

2ND EDITION

SOYBEAN OIL INNOVATIONS

Superior Functionality
Improved Nutrition
Trans Fat Solutions



Soybean Oil Delivers Better-for-You Products

One of the world's most widely used edible oils.

Almost all margarine and shortenings in the United States contain soybean oil. It also is almost universally found in mayonnaise, salad dressings, frozen foods, imitation dairy and meat products and commercially baked goods. Soybean oil has little flavor, which is an advantage because it won't interfere with the overall taste of the food. Most but not all oils sold as "vegetable oil" are actually soybean oil.

VERSATILE

Soybean oil's clean, natural taste and nearly imperceptible aroma support and enhance the natural flavors of prepared foods. Whether used as a shortening for an old-fashioned pie crust or blended with a flavored vinegar for a new dressing, soybean oil's neutral flavor lets the real taste of the food product come through.

Adaptable to nearly every fat or oil application in the food industry, soybean oil works well with other ingredients including other fats and oils, making it very suitable for use in salad dressings, sauces and baked goods. Soybean oil is available with OSI (Oil Stability Index) stability levels ranging from 7 to over 60 hours, and it is a proven performer in the wide range of applications required by snack food manufacturers, bakeries, foodservice providers and more.

Liquid soybean oil is used in 100% formulations for cooking oil and to create mayonnaise, salad dressings and sauces. Soybean oil can turn 2 ounces of olive oil into a whole pint of flavored oil for dressings. The distinctive olive oil aroma will be evident, even though the bulk of the dressing's oil component comes from inexpensive soybean oil. Oils that are flavorful, such as olive, peanut and walnut, are generally expensive and it only takes a small amount in a blend with soybean oil to make a large quantity of flavored oil. Chefs and food companies have long practiced oil blending to gain the benefits of flavored oils and save money on ingredient costs.

Soybean oil also is found in breads, crackers, barbecue sauce and non-dairy creamers. Soybean oil is used in prepared foods such as whipped toppings, potato chips and battered and breaded snacks and vegetables.



Compared to other vegetable oils, soybean oil has good emulsifying ability. This makes it an appropriate ingredient in mayonnaise, and the first choice of the general food industry.

WIDELY AVAILABLE

Because soybeans are a primary protein source for feeding livestock, food manufacturers can depend on an abundant, steady supply of economically priced soybean oil, year in and year out. The abundant supply of soybeans grown for agricultural needs also ensures that soybean oil is economical. Efficient production of soybeans and bulk transport of soybeans from farms to oil mills also saves money. These factors represent some of the reasons why soybean oil significantly outpaces all other types of edible oils combined.

NUTRITIONALLY BALANCED

Liquid soybean oil is among the healthiest of all edible oils and has a very favorable fatty acid profile. It is relatively low in saturated fat, high in polyunsaturated fat and contains monounsaturated fat. The Institute of Medicine's Dietary Reference Intakes (DRI) acknowledge that unsaturated fatty acids reduce blood cholesterol and lower the risk of heart disease when they replace saturated fats in the diet, and recommends intakes for both linoleic and alpha-linolenic acid (ALA).

RICH SOURCE OF OMEGA-3 AND OMEGA-6 FATTY ACIDS FOR HEART HEALTH

Soybean oil is one of the few non-fish sources of omega-3 polyunsaturated fatty acids, which have various physiological benefits including cardioprotective effects. While fish oil is the preferred source of omega-3s because of the bioavailability of eicosapentaenoic (EPA) and docosahexaenoic acid (DHA), the ALA in soybean oil is the principal source of omega-3s in the American diet, according to the *American Journal of Clinical Nutrition*, Vol. 71 No.1. As discussed in *The Next Generation of Soybean Oil Enhancements* section, efforts are underway to develop increased omega-3 soybeans with improved bioavailability.

The first increased omega-3 soybean that is being developed for commercialization will become widely available in just a few years. It will contain stearidonic acid (SDA), an omega-3 fatty acid. (Increased omega-3 soybeans with EPA and DHA will follow later.) SDA is much more efficiently metabolized to the long chain omega-3s, DHA and EPA, as compared to the shorter chain ALA, so it does provide improved bioavailability and the development only involves three genes. Developing EPA and DHA is more complicated and involves at least 12 genes. SDA is also more stable to oxidation than EPA and DHA.

Omega-6 fatty acids, found naturally in soybean oil, may also decrease risk of heart disease, according to a science advisory published by the American Heart Association in January 2009. Containing about 50% omega-6s, conventional soybean oil is one of the most concentrated sources of this polyunsaturated fat.

Liquid soybean oil is relatively low in saturated fat, contains no trans fat and is high in poly- and monounsaturated fats. It's also the principal source of omega-3 fatty acids and the primary commercial source of vitamin E in the U.S. diet.

VITAMIN E

Soybean oil is the primary commercial source of alpha-tocopherol, also known as vitamin E. Vitamin E is the body's primary lipid-soluble antioxidant defense against free radical induced cell damage, which has been linked to a number of cancers, heart disease, cataracts, premature aging and arthritis.

PHYTOSTEROLS

Soybean oil contains a number of phytosterols including β -sitosterol, campesterol and stigmasterol. In particular, β -sitosterol and its hydrogenated and esterified derivatives, known as sitostanol esters, have been shown to reduce serum cholesterol and LDL cholesterol by 5 to 10% or more.

CONSUMER ATTITUDES – ACCEPTANCE OF SOYBEAN OIL

Soy has earned a positive reputation for the many health benefits it may offer consumers, including the prevention of some cancers and coronary heart disease. In fact, the FDA awarded a health claim for soy's cholesterol lowering properties in 1999. Soy protein's reputation appears to extend a "halo effect" to soybean oil, too.

According to USB's 2011 *Consumer Attitudes about Nutrition* survey, soybean oil was among the top three oils ranked "very healthy" by consumers, along with olive and flaxseed oils.

Manufacturers of packaged goods can take advantage of the health cache that soy carries as a marketing opportunity. Instead of listing "vegetable oil" on the ingredient label, food companies should consider the benefits of calling out soybean oil on their packaging.

Soybean oil is one of two oils consumers say they use most often.

SOYBEAN OIL FITS INTO TODAY'S HEALTHY SNACKING & EATING TRENDS

In summary, for decades, food manufacturers have selected soybean oil for its versatility, availability and competitive pricing. The neutral flavor and well-balanced fatty acid profile of soybean oil make it a desirable ingredient for a variety of applications ranging from baked goods to salad dressings.

In terms of U.S. consumption, soybean oil significantly outpaces all other types of edible oils combined. This abundant supply makes it clear why large-scale improvements to the edible oil supply will be soybean oil-based solutions. Let's take a closer look at the needs for enhanced oils, and the industry's progress.

Soybean Oil is the Right Choice for Food Companies



An increase in consumer demand for healthy foods requires farmers and soybean oil processors to improve human health through access to safe, nutritious foods.

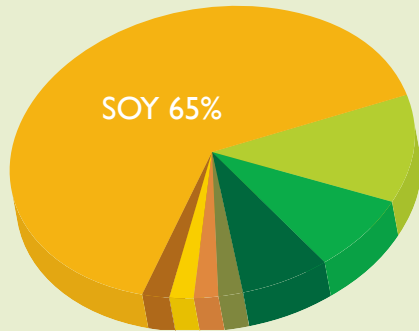
Providing healthful ingredients to the food industry is more important than ever. When the U.S. Food and Drug Administration (FDA) mandated the labeling of trans fatty acids on the Nutrition Facts panel in 2006, the soybean industry recognized the food industry's need for oil alternatives that could essentially eliminate trans fat from foods. Through several coordinated initiatives, such as QUALISOY™, the soybean industry addressed the trans fat issue and offered soy-based solutions to the marketplace. In addition, the functional foods trend requires continual innovation to provide ingredients for heart health.









The United Soybean Board is championing innovative processes used to produce healthier soybean oils.

With fat replacement, processed foods experience changes in flavor, stability and overall functionality, requiring a laborious reformulation to maintain quality standards. The soybean industry recognizes this challenge, and continues to strive to develop oils that are not only healthy but highly functional, in order to make the transition as simple as possible.

The United Soybean Board (USB) is working with the food industry to introduce the latest soybean oil options and with farmers to increase supply of these soybean varieties. In addition, USB is championing innovative processes used to produce healthier soybean oils, while continuing a dialogue with food companies about the evolving needs of consumers.

U.S. Edible Vegetable Oil Consumption*



<u>Oil</u>	<u>Market Share</u>
 Soy	65%
 Canola	12%
 Palm	8%
 Corn	7%
 Cottonseed	2%
 Sunflower	2%
 Olive	2%
 All other	2%

Source: U.S. Department of Agriculture, Economic Research Service: 2010 ERS Oilseed Yearbook

*Chart represents market share for soybean and competitive oils consumed in the U.S.

The soybean industry is working to develop new products and provide support to food companies.

The innovation doesn't stop at addressing the trans fat challenge.

With trans fat largely out of our food supply, the soybean industry also recognizes opportunities to contribute other important functionality and nutrition improvements. Research is underway to develop products that deliver the nutrition benefits consumers demand now, and those predicted to become dietary trends for the future.

Most food products in the grocery store that previously contained trans fat have already been reformulated and can now claim zero grams of trans fat per serving on the Nutrition Facts label. Good progress has been made but more work is needed. The soybean industry is working to provide support to food companies for future success.



Processing Solutions for Foods Low in the “Bad” Fats



Many soybean oil processing methods are available for developing products with zero grams of trans fat per serving, while keeping saturated fat content in check, illustrating the versatility of soybean oil as a stable product with neutral flavor and health characteristics consumers require. Liquid soybean oil is not naturally highly stable.

BLENDING

One popular method for avoiding the introduction of trans isomers involves combining a fully hydrogenated soybean oil (a hard stock that does not contain trans fat) with a non-hydrogenated oil such as traditional liquid soybean oil, trait-enhanced varieties or alternative vegetable oils. Blending with fully hydrogenated soybean oil is primarily used to formulate products for bakery applications.

Blending with partially hydrogenated oil can be used for baking and frying applications. In this case, soybean oil can be used with partially hydrogenated oil in blends that are formulated to limit trans below the level that would warrant labeling. It is necessary to label the partially hydrogenated oil in the ingredient list, but inclusion of an amount of trans fat on the Nutrition Facts label depends on the quantity in food. The FDA regulation for trans fat labeling is based on the product serving size and labeling is required for food that contain 0.5g or more of trans fat per serving.

It is possible to blend fully hydrogenated soybean oil and non-hydrogenated oil to create a final product with zero grams of trans fat.

INTERESTERIFICATION

Interesterification is a processing technique that rearranges the fatty acids within and among molecules of oil (triglycerides). Unlike the hydrogenation process, interesterification does not cause isomerization, and no trans fatty acids are formed.

Traditional interesterification changes the melting profile of a blend of saturated and unsaturated fats. During this process, the fatty acids of the triglycerides are randomly shifted, providing options for modifying the melting point to improve structural stability and creaminess without producing trans fatty acids. The most commonly used catalysts are sodium methoxide and sodium ethoxide.

Another method for interesterification utilizes enzymes and allows for more precision and control over achieving specific melting profiles. Different types of enzymes can be used, including lipases that randomize all fatty acids or 1:3-specific lipases that rearrange fatty acids in the 1- and 3- positions of triglycerides. The reaction can be controlled and stopped at any given time to ensure the right degree of interesterification.

The interesterification process can be used to rearrange fatty acids within an oil or in blends with other oils including fully hydrogenated or partially hydrogenated oils to produce a wide range of products with either zero grams or reduced trans fat content.

INCREASED USE OF ANTIOXIDANTS

Natural and synthetic antioxidants can be added to edible oils used in food applications to control oxidation and extend product shelf life. The most commonly used natural antioxidants are tocopherols, found in soybean oil up to 1,000 ppm. While processing removes some tocopherols, companies can modify deodorization conditions to make sure an appreciable amount remains to help prevent oxidation.

The most commonly used synthetic antioxidants are:

- Butylated hydroxyanisole (BHA)
- Butylated hydroxytoluene (BHT)
- Propyl gallate
- Tertiarybutylhydroquinone (TBHQ)

Studies have shown that adding 0.02% TBHQ increases stability almost four times of that observed in soybean oil without added antioxidants. This creates another option for reducing oxidation and enhancing stability without utilizing the hydrogenation process, particularly when used in conjunction with some of the aforementioned technologies.

For vegetable oils such as soybean oil, TBHQ is one of the most effective antioxidants.

IMPROVED HYDROGENATION

Some companies now modify the hydrogenation process itself to minimize the formation of trans fatty acids.

Methods used in this process include:

- Change in processing parameters
- Modification to processing equipment
- Utilization of new analytical techniques to closely monitor and control the process

By using improved hydrogenation techniques, a number of basestocks used to formulate multi-purpose and specialty shortenings can now be produced with 10% or less trans fat, and reductions to 5% or lower are being achieved.



The Next Generation of Soybean Oil Enhancements

SOYBEAN TRAIT INNOVATIONS – GOALS

In addition to innovations in processing techniques, the industry continues to work toward developing soybean varieties with enhanced compositional traits to produce healthier oils with improved functionality characteristics. Whether through traditional breeding or advancements from biotechnology, the ultimate goal is to anticipate and better meet the needs of edible oil end users.

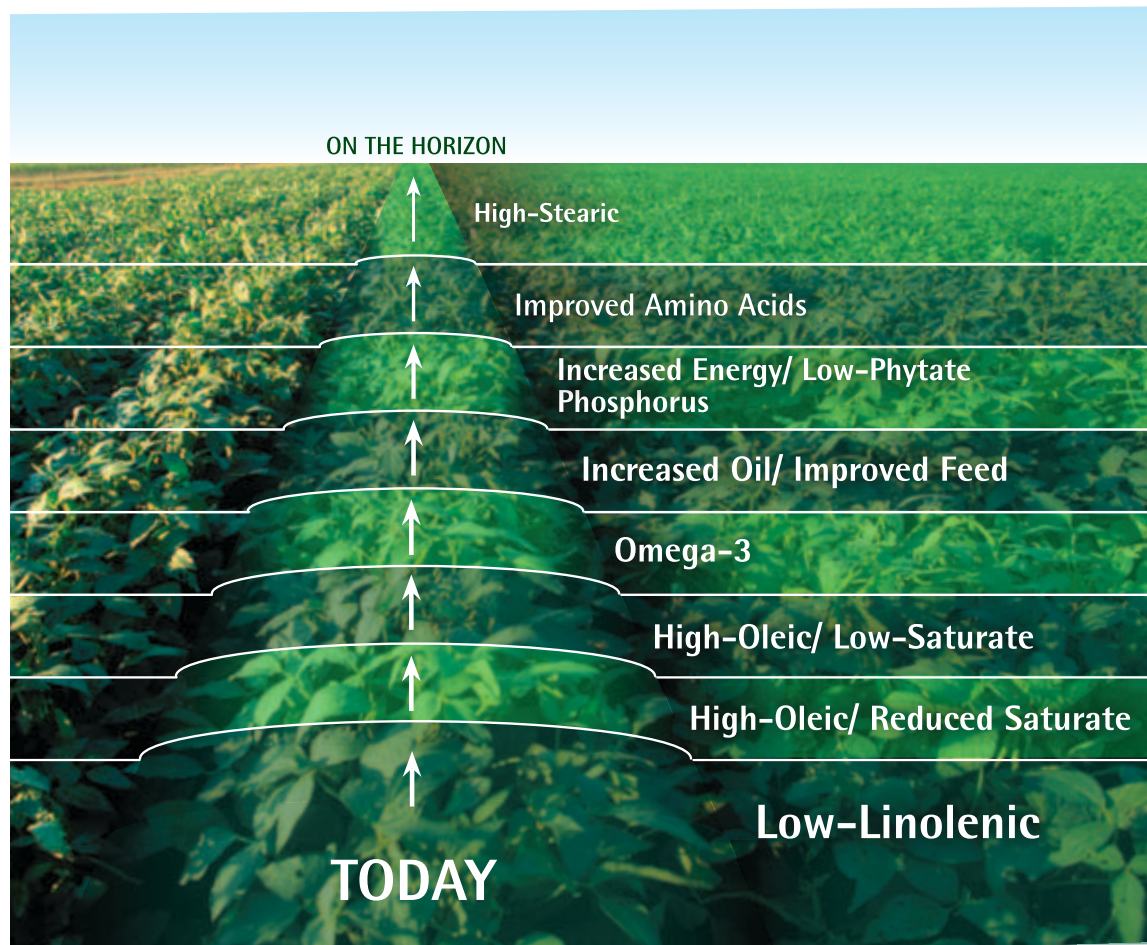
QUALISOY™

Recognizing the food industry's need for improved soybean oils, USB helped form QUALISOY™ – a collaborative effort throughout the soybean industry to help bring improved traits to the marketplace. Through QUALISOY, the soybean industry has identified the value of various enhanced oil options to food companies, and drives the adoption and communicative outreach about varieties available now as well as those in the research pipeline.

QUALISOY has set research priorities and quality standards for trait improvements, such as low-linolenic and high-oleic varieties. Currently, leading targets for soybean trait modifications include:

- **Reduced saturates (maximum of 7%)**
This oil is available in limited commercial quantities.
- **Reduced linolenic acid (maximum of 3%)**
This oil is now in full commercial production with annual availability of over a billion pounds.
- **Increased oleic acid (striving for 75% or more)**
Seed breeders have been very successful in developing soybeans with increased oleic acid with a high-oleic soybean oil ready to enter commercial production with approximately 75 percent oleic acid.

These modifications can be combined to produce soybeans with stacked-trait innovations.



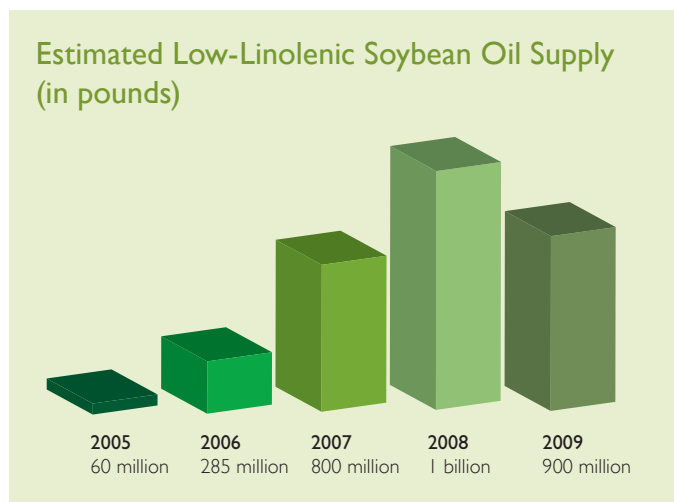
Soybean Trait Enhancements in the Pipeline

1 BILLION pounds of low-linolenic soybean oil were available in 2008 and can meet many needs of the food industry. High-oleic/reduced saturate soybean oil is also ramping up to provide a functional oil for high-heat applications — a trans fat solution without raising saturated fat.



LOW-LINOLENIC

The first trait innovation to become commercially available in significant quantities was the low-linolenic variety. Major food companies have made the transition to low-linolenic soybean oils from partially hydrogenated oils for frying and processed food applications. Decreasing linolenic acid increases the flavor stability and supports the oxidative stability of the oil, thus resulting in a product that can be used in place of partially hydrogenated oil in many applications.



HIGH-OLEIC/REDUCED SATURATE

For improved oxidative stability with superior flavor stability, up next are soybeans with high levels of oleic fatty acid and reduced levels of saturated fats. Products requiring high heat during processing will benefit from this oil because of a superior resistance to flavor breakdown. At the same time, consumers will enjoy heart-health benefits, as high-oleic offers a trans fat solution without raising harmful saturated fat content. The new varieties of high-oleic soybean oil will also have a reduced linolenic acid content and a reduction in saturated fat (less than 12% compared with 15% in conventional soybean oil).

Applications for high-oleic soybean oil (approximately 75% oleic acid) include usage as a spray oil for crackers, a blending component for formulating numerous types of margarines and shortenings, in heavy duty frying and in a wide variety of bakery applications.

High-oleic soybean oils show favorably on the oxidative stability index (OSI), which is defined by the number of hours needed to reach an end point at a given temperature (usually 110°C). The OSI values for high-oleic soybean oil are 40 to 60 hours, while commodity oils (such as soybean, corn, cottonseed, canola and sunflower) show values of 3 to 14 hours.

The soybean industry is evaluating new and existing traits and determining future trait enhancements that would best benefit the food industry. Companies should anticipate oils that will be functional yet healthful while containing zero grams of trans fat per serving and minimal saturated fat. Looking ahead, the following soybean oil trait enhancements are soon to follow.

HIGH-OLEIC/LOW-SATURATE

This soybean oil combines two innovations, high-oleic as discussed above and even lower saturated fat (less than 7%). While soybean oil naturally has a low-saturated fat content relative to many competing oils, significant research is underway to develop varieties with further reduced saturate content, especially reduced palmitic fatty acid, to support cholesterol reduction and improve heart health.

Another low-saturate soybean oil (without the high-oleic stacked trait) is available in limited quantities.

INCREASED OMEGA-3: STEARIDONIC ACID

Soybean oil is the primary source of heart-healthy omega-3s in the U.S. diet in the form of alpha-linolenic acid (ALA). Eicosapentanoic (EPA) and docosahexanoic (DHA) are the preferred forms of omega-3s. These are present in cold water fish, but the American diet contains only a limited amount of omega-3s from these sources. Americans need additional sources of these preferred omega-3s in their diet to provide adequate consumption. Researchers are developing soybeans with increased levels of stearidonic (SDA), a type of omega-3 that is structurally closer to EPA and DHA than ALA. An American Heart Association human clinical study presented in 2009 found that the increased omega-3 soybean oil with SDA could be an effective alternative to fish oil as a source of heart-healthy omega-3 fatty acids.

	SATURATED FATTY ACID	OLEIC ACID	LINOLEIC ACID [Ω6]	LINOLENIC ACID [Ω3]	OSI [110°C]
Soybean Oil	14	24	54	7	5-6
Low-Linolenic Soybean Oil	14	26	56	≤3	5-8
High-Oleic/Reduced Saturate Soybean Oil	<12	≥75	1.5-5	<3	40-60
Corn Oil	13	28	57	-1	7-8
Sunflower Oil	13	19	67	-0.7	4-5
Canola Oil	7	61	22	9	6-8
Palm Oil	50	39	10	-0.3	15-20
Cottonseed Oil	26	19	54	-0.7	5-8
Olive Oil	13	80	6	-0.6	n/a

The FDA has issued a notice confirming that increased omega-3 soybean oil with SDA can be used in foods and beverages. Pending similar clearance from the U.S. Department of Agriculture, farmers can plant these new soybeans. The oil will lend itself well to a wide range of food products such as yogurts, salad dressings, breakfast cereals, baked goods, nut products and soups.

HIGH-STEARIC

Research on a soybean variety with high-stearic fatty acid content is also underway. Considerable clinical evidence indicates that stearic acid is cholesterol-neutral compared to other saturated fatty acids. High-stearic soybean oil would be stable and neutrally flavored, serving as an option for applications requiring a more solid fat, such as baked goods.

INCREASED OMEGA-3: EPA AND DHA

In the long-term, researchers will introduce a soybean with EPA and DHA. Clinical evidence suggests long-chain omega-3 fatty acids have strong cardioprotective effects in the human body.



How Do I Use It?

Blending can be used to produce a variety of shortenings with solid fat content profiles similar to that of hydrogenated shortenings. It is a cost-effective technique compared to other methods of producing shortenings containing zero or low amounts of trans fats.

Interesterification enhances functionality beyond basic blending and can yield basestocks and shortenings similar to hydrogenated shortenings. With sharper, steeper sloped solid fat content curves, interesterified shortenings can be formulated for nearly any bakery application.

For any application using liquid oil, or for single-use frying applications, the use of **antioxidants** can support improved performance and oxidative stability.

Low-linolenic soybean oil can be used as a direct replacement for lightly hydrogenated oil in many applications, including light frying, sauces, rolls and pizza dough.

Applications for **high-oleic/reduced saturate soybean oil** include usage as a spray oil for crackers, a blending component for formulating numerous types of margarines and shortenings, in heavy duty frying and in a variety of bakery applications.

High-stearic soybean oil appears to offer the best direct alternative to the partially hydrogenated basestock used to formulate a wide range of shortening products.



DEDICATED TO THE FUTURE OF EDIBLE OILS

As consumer demand for soybean oil increases, the United Soybean Board (USB) is committed to ongoing research and continuous improvement of an already superior product. USB has established a core team of exceptional academic and industry professionals who are developing soybeans with enhanced compositional traits that will result in soybean oil varieties with improved functionality and nutrition composition. A farmer-led organization comprised of 69 farmer-directors, USB oversees the investments of the soybean checkoff on behalf of all U.S. soybean farmers. For more information, please visit SoyConnection.com.

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