Cottonseed oil as a frying medium

The following article on cottonseed oil was prepared by C. Clay King and Mary Ellen Camire of the Department of Nutrition and Food Sciences at Texas Woman's University, Denton, Texas, and Frank Orthoefer of Riceland Foods, Stuttgart, Arkansas.

Cottonseed oil, the nation's first vegetable oil, dominated the U.S. market for almost 100 years, until the 1940s, and has maintained an important position in its role as a cooking and frying oil. U.S. Department of Agriculture (USDA) 1987 figures (1) show 405 million pounds of cottonseed oil were used as salad and cooking oil, and an additional 136 million pounds were used as baking and frying fat. The production of corn and soybean oils, however, has increased during the past three decades, and cottonseed oil now ranks third in volume.

"Cottonseed oil's composition, flavor and stability make it ideally suited for the rigors of frying," according to Lynn Jones, director of research and education for the National Cottonseed Products Association. "This is why it has maintained a premium value among domestic oils although it is only about 6% of the U.S. oil supply."

Oil composition

The demand for cottonseed oil has persisted because the oil's composition is well suited for frying. Although the composition may vary somewhat, the fatty acid profile of cottonseed oil generally consists of 22% saturated fatty acids, primarily palmitic; 18% oleic acid, a monounsaturated fatty acid; and approximately 54% linoleic acid, which is an essential fatty acid (2). This composition gives cottonseed oil its ability to resist oxidation.

The triglyceride composition of cottonseed oil also is unique. About 22% of the molecules contain two linoleic and one saturated fatty acid; the next most common type consists of two saturated fatty acids, usually palmitic, at the one and three acyl positions and either oleic or linoleic at the two position (3). Cottonseed oil also is rich in tocopherols, which are natural antioxidants with varying degrees of vitamin E activity. This, too, contributes to its stability.

Frying process

Deep-fat frying allows higher temperatures to be reached during cooking than in baking or boiling, and desirable browning and flavors develop (4). Many processes occur simultaneously during the frying of foods. These include: the release of water, lipids, pigments and other compounds from the food into the oil; the absorption of the oil by the food; the hydrolysis of triglycerides into free fatty acids and glycerol; and the oxidation of the fatty acids of triglycerides and the formation of hydroperoxides and other breakdown compounds (5). Other physical and chemical changes that occur in frying oils are darkening, increased viscosity, decreased iodine value and increased peroxides and free fatty acids.

Thus, a good frying oil is one which resists both oxidative and hydrolytic rancidity and exhibits good sensory characteristics. Saturated fatty acids are less susceptible to oxidation, and longer chain fatty acids are less likely to produce off-flavors and aromas. Also, the frying oil should possess a light color and a bland or pleasant mild flavor. For example, a food may absorb 5–40% of its weight in fat (6); therefore, the quality of the frying medium is crucial to the quality and shelf-life of the final product.

Sensory quality

Cottonseed oil has a light golden color and a mild pleasant flavor. Kathleen Warner of USDA's Northern Regional Research Center reported that sensory panelists described the flavor of cottonseed oil as nutty/buttery, which is 8 on the AOCS Flavor Quality Scale (7). Some cold-pressed oils, such as olive and peanut, are valued for their characteristic mild flavors; strong flavors are not preferred. Cottonseed oil is well-known for its bland, slightly nutty taste. For this reason, when used with certain foods, cottonseed oil often is the standard against which other oils are compared for odor and flavor (8).

Warner (7) also evaluated the frying stability of cottonseed, soybean, low erucic acid rapeseed, sunflower and high-oleic sunflower oils and found that the cottonseed and high-oleic sunflower oils produced much less room odor when heated. A mild odor is an indication of quality. Cottonseed and other oils which contain palmitic, stearic and oleic acids in large amounts are more stable because they are "naturally hydrogenated."

Flavor stability

In general, off-flavors are caused by products of the oxidation of the frying oil and the oil absorbed by the food. The oil extracted from potato chips in one study had increased volatiles and peroxide values that resulted from the oxidation of the soybean oil in which the chips were fried (9). The iodine and diene values of cottonseed oil are lower than those of soybean oil. As a result, cottonseed oil has a longer shelf life.

In another potato chip study by Robertson and coworkers (8), sunflower, cottonseed and palm oils were evaluated for their contribution to flavors. The chips fried in cottonseed oil were used as the standard to which the chips fried in other oils were compared. The flavor of chips fried in the three oils deteriorated at the same rate during storage. During the first eight weeks of storage, cottonseed- and sunflower-oil fried chips had better flavors than chips fried in palm oil. At 10 weeks of storage, all chips had poor flavor, but cottonseed-oil chips received the smallest percentages of rancid and off-flavor responses. In a study at the Univer-

sity of Manitoba, potato chips fried in cottonseed oil and stored in the dark were more resistant to oxidation than chips fried in canola oil (10).

Resistance to oxidation

Potato and corn chips are products with relatively high turnover rates (8). Since the water activity in chips is low, most of the deteriorative changes that occur with time involve the lipids in the chips. Manufacturers aim to minimize rancidity in chips up to 90 days old, but chips are generally sold or removed from store shelves by 50 days.

The oils used in commercial chipping are not abused as much as oils in fast food operations, and temperature and replenishment are regulated more carefully. Thompson and associates (11) compared cottonseed oils used by a potato chip company and another food manufacturer. The chip oil was not abused, but the damage in the other used oil was visible. Still, deterioration in the frying oil is reflected in the final chip. The longer a frying oil is used, the greater is the decrease in the quality of the oil and the chips.

Antioxidants

Antioxidants in frying oil can carry through to chips. The antioxidants protect the chips against oxidation during storage. Although deterioration is inevitable, many snacks are consumed well before any rancidity is detectable. Many synthetic antioxidants are approved by the Food and Drug Administration for use in foods as long as each compound is present at levels of 0.01% or less. If two antioxidants are used in a system, the allowed level is 0.02%. Potato chips fried in cottonseed oil that contained no antioxidant, BHA, ascorbyl palmitate, BHT and propyl gallate were rancid in 10, 10, 15, 14 and 24 days, respectively (12). The chips cooked in cottonseed oil contained more tocopherols than chips fried in peanut oil (13).

Hydrogenation effects

The processing of the oil used in frying may contribute to the flavor of the chip as well. Chips fried in hydrogenated vegetable oils, particularly soybean, have a "hydrogenated" or "hardened" flavor compared to chips fried in nonhydrogenated oils (14). Only expert tasters may detect this flavor in fresh chips, but the flavor intensifies as the chips are stored, and is noticeable to consumers. Less expensive soybean oil is used by chippers despite its flavor problem, but a blend of 15-25% cottonseed oil with 75-85% partially hydrogenated soybean oil can overcome the taste problem of soybean oil (4) and minimize oil expenses.

Several physical states of cot-

tonseed oil are used in frying: oil, liquid shortening that is partially hydrogenated and shortening that has been hydrogenated to a solid state. According to the Institute of Shortening and Edible Oils (15), there is a misconception that hydrogenated fats are saturated when, depending upon the degree of hydrogenation, they may contain a large amount of monounsaturates as well as some polyunsaturates.

Influence on texture

The texture or mouthfeel of a finished chip is very dependent upon the type and amount of fat absorbed. Fat pickup is reduced by 10-15% when the chip is fried in a vegetable oil, such as cottonseed oil, vs. in a fat which is a solid at room temperature (16). The better draining of oil from the cooling chip is probably responsible for a lower fat absorption and resistance to hydrolysis than that found in solid fat-fried chips. Increased viscosity of the fat and the surface characteristics of the chips may cause excessive fat to cling to the chip as its exits the fryer. Other factors influencing fat pickup are moisture content of the chip, oil temperature, length of frying time and chip thickness.

In addition to the amount of fat absorbed, the quality of the fat will affect the texture. If the Solid Fat Index (SFI) of the absorbed fat is too low, the product will exhibit a shiny, oily appearance and the surface texture may be weakened. If the SFI is too high, the chip texture may be gummy or waxy (14, 16). Bessler and Orthoefer (17) noted that the nonoily appearance of chips fried in cottonseed oil is due to the greater proportion of diunsaturated and monosaturated triglycerides in this oil. The use of cottonseed oil in chip frying results in a pleasant mouthfeel and a bright finish (4).

Use in snack foods

Many potato chip manufacturers use cottonseed oil exclusively for frying their products because of the good flavor imparted to the chips as well as cottonseed oil's stability compared with other vegetable oils (18). Cottonseed oil may enhance the toasted corn flavor of corn chips (14) because the oil has a slightly nutty taste.

Melnick, Luckmann and Gooding (19) sampled fresh and heated oils used by commercial potato chip manufacturers and found cottonseed oil was the predominant oil used. In the oils of 95% of the chippers, the free fatty acid value was 0.60% or less and the iodine value decreased by 3.0% or less in the frying oils. Corn oil, at 0.39%, exhibited the greatest increase in free fatty acid values after heating, while cottonseed cooking oil values increased by less than half that amount.

Food service applications

Frying oils used by manufacturers have a relatively high turnover rate, which can be up to 100% daily. Due to the large quantities of foods which are fried, the fat absorbed by the food is removed continuously and must be replaced. Fats used in food service operations are replenished at lower rates, averaging 20-35% per day (20), and thus are subjected to more thermal and oxidative degradation than are oils used by chippers. As fast foods are consumed immediately after preparation, rancidity is not generally a problem, but off-flavors in the cooking oil will carry through to the food.

Hydrogenated fats are used widely as frying shortening because they have greater resistance to oxidation. As previously noted, hydrogenated soybean oil has some flavor problems which can be masked by blending with cottonseed oil. Such blends are used widely in restaurants. Tallow-cottonseed blends are especially popular now for frying french fries. Another advantage of using blends is the minimization of changes in product flavor due to changing the oil used when market conditions favor one type of oil over the other. Customers come to expect their favorite menu item will always taste the same, but this is not possible if the type of frying oil used is constantly changing. As with manufacturing use, cottonseed oil meets the needs of food service frying operations.

Cottonseed oil blends

Soybean and canola (rapeseed) oils, in particular, develop objectionable fishy odors during frying due to their high linolenic acid contents. Frying oil odors may linger, limiting the use of oils, especially canola which contains up to 10% linolenic acid, in some food service situations. Odor intensity and the production of volatiles and furfural were reduced in heated canola oil when cottonseed oil was added to dilute the linolenic acid of the canola (21). When stored at 40°C, used cottonseed oil had less rancid odor than did used canola oil (10). The rancid odor scores for used canola oil stored at 40°C and in the presence of light also were higher than those for cottonseed oil, but the differences between the two oils were not as great. Thus, the adverse characteristics of canola may be overcome by blending with cottonseed oil.

Soybean is the major vegetable oil in the U.S. due to its availability and low cost. Although bland when first processed, soybean oil can undergo an unpleasant flavor reversion. Consequently, it is blended with 15-20% cottonseed oil for frying to mask this flavor (4). Soy oil also produces unpleasant odors when heated. Blends of cottonseed oil with soybean oil, ranging from 0-100%, were evaluated by a sensory panel for room odor intensity value and pleasantness score (22). Fishy and rancid odors were higher in the blends containing more soybean oil. The highest preference scores were given to the oils containing 75% or more cottonseed oil.

The popularity of beef tallow for the unique flavor it imparts to french fries has increased the use of tallow-cottonseed oil blends by food service operators (23). Since the cottonseed oil is unsaturated, health-conscious consumers are more likely to accept the blends over the saturated tallow. The mild taste of cottonseed oil enhances the tallow flavor, and the cost of the

blend is less than 100% vegetable oil.

Choice of the U.S. food industry

Because of its composition, flavor and stability, the use of cottonseed oil in its various forms, particularly in blends with other fats and oils, will remain strong in frying applications. According to R.W. Garcia in an interview for *Snack Food* magazine (24), cottonseed oil is used to fry his firm's tortilla chips because it has "good color, a nutty flavor, good shelf life and good stability in manufacturing."

Don Kline of Snyder's of Hanover, a snack food manufacturer, said in the April 1988 *Snack World* (18) that cottonseed oil does not require hydrogenation for good frying stability, unlike safflower, sunflower, corn and peanut oils.

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HEALTH & NUTRITION

National conference eyes cholesterol

The following article highlighting findings discussed at the First National Cholesterol Conference sponsored by the National Cholesterol Education Program (NCEP) was prepared by J. Edward Hunter of Procter & Gamble Co., Associate Editor for JAOCS *News for Health and Nutrition.*

The First National Cholesterol Conference, entitled "Cholesterol: A Risk Factor Whose Time Has Come," was held Nov. 9-11, 1988, in Arlington, Virginia. The purpose was to allow researchers, physicians, and policy and program experts the opportunity to share their knowledge and program successes in the field of cholesterol. The conference included discussion of current adult treatment guidelines, planning sessions related to diet and blood cholesterol, workshops on cholesterol measurement and screening, and exhibits displaying equipment, products and services related to cholesterol education and control.

About 25% of adult Americans are considered at increased risk of developing coronary heart disease (CHD) due to high blood cholesterol, namely those with total serum cholesterol levels greater than 240 mg/dl, according to NCEP officials. Surveys indicate that less than half of all adults have had their cholesterol checked during the last year, and only 7% know their own level. Although there appears to be agreement that total blood cholesterol levels less than 200 mg/dl are desirable for adults, some speakers pointed out that even individuals with total cholesterol levels under 200 mg/dl could be at increased risk if their high density lipoprotein (HDL) levels also are low, i.e., less than 35 mg/dl.

Adult Treatment Panel guidelines

In three concurrent sessions, experts in lipid research and cholesterol education expressed their views on the NCEP Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol (Adult Treatment Panel report). The panel had classified people with total serum cholesterol values ranging from 140 to 300 mg/dl into three groups: "desirable"as less than 200 mg/dl, "borderline high" as 200-239 mg/dl, and "high" as greater than 240 mg/dl.

NCEP's Step-One Diet, which is identical to the American Heart Association's prudent diet, includes reducing daily fat intake to less than 30% of calories, with less than 10% from saturated fat, no more than 10% from polyunsaturated fat