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Robert M. Kerr Food & Agricultural Products Center

FOOD TECHNOLOGY FACT SHEET

Adding Value to OKLAHOMA

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Shortenings

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Shortenings and margarines are fat systems that are formulated to deliver specific nutritional and functional properties required by the user and the application. In general, shortenings consist of 100 percent fat as compared to 80 percent fat in margarines (see fact sheet FAPC-210). Shortenings are formulated with vegetable oil and animal fat. Lard, tallow and ghee are traditional products which contain 100 percent animal fat. Vanaspati is another shortening-like vegetable oil-based product widely used in Eastern countries.

The name "shortening" refers to the property that imparts "shortness" to the food products. Shortenings lubricate, weaken or shorten the structure of food components providing desirable textural properties to the final product. For example, in a baked product made without shortening, gluten (flour protein) and starch particles adhere to each other resulting in a hard and tough sensation in the mouth. On the other hand, when a product is formulated with shortening, the fat disrupts the continuity of the protein and starch structure producing a tender, flakey and aerated bakery product. During frying, shortenings facilitate quick and uniform heat transfer and form a moisture barrier locking the moisture in the food and resulting in a moist product.

Shortenings are generally soft, odorless and have bland flavor and plastic solid consistency. The term plastic refers to a solid, non-fluid, non-pourable and non-pumpable shortening at room temperature. Shortenings also are available in the form of liquid, dry powder, pellets or flakes encapsulated in water soluble materials such as skim milk, cheese whey and soy protein isolate. Some products might have pale yellow butter like hue and flavor. They mostly are used for frying and baking. Liquid shortenings used for cooking and salad dressings may contain some solid fat and emulsifiers suspended in oil.

Shortenings give several desirable attributes to the bakery products: tenderness and texture, mouth feel, structural integrity, lubrication, air incorporation, heat transfer and extended shelf life. The functionality of a shortening is determined by three factors: i) ratio of the solid phase to the liquid phase in the shortening, ii) plasticity and iii) oxidative stability of the shortening.

The solid fat index (SFI) is an analytical tool used to determine solid fat content in fats and oils. SFI is temperature dependent and a good indicator of the plastic range of a shortening formulation. For example, high stability shortenings display a steep SFI, meaning SFI decreases rapidly with increasing temperature (SFI = 50 or greater at 10 degrees Celsius or 50 degrees Fahrenheit, usually SFI = 10 at 40 degrees Celsius or 104 degrees Fahrenheit). High stability shortenings tend to be hard and brittle below 65 degrees Fahrenheit or 18.3 degrees Celsius and soft over 90 degrees Fahrenheit or 32.2 degrees Celsius. Hence, they are not workable over wide temperature range. The applications of high stability shortenings include deep fat frying, confectionary, bakery, butter replacement, coatings, crackers and hard cookies.

All-purpose shortenings are designed for household use and for small companies that produce several different products and cannot afford to stock shortenings separately for each application. Solid fat content (crystalized fat) of all-purpose shortenings usually varies between 15

and 30 percent and retain these solids in the temperature range of 16 to 32 degrees Celsius or 60 to 90 degrees Fahrenheit. All-purpose shortenings may contain emulsifiers to improve creaming and air retention. Shortening without emulsifiers are suitable for frying, cookies and crackers. All-purpose shortenings can be prepared by partial hydrogenation of the base oil to an iodine value (IV) of 65 to 80. Iodine value measures the degree of unsaturation in fats and oils (a fat or oil with high IV indicates high unsaturation level, i.e. vegetable oils have higher IV than animal fats). It is important to note partially hydrogenated oils might contain trans fats (see fact sheets FAPC-133, 134 and 164). General purpose shortenings also may be prepared by blending oils that have been hydrogenated to a low SFI and low IV and adding about 10 percent long-chain saturated fats such as stearins or flakes (highly hydrogenated or fully hydrogenated vegetable oils). The melting points of shortenings are usually below body temperature to prevent a greasy mouth feel. Monoglycerides, lactylated monoglycerides, propylene glycol esters, lecithin, polyglycerol esters, polysorbate 60 and sodium stearoyl lactylate are the most common emulsifiers used in shortenings.

Fluid or pourable shortenings can be pumped and metered, hence, they are convenient to handle during large scale food production. SFI profile (SFI versus temperature curve/line) of these products are very flat due to their very low solid content. Solid fat phase comprises of small (less than or equal to 15 micron) size stable crystals. Liquid shortenings can be produced by partial hydrogenation of vegetable oils. Partially hydrogenated oil is fractionated to separate liquid and solid phases. The liquid phase or oil is usually free of solids above 16 degrees Celsius or 60 degrees Fahrenheit. Liquid shortening also can be prepared by blending a hard fat such as lard and an emulsifier (e.g. lecithin) and cooling it slowly while mixing the blend gently. The final product retains its fluidity for an extended time. An emulsifier prevents co-crystallization of liquid and solid components during cooling. Air incorporation should be minimized during fluid shortening production because small air bubbles could push the fat crystals to the surface resulting in a non-homogenous product. Fatty acid esters of dextrin, fatty acid esters of disaccharides such as sucrose esters, fatty acid esters of polyglycols and sorbitol are some of the additives that inhibit co-crystallization.

Liquid and fluid shortenings can be distinguished by their appearance. Fluid shortenings appear opaque (not clear) because of the presence of suspended solids (usually 5 to 15 percent) such as high melting emulsifiers and/or fully hydrogenated fats. These products are usually fluid in the range of 18.3 degrees Celsius (65 degrees Fahrenheit) to 32.2 degrees Celsius (90 degrees Fahrenheit. Outside this temperature range, fluid shortenings lose their fluidity and cannot be poured or become liquid losing their opaqueness, depending on the temperature change. Fluid shortening are mostly used in frying applications but also formulated for bakery applications such as cakes, bread, buns, rolls and pie crust.

Flavor and oxidative stability are the most important characteristics of a good frying shortening. Foods fried in a shortening formulated with fats that melt at high temperatures may impart a greasy or waxy sensation in the mouth due to the thick fat layer formed on the surface of the product during frying. Potato chips absorb significant amounts of fat during frying, hence, shortenings with low solid content would be a healthier option for this application. Coated doughnuts require a high stability and high melting temperature frying fat. Powdered sugar coatings may not adhere to the doughnut surface well if the solid content of the frying shortening is too high. On the other hand, if the solid content of the frying shortening is too low, glazes will not stick and too much powdered sugar will adhere to the doughnut surface. In such a case, the coating could fall off in clumps, and the product would soak up too much oil and end up being an unpleasant greasy product.

In general, larger bakeries prefer pumpable shortening rather than traditional bag-in-box plastic shortenings. Liquid and fluid shortenings provide a number of advantages including easier compliance with recycling regulations, improved hygiene, more flexibility for oil selection, can be reformulated if needed, reduce costs due to the less work force and raw material needs, and ease of handling and incorporation into product mix.

Specialty Shortenings

Roll-in shortenings are specifically formulated for bakery applications, specifically puff pastry, which is made by placing one layer of shortening on a layer of dough. This is folded and sheeted until there are hundreds of layers of dough-fat layers. During baking, steam is released puffing the thin dough layers creating a flakey structure. SFI profile of puff pastry shortening is very flat with solid content of 40 percent or higher at 10 degrees Celsius or 50 degrees Fahrenheit and about 20 percent solids at 33.3 degrees Celsius or 92 degrees Fahrenheit.

The shortenings formulated for icing and cakes where performance is crucial, may contain 5 to 8 percent mono and diglycerides as emulsifiers. Saturated mono-

glycerides are preferred in cake shortenings because they form complexes with the amylose fraction of starch producing softer crumbs and longer shelf-life to the final product. Soybean, cottonseed, canola and corn oil and animal fat often are used in formulating cake shortenings. Crystal structure of the solid fat used in shortenings is critical for its functionality and the texture of the final product. Beta-prime-type crystals provide a smooth texture and improve air incorporation into the dough. Wide temperature fluctuations cause a phase change, converting beta-prime crystals to beta crystals, which are less effective in incorporating air and reduce cake baking performance.

Shortening content of cream icings is about 40 percent. Solid fat content and crystal structure of the shortening used for icing is critical for the consistency. Beta-prime crystals of high melting point fats impart good texture and body over a broad temperature range. Addition of hydrophilic emulsifiers to the shortening improve aeration, stability and melting profile in the mouth.

Filler shortenings are used for bakery products where one layer of filler mixture is placed between two pieces of cookies or wafers in a sandwich form. Filler fat shortenings should be firm to provide support to the fragile cookies and should not snap or squeeze out when pressed or broken. A shortening with high solid content at room temperature provides the desired properties. The shortening must completely melt in the mouth at body temperature to avoid a waxy mouth feel. SFI profile of a desirable filler shortening is significantly steeper than the SFI profile of an all-purpose bakery shortening. A low solid fat content at low temperature (about zero at 40 degrees Celsius), good stability at higher temperatures without oiling out or sticking and a short plastic range are desirable characteristics of a good filler shortening. Typically, a ratio of 60:40 of partially hydrogenated fat to vegetable oil and 1 to 5 percent emulsifier are used in filler shortenings.

A typical bread formulation contains about 3 percent shortening based on flour weight. Too much fat can inhibit rising of dough during proofing. Bread shortening provides lubrication during dough mixing. Solid fat content of the bread shortening is vital to strengthen the dough and retain gas during the initial stages of baking. Bread shortenings have a wide plastic range at room temperature. For example, a typical plastic bread shortening would have more than 90 percent partially hydrogenated blend of vegetable oils (IV is about 75), i.e. soybean (85 percent) and cottonseed (15 percent) and 5 percent emulsifier.

The function of the shortening in pie formulations is to provide lubricity and tenderness, not aeration, without significantly affecting the water absorbing properties of the flour. Pie crust shortening tenderizes and shortens the crust and prevents sogginess. Grainy crystal structure of the shortenings used for making pie crust results in a flakey texture. Emulsifier addition to the shortening improves uniform fat dispersion, hence, is detrimental to flakiness. Solid fat content of a pie crust shortening is similar to an all-purpose shortening.

Dry shortenings are fats that are encapsulated in a coating material. They are sold in the form of pellets, powder and free-flowing starch-shortenings. The pellets have a soft fat center coated with a harder fat. These products are relatively easy to store and distribute. The powdered shortenings are produced by encapsulating fat in a material that can be dried, i.e. microcrystalline cellulose or water-soluble protein. Spray drying is the most common method used for production of dry shortenings. Free flowing starch-shortenings are basically dry baking mixes. These are used for sweet dough, biscuits, cake and pie crust mixes. Dry baking mixes are made by incorporating shortening into flour, sugar, non-fat milk solids, emulsifiers and salt. As the name implies, these products are dry to the touch, and the shortening should not exude from the mix.

Conclusions

The concerns over the adverse health effects of trans fats are leading to a series of changes in product labeling rules and having a significant impact on the margarine and shortening industry. The challenge is finding trans fat-free alternatives without compromising functionality affecting product flavor, texture, shelf-life and, consequently, consumer acceptance of the final product. Today, many companies offer low trans and trans-free shortenings. It is important food product formulators and producers work closely with their ingredient suppliers to determine the best shortening options for their applications. Many shortening suppliers would work with their customers to develop custom shortening formulations for specific applications.

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