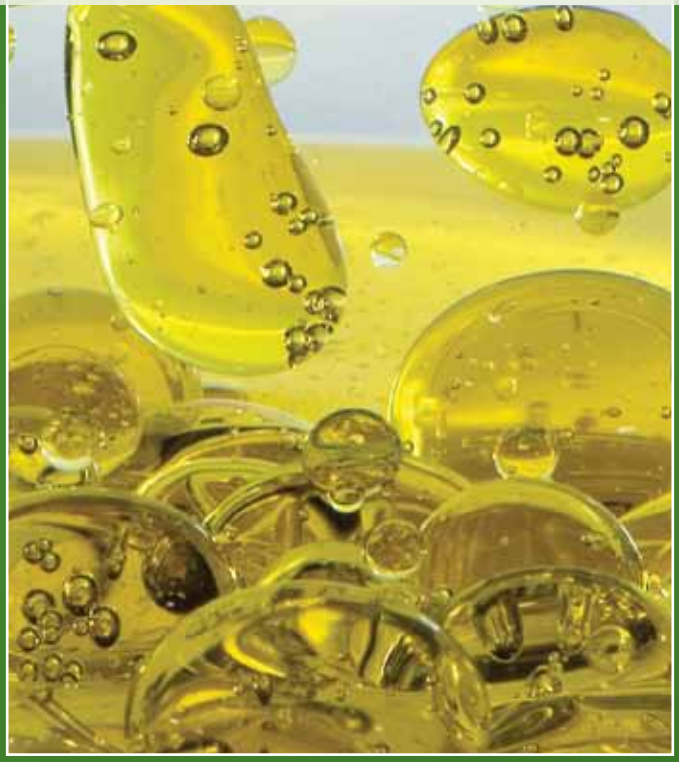
soy20/20
building the business of soy



Value-adding opportunities for soybean oil

About Soy 20/20

Soy 20/20 brings together government, academic and industry partners to stimulate and seize new global bio-science opportunities for Canadian soybeans. Soy 20/20 is supported by the Grain Farmers of Ontario, the University of Guelph, and by Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture, Food and Rural Affairs under Growing Forward, a federal-provincial-territorial initiative.

The organization focuses its activities on both industrial and food uses and opportunities for Canadian soybeans. This includes facilitating linkages between value-added market opportunities and the resources needed to make those opportunities a reality.

Soy 20/20:

- Connects companies with funding to develop or expand their manufacturing capabilities;
- Facilitates constructive interactions between companies and the soy research community;
- Builds bridges among companies to enhance the profitability and competitiveness of alternative soy market opportunities in Canada; and
- Helps companies with market analysis and business plan development as a basis for developing or expanding opportunities.

Canada's strengths in research capability, industrial output, agricultural production, and educational excellence combined with the ability to build networks and combine these strengths in a focused effort will help keep the Canadian soybean sector a global leader. Soy 20/20 is acting as a catalyst in building this network, by focusing on real opportunities, identifying and circumventing constraints and helping existing companies develop or expand manufacturing capabilities. By working together and aiming at achievable opportunities, we can succeed.

soy20/20
building the business of soy

Message from the President

Members of Canada's soybean value chain, from plant breeders and farmers to processors and end users, can help grow our national economy by taking advantage of the new opportunities offered by soy-based biomaterials, chemicals, and food products and ingredients.

With oil prices rising and fossil fuel resources becoming increasingly more difficult and more expensive to extract, the potential of oleochemicals is growing rapidly. Soybeans' natural properties make their components – oil, protein, fibre and others – ideally suited for use in industrial products, while at the same time addressing a multitude of other needs. These include resolving environmental concerns, green marketing, lowering costs, solving problems of supply, improving performance and addressing consumer health and wellness.

As this industry grows and evolves in Canada, imported products and chemical intermediates could be replaced with ones produced by our homegrown farms and businesses. However, the Canadian industry is still very much an emerging one.

At Soy 20/20, we work on a confidential level with many Canadian companies, researchers and businesses where exciting new developments are happening that will foster the replacement of petroleum-based derivatives and chemicals with soybean-based alternatives. Canada is strong in research, industrial output, agricultural production and educational excellence. Soy 20/20 brings all of these elements together with the common goal of helping to make this country a globally competitive leader in the emerging bio-based economy.

Jeff Schmalz
President, Soy 20/20

An overview of industrial and food uses for soybeans

Industrial uses

Soybean components such as oil, protein, hulls and others are increasingly being incorporated into industrial products. The reasons are many, including addressing environmental concerns, green marketing opportunities, lowering costs, solving supply problems, and improving product performance. Globally, soy is used in hundreds of products, from adhesives, waxes and cosmetics to car parts, asphalt sealants and solvents. Traditional markets include the use of soybean meal in livestock and pet feed.

Protein

Livestock feed

Soybean meal is one of the most consistent, high-quality protein sources available for feeding livestock and poultry, which is why almost all soybean meal consumed in Canada is used for this purpose. Soybean meal is a co-product of the oil extraction process.

Wood adhesives

New soy-based alternatives are being developed for the wood adhesives industry in response to health and environmental concerns, as well as increasing costs for petroleum-based products. Finely ground soy flour can be combined with other commercially available resins to form wood adhesives.

Rubber, plastics, resins and cosmetics

Soy protein is used as filler in plastics and rubber. Automakers are starting to develop rubber products using soy protein instead of petroleum-based fillers for door seals, floor mats, gaskets and splash shields. Soy protein polymer can be used in the development of resins for use in machinery parts and bathroom components. Purified soy protein can also be 'spun' into a cloth that has a soft, silky texture. Soy-based cosmetics are gentle on the skin, readily biodegradable and have restorative properties.

Fibre

Ethanol and burner fuels

Work is underway to develop biofuels – also known as cellulosic ethanol – from non-food plant sources, such as soy straw, wheat stalks and non-edible biomass plants. The Ontario Ministry of Agriculture, Food and Rural Affairs estimates, however, that only about 40 per cent of all soybean crop residues are able to be practically or sustainably removed from the fields for this use.

Plastics

Research is ongoing into the possibilities of using soy stalks as filler in plastics and rubber. Currently, soy stalks are not an easily sourced ingredient in the large quantities required for commercial production of plastic or rubber parts. Researchers are also looking at mixing soy stalks with other natural fibres, such as corn stover and wheat straw, in hopes of circumventing this problem.

Other components

Soy seed coats / hulls

Research has shown that an enzyme called soybean peroxidase, found in soy hulls, can be used to oxidize phenolic compounds in industrial waste water. The enzyme builds up the phenolic compounds in the water until they become insoluble and can be physically removed from the water. The clean water remaining behind can be safely re-used. Scientists are also working on methods to use soy hulls and soy meal as extenders in plastics and rubber that can be made into parts for the internal structures of automobiles, such as panels and dashboard parts.

The complete Soy 20/20 special report "Industrial Uses and Opportunities for Canadian Soybeans" is available online at http://www.soy2020.ca/pdfs/Industrial-Uses-and-Opportunities.pdf.

Oil

Foam

Polyurethane foams containing soy-based polyols are currently the primary industrial market use for soy oils (aside from biodiesel). Manufacturing soy foam includes substituting soy polyols for a portion of petrochemical polyols used. Using soy-based polyols as an ingredient in car seats is predicted to be a $50 billion market by 2015, according to the Ontario BioAuto Council.

Lubricants and fluids

Another rapidly growing market for soy oil is bio-based lubricants and industrial fluids. This includes everything from hydraulic and transmission fluids to greases, motor oils, fuel additives and even a WD-40-like product.

Paints and coatings

Soybean oil has been a major ingredient in making oil-based paints, but as their popularity has declined, newer soy technology is focused on a water-base with lower volatile organic compounds. Several prominent brands of wood protective coatings, such as Urethane, are using soy in their formulations.

Waxes, solvents and biodiesel

Packaging is the single largest sector use of wax in Canada, where it serves largely to protect cardboard against moisture. Methyl soyate, a methyl ester derived from soybean oil, is used as a solvent in place of chlorinated or petroleum-based ingredients in chemical cleaners and strippers. It can also be used to clean up and recover spilled petroleum products from shorelines, rivers and streams. Biodiesel is a diesel fuel substitute that can be made from soybean oil and blended with diesel, resulting in lower greenhouse gas emissions and improved engine lubricity.

Food uses

Oil

Soybean oil is second only to canola as the largest source of edible oil in Canada. It is refined and then sold to repackers, distributors and further processors for the production of margarine, shortening, cooking and salad oil. Ultimately, these products end up in food retail, food manufacturing and food service.

Protein

Soy protein is one of the most complete of all vegetable protein sources, providing all the essential amino acids needed to meet human nutritional requirements. There are three principal types of soy protein: defatted soy flour, soy protein concentrates and soy protein isolates, which are approximately 50 per cent, 65 per cent and 90 per cent protein, respectively.

Other components

Soybean hulls are a by-product of oil extraction and in food, are traditionally used as a fibre supplement. Other co-products and minor soybean components, such as lecithin, tocopherols, saponins, glycerol, isoflavones and phytoserols, have applications in food processing or represent potential human health benefits as a result of their anti-oxidant qualities.

The complete Soy 20/20 special report "Food Uses and Opportunities for Canadian Soybeans" is available online at http://www.soy2020.ca/pdfs/Food-Uses-and-Opportunities.pdf.

The seeds of most plants contain oil, which are comprised of lipids and serve mainly as a high-energy storage essential for seedling growth.

Lipids

A lipid is generally considered to be any molecule that is insoluble in water and soluble in organic solvents. Biological lipids usually refer to a broad group of naturally occurring molecules which includes fatty acids, waxes, triglycerides, phospholipids, sterols, fat-soluble vitamins (such as vitamin E) and others. In the context of soybean oil, lipids are fatty acids and their naturally occurring derivatives, and substances.

Fatty acids

Fatty acids are compounds that can be synthesized by the plant that usually contain even numbers of carbon atoms (commonly C14 to C24), and may be saturated or unsaturated. In the case of the soybean oil the major unsaturated fatty acids are linoleic, oleic and linolenic and the unsaturated fatty acids are palmitic and stearic.

Triglyceride

Triglyceride is a naturally occurring ester of three fatty acids and glycerol that is the chief constituent of fats and oils. Nearly all of the commercially important fats and oils of animal and plant origin consist almost exclusively of the simple lipid class triglycerides. In nature, they are synthesized by enzyme systems which determine the different fatty acids in each position.

Soybean oil can be used to make many different products that are traditionally manufactured using a petroleum base. These include waxes, foams, films, lubricants, plastic molded parts, composites and packaging.

Soybean oil can be processed in a variety of ways to extract different components that can be used by manufacturers to create a wide range of soy-based products. Although many of these technologies and processes are still in their infancy, there is definite potential to replace petroleum-based ingredients with those resulting from soy.

An overview of specialty-attribute soybeans

Low linolenic soybean oil

Low linolenic soybeans contain lower levels of linolenic acid, which means oil from these types of soybeans does not need to be hydrogenated in order to be used in many food processing applications. This reduces or eliminates trans fats in foods but still provides the stability required for processing. Low linolenic soybean oil was the first enhanced oil available in the marketplace and contains less than three per cent linolenic oil.

High stearic acid soybean oils

These soybeans, currently in development, contain elevated levels of stearate, which enhances the texture and increases the stability for many food products that require solid fat functionality. Although stearate is also a saturated fat, nutritional research is showing that it is a heart-neutral type of saturated fat – it does not increase the levels of LDL or so-called "bad cholesterol" in our bloodstream.

Omega-3 soybean oil

Soybean oil is one of the few non-fish sources of omega-3 polyunsaturated fatty acids. The goal of developing omega-3 soybeans is heart healthy oil – with an omega-3 fatty acid content that provides the benefits usually found in fish. Omega-3 soybean oil could be used as an ingredient in a wide range of food products, including yogurt, salad dressing, vegetable marinades, granola bars and spreads and should give consumers yet another source of foods rich in omega-3 fatty acids.

High oleic soybean oil

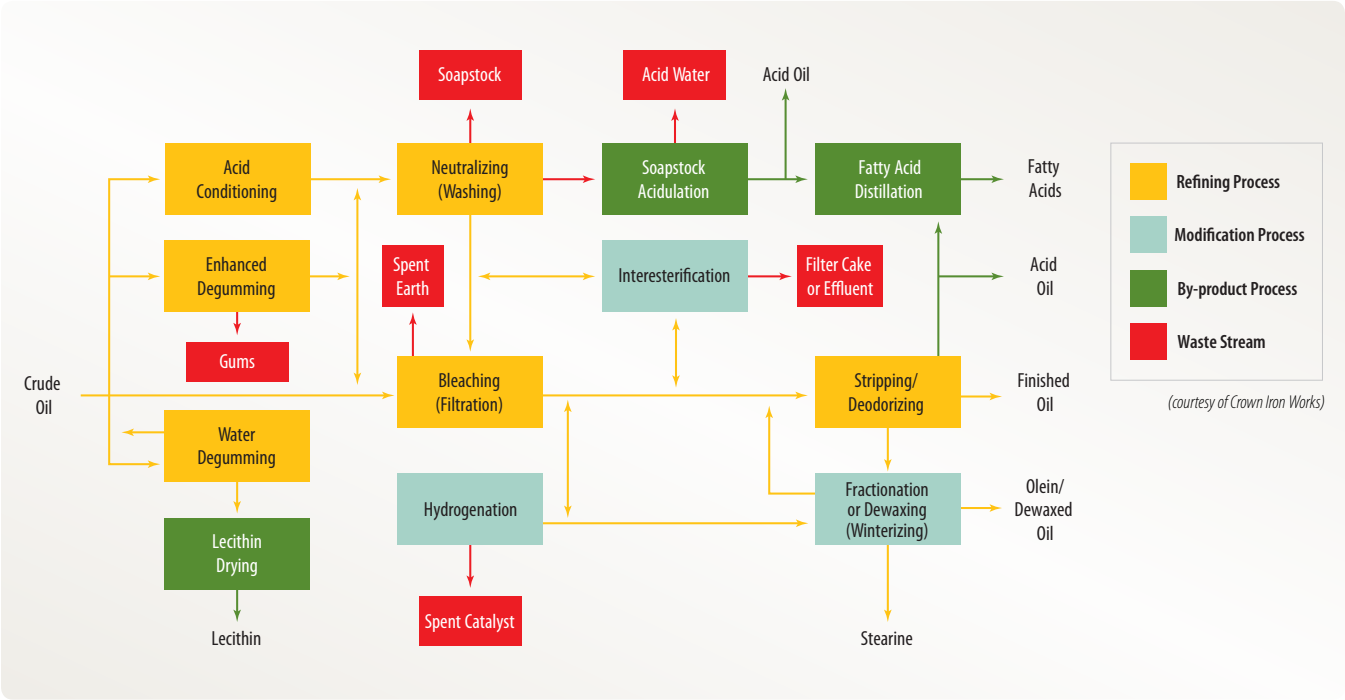
Soybeans with high oleic acid content (more than 70 per cent) significantly increase the oil's stability and provide greater flexibility in food applications. The end product also has zero grams of trans fats, and generally has a lower saturated fat level than conventional soybean oil, making it an attractive ingredient for consumer food products. Its high heat stability means it's suitable for frying and baking applications.

High oleic soybean oil also has opportunities for industrial applications, including lubricants, sufactants and poymers.

Although many of these technologies and processes are still in their infancy, there is definite potential to replace petroleum-based ingredients with those resulting from soy.

Road map for oils and fats refining

Once oil is extracted from the soybean, it is refined and modified to make it suitable for use in a variety of applications and processes.



(courtesy of Crown Iron Works)

Refining processes

(Source: www.fediol.be)

Degumming

The first step of chemical refining is degumming. Its main purpose is to remove phospholipids from the crude oil. It also removes seed particles, impurities, carbohydrates, proteins and traces of metals. The crude soybean oil is treated with processing aids and/or water, which leads to hydration of the phospholipids and most of the other impurities. The hydrated materials precipitate from the oil and are removed by centrifugation. The phospholipids are often recovered and further processed into a variety of lecithin products.

Neutralization

Neutralization reduces the content of the free fatty acids and oxidation products of free fatty acids, residual proteins, phosphatides, carbohydrates, traces of metals and a part of the pigments. The oil is treated with an alkali solution that reacts with the free fatty acids and converts them into soap stock. The oil is then washed with water and centrifuged to remove the soap, alkali solution and other impurities. The soap stock may be sold to soap manufacturers or it may be treated with an acid treatment to set free the fatty acids contained in it. These are used for feed purposes, but also for soap or candle manufacturing.

Acid Conditioning

This is part of the degumming process whereby any remaining impurities are stripped out of the oil.

Bleaching

The purpose of bleaching (or decolourizing) is to reduce the levels of pigments such as carotenoids and chlorophyll. It also further removes residues of phosphatides, soaps, traces of metals, oxidation products, and proteins. These trace components interfere with further processing. They reduce the quality of the final product and are removed by adsorption with activated clay and silica.

Deodorization

Deodorization is a vacuum steam distillation process that removes the relatively volatile components that give rise to undesirable flavours, colours and odours in fats and oils. This is feasible because of the great differences in volatility between these undesirable substances and the triglycerides. This process will improve the stability and the colour of the oil, whilst preserving the nutritional value.

Saponification

Saponification is a process that produces soap, usually from fats and lye. In technical terms, saponification involves base hydrolysis of triglycerides, which are esters of fatty acids, to form the sodium salt. In addition to soap, traditional saponification processes produce glycerol.

Adding value to soybean oil through refining and modification

Modifications can be used for both food and industrial applications, like margarine or wax products.

Modification processes

(Source: www.fediol.be)

Hydrogenation

Hydrogenation is the process by which hydrogen is added directly to points of unsaturation in the fatty acids. The purpose of hydrogenation is to obtain oils and fats with specific melting profiles or oxidative stability by reducing unsaturated double bonds in the oil system. Since hydrogenation converts unsaturated triglycerides into saturated ones, it converts liquid oils to the semi-solid form for greater use in foods, to make wax for candles and in a variety of industrial and consumer applications.

Interesterification

This process permits the production of high-stability blends that have highly desirable melting qualities. Interesterification has been used to manufacture fats for use in the confectionery industry for many years. It's a process often used to increase the solidity of a fat without partial hydrogenation and can be used to combine the fatty acids of liquid oil with a fully hydrogenated fat to create a product without trans fat. The liquid oil and the solid fat combined take on a true combined function.

The interesterification process does not change the oil's nutritional profile, but simply causes a redistribution of the fatty acids on the glycerol backbone of the triglyceride.

After breaking the triglycerides molecule apart, the fatty acid molecules can be reconfigured, combining any three Omega 3, Omega 6, Omega 9 or saturated molecules, in whatever combination is chosen combination determines the hardness of the fat.

The interesterification process can produce many types of fats or oils, including heavy fats suitable for deep-frying, semi-solid fats to make margarine, or liquid oils for bottling.

Winterization

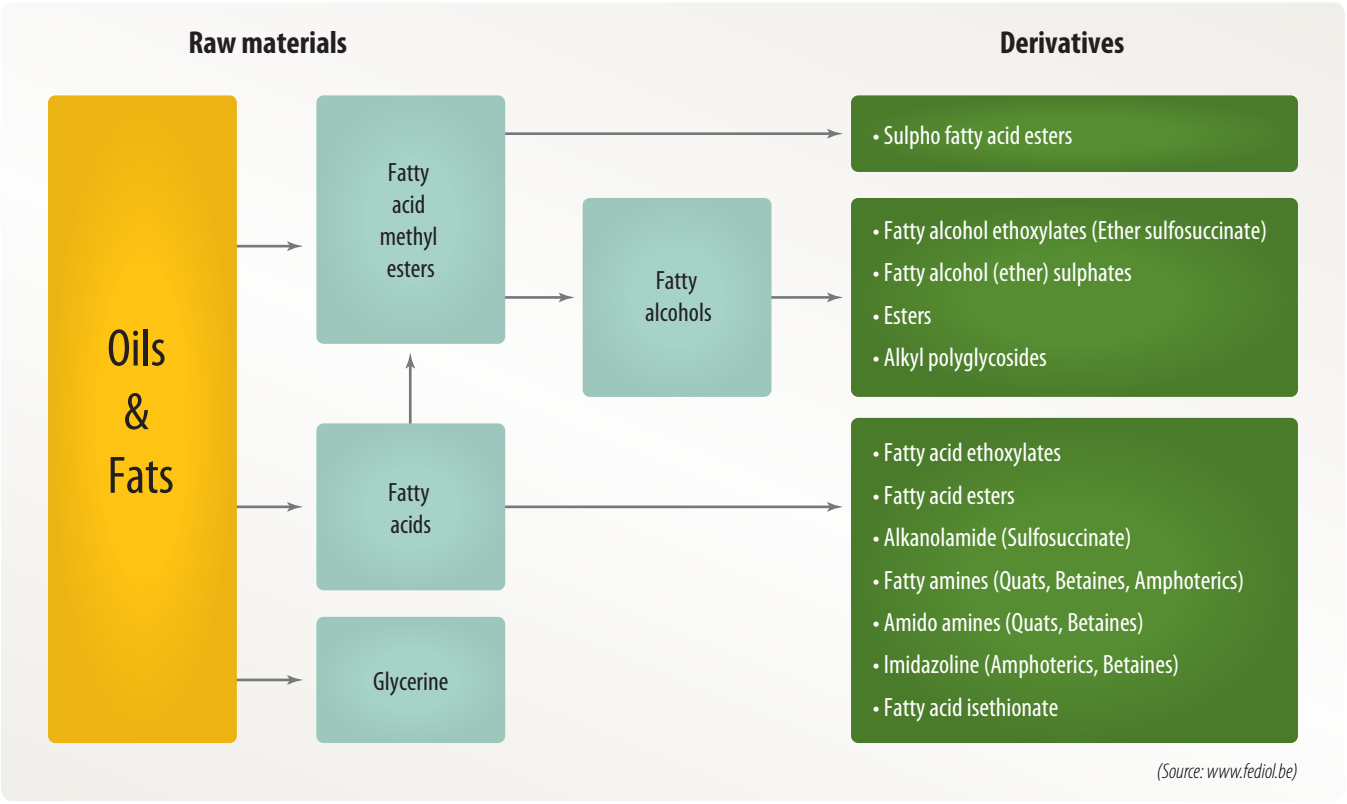
Winterization or dewaxing is a process whereby waxes are crystallized and removed in a filtering process to avoid clouding of the liquid fraction at cooler temperatures. The filter cake that remains after the filtering process consists of oil, waxes and filter aid. The filter cake can be recycled and added to the meal or sold as such as a feed ingredient. The term winterization was originally applied decades ago when cottonseed oil was subjected to winter temperatures to accomplish this process.

Fractionation

The fractionation process consists of the removal of solids by controlled crystallization and separation techniques involving the use of solvents or dry processing. Dry fractionation encompasses both winterization and pressing techniques and is the most widely practiced form of fractionation. It relies upon the differences in melting points and triglyceride solubility to separate the oil fractions. Main food applications for fractionation are in salad dressing oils, margarines, frying and cooking oils and specialty fats.

Soy wax pellets, used for candles and a variety of industrial and consumer applications.

Industrial ingredients



(Source: www.fediol.be)

Oleochemical applications

Oleochemicals are chemicals derived from plant and animal fats and oils. They are analogous to petrochemicals which are chemicals derived from petroleum.

The oleochemical industry makes secondary resources out of vegetable fats and oils, such as fatty acids, fatty acids esters, fatty alcohols and glycerine. They are excellent substitutes for mineral base chemicals and represent a new generation of environmentally friendly materials.

Vegetable-based oleic acids have become increasingly important to the oleochemical industry.

(United Soybean Board/Soybean Checkoff)

Major processes are:

- fat splitting
- transesterification to produce biodiesel and solvents
- distillation to produce fatty acids

The fat splitting (or hydrolysis) of the triglycerides produces fatty acid s and glycerol.

The most common application of oleochemicals is biodiesel production. Fatty acids are esterified with an alcohol, commonly methanol, to form methyl esters. Other applications are the production of detergents, lubricants, green solvents and bioplastics.

By applying chemical expertise, these oleochemical feedstocks are converted into a wide range of chemical products for use in cosmetics, paints and inks, lubricants, biofuels, textile and leather, plastics, rubber, soaps and detergents, pharmaceuticals and many other industries.

(United Soybean Board/Soybean Checkoff)

From farmer to product

Soybean farming

Crude soybean oil

20%

Soybean

Soy oil refining and modification

Soybean oil

Human food

Salad dressing, cooking and frying oil

Interesterification

Human foods

Combined with fully hydrogenated fat, foods, a solution to trans fat concerns

Hydrogenation

Human foods, waxes

Margarines, shortening, candles, industrial processes (fractionation) and consumer uses

Industrial soy oil base stock

Soy lubes, coatings, sealants

Lubricants for equipment, hydraulics, coolants, grease, consumer home products, transportation, asphalt, sealants

Soybeans

Human Food

Animal Feed

Processing

Transesterification

Methly soyate

Biodiesel, cleaning products, hand lotions, paint strippers and other solvents

Soy polyol production

Soy polyol

Insulation, foam for cars, furniture cusions and carpet backing

Soy resin production

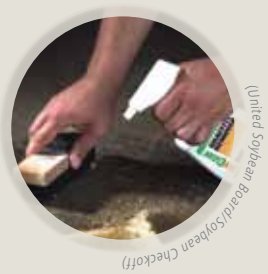
Soy resin

Vehicle and equipment exterior panels

Fat splitting/distillation

Oleochemicals

Surfactants, soaps, detergents



(United Soybean Board/Soybean Checkoff)

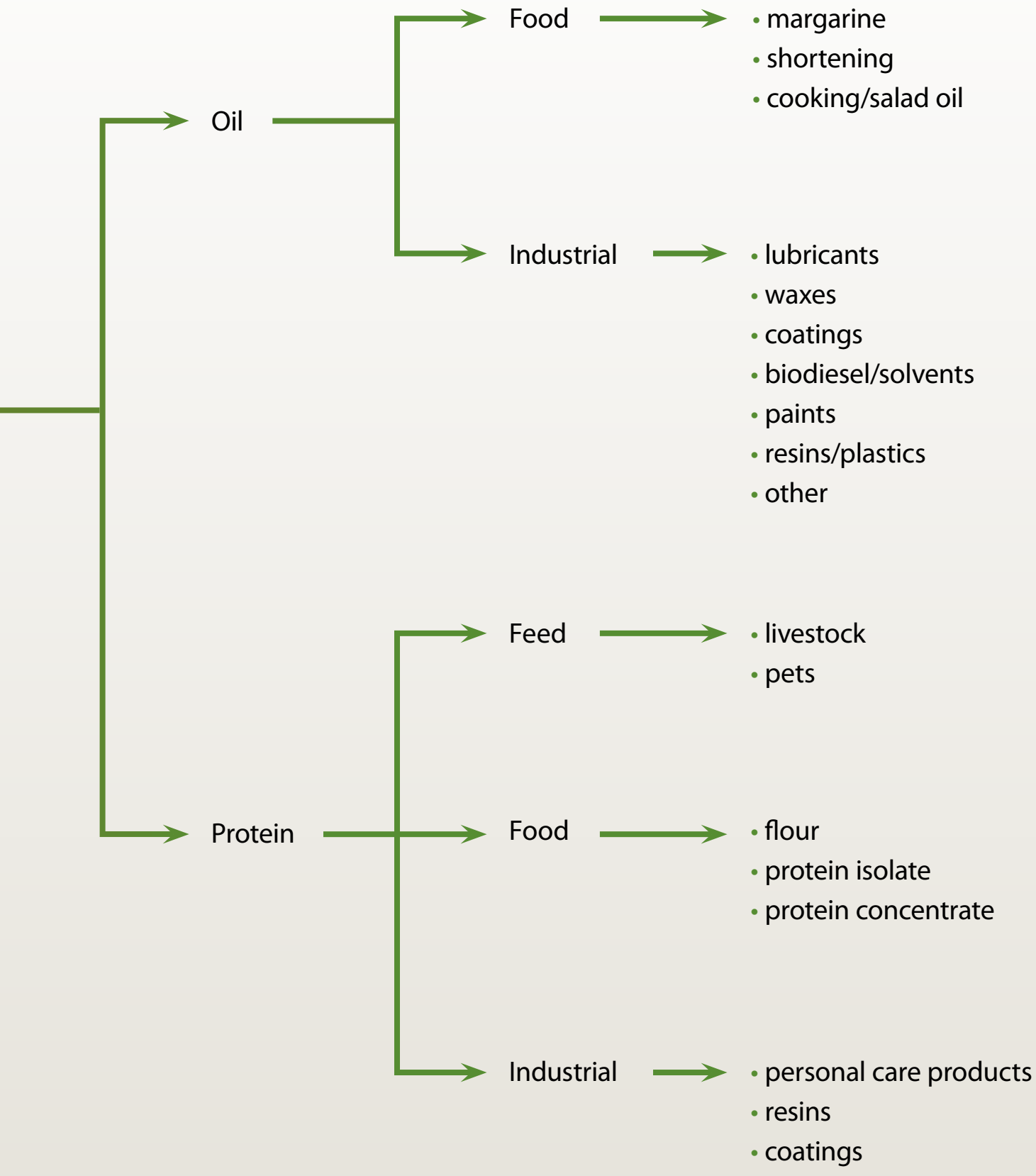
The soybean value chain

The soybean value chain follows a fairly linear path. From trait development to processing, there is a sequential order of partners that work together to take the soybeans from one link in the chain to the next.

But once soybeans reach the processing stage, the possibilities for use extend in many different directions, both in specific parts of the soybean, such as oil, hulls/other and protein, and then in more specific uses of each of those soybean components.

Up to the processing stage, the Canadian soybean industry is a well-developed world leader. Now work is underway to develop uses and markets for the soybean beyond processing—new products, new applications and new end users.

Trait Developers → Seed Producers → Growers → Elevators → Processors


Oil
Food
margarine
shortening
cooking/salad oil
Industrial
lubricants
waxes
coatings
biodiesel/solvents
paints
resins/plastics
other
Protein
Feed
livestock
pets
Food
flour
protein isolate
protein concentrate
Industrial
personal care products
resins
coatings

Going beyond the bean

The utility of soybeans is impressive. The refining and further processing into the various component parts provide a multitude of applications and product possibilities – for farmers, for processors and for developers of products seeking renewable, sustainable ingredients.

The oil can be transformed into a wide array of products and ingredients, involving many manufacturing processes serving industry and consumers.

The development of soybean oil is a global activity with research, innovation and commercialization taking place in many different parts of the world. Here in Canada, we too have to support the development and implementation of these kinds of processes in order to grow our soybean industry from the bean through to the final product. This support can come in many different forms, including research funding, infrastructure construction and industry development. To achieve this, it will take co-operation and collaboration from all members of the value chain, from plant breeders through to end users, whether they are makers of salad dressing or producers of industrial coatings and sealants.

As the world increasingly seeks alternatives to petro-chemical ingredients, the potential of soybean oil-based products and applications is one that shows promise for long-term growth and sustainability.

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