

Olestra

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Abstract: Olestra is a mixture of hexa-, hepta- and octa- ester of sucrose with fatty acids. It is a fat replacer. It has the potential to reduce intake of energy from dietary fats because it is not digested or absorbed by human body. Although, its properties such as taste, flavor and texture, are similar to fat, it does not have any calories like fat and oil. Olestra is stable at high temperatures so it may be used instead of fats and oils in snack foods. Since olestra can inhibit absorption of the certain fat soluble vitamins, olestra food is enriched with vitamins A, D, E and K.

Keywords: Fat replacer, sucrose polyester, dietary fats, oil, snack foods

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Özet: Olestra sakkarozun hexa-, hepta-, ve okta- esterlerinin bir karışımı olan yağ ikamesidir. İnsan vücudu tarafında sindirilemediği ve absorbe edilmediği için, yağdan gelen enerjiyi düşürebilme potansiyeline sahiptir. Tat, flavor ve tekstür gibi özellikleri yağa benzemesine rağmen yağın aksine kalorisi yoktur. Yüksek sıcaklıklarda stabil olduğundan, çerez gıdalarda yağ yerine kullanılabilir. Olestra yağda çözünen vitaminlerin absorpsiyonunu önlediği için olestra katkılı gıdalar vitamin A, D, E ve K ile zenginleştirilmektedir.

Anahtar Kelimeler: Yağ ikamesi, sakkaroz poliester, diyetel yağlar, yağ, çerez gıdalar

Introduction

Demands of consumers to low fat product has forced the food manufacturers to find new substances to replace the most of the fat in the food (Anonymous, 2003a). Intake of dietary fats, because of the high energy density and readily converted into the body fat, has been linked to cardiovascular disease, obesity and some type of cancer (Rolls et al., 1992). Fat replacers can be useful tool in reducing fat intake and can help to reduce health risk associated with intake of fats. On the other hand, fats and oils contribute flavor, palatability, mouthfeel, creaminess, and lubricating action to foods. Therefore, the ideal fat replacer should recreate the attributes of the fat while decreasing fat and calorie content (Akoh and Swanson, 1994).

Fat replacer can be carbohydrate-, protein-, and fat- based fat substitutes. The first introduced fat substitute which was carbohydrate based e.g., Avicel. They are used in a variety foods in today, including lunch meats, salad dressing, frozen dessert, dips, and candy. Protein based fat substitutes entered market after carbohydrate- based fat ones. Although, these fat substitutes give better sensation in the mouth than carbohydrate-based ones, neither protein-based, nor carbohydrate-

based fat substitutes are suitable for frying (Anonymous, 2003a).

Procter & Gamble, in 1968, synthesized a fat substitute called sucrose polyester while creating a way of increasing premature babies intake of fat (Anonymous, 2003b). It was patented by the Procter&Gamble company in 1971(Roller and Jones, 1996). Its brand name is Olean. Food and Drug Administration approved olestra on January 24, 1996 (Anonymous, 1997), for use in certain snack foods and required all products containing olestra be labeled (Klis, 1996). That approval was renewed and confirmed in June 1998 (Anonymous, 1999).

Olestra appears to be an exception among the other fat substitutes. Because it is combination of sucrose polyester and fatty acid, its properties are very similar to fat (Anonymous, 2003a). It can give the flavor and the desirable texture of fat and oil to food without adding any fat and calories (Anonymous, 2003c). The structure of olestra is the analogous of triglyceride molecule. It consists of one molecule of glycerol attached to three molecules of fatty acids while olestra consists of one molecule sucrose attached to six or eight molecules of fatty acids (Figure 1)

(McNutt, 1997). This review will focus on the general characteristic of olestra as well as the advantages and the concerns of it.

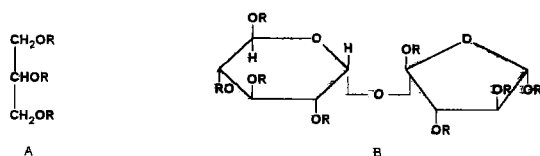


Figure 1. A: The structure of triglycerides; B: The structure of olestra; R: Fatty acids.

General Characteristics of Olestra

Olestra is a water insoluble sucrose polyester because of its large molecular size and the lack of the ionizable groups and the hydrogen bonding ability (Freston et al., 1997). It exists as an oil phase. Sucrose, table sugar, has sweetener properties and positive calorie content while olestra is bland and contributes no calories (Akoh and Swanson, 1994). Olestra is a mixture of hexa-, hepta- and octa- ester produced by the reaction between sucrose and long-chain fatty acids isolated from a natural oil (Daher et al., 1997). The type of the fatty acids depends on the source of oil used to prepare the olestra. More than 70% of the esters must be octa and the remaining 30% of the esters are mainly hepta, and small amount of hexa and penta. The fatty acid composition must be more than 78% C16-C18. The remaining 22% may be composed of 1% C12, 1% C14 and 20% C20 (Prince and Welschenbach, 1998). The number and the type of the fatty acids esterified to sucrose backbone determine the physical properties of olestra as well as the capability of absorption by gastrointestinal system. Mono through tetraesters can be digested and absorbed to a limited amount across the gastrointestinal system. However, olestra, sucrose polyester with six or more fatty acids, are nonabsorbable and excreted unchanged in the stool. The large molecular size and the water insolubility of olestra make it nonabsorbed by the gastrointestinal system (Freston et al., 1997).

Olestra is made from a natural oil. To make olestra, the natural oil like cottonseed, coconut and soy bean oil is heated with methanol to detach the fatty acid as methyl ester in the

presence of a base. The glycerides settle out and the methyl esters are distilled. After that, sucrose and another base catalyst are added to the fatty acid methyl esters with emulsifiers. Under the high temperature, olestra is formed and methanol is removed (Kirshner, 1997). The crude is refined as an ordinary fats to reduce the free fatty acid content, the coloured materials, the flavors and the volatiles. These esters are not affected by weak acids. However they are hydrolyzed by strong acids and by exposing moisture at high temperatures (230 °C). They are saponified in alkali. Exposing to oxygen, above 50 °C, causes oxidation of the unsaturated fatty acids to form hydroperoxides and other products (Anonymous, 1999).

As triglycerides, fatty acid composition determines the physical properties of sucrose polyester (Jandacek and Webb, 1978). Sucrose polyester containing mainly polyunsaturated fatty acid is liquid like vegetable oils while those containing mainly saturated fatty acid are solid like butter. Olestra is stable at high and ambient temperatures during storage and because of its heat stability, olestra reacts in similar way as triglycerides during the frying of the food. The same chemical and oxidative changes occur during frying on the fatty acids of olestra and fats. Also, olestra does not give any different or more by-products than the conventional frying fats (Giese, 1996). The taste, the appearance, the density, and the aroma of olestra are the same as those of triglycerides with the same fatty acid composition. It can be used in the producing of many foods as a replacement for triglycerides without changing the taste and texture (Jandacek, 1984).

Olestra can be modified by changing the fatty acid length or degree of saturation of the fatty acid so it can be used in baked and fried foods, dairy products, cooking oil, margarine, spreads and shortenings. Olestra gives similar flavor, texture, mouthfeel, satiety and shelflife properties as triglycerides without having calories (Giese, 1996). Olestra has been approved as the calorie free replacement for the conventional fats and oils in the preparation of snacks such as flavored and unflavored chips, crackers and tortilla chips (Anonymous, 2003b). It may also be used in place of fats and oils for

frying and baking of pre-packaged ready-to-eat savory snacks in dough conditioners, sprays, filling ingredients and flavors (Anonymous, 2003d).

Absorption and Digestion of Olestra

Olestra can not be digested so it does not provide any calories. While a normal fat consists of one molecule glycerol attached to three molecules of fatty acids, olestra consists of one molecule sucrose attached to six or eight molecules of fatty acids (Figure 1) (McNutt, 1997). The molecule is too large to be metabolized by enzyme and bacteria in the gut (Anonymous, 2003b). Digestive enzymes, gastric lipase and pancreas (Mattson and Volpenheim, 1972; Roller and Jones, 1996), can not get into sucrose center, and can not hydrolyze olestra. Our body does not know how to absorb olestra, so it can pass through stomach and intestine without being absorbed, like dietary fiber (Anonymous, 1997). Olestra is neither absorbed nor digested, but it is excreted unchanged in the feces of humans and animals. Studies showed that, intravenously injected olestra was rapidly taken up by liver and spleen, and slowly excreted unchanged in the bile and feces (Akoh and Swanson, 1994).

Animal and clinical researches demonstrated that olestra has a dose-dependent effect on the absorption of cholesterol from the diet and from the bile. When olestra was substituted for a large portion of the dietary fat, the greatest reduction was observed in the level of serum cholesterol. When overweight patients were fed 12-27 g/day of olestra, 16% reduction in LDL cholesterol was observed (Akoh and Swanson, 1994). The study in humans showed that olestra reduced the LDL-cholesterol while the HDL-cholesterol remained unchanged (Mellies et al., 1985). Since olestra decreases the absorption of cholesterol, it can decrease the atherosclerosis associated with the blood cholesterol concentration (Akoh and Swanson, 1994).

Nutritional Effects of Olestra

Since olestra is a non-absorbable lipid-like substance, it can remove fat-soluble nutrients from the body (Akoh and Swanson, 1994; Peters

et al., 1997). Olestra is not absorbed by the body and passes through the digestive tract unchanged. Therefore, it can compete with the intestinal micelles in the uptake of lipid-soluble molecules. This occurs, when octanol-water partition coefficient is greater than 6, such as, lipid soluble vitamins, and carotenoids and sterols e.g., cholesterol. It is only occurred, when olestra and the fat-soluble molecules are together in the gut (Anonymous, 1997). The studies showed that, olestra could cause the dose-responsive decrease in the absorption of fat soluble vitamins A, D, E, and K. Therefore, its adverse effects on these vitamins can be compensated by the addition of these vitamins to the olestra foods. Olestra does not affect the absorption of carbohydrates, proteins, minerals and water soluble vitamins (Cooper et al., 1997; Schlagheck et al., 1997; Anonymous, 2003c).

Generally it is known that, the consumption of fruits and vegetables decreases the incidence of the certain type of chronic disease such as cancer, coronary heart diseases, stroke and cataracts. Carotenoids are one of the protective components of fruits and vegetables, and they can be affected by the consumption of olestra. However, on January 18, 1996, the National Cancer Institute announced that, carotenoids did not have an effect on cancer, moreover lung cancer and deaths were more occurred in human who consumed beta carotene group. Carotenoids can promote lung cancer among the smokers. For this reason, FDA (Food and Drug Administration) has not allowed carotene supplements to the snack foods (Anonymous, 1997).

Gastrointestinal Effects of Olestra

Olestra can cause the gastrointestinal symptoms like diarrhea, loose stools, anal leakage, nausea and gas. It was claimed that, olestra causes the same gastrointestinal effects with the consumption of high amount dietary fiber. However, the gut microflora adjust itself to increased fiber amount but not adjust itself to olestra. The effect of the high amount of fiber in the gut is temporary while the effect of olestra is permanent (Anderson and Akanji, 1991; Anonymous, 1995).

Gastrointestinal (GI) tract is the only organ to expose to the olestra, so a lot of study has been done on animals to demonstrate whether olestra is safe or not in the GI tract. It was shown that, there was no histological changes in the GI tract of any animals. The pancreas responds to the olestra as a non-nutrient and non digestible fat. In-vitro and in-vivo studies demonstrated that the microflora of digestive tract was not affected by olestra, and it could not degrade olestra (Anonymous, 2003c).

Studies showed that, people had some digestive changes, when they had olestra in excessive amounts. These changes included boating, abdominal cramp, flatulence, and loose or soft stools. To inform people about these digestive changes, an information label is present on the olestra snack food packages. This label states that "This products contain olestra. Olestra may cause abdominal cramp and looses stools" (Olean, 2003). Reported symptom, called anal-leakage, was solved many years ago and does not occur with the current FDA-approved olestra. Reformulation of olestra by using palmitic or longer chain saturated fatty acids solved the anal leakage problem (Giese, 1996).

All available incidence showed that the number of people, who experienced intestinal symptoms when they had olestra, was low (Anonymous, 1997). The effect of olestra is similar to that caused by some foods, such as, beans, some milk products and fruits (Anonymous, 2003c). Also, the gastrointestinal discomfort is caused by something people eat, stress or sickness. The gastrointestinal discomfort, caused by olestra, is negligible when it is compared the other reason which causes the gastrointestinal discomfort (Anonymous, 1997).

Toxicology of Olestra

The study in the rats, rabbits, hamster and dogs showed that, olestra was not toxic, carcinogenic, genotoxic or teratogenic. It is neither metabolized nor absorbed by body and it passes through the gastrointestinal tract intact and undigested (Wood, 1991; Prince and Welschenbach, 1998).

Environmental Safety of Olestra

Olestra has shown that, the manufacturing and using of olestra as a food additive in the preparation of savory snacks do not have any adverse effects on either natural environment or engineered waste treatment system. Olestra is biodegradable in the environment, and is not toxic to aquatic and terrestrial plants and animals, so it will not affect waste water system or septic tanks. Unlike anaerobic microorganism, lipases of aerobic microorganism found in the environment can break down olestra so it is biodegradable (Freston et al., 1997; Anonymous, 2003c).

Role of Olestra in the Diet

Excessive fat consumption causes increased the risk of coronary hearth disease, stroke, certain types of cancer, and obesity. Although, the health professionals recommend that, the diet should not provide more than 30% of calories from fat, Americans continue to eat more than the recommended level of fat. Olestra can provide a tool to help people to reach the recommended level (Anonymous, 2003c).

A lot of studies confirmed that, olestra can help people to reduce calorie intake from the fat. The studies done with human showed that, replacement of dietary fat with olestra reduced body weight and total body fat (Miller et al., 1998; Bray et al., 2002; Roy et al., 2002; Anonymous, 2003c).

Use of fat replacers by small children, especially those under age of 2, may not be compatible with their high energy needs. Calorie intake of them should not restricted because they need energy for growth. Regular fat provides critical nutrition for their nervous system development at this age (Prince and Welschenbach, 1998). Animal toxicology testing, and nutrient studies in animals and humans demonstrated that, olestra was safe during pregnancy and lactation. However, women should not restrict their calorie intake during pregnancy to ensure good health for both mother and baby (Anonymous, 2003c). Clinical studies demonstrated that, olestra was safe for the diabetes patients, because the sugar molecule in the olestra is also not digested (Anonymous, 1997).

Drug Absorption Effects of Olestra

Because of lipophilic nature of olestra, its effect on the bioavailability of lipophilic drugs was investigated. It was found that their absorption, including that of oral contraceptives was unaffected (Miller et al., 1990; Prince and Welschenbach, 1998).

Regulatory Status

Olestra can cause inhibition of the absorption of some fat-soluble nutrients, gastrointestinal disturbance and the other adverse effects in the body. Olestra safety program, in animals with additional testing in controlled human clinical studies, has exceeded the typically required for regulatory approval of food ingredients. FDA is known as the toughest regulatory body in the world. Its approval for olestra took almost 9 years after reviewing a lot of studies. Finally, FDA approved olestra as a safe fat replacer for consumption in salty snack. Although there are some adverse effects of olestra, such as, diarrhea and absorption of certain vitamins are not surprising because olestra is not metabolized and absorbed in the GI tract, and is excreted in the feces without changed.

On January 24, 1996, the FDA approved the use of olestra to replace 100% of the vegetable oil used in the preparation of savory snacks. Savory snacks include flavored and unflavored chips, e.g., potato chips, corn chips, tortilla chips, etc., flavored and unflavored extruded snacks e.g., cheese puffs, cheese curls, etc., and crackers, saltines etc., (Anonymous, 2003c).

The *Federal Register* of January 30, 1996 includes addition of a new section 172.867 to 21 CFR Part 172. This states that "olestra may be

used in place of fats and oils in prepackaged ready-to-eat savory (i.e., salty or piquant but not sweet) snacks, in such foods, in dough conditioners, in sprays, in filling ingredients, or in flavors" (Giese, 1996).

In spite of being approved as being safe by FDA, all snacks containing olestra must carry the label stating that, "This product contains olestra. Olestra may cause abdominal cramping and loose stools. Olestra inhibits the absorption of some vitamins and other nutrients. Vitamin A, D, E, and K have been added (Anonymous, 2003b).

That approval was renewed and confirmed in June 1998 (Anonymous, 1999) by FDA Advisory Committee. The committee concluded that "reasonable certainty of no harm from olestra".

Conclusion

Olestra is a fat replacer that passes through digestive tract unchanged. Therefore, it does not have any calories. It can be effective tool in weigh loss management. Since olestra can cause diarrhea, abdominal cramp, anal leakage and inhibition of absorption of certain fat-soluble nutrients, it has been a controversial topic. However, adverse effect of olestra on fat-soluble vitamins can be compensated with the addition of these vitamins. The other effects such as diarrhea, abdominal cramp and anal leakage are not surprising because olestra is neither absorbed nor digested by body. If it is consumed moderately in combination with balanced diet, it can help some people who suffer from obesity and high level of cholesterol.

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