

SoyConnection

FALL 2016 VOLUME 24, NUMBER 4

Health & Nutrition News About Soy

THE TWO FACES OF EDIBLE SOY: VEGETABLE OIL, AND PROTEIN

By Mark Messina, PhD

When one thinks of soy, the traditional Asian soyfoods—tofu, miso, natto, tempeh—most likely come to mind. While these foods play key roles in Asian cuisines and increasingly in non-Asian cuisines, they account for only a small percentage of the soybeans produced worldwide.

About 600,000 US soybean farmers produce nearly four billion bushels of soybeans per year, which is equivalent to over 800 billion pounds.¹ The US crop represents about 40 percent of the world's soybean production. Most of the soybeans—about 85 percent—are processed into meal (protein) and oil. The former is used primarily as animal feed, whereas the latter has become the most widely consumed vegetable oil in the world. In fact, soybean oil accounts for about 7 percent of the caloric intake of Americans and contributes over 40 percent of the US intake of both essential fatty acids.²

Soybean oil is used extensively by the food industry, although most oil is purchased directly by consumers. However, since soybean oil is typically marketed as 100 percent vegetable oil, many consumers may not recognize they are actually consuming soy. If not being exposed to soy via soybean oil, for many consumers exposure to soy will occur in the form of lecithin.

In this country, soybean oil is the primary source of this emulsifier which is widely used by the food industry and which has also been studied for a number of health benefits especially in the areas of cognitive function³⁻⁶ and inflammatory-related diseases.^{7,8} Soybean oil is also a rich source of vitamins E and K.⁹ The predominate form of vitamin E in soybean is gamma-tocopherol,¹⁰ which has been



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less well studied than alpha-tocopherol but which may have some desirable health attributes not shared with alpha-tocopherol.^{11,12}

Soybean oil has a very heart-healthy fatty acid profile as it is comprised of almost 90 percent unsaturated fatty acids, about two-thirds of which is linoleic acid.¹³ Nevertheless, new varieties of soy oil are being developed. For example, as discussed by Wang and MacDonald elsewhere in this issue, high-oleic soybean oil was developed in response to the almost complete removal of trans fatty acids and partially hydrogenated oils (PHO) from the US food supply. PHOs were designed to be healthful alternatives to saturated sources of fat, such as lard and butter, but were later shown to have adverse effects on blood lipids at modest levels of intake. Alternatives are needed to replace the functional properties provided by trans fat sought by the food industry. New oils with the desired properties can also be created by interesterification and blending.

Many consumers who aren't directly consuming soyfoods are still meeting part of their protein needs from soy protein. A small percentage of meal that is left after removing the oil is used to make several soy protein products including soy protein isolate, soy protein concentrate and soy flour. By definition, these products are approximately 90 percent, 70 percent and 50 percent protein, respectively.

As discussed by Riaz, also in this issue, these soy products have a variety of functional properties that account for why small amounts are added to literally hundreds of commonly consumed foods. In addition, because consumers are looking to increase their protein intake, soy protein, especially in the form of soy protein isolate, is being added to foods to increase their overall content of this macronutrient. Finally, various forms of soy protein are ideal base ingredients for meat analogs such as burgers, sausages and chicken nuggets because soy is a high-quality protein and has a largely neutral flavor profile that allows food scientists to develop products that taste similar to their meat-containing counterparts.

In conclusion, soybeans are important, sustainable, components of the food supply because they provide a wide

variety of healthful oils that can be tailored for their nutritional and functional properties, are sources of high quality protein,¹⁴ and are ideal for the formulation of a plethora of nutrient dense and affordable foods. 🌱

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The *Soy Connection*, funded by farmer checkoff dollars, is produced by the United Soybean Board. An electronic version of this newsletter, with complete references, can be found at www.soyconnection.com.

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SOYBEAN OIL CORNER



Soy Oil Advances with Food Applications Through Emerging Technologies

By Tong Wang, PhD, and Ruth MacDonald, PhD

Soybean oil was introduced to the American consumer during World War II when domestic and imported sources of fat became limited. Because of its versatility for home and commercial food preparation, soybean oil grew to be the major contributor of both essential fatty acids to the US diet.

The richest dietary sources of n-3 fatty acids are fish and fish oils, and flaxseed. Soybean and canola oil contain alpha-linolenic acid (ALA) (Table 1) in amounts higher than corn, olive or palm oil. The endogenous conversion of ALA to the longer chain omega-3 fatty acid, eicosapentanoic acid (EPA) is, however, inefficient. Therefore substantial research has been undertaken to develop new varieties of soybean that contain fatty acids which are more likely to be converted to health-promoting fatty acids such as EPA.

The result has been a soybean oil that contains 18–20 percent of the omega-3 stearidonic acid (SDA). Not only is this oil about 3x higher in omega-3 fatty acids than conventional soybean oil, but SDA is more efficiently converted by the human body to EPA than ALA.^{1,2} The FDA has approved

the use of SDA soybean oil and it is currently being developed for commercial scale production.³

Full or partial hydrogenation was developed in 1911 with the commercialization of Crisco, and became commonly used during the 1950s as a means to modify soybean and other vegetable oils to generate shortening and margarines to replace solid fats such as lard and butter. Concerns about saturated fats and cholesterol led nutritionists and public health authorities to recommend expanded use of margarines and shortenings and food manufacturers were under great pressure to eliminate animal fats from their products. Partially hydrogenated vegetable oils (PHOs) provided the functionality and product quality that food manufacturers needed in addition to being lower in saturated fat and free of cholesterol. Consequently, PHOs became widely used. The purpose of hydrogenation is to reduce the number of double bonds so the oil becomes more solid at room temperature and to increase oxidative stability. However, a negative consequence of the process is that some of the naturally occurring cis-double bonds are changed

Table 1. Typical fatty acid composition of oil (%)

Oil source	Palmitic acid (C16:0, saturated)	Stearic acid (C18:0, saturated)	Oleic acid (C18:1n9, monounsaturated)	Linoleic acid (C18:2n6, polyunsaturated)	Linolenic acid (C18:3n3, polyunsaturated)	Stearidonic acid (C18:4n3, polyunsaturated)
Soybean	11	4	23	54	8	
Corn	12	2	28	57	1	
Canola	4	2	64	19	9	
Olive	14	3	71	10	1	
Palm	45	5	39	9	0	
High oleic soybean ⁶	7	3	76	8	2	
Stearidonic acid soybean ³	12	4	15	20	18 (n3 and 6)	28

to the trans configuration. Although not recognized at the time, the unusual confirmation of trans-fats causes them to have adverse effects on blood lipids by increasing LDL-cholesterol and decreasing HDL-cholesterol, which are known risk factors for heart disease and atherosclerosis.⁴

Rising concerns about the health effects of trans-fats led the FDA to require them to be listed on the Nutrition Facts panel in 2003. Because PHO are a source of trans-fats, the FDA in 2015 determined that they should be removed from the “Generally Recognized as Safe” list and required food manufacturers to reformulate their products without PHO by 2018. Hence, efforts to eliminate trans-fats and to find replacement for PHO have been ongoing for several years.

Food scientists have been creative in developing ways to modify oils to achieve useful liquid-solid ratios without generation of trans-fats. The inter-esterification reaction (mostly catalyzed by enzymes) uses liquid oil and a saturated fat source to redistribute fatty acids in the triglyceride structure to make the product more solid. A saturated fraction of palm oil (palm stearin) or palm kernel oil can also be modified using this approach to produce a solid fat that contains zero-trans.

Fractionation is another tool that physically separates an oil into a more saturated stearin (solid) and a less saturated olein (liquid) fraction. The stearin fraction can then be blended with soybean oil to produce a semi-solid fat without trans-fats, making it suitable for a wide range of food applications. Another novel technology for converting liquid oil to solid or semi-solid fat is the creation of an oleogel. A gelator, such as a cellulose-based compound or plant wax, can be added to soybean oil to form a fat that has similar structural and mechanical properties as that of fat made using partial hydrogenation.⁵

Finally, the development of a high-oleic soybean variety which has a reduced saturated fat content and three times the oleic acid content of conventional soybean oil has potential to replace PHO, especially for frying. High oleic soybean oil may also be used in blending and inter-esterification for making margarines and shortenings that are trans-free.⁶ It is projected that 9.3 billion pounds of high oleic soybean oil will be available by 2024.⁷



The future of soybean oil for food manufacturing and home food preparation continues to be bright as new varieties with health-promoting benefits and food applications are being developed, and novel ways to modify fats and oils are created. 🌱

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Soy Protein Prevalent In Food Products, Uses

By Mian N. Riaz, PhD, CFS

Consumers continue to demand healthier food products. Given the choice, most consumers would prefer to enhance or improve their diet using food and drink related products rather than pharmaceuticals.¹

Soy ingredients are being used in food products by the food industry to enhance functional properties and to provide better nutrition.

Soybeans have great potential for use as human food because of their high level of good quality protein and their unique functional and nutritional properties. Soy protein supplies all nine essential amino acids and provides many functional benefits to the food processors. Most of the food industry uses soy ingredients in their products for a healthy image as well as for improving the product quality and managing cost.

Traditional soyfoods such as tofu, soy milk, miso and tempeh have been consumed for centuries by Asian populations. Adding these ingredients into mainstream food is not an easy process and sometimes taste becomes an issue. Instead of these products, the soy processors have come up with several soy ingredients such as soy flour, concentrates, isolates and textured soy protein

that provide functional properties that have been widely embraced by the food industry.

One of the most important properties of soy protein in food systems is its ability to form gels after heating. Heat gelation contributes to textural properties, shapes the product, holds other food components and retains water in the product. Most functional soy protein ingredients are used to accomplish the following objectives: bind or immobilize fat and water; improve sensory or organoleptic properties; improve shelf life; regulate viscosity and modify gel structure.² This information is essential for manufacturing and utilizing soy protein ingredients that will meet the food industry's functionality requirements. From a sensory point of view, taste and color are the most important properties when using soy protein in food formulations, followed by texture and mouthfeel. Organoleptic properties include several variables, such as texture, fibrosity, juiciness, taste, flavor and color.

During the manufacturing of soy protein isolates, which by definition are at least 90 percent protein, unwanted flavors are removed. Sometimes, for certain applications, a flavor profile can be altered to accommodate specific needs. Research on flavor and taste continues to be important for future soy protein applications in food, since a

small percentage of the flavor can carry through to the finished products (both in a positive and negative sense). The successful application of soy protein ingredients in the food industry requires they be capable of providing one or more key functional attributes at various critical stages in the fabrication, handling, storage,



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preparation and utilization of a given food product.

The food industry takes advantage of some of the functional properties including: adhesion, coagulation, color control, cohesion, colloidal stability, dispensability, elasticity, emulsification, fat absorption, flavor binding, foaming/aeration, gelation, hydration capacity, rehydration, solubility, viscosity, water absorption and binding.³ Additionally, soy can be applied as a fat substitute in items such as meat, fish, milk, cereal-based products and infant formulations. Food processors take advantages of these properties in different foods including, meat, sausages, baked goods, flour tortillas, desserts, pasta products, bread, simulated meats, whipped topping, desserts, cakes, beverages (dairy and non-dairy), soy drinks, soups, and gravies.⁴

The food industry uses soy ingredients to achieve specific functions. Examples of such uses include: soy flour, soy concentrates, and soy isolates. These are used in meat, sausages, baked goods, flour tortillas, desserts, and pasta products where protein acts as adhesive material and provides adhesion. Full fat soy flour is used in bread and allied bakery products, where lipoxygenase enzymes bleach the flour and bakers control the color of their products. Soy isolates are used in meat and meat products and bakery items to provide elasticity through disulfide links in gel deformable action. Textured soy protein and concentrate are used in meat and breakfast cereals. Soy fibers are used in beverages and other cereal based products and soy lecithin is used in the bakery industry. 🍌

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Many Soy Ingredients Available for Food Applications

Currently, there are more than 20 different soybean ingredients that are available on the market for food application. These ingredients include:

- Roasted soy nuts
- Enzyme-active full-fat soy flour and grits
- Enzyme-inactive full-fat soy flour and grits, also called toasted full-fat soy flour and grits or heat-treated full-fat soy flour
- Extruder-processed full-fat soy flour and grits (enzyme-inactive)
- Enzyme-inactive low-fat soy flour or grits
- Enzyme-active defatted flake/soy flour (90 PDI)
- Defatted soy flake/flour with 70 PDI
- Defatted soy flake/flour with 20 PDI
- Soy flour (textured, refatted or lecithinated)
- Soy concentrates
- Textured soy concentrates
- Soy isolates
- Soy germ
- Soy isoflavones (mechanically extracted)
- Soy isoflavones (chemically extracted)
- Fiber from hulls
- Soy fiber from cotyledon
- Organic soy flour and organic concentrates



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