SCIENTIFIC STATUS SUMMARY

This Scientific Status Summary addresses key characteristics and functions of fat replacers.

Awareness of adverse affects of excessive dietary fat intake is virtually universal. Consequently, health conscious individuals are modifying their dietary habits and eating less fat (Miller and Groziak, 1996). Consumer acceptance of any food product depends upon taste— the most important sensory attribute. Although consumers want foods with minimal to no fat or calories, they also want the foods to taste good. Because several foods formulated with fat replacers do not compare favorably with the flavor of full-fat counterparts, it is difficult for some people to maintain a reduced fat dietary regimen. Food manufacturers continue to search for the elusive “ideal fat replacer” that tastes and functions like conventional fat without the potential adverse health impact.

This Scientific Status Summary briefly reviews key characteristics and functions of fat replacers that are commercially available and a few that are under development.

Rationale for Fat Replacers

As a food component, fat contributes key sensory and physiological benefits. Fat contributes to flavor, or the combined perception of mouthfeel, taste, and aroma/odor (Ney, 1988). Fat also contributes to creaminess, appearance, palatability, texture, and lubricity of foods and increases the feeling of satiety during meals. Fat can also carry lipophilic flavor compounds, act as a precursor for flavor development (e.g., by lipolysis or frying), and stabilize flavor (Leland, 1997). From a physiological standpoint, fat is a source of fat-soluble vitamins, essential fatty acids, precursors for prostaglandins, and is a carrier for lipophilic drugs. Fat is the most concentrated source of energy in the diet, providing 9 kcal/g compared to 4 kcal/g for proteins and carbohydrates.

High fat intake is associated with increased risk for obesity and some types of cancer, and saturated fat intake is associated with high blood cholesterol and coronary heart disease (AHA, 1996; USDHHS, 1988). The 1995 Dietary Guidelines (USDA and USDHHS, 1995) recommend limiting total fat intake to no more than 30% of daily energy intake, with saturated fats no more than 10% and monounsaturated and polyunsaturated fats accounting for at least two-thirds of daily energy intake. Consumer surveys indicate that 56% of adult Americans try to reduce fat intake and many show interest in trying foods containing fat replacers (Bruhn et al., 1992). A survey conducted by the Calorie Control Council (CCC, Atlanta, Ga.) found that 88% of adults reported consuming low-fat, reduced-fat or fat-free foods and beverages (CCC, 1996). Although fat intake is declining, probably due to the increased availability of low- and reduced-fat products and lean meats, fat consumption is greater than the recommended levels, and the prevalence of the population classified as overweight is increasing (Frazao, 1996). Foods formulated with fat replacers are an enjoyable alternative to familiar high-fat foods. By choosing these alternative foods, health conscious consumers are able to maintain basic food selection patterns and more easily adhere to a low-fat diet (CCC, 1996).

Fat may be replaced in food products by traditional techniques such as substituting water or air for fat, using lean meats in frozen entrées, skim milk instead of whole milk in frozen desserts, and baking instead of frying for manufacturing or preparing snack foods (CCC, 1992). Fat may also be replaced in foods by reformulating the foods with lipid-, protein-, or carbohydrate-based ingredients, individually or in combination. Fat replacers represent a variety of chemical types with diverse functional and sensory properties and physiological effects. Table 1 lists the general functions of fat replacers in selected applications and food product categories.

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Fat Replacers

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Types of Fat Replacers

The terms and definitions used to describe fat replacers vary among authors and are often confusing and misunderstood. Fat replacers chemically resemble fats, proteins, or carbohydrates and are generally categorized into two groups—fat substitutes and fat mimetics.

Fat substitutes are macromolecules that physically and chemically resemble triglycerides (conventional fats and oils) and which can theoretically replace the fat in foods on a one-to-one, gram-for-gram basis. Often referred to as lipid- or fat-based fat replacers, fat substitutes are either chemically synthesized or derived from conventional fats and oils by enzymatic modification. Many fat substitutes are stable at cooking and frying temperatures.

Fat mimetics are substances that imitate organoleptic or physical properties of triglycerides but which cannot replace fat on a one-to-one, gram-for-gram basis. Fat mimetics, often called protein- or carbohydrate-based fat replacers, are common food constituents, e.g., starch and cellulose, but may be chemically or physically modified to mimic the function of fat. The caloric value of fat mimetics ranges from 0–4 kcal/g. Fat mimetics generally adsorb a substantial amount of water. Fat mimetics are not suitable for frying because they bind excessive water and denature or caramelize at high temperatures. Many fat mimetics are suitable for baking and retorting. Fat mimetics are generally less flavorful than the fats that the mimetics are intended to replace; they carry water-soluble flavors but not lipid-soluble flavor compounds. Successful incorporation of lipophilic flavors into foods that are formulated with fat mimetics may, therefore, require emulsifiers.

• Fat Substitutes. The composition, developers, and key sources of several synthetic fatty acid-based and lipid-like fat substitutes are listed in Table 2.

Sucrose fatty acid polyesters are mixtures of sucrose esters formed by chemical transesterification or interesterification of sucrose with six to eight fatty acids. Trans-esterification is the exchange of an acyl group or radicals between an ester and an acid, alcohol, or an amine. Interesterification is the exchange of an acyl group or radicals between two esters. The sucrose polyester commonly known as olestra (Olean®, The Procter & Gamble Co., Cincinnati, Ohio) is manufactured from saturated and unsaturated fatty acids of chain length C12 and higher, obtained from conventional edible fats and vegetable oils (Akoh, 1994; Akoh and Swanson, 1990; Rizzi and Taylor, 1978; Shieh et al., 1996).

The first step of the process involves hydrolyzing and methylating fatty acids to form fatty acid methyl esters. The esters are added to sucrose for transesterification or to sucrose octaacetate for ester interchange using catalysts, such as alkali metals or

<table>
<thead>
<tr>
<th>Specific Application</th>
<th>Fat Replacer</th>
<th>General Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baked goods</td>
<td>Lipid based</td>
<td>Emulsify, provide cohesiveness, tenderize, carry flavor, replace shortening, prevent staling, prevent starch retrogradation, condition dough</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate based</td>
<td>Retain moisture, retard staling</td>
</tr>
<tr>
<td></td>
<td>Protein based</td>
<td>Texturize</td>
</tr>
<tr>
<td>Frying</td>
<td>Lipid based</td>
<td>Texturize, provide flavor and crispiness, conduct heat</td>
</tr>
<tr>
<td>Salad dressing</td>
<td>Lipid based</td>
<td>Emulsify, provide mouthfeel, hold flavorants</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate based</td>
<td>Increase viscosity, provide mouthfeel, texturize</td>
</tr>
<tr>
<td></td>
<td>Protein based</td>
<td>Texturize, provide mouthfeel</td>
</tr>
<tr>
<td>Frozen desserts</td>
<td>Lipid based</td>
<td>Emulsify, texturize</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate based</td>
<td>Increase viscosity, texturize, thicken</td>
</tr>
<tr>
<td></td>
<td>Protein based</td>
<td>Texturize, stabilize</td>
</tr>
<tr>
<td>Margarine, shortening, spreads, butter</td>
<td>Lipid based</td>
<td>Provide spreadability, emulsify, provide flavor and plasticity</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate based</td>
<td>Provide mouthfeel</td>
</tr>
<tr>
<td></td>
<td>Protein based</td>
<td>Texturize</td>
</tr>
<tr>
<td>Confectionery</td>
<td>Lipid based</td>
<td>Emulsify, texturize</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate based</td>
<td>Provide mouthfeel, texturize</td>
</tr>
<tr>
<td></td>
<td>Protein based</td>
<td>Provide mouthfeel, texturize</td>
</tr>
<tr>
<td>Processed meat products</td>
<td>Lipid based</td>
<td>Emulsify, texturize, provide mouthfeel</td>
</tr>
<tr>
<td>Dairy products</td>
<td>Lipid based</td>
<td>Provide flavor, body, mouthfeel, and texture; stabilize, increase overrun</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate based</td>
<td>Increase viscosity, thicken, aid gelling, stabilize</td>
</tr>
<tr>
<td></td>
<td>Protein based</td>
<td>Texturize</td>
</tr>
<tr>
<td>Soups, sauces, gravies</td>
<td>Lipid based</td>
<td>Provide mouthfeel and lubricity</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate based</td>
<td>Provide mouthfeel, texturize</td>
</tr>
<tr>
<td></td>
<td>Protein based</td>
<td>Texturize</td>
</tr>
<tr>
<td>Snack products</td>
<td>Lipid based</td>
<td>Emulsify, provide flavor</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate based</td>
<td>Texturize, aid formulation</td>
</tr>
<tr>
<td></td>
<td>Protein based</td>
<td>Texturize</td>
</tr>
</tbody>
</table>

*Functions are in addition to fat replacement.
their soaps, under anhydrous conditions and high vacuum. As for vegetable oils, the resulting crude olestra product is purified by washing, bleaching, and deodorizing to remove free fatty acids and odors, followed by distillation to remove unreacted fatty acid methyl esters and sucrose esters with low degrees of fatty acid substitution. Olestra is defined by specifications that include the fatty acid composition and degree of esterification (FDA, 1996). The types of fatty acids used in the manufacture of olestra ultimately govern the functionality, physical properties, and potential applications (Akoh and Swanson, 1994).

Olestra is approved (FDA, 1996) for replacing up to 100% of the conventional fat in savory snacks (i.e., snacks that are salty or piquant but not sweet, such as potato chips, cheese puffs, and crackers) and for frying of savory snacks. Olestra (Fig. 1) is not absorbed or metabolized (Grossman et al., 1994; Matson and Nolen, 1972) and is non-caloric because the size and number of the nonpolar fatty acid constituents prevent olestra from being hydrolyzed by digestive lipases.

Because olestra passes through the gastrointestinal tract without being digested or absorbed and is lipophilic, olestra has the potential to cause gastrointestinal effects, such as abdominal cramping and stool softening or loosening, and to reduce absorption of fat-soluble vitamins and nutrients, which partition into olestra when ingested at the same time. As a result, the Food and Drug Administration (FDA) requires that foods containing olestra be labeled with the statement: “This Product Contains Olestra. Olestra may cause abdominal cramping and loose stools. Olestra inhibits the absorption of some vitamins and other nutrients. Vitamins A, D, E, and K have been added.” The label statement is intended to inform consumers about potential gastrointestinal effects and the addition of vitamins to compensate for the effects of olestra on absorption of vitamins A, D, E, and K.

The concentration of vitamins A, D, E, and K required for supplementation in olestra-containing foods are 0.34 X RDA for vitamin A/10g olestra, 0.94 X RDA for vitamin E/10g olestra, and 1.0 X RDA for vitamin K/10g olestra. Although olestra decreases the absorption of some lipophilic carotenoids, supplementation with vitamin A compensates for olestra’s effect on the provitamin A function of carotenoids. Olestra does not significantly affect the absorption of other macronutrients such as carbohydrates, proteins, or water-soluble vitamins and minerals.

A series of 13 studies that were part of the research program to assess the potential for olestra to cause physiological and nutritional effects was published in August 1997 in a Supplement to the Journal of Nutrition. Cheskin et al. (1998) reported that ad libitum consumption during one sitting of potato chips made with olestra was not associated with increased incidence or severity of gastrointestinal symptoms.

In approving olestra, the FDA concluded that olestra is not toxic, carcinogenic, genotoxic, or teratogenic; all safety issues were addressed; and there is reasonable certainty that no harm will result from the use of olestra in savory snacks (FDA, 1996). The approval of olestra, however, was controversial. The Center for Science in the Public Interest (CSPI, Washington, D.C.), an advocacy and education organization, publicized opposition on the basis of several allegations, including gastrointestinal disturbances, and petitioned the FDA to repeal approval. Despite the controversy and concerns, however, olestra does demonstrate potential to benefit some segments of the population. For example, replacement of conventional fat with olestra can benefit people at high risk of coronary heart disease, obese individuals, and colon cancer patients by helping them to lower total fat intake, lose weight, and possibly lower blood cholesterol levels (Adams et al., 1981; Crouse and Grundy, 1979; Fallat et al., 1976; Glueck et al., 1979, 1983, 1994; Grossman et al., 1994; Grundy et al., 1986; Jandacek et al., 1990; Matson and Jandacek, 1985). Olestra consumption...
tion does not appreciably affect the serum concentration of high-density lipoprotein (HDL) cholesterol (FDA, 1996; Grossman et al., 1994; Mellies et al., 1983).

Sucrose fatty acid esters (SFE), a second category of fat substitutes, are mono-, di-, or tri-esters of sucrose with fatty acids, made in a manner similar to sucrose polyester (Osipow et al., 1956). Unlike olestra, with a high degree of fatty acid substitution/esterification, SFEs are easily absorbed and hydrolyzed by digestive lipases and are, thus, caloric. The balance in SFEs of five to seven free hydroxyl groups with one to three fatty acid esters results in hydrophilic and lipophilic properties and, hence, excellent emulsification and surfactant functionality. SFEs are approved (21 CFR 179.859) in the United States for use as emulsifiers and stabilizers in a variety of food categories and as components of coatings to retard ripening and spoilage in several types of fresh fruits. In addition, SFE are effective lubricants, antaciking agents, thinning agents, and antimicrobials (Harrigan and Breene, 1993; Kabara, 1978; Marshall and Bullerman, 1994).

Other carbohydrate fatty acid esters and polyl fatty acid esters hold potential for fat replacing systems. Polyl fatty acid esters are prepared by reacting one or more fatty acid esters with a polyl containing at least four hydroxy groups in the presence of a basic catalyst (Unilever NV, 1988). Examples include sorbitol, trehalose, raffinose, and stachyose polyesters (Akoh, 1994). Sorbetin (Cultor Food Science, Inc., N.Y.), or sorbitol polyester for example, is a mixture of tri-, tetra-, and pentaesters of sorbitol and sorbitol anhydrides with fatty acids. The caloric value of Sorbetin is 1.5 kcal/g. Sorbetin is sufficiently heat stable to withstand frying temperatures. Sorbetin, which is not yet commercially available, is intended for replacement of fat in salad dressings, baked goods, and frying.

Alkyl glucoside polyesters, such as methyl- or octyl glucoside fatty acid polyesters, may be used to replace conventional fat in food formulations (Akoh, 1994). These polyol fatty acid esters are still under development.

Emulsifiers, such as sucrose fatty acid esters, mono- and diglycerides, sodium stearoyl-2-lactylate, lecithin, and polyglycerol esters, contain both hydrophilic and lipophilic properties that enable the emulsifier to stabilize the interface between fat and water droplets through hydrogen bonding. By acting as surface active molecules, emulsifiers can replace up to 50% of the fat in a formulation (CCC, 1996). They also provide and stabilize aer-ation, provide lubricity, complex with starch, interact with protein, modify the crystallization characteristics of other fats, promote and stabilize foam, control syneresis, carry flavors, and control rheology. Emulsifiers are most effective in replacing the functionality of fat when used in combination with other ingredients (CCC, 1996). Emulsifiers are useful in margarines, baked goods, frozen desserts, dairy products, spreads and shortenings, processed meats, whipped toppings, cake frostings and fillings, and confections.

Structured lipids (SL, Fig. 2) are triglycerides containing short chain fatty acids (SCFA) and/or medium chain fatty acids (MCT) and long chain fatty acids (LCFA). SL are prepared by chemical and enzymatic synthesis or random transesterification (Akoh, 1995a; Heird et al., 1986; Kennedy, 1991). SL are developed for specific purposes, such as reducing the amount of fat available for metabolism and, potentially, caloric value (Akoh, 1995a).

Medium chain triglycerides (MCTs) contain predominately saturated fatty acids of chain length C8:0 (caprylic) to C10:0 (capric) with traces of C6:0 and C12:0 fatty acids. MCTs are manufactured from vegetable oils, such as coconut and palm kernel oils, by hydrolysis followed by fractionation of the resulting fatty acids to concentrate C8 and C10 fatty acids and reesterification with glycerol to form triglycerides (Babayan, 1987; Bach et al., 1996; Megremis, 1991). The chemical structure of MCTs results in functional properties that are different from conventional fats and oils. MCTs, which contain saturated fatty acids, are stable at high temperatures and do not readily undergo oxidation (Babayan and Rosenau, 1991). MCTs are also稳定 at temperatures as low as 0°C and remain clear and nonviscous. MCTs are more soluble in water than long chain triglycerides (LCT). MCTs, which provide 8.3 kcal/g, are commercially available on the basis of GRAS self determination. They are used to replace liquid vegetable oils in low- and reduced-calorie foods, to carry flavors, colors, and vitamins; and to provide gloss and prevent sticking on confectionery products.

MCTs have been used clinically since the 1950s in enteral and parenteral diets for individuals with lipid absorption, digestion, or transport disorders. MCTs are metabolized differently from LCTs (Labarge, 1988). MCTs are absorbed intact into the intestine as free fatty acids, without the need for enzymes or bile salts as is required for LCT metabolism. MCTs bind to serum albumin and are transported to the liver via the portal system rather than the lymphatic system. In the liver, MCTs are oxidized to ketone bodies. Although MCTs are not a source of essential fatty acids, they are a source of readily absorbed, rapidly utilisable energy (Megremis, 1991). MCTs are less likely than LCTs to be stored in adipose tissue. For these reasons, fitness enthusiasts, body builders, and runners, in particular, may use MCTs as an energy source.

Caprocaprylohebolic triacylglyceride, commonly known as caprenin (The Procter & Gamble Co.), is manufactured from glycerol by esterification with caprylic (C8:0), capric (C10:0), and behenic (C22:0) fatty acids. Because behenic acid is only partially absorbed and capric and caprylic acids are more readily metabolized than other longer chain fatty acids, caprenin provides only 5 kcal/g. Caprenin's functional properties are similar to those of cocoa butter. As a result, caprenin is suitable for use in soft candy and confectionery coatings. The Procter & Gamble Co. filed a GRAS affirmation petition for use of caprenin as a confectionery fat in soft candy and confectionery coatings (CCC, 1996). Caprenin, in combination with polydextrose, was commercially available briefly in reduced-calorie and reduced-fat chocolate bars.

Salatrim (short and long acyl triglyceride molecule) is the generic name for a family of structured triglycerides comprised of a mixture containing at least one short chain fatty acid (primarily C2:0, C3:0, or C4:0 fatty acids) and at least one long chain fatty acid (predominantly C18:0, stearic acid) randomly attached to
the glycerol backbone. Because short chain fatty acids have a lower caloric value than long chain fatty acids and because stearic acid is incompletely absorbed, the caloric value of Salatrim is only 55% or 5/9 the value of conventional fats (Smith et al., 1994). Developed by Nabisco Foods Group (Parispanny, N.J.), Salatrim is licensed to Cultor Food Science, which established the brand name Benefat™ for manufacture and marketing. FDA accepted for filing in 1994 a GRAS affirmation petition submitted by Nabisco Foods Group.

Salatrim compositions with differing amounts of SCFA and LCFA provide select functional and physical properties, e.g., a range of melting points, hardness, and appearance. Salatrim was designed for a variety of applications, including chocolate-flavored coatings, dejected chips, caramels and toffees, fillings and inclusions for confectionary and baked products, peanut spreads, savory dressings, dips and sauces, and dairy products such as sour cream, frozen dairy desserts, and cheese (Kosmark, 1996). Salatrim, however, is not suitable for frying. The first Salatrim product, Benefat 1, was developed primarily to replace cocoa butter in confectionary applications.

Dialkyl dihexadecylmalonate (DDM) is a fatty alcohol dicarboxylic acid ester of malonic acid and alkylmalonic acid, synthesized by reacting a malonyl dihalide with a fatty alcohol. Alkyl halide, in a basic solvent, may be used to increase the molecular weight of DDM (Arzt and Hansen, 1994). Frito-Lay, Inc. (Dallas, Texas) patented DDM for use in replacing oil in food formulations or in frying (Fulcher, 1986). DDM is noncaloric because it is not digested or absorbed. It is not yet commercially available.

Esterified propoxylated glycerols (EPGs) comprise a family of derivatives of propylene oxide, synthesized by reacting glycerol with propylene oxide to form a polyester polyol that is subsequently esterified with fatty acids. EPGs differ from conventional triglycerides in the positioning of an oxypropylene group between the glycerol backbone and the fatty acids. Patented by ARCO Chemical (Wilmington, Del.) in the United States (White and Pollard, 1989) and in Europe (Cooper, 1990), EPGs are being developed by ARCO Chemical Co. and CPC International/Best Foods (Englewood Cliffs, N.J.) as a replacement for fats and oils in a variety of products including frozen desserts, salad dressings, baked goods, and spreads and for cooking and frying. EPGs can be tailored to produce specific functional properties (Harrigan and Breene, 1993) and are expected to be low in caloric value due to their lipase resistance. EPGs are not yet commercially available.

Trialkoxytricarballylate (TATCA), trialkoxycitrate (TAC), and trialkoxyglyceryl ether (TGE) are polycarboxylic acids with two to four carboxylic acid groups esterified with saturated or unsaturated alcohols having straight or branched chains of 8-30 carbon atoms (Hamm, 1985). Because the ester units of the substances are reversed from the corresponding ester present in triglycerides, these compounds are not susceptible to complete hydrolysis by lipases (Hamm, 1986). The synthesis and functional properties of the polycarboxylic acid esters and ethers are described by Hamm (1984). A U.S. patent (Hamm, 1985) for the polycarboxylic acid esters and ethers was assigned to CPC International. TATCA, TAC, and TGE are not yet commercially available.

• Protein-based Fat Mimetics.

Several fat replacers are derived from a variety of protein sources, including egg, milk, whey, soy, gelatin, and wheat gluten. Some of these protein-based fat mimetics are microparticulated (sheared under heat) to form microscopic coagulated round deformable particles that mimic the mouthfeel and texture of fat. Some fat mimetics are processed to modify other aspects of ingredient functionality, such as water binding and emulsification properties. Although the substances are generally not sufficiently stable to withstand frying, they are suitable for use as ingredients in foods that may undergo cooking, re-torting, and ultra high temperature processing. Protein-based fat mimetics are generally used in dairy products, salad dressings, frozen desserts, and margarines.

One of these mimetics, Simplesse® is manufactured from whey protein concentrate by a patented microparticulation process. Developed by the NatureSweet Kelco Co. (a unit of Monsanto Co., San Diego, Calif.), Simplesse was affirmed as GRAS (21 CFR 184.1498) in 1990 for use in frozen dessert products and in 1994 for use in yogurt, cheese spreads, frozen desserts, cream cheese, and sour cream. Simplesse is suitable for use in additional products that do not require frying, such as baked goods, dips, frostings, salad dressing, mayonnaise, margarine, sauces, and soups. The caloric value of Simplesse, on a dry basis, is 4 kcal/g. Formulation with hydrated gel forms, however, enables calorie reduction; for example, a 25% gel provides 1 kcal/g. Simplesse provides fat-like creaminess in high-moisture applications, but like other proteins it tends to mask flavor. Simplesse retains the biological value of the protein used and, hence, any antigenic/allergic properties of the protein (Gershoff, 1995).

• Carbohydrate-based Fat Mimetics.

Carbohydrates have been used in some foods for several years to partially or totally replace fat. Digestible carbohydrates such as modified starches and dextrins provide 4 kcal/g, while nondigestible complex carbohydrates provide few calories. Many carbohydrate products serve as thickeners or gelling agents in foods. Gums, starches, pectin, cellulose, and other carbohydrate ingredients provide some of the functions of fat in foods by binding water. They also provide texture, mouthfeel, and opacity (Giese, 1996). Corn syrups, syrup solids, and high-fructose corn syrups are used as fat replacers in many fat-free and reduced-fat foods to control water activity (aw). Polysaccharides such as sorbitol and maltitol as well as fructooligosaccharides may also be used to control aw. Fat-free salad dressings contain xanthan gum and carrageenan as stabilizers. Carbohydrate-based fat mimetics are not suitable for frying but can be used as fat barriers for frying and for baking.

Gums are high molecular weight negatively-charged carbohydrates used as thickeners to increase viscosity at concentrations of 0.1-0.3%, and as stabilizers and gelling agents. Gums that are used in fat replacing systems with other gums, fats, or fats replacers, or bulking agents include guar, xanthan, locust bean gum, carrageenan, gum arabic, and pectins. Gums are used in salad dressings, icings and glazes, desserts and ice cream, ground beef, baked goods, dairy products, and soups and sauces.

Starches of varying sources, types, and functional properties are used in fat replacing systems to provide sensory properties of oil, e.g., slippery mouthfeel. Starch sources include common corn and high amylose corn, waxy maize, wheat, potato, tapioca, rice, and waxy rice. Although native starch can sometimes be used to replace fat, starch modified (21 CFR 172.892) by acid or enzymatic hydrolysis, oxidation, deamination, crosslinking, or mono-substitution is more commonly used to achieve desired functional and sensory properties. Available in pregelatinized or instant forms, starches generally perform well in high moisture,
Fat Replacers

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Some polysaccharide gums and hydrocolloids, such as gums and pectins, to replace fat. Cellulose-based fat replacers that are plant in origin are obtained by mechanical grinding (e.g., powdered cellulose), chemical depolymerization and wet mechanical disintegration (e.g., microcrystalline cellulose/cellulose gel) and chemical derivitization (e.g., sodium carboxymethyl cellulose/cellulose gum, methyl cellulose/modifed vegetable gum and hydroxypropyl methylcellulose/carbohydrate gum).

Microcrystalline cellulose, considered GRAS, is noncaloric. Micr...


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