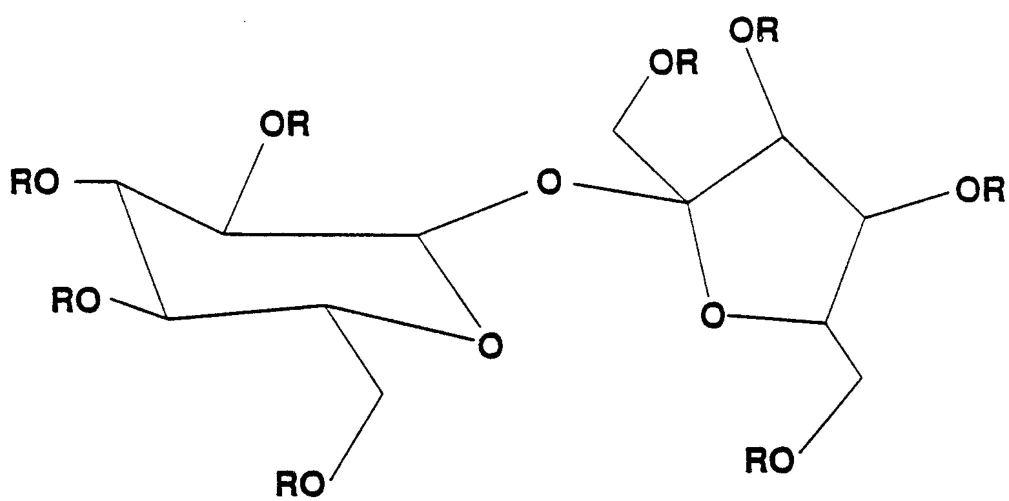
*Pennington, JAT, Food Value of Portions Commonly Used, Ed. 15, 1989.

FIGURE 1. THE STRUCTURE OF TRIGLYCERIDE AND OLESTRA

TRIGLYCERIDE
(Glycerol with Fatty Acids)



OLESTRA
(Sucrose with 6 - 8 Fatty Acids)



R = FATTY ACID $(CH_3-CH_2)_n-\overset{O}{\overset{\|}{C}}-$)

FIGURE 2. EXAMPLES OF FAT AND CALORIE REDUCTION IN RESTAURANT FOODS DEEP-FRIED IN A BLEND OF FAT WITH 75% OLESTRA. Data Source: (See Figure)

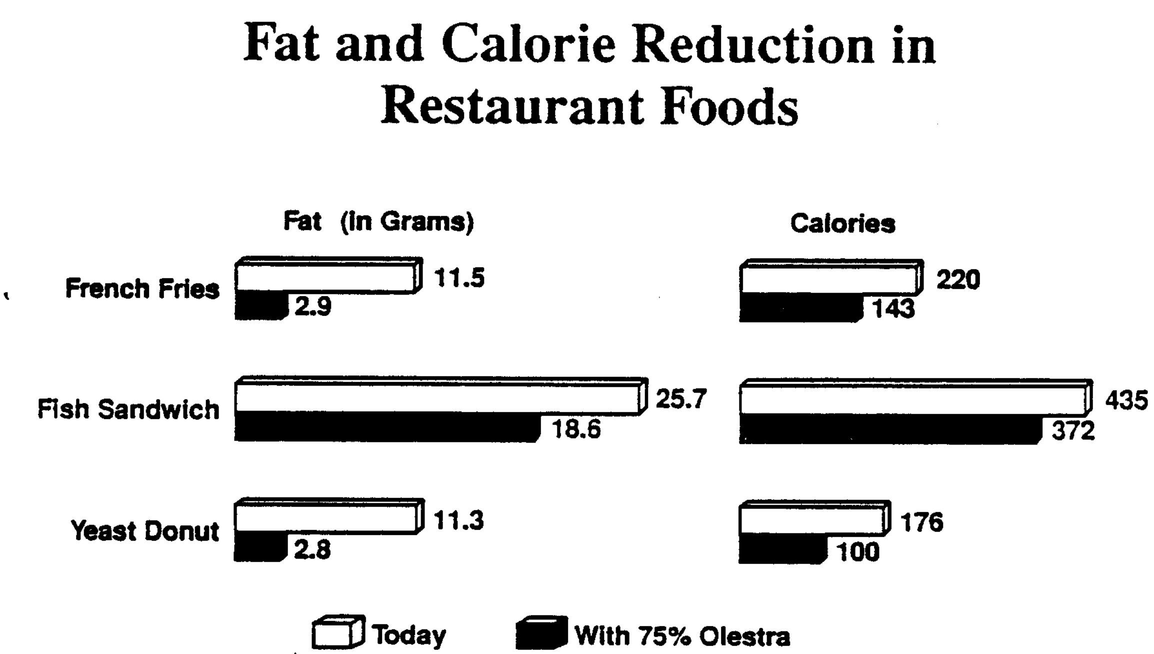


FIGURE 3. EXAMPLES OF FAT AND CALORIE REDUCTION IN FOODS PREPARED AT HOME WITH SHORTENING OR OIL CONTAINING 35% OLESTRA.