Industrial Uses and Opportunities for Canadian Soybeans

soy20/20
building the business of soy

The Soy 20/20 Project

Soy 20/20 is a unique partnership between farmers, industry, government and academia to encourage and maximize new bioscience opportunities for Canadian soybeans. Soy 20/20 assists researchers, industry, growers and policy makers in focusing on key opportunities and working together to realize them. Funding for Soy 20/20 is provided by Grain Farmers of Ontario and the University of Guelph and under Growing Forward, a Federal-Provincial-Territorial initiative. This report is the second in a three-part series and highlights the potential industrial uses and opportunities for Canadian soybeans. Part one, which can be found at *www.soy2020.ca/pdfs/Canadas-Soybean-Value-Chain.pdf*, outlined the Canadian soybean industry value chain and highlighted the current status, activities and opportunities of the emerging bioeconomy. Part three focuses on food uses for Canadian soybeans and can be found at *www.soy2020.ca/pdfs/2010-Soy-Report.pdf*.

Industrial applications for soybeans are just beginning to emerge. Our goal at Soy 20/20 is to encourage the development of these new applications through increased investment in Canadian soybean processing businesses. It is expected this will generate more value for everyone along the value chain from plant breeders and farmers, to processors, distributors and end users of these innovative new products.

Welcome message

Canadian industry, farmers and soy processors can help the economy and the environment by taking advantage of the new opportunities offered by soy-based bio-materials and chemicals.

Soybean components—like oil, protein, fibre and others—are increasingly being incorporated into industrial products and for a variety of reasons. These include resolving environmental concerns, green marketing, lowering costs, solving problems of supply, improving performance and addressing consumer health and wellness.

Developing a market for bio-materials will be a boost for the Canadian economy. Imported products and chemical intermediates could be replaced with ones produced by Canadian farms and businesses. Many smaller companies are ideally suited to working with new products, creating jobs in local communities but also assuring the agricultural sector of new income.

Environmentally, bio-materials are also a winner. As a renewable resource, they reduce our dependence on fossil fuels and their manufacturing processes are cleaner, safer and more efficient than what is currently in use.

Internationally, soy is used in thousands of products, from adhesives, waxes and cosmetics to car parts, asphalt sealants and solvents. The automotive sector—bumpers, foams and other car parts—is the most immediate bio-materials market, but there are also emerging opportunities for products like paper, insulation, plastics, building materials and fabrics. However, the Canadian industry is still very much in its infancy. Soy 20/20 works on a confidential level with many Canadian companies, where exciting new developments are happening on an ongoing basis. The replacement of petroleum-based derivatives and chemicals with soybean-based alternatives represents a major opportunity for the sector. Our ability to develop, plant, harvest, segregate and bring to market specific varieties of soybeans for specific uses is exceptional.

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

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An overview of soybean uses in food

Oil

Soybean oil is second only to canola as the largest source of edible oil in Canada. Soybean oil, which enjoys a 34 percent market share, 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.

Approximately 21 percent of a Canadian soybean is comprised of oil. The need to replace the trans fatty acids (TFAs) found in many of our processed and fast foods has resulted in the development of oilseeds—like soybeans—that do not require hydrogenation, amongst a host of other exciting new traits.

Protein

Soy protein products have been used since the 1960s as nutritional and functional food ingredients in every food category available to consumers. Soy protein is one of the most complete of all vegetable protein sources and provides all the essential amino acids needed to meet our human nutritional requirements. It closely resembles high quality animal protein sources.

There are three principal types of soy protein: defatted soy flour, soy protein concentrates and soy protein isolates, approximately 50 percent, 65 percent and 90 percent protein, respectively. They are used in food products to replace more costly sources of protein and to deliver human health benefits. Soy proteins can improve water absorption, increase the emulsification of fats with other ingredients, provide body and resiliency and have a tenderizing effect, amongst other attributes.

Other components

This is an area where uses haven't yet been as well developed as for oils and proteins. Soybean hulls are a by-product of oil extraction. In food, they are traditionally used as a fibre supplement. Other by-products and minor soybean components, such as lecithin, tocopherols, saponins, glycerol, isoflavones and phytoserols, have applications in food processing or present potential human health benefits as a result of their anti-oxidant qualities.

For more information:

Soyfoods Canada
www.soyfoodscanada.com

Grain Farmers of Ontario
www.gfo.ca

Soy 20/20
www.soy2020.ca

Soybean meal

Soyfoods 101

Whole, dry soybeans

Prepared and used in ways similar to dried beans and peas. Soybeans must be soaked and cooked or roasted before being used in recipes. Dry soybeans can be purchased at bulk food stores, health food stores and some supermarkets. Canned and frozen soybeans, which are already soaked and cooked, are also available.

Tofu

Also known as soybean curd and made by curdling fresh soymilk. Tofu is relatively flavour-less on its own, but its great ability to take on the flavour of whatever spices or ingredients are added to it makes it a very versatile food ingredient.

Soy drinks

A lactose-free alternative to milk that is one of the easiest ways to add soy to your diet. Both shelf-stable and refrigerated varieties are available.

Soy nuts

A great snack food containing all the benefits of soybeans. A quarter cup serving of roasted soy nuts contains 15 g of healthy soy protein. Soy nut butter, similar to peanut butter, is also available.

Meat alternatives

Many available soy-based products, including ground beef-style and hot dogs, to deli meat and chicken or beef-flavoured chunks for stir-fries. The quality and flavour of meat alternatives have improved significantly in recent years as a way of broadening consumer appeal. Most of these products are low in fat and require much less cooking time than meat.

Soy dairy alternatives

Soy-based foods, such as frozen desserts and cheddar-flavoured soy slices, developed for people suffering from lactose intolerance. As with the meat alternatives, new technologies have improved the taste of soy dairy alternatives considerably in the past decade.

Textured soy protein (TSP)

Made from defatted soy flour that is compressed and processed into granules or chunks and sold as a dried product. Ground TSP can be used to replace all the meat in spicy dishes such as chili or tacos, or use a quarter teaspoon in meat loaves or burgers. When rehydrated with boiling water, ground TSP has a texture similar to ground beef; chunk-sized pieces of TSP take on the consistency of stew meat.

Soy flour

A gluten-free product that can be used in some recipes as a substitute for wheat flour. It can also be used to thicken gravies and cream sauces.

Miso

A smooth, salty paste made of ground soybeans and used extensively in Japanese cooking. It can be used in place of salt and soy sauce in a recipe and is generally added at the end of the cooking process.

Tempeh

A chunky, tender soybean cake that is a traditional Indonesian food. It has a firm texture and distinctive mushroom-like flavour. Tempeh can be marinated and grilled or added to soups, casseroles or chili.

Tempeh

Source: Soyfoods Canada, www.soyfoodscanada.com

Industrial uses for soybeans – Protein

(United Soybean Board/Soybean Checkoff)

The most voluminous product of soybean crushing is soybean meal. Approximately 80 percent of a soybean (by weight) will be sold as soybean meal. Traditional uses for soybean meal have focused on the livestock and poultry industries, which use it as a high quality protein source in feed. New uses that are being developed include adhesives, rubbers and plastics, personal care products, textiles, resins and coatings.

Soy flour and meal can also be found in products like drywall tape compound, textured paints, fermentation nutrients, paper coatings, fire-fighting foams and fire resistant coatings, asphalt emulsions and cleaning compounds.

For more information on soy used in animal feed, please consult the Soybean Feed Industry Guide at www.cigi.ca/pdfs/2010%20Soybean%20Feed%20Industry%20Guide.pdf.

Livestock and pet feed

Soybean meal is one of the most consistent and 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. A co-product of the oil extraction process, it is usually 48 percent protein with less than one percent oil and is sold as a flake or pellet.

Over 90 percent of the soybean meal produced in Canada is processed at solvent extractions facilities in Hamilton and Windsor, Ontario. Combined, these facilities have the capacity to produce over 1.7 million tonnes of soybean meal annually. Imports have accounted for approximately 55 percent of total supply in recent years, virtually all from the United States, the world's largest producer. Ontario accounts for roughly half of Canada's soybean meal imports.

Wood adhesives

New soy-based alternatives are being developed for the wood adhesives industry in response to health and environmental concerns and the increasing costs for petroleum-based products. New soy adhesives are expected to be safer to handle and will reduce volatile organic compound emissions.

Finely ground soy flour with specific properties can be combined with other commercially available resins to form wood adhesives, generally by dissolving soy flour in a sodium hydroxide solution. These adhesives are used for producing wood panels, replacing the formaldehyde that is traditionally used in plywood adhesives. Soy-based wood adhesives can be used across various lumber products, including wood panel products (plywood, veneer, oriented strand board, particle board and medium-density fibre board), engineered lumber, green framing lumber and wood pallets.

Columbia Forest Products began their search for alternatives to urea formaldehyde (UF) adhesives used in the manufacturing of hardwood plywood in 2001. In conjunction with Oregon State University, they developed a soy-based adhesive for plywood that entered commercial production in 2004. All seven of their plywood mills have been converted to using the new adhesive system. They also developed an adhesive for particle board. Trials for this product were conducted at the Columbia Forest Product particle board facility in Hearst, Ontario. Columbia is the largest manufacturer of hardwood plywood and veneer products in North America.

Rubbers and plastics

Soy flour is also being used as filler in plastics and rubbers. The challenge with using soy flour in these applications is the availability of the right type of soy flour. It must be finer than regular soy flour used in food production and contain less moisture or else it will not work properly. Since this is such a new discipline, there is a lack of expertise in industrial applications of soy flour, leaving product developers to work in conjunction with food researchers and scientists.

Textiles

Protein can be separated from soybean meal and spun into a cloth that has a soft, silky texture. Canada's domestic textile industry is very small however, so developing this alternative use does not present significant market opportunities. Production of this product currently resides in Asia and is sold to textile mills for further usage in the garment industry.

Resins

Soy protein polymer can be used in the development of resins. Ashland Inc, a US-based supplier of resins, adhesives and other chemical products, has developed soy-based polyester resins. This resin is being used in molded parts for the Model 9750 John Deere Harvester combine, as well as in bathroom components.

Printing inks

Soy-based printing ink has been used by newspapers in North America for the last two decades, with over 90 percent of the 1,500 daily newspapers in the US using soy ink in their presses. Soy-based toner for printers and copy machines has been developed in the US with work now underway to make the product commercially available.

Cosmetics

Cosmetics and beauty products made from soy and other natural ingredients are in demand. The products are gentle on the skin, readily biodegradable and have restorative properties. According to industry leaders, the global personal care industry is valued at over $150 billion US in revenues with the skin care and hair care segments representing almost 50 percent of the total global market. Sales of natural products are growing at an average annual rate of 15 percent.

(United Soybean Board/Soybean Checkoff)

Soy-based printing ink

Allergenicity

According to Agriculture and Agri-Food Canada, soy is the fifth most common food allergen on their list of top food allergens. This has led to concern that using soy as an ingredient in cosmetics and other products—like foam pillow mattresses—could have negative effects on the product end users suffering from sensitivities to soy.

Generally, it is the protein content within soy that causes food allergies. Researchers at Agriculture and Agri-Food Canada are working to identify which soybean proteins are the ones provoking the allergies, with the goal of developing a soybean seed that will be without most of the major allergens.

Products like foam pillows and mattresses are made from soy-oil polyols, which contain very little if any soy protein. Soy cosmetics can contain either oil or protein. These are emerging products so little research has been conducted in Canada to date concerning soy-based products and allergies. However, it is currently believed that there is very little allergy risk to consumers from these products.

In the US, the Food and Drug Administration's Select Committee on GRAS Substances (SCOGS) concluded that there is no evidence in the available information on soy protein isolate that demonstrates, or suggests reasonable grounds to suspect, a hazard to the public when it is used at levels that are now current or might reasonably be expected in the future.

Visit http://www.fda.gov/Food/FoodIngredientsPackaging/GenerallyRecognizedasSafeGRAS/GRASSubstancesSCOGSDatabase/ucm084104.htm#ftn2 for more information.

Industrial uses for soybeans - Oil

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

Foam

Polyurethane foams containing soy-based polyols currently represent the principal market opportunity for soy oils. As an example, using soy-based polyols to produce foam for car seats is predicted to be a $50 billion market by 2015, according to the Ontario BioAuto Council.

Ford, in particular, has focused on this area, with many of its vehicle platforms currently using the material in cushions and seatbacks. Soy-foam seats were introduced by Ford in 2007 on the 2008 Ford Mustang.

Woodbridge Foam is the Ontario-based manufacturer of automotive foam made using soybeans. They launched their soy-based polyol foam product in 2006. It offers the same or better comfort and durability as conventionally produced product and its current applications include head and armrests, seats and headliners.

Vita Foam Canada, another company headquartered in Ontario, is currently producing flexible foam for furniture applications that uses a soy-based polyol blended with traditional petroleum-based polyols. The process for manufacturing soy foam includes substituting soy polyols for a portion of petrochemical polyols. This process uses only the oil portion of a soybean.

Lubricants and fluids

Another rapidly growing market for soybean oils 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, produced by companies like Renewable Lubricants of Ohio. Their Canadian distributor is DM's Bio-Based Fluid Supply Inc. of Bolton, Ontario.

DM President Don Marentette expects the bio-lubricant market to grow steadily as consumers become more eco-friendly. Although he currently only distributes US-made product, his company owns manufacturing rights that he plans to implement once the Canadian market gets bigger.

Over the last year, Marentette has involved several of his products in a field trial with the University of Guelph. The University tested a 5W20 motor oil—used extensively in Ford and Chrysler vehicles—as well as a 15W40 diesel engine oil, a diesel fuel additive and chain saw oil. The reason behind the trial was to evaluate performance and ensure the bio-based products did as well or better than the conventional products in use at the school.

The trials proved to be a success. The soy-based chain saw oil is not only less harmful to plants and grasses, but also lasted longer than the conventional product. The motor oil also performed well, extending out the oil change life of each vehicle where it was used from 5,000 km to 8,000 km. The University has switched over to these green products for its snowplows, trucks and other vehicles on campus.

Trials are ongoing and now include hydraulic oils for its snow removal equipment as well. The City of Guelph is also switching its sidewalk snow removal fleet to DM's bio-based hydraulic oils, as is the City of Vaughan, among others.

Another Canadian company, White Court Oil in Vaughan, Ontario, is a developer and producer of soy-based fluids for the metalworking industry. This includes products like rust preventatives, cleaners, cutting and grinding fluids and industrial lubricants.

Soy 20/20 also works with other companies in this field to help build the Canadian market for soy-based lubricant products. Environmental Lubricants Manufacturing, for example, has developed a series of bio-based home lubricants for items like appliances, hinges, chainsaws, toys and lawnmowers.

Leading the way in soy-based lubricant research is the National Ag-Based Lubricants (NABL) Centre established at the University of Northern Iowa in 1991. Along with the first multi-season grease, the first bio-based stick lubricant and the first soybean-based transformer fluid, NABL also patented a soy-based wood preservative.

Asphalt sealants

A soy-based asphalt sealant is being tested in several parts of Ontario in hopes that it may help municipalities realize savings in their road repair budgets. The product is a pavement preservation agent that extends the life of existing asphalt surfaces, like roads and parking lots, by protecting them from the freezing and thawing cycles of Canadian winters. Without the use of a sealant, asphalt oxidizes and wears out due to the oxygen in the air. The small cracks that form in the asphalt fill with water, which freezes in the winter, causing larger cracks and potholes.

The average life span of asphalt-paved surfaces is 15 to 17 years, which can potentially be stretched to as much as 20 years by using this sealant. It is estimated that a one kilometre application of the sealant will use just over 36 bushels of soybeans.

Paints and coatings

Soybeans are a promising raw material for paints and coatings. Soybean oil has been a major ingredient in making oil-based paints but the increasing popularity of latex or waterborne paints, the market for alkyd resins made from soybean oil has declined.

Generally, solvent-based soy paints and coatings contain a lot of solvent but newer soy technology is focused on a water-base with lower volatile organic compounds (VOCs). These paints perform like oil-based paints but are as easy to clean up and as user friendly as latex products.

US paint manufacturer Sherwin-Williams is using soy as an ingredient in several of its lines of paint. They also use soy ink to print some of their paint can labels.

Soy Products and Uses

Industrial

Protein Products (38%*)

Soy Flour, Protein Concentrates and Isolates

adhesives
plywood
wallboard
particle board
insecticides
dry-wall tape compound
textured paints
fermentation nutrients
yeast carriers
linoleum backing
antibiotics
paper coatings
fire-fighting foams
fire-resistant coatings
asphalt emulsions
cleaning compounds
cosmetics
printing inks
leather substitutes
water-based paints
plastics
textiles

Refined Oil (18%*)

anti-corrosion agents
anti-static agents
caulking compounds
soap
shampoo
detergents
solvents
core oils
lubricants
biodiesel
hydraulic fluids
waterproof cement
disinfectants
electrical insulations
pesticides
linoleum backing
oiled fabrics
candles
cosmetics
crayons
printing inks
protective coatings
plastics
wallboard
dust suppressants
paint removers
epoxys
metal casting agents
paints

Hull Products / Fibre (8%*)

filter material
peroxidase

Lecithin (0.5%*)

anti-foam agents
anti-spattering agents
cosmetics
dispersion agents
printing inks
insecticides
paints
synthetic rubbers
stabilizing agents
wetting agents
yeast

Fatty Acids (minor*)

soaps
detergents
oleochemicals
structured lipids

Glycerol (minor*)

chemicals
lubricants
structured lipids
antifreeze
printing acids
cements
explosives
cosmetics

With the rising and increasingly variable cost of petroleum-based feedstocks, industry is now seriously considering bio-based feedstocks as an alternative. This creates potential new demand for soybeans that could ultimately be more significant than food and/or feed uses. This opportunity will develop globally. We have an opportunity in Canada to be a leader in this area, both in terms of industrial development, and in terms of developing varieties that will add value to industrial applications.

* percent composition of whole soybean

Industrial uses for soybeans - Oil *continued from page 7*

Wax

Packaging is the single largest sector use of wax in Canada, using approximately 1/3 of all wax as a means of protecting packaging against moisture. Aside from packaging (31 percent), candles (23 percent), construction materials (16 percent) and fire logs (7 percent), no other sector makes up more than 5% of total wax use. Invented in 1991, soy wax is produced by hydrogenating soybean oil or by metathesis. It serves as an alternative to paraffin wax, which is a petroleum-based product.

The global leader in the soy wax market is Elevance Renewable Sciences in Illinois, who manufacture high performance waxes, as well as functional oils, antimicrobials, lubricants, additives and other chemicals. Elevance anticipates growing its revenues from these types of products to over one billion dollars within the next decade.

Methyl Soyate (solvents)

Methyl soyate, a methyl ester derived from soybean oil, is being used as a solvent to replace chlorinated or petroleum products in chemical cleaners and strippers, and can also be used to clean up and recover spilled petroleum products from shorelines, rivers and streams. Consumer products ranging from hand cleaners to auto and personal care products using methyl soyate are already on the market. Emerging applications include bio-remediation, paper pulp cleaning and highway paving materials as a replacement for asphalt.

Its high flashpoint (approx. 182°C) and high boiling point (over 200°C) make it safer to store and handle than traditional commercial solvents.

Biodiesel

Biodiesel is a diesel fuel substitute that can be made from soybean oil, as well as other vegetable oils and animal fats such as recycled cooking greases. It can be blended with diesel, resulting in lower greenhouse gas emissions, as well as markedly improved engine lubricity. Biodiesel improves air quality by sharply reducing the emissions, including particulate matter, that straight petroleum diesel releases when it burns.

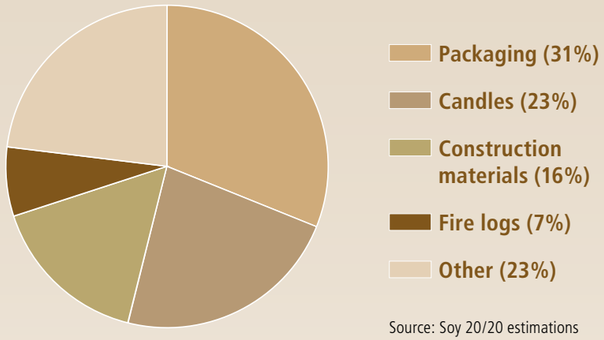
For more information: Canadian Renewable Fuels Association, www.greenfuels.org

Biomaterials research chair

A new Senior Industrial Research Chair focusing on biomaterials was established at Trent University in Peterborough, Ontario in 2010. Held by Dr. Suresh Narine, Director of the Trent Biomaterials Research Program, the initiative is funded, amongst others, by the National Science and Engineering Research Council, Elevance Renewable Sciences Inc. and Grain Farmers of Ontario. Research in the Trent Biomaterials Research Program is focussed on using vegetable oils, like soybean, in products like lubricants, greases and waxes, and for use as healthy food materials.

More information can be found at http://www.trentu.ca/biomaterials/overview.php

Canadian Wax Applications



Source: Soy 20/20 estimations

Industrial uses for soybeans – Fibre

The soy stalk is another under-valued part of the soybean equation. Currently, no real market exists for soy straw, the plants that are leftover after soybeans are harvested. Traditionally, soy straw has been left in the field as a nutrient source and as mulch that conserves soil and moisture. But research is underway to examine the potential for developing some value-added market opportunities.

Ethanol and burner fuel

Biofuels produced primarily from food crops—such as ethanol or biodiesel—are starting to be seen as somewhat limited in their ability to lessen dependence on petroleum-based fuels on a large scale. Concern is rising over long-term sustainability, their contribution to higher food prices and the potential impact on biodiversity, water scarcity and increased deforestation.

Work is underway to develop biofuels—called cellulosic ethanol—that are produced from non-food plant sources, such as soy straw, wheat stalks and non-edible biomass plants. The United States Department of Agriculture (USDA) has bred some soybean varieties specifically for this purpose, but these have not been commercialized to date as cellulosic ethanol itself is still in development stages.

In Canada, a Shell gas station in Ottawa became the first in the world to sell cellulosic ethanol to consumers in 2009. The blended fuel included 10 percent biofuel content made from wheat stalks as part of Shell's ongoing research into fuels sourced from non-food agricultural products.

The Ontario Ministry of Agriculture, Food and Rural Affairs estimates there is some potential for soy straw to be used as biomass for burner fuel, with annual crop residue thought to be around 2.1 million metric tonnes. However, it is estimated only about 40 percent of this material may be practically or sustainably removed from fields for use as biomass, leaving soybeans far behind other sources of feedstock such as corn stover or biomass-specific crops like switchgrass and miscanthus.

Building composites

An estimated 230 North American mills produce approximately 40 billion square feet of combined particle board, medium-density fiberboard (MDF), plywood and oriented strand board (OSB) every year. In some composites, wood components are being replaced with a different cellulose source, such as soy straw.

Plastics

Similar to his work with soy hulls, Dr. Amar Mohanty at the University of Guelph is also exploring the possibilities of using soy stalks as filler in plastics and rubber. So far, his results have been promising, although because the market is still relatively small, soy-based materials are currently more expensive than conventional products.

Supply is also an issue. Soy stalks are not easy or inexpensive to source in the large quantities required for commercial production of plastic or rubber parts. Currently, Mohanty is experimenting with mixing soy stalks with other products such as corn stover, wheat straw and corn stalks in hopes of alleviating the supply problem.

All wood fir veneer made using soy-based adhesives.

Industrial uses for soybeans – Other components

Soybean hulls

There is a common misconception that hulls are a waste product of soybean processing.

Soybean seed coats (hulls) are primarily a by-product of oil extraction. Traditionally, they have been used as a fibre supplement in animal feed as way of creating some value-added use. Work is now focusing on developing new end uses but these are still largely in their infancy.

There is a fairly common perception that hulls are a waste product of soybean processing. This is not accurate—soybean hulls, on a per tonne basis, have a value of approximately 25 - 50 percent of the value of soybean meal and have a market price that is established in a manner similar to soybeans, soybean oil and soybean meal.

To date, the seed coat is a part of the soybean that has seen only limited research. This means there is little understanding of its potential, of the protein formation in the seed coat or of any interactions between the seed coat and soybean meal. Soy 20/20 has been involved in supporting some research activity in this area as a means of furthering understanding of the opportunities that could exist for hulls.

Waste water treatment

Keith Taylor, a professor in the Department of Chemistry and Biochemistry at the University of Windsor, and colleagues have been studying how soybean peroxidase can be used to clean industrial waste water, especially from refineries, metal casting industries, wood products production and coal tar processing.

The peroxidase is extracted from the soybean hulls and the enzyme is used to oxidize phenolic compounds in the waste water. This means the enzyme actually builds up the phenolic compounds in the water to the point where they become insoluble and can be physically separated from the water.

The clean water can then be safely re-used. It's hypothesized that once the peroxidase has been removed from the hulls they can still be used in animal feed without any impact on the quality of the feed.

Currently, there are no providers of the enzyme on a commercial level, so the opportunity exists for development of a commercial enzyme extractor that would provide a product for use in global wastewater treatment. Such an extractor could also be used to extract other natural materials from soybean hulls such as trypsin inhibitors, which have been shown to be an effective cancer treatment.

The commercialization of soybean peroxidase, by using one industry's by-product to treat the waste of another's, represents a whole new level of transition from a petroleum-based economy to a bioeconomy.

Plastics and rubber

Work is underway to explore the use of soy hulls and soy meal as extenders in plastics and rubber. Dr. Amar Mohanty, Director of the Bioproducts Discovery and Development Centre (BDDC) at the University of Guelph, has been heading up this research.

His work with soy hulls and plastics is focused on two main areas:

- **green composites**: mixing soy hulls with renewable resource-based based bio-plastics
- **bio-composites**: the soy seed coats are mixed with petroleum-based plastics.

Dr. Amar Mohanty

The main difference between the two composites is their biodegradability. The green composites are biodegradable under compost conditions, but the bio-composites, even though they also contain some soy ingredients, are not fully degradable.

Both of these products are being made into parts for the internal structures of automobiles, such as panels and dash board parts, as well as construction panels and rigid plastic boxes for a variety of sustainable packaging uses. A project using soybean meal to develop a biodegradable plastic for grocery bags, as well as work on soy-based rubber parts for the automotive industry, is also underway.

Currently, Mohanty's biggest problem is one of supply. It is difficult to consistently source large volumes of soy hulls or stalks, or even to do so in an economical and practical fashion for high volume uses in auto-parts and sustainable packaging. This has led him to also work with hybrids—mixing soy with other agricultural ingredients such as corn stover, corn stalks, wheat straw, switch grass or miscanthus. Not only does this address the current supply issue, it can also, in many instances, result in stronger product.

Despite the challenges, the benefits of these green products are considerable, says Mohanty. In addition to being biodegradable, using soy hulls can help lower the industry's greenhouse gas emissions and provide a lower cost alternative to certain petroleum-derived ingredients.

Wood stains and preservation

Lecithin is a principle by-product of soy oil degumming and has been found to have many functional properties. These include emulsifying, wetting and as a colloidal and antioxidant. It has many uses in the food industry but one of its principle non-food uses is industrial coatings such as wood stains and preservation materials, where it helps keep pigments dispersed in paints to prevent agglomeration. In Canada, Home Hardware has launched some wood stain and preservation products containing soy lecithin.

Pharmaceuticals and health

Tocopherols, also known as vitamin E, are an important antioxidant present in soybeans in relatively high concentrations. Saponins are a natural surfactant with antioxidant properties also having the potential to lower cholesterol and prevent cancer. Isoflavones contain potential health benefits such as prevention and treatment of cardiovascular disease, cancer and osteoporosis. Soybean phytosterols are a by-product of vitamin E manufacturing and are being studied in relation to cardiovascular diseases.

Glycerol

Glycerol is a by-product of oil processing and significant volumes are produced through the making of biodiesel. Large amounts of glycerol are used in the manufacturing of pharmaceuticals, cosmetics, toothpaste, urethane foam, synthetic resins and tobacco as well as food processing. Dr. Mohanty of the University of Guelph is currently experimenting with using glycerol in processes to create soy-based composites.

Resources, Challenges and Opportunities

Although various industrial applications for soybeans have been available for some time, the industrial soy products market as a whole is one still very much in its infancy. There are challenges that are keeping growth in the sector from moving ahead as rapidly as it could, but despite this reality, possibilities of the new bio-based economy seem almost limitless. However, given the realities of the Canadian market, it would also be safe to say that Canada will ultimately need to be selective in the types and numbers of opportunities that are developed.

Funding

Research and commercialization capabilities and support are also available from public research institutions or from not-for-profit innovation and commercialization organizations, like Soy 20/20. Canadian suppliers and manufacturers of potential soy-based products can also access government support in the form of Scientific Research and Experimental Development (SRED) tax credits or research and development grants from the federal government. Most grants involve some form of matching funding commitment by the recipient, although levels are specific to each individual program.

For more specific information, contact:

Industry Canada
www.ic.gc.ca

Canada Revenue Agency
www.cra-arc.gc.ca

Research

Traditionally, soybeans have been thought of in terms of food uses and application. This mindset is definitely changing, but there is still a lack of expertise in some of areas already mentioned. For example, soy flour is generally used in food products and there are many food scientists who are experts in this area. However, the use of soy flour in industrial applications such as plastics, rubber or adhesives is still very new. Accordingly, identifying experts with an appropriately transferable skill set who are interested in developing such technology can be challenging.

Cost, scale and volume

Although all of the products described in this publication are available on the market, many are not yet produced in Canada. As well, general public demand is not yet significant enough to make them an economically feasible alternative for most consumers.

Canada is not a large market. The country accounts for approximately 1.5 percent of global soybean production, with much of that destined for premium food grade markets. This is accompanied by what is—from a global perspective—a small consumer market, which ultimately means that each opportunity must be evaluated individually for strategic fit.

Processing

One challenge facing Canadian growers and manufacturers is the lack of processing facilities to support these new opportunities. Companies are generally reluctant to make large scale investments in processing infrastructure until new products are proven in the marketplace. And that can often be difficult to do until a product is mass-produced.

Ingredients

Sourcing ingredients can be difficult. Sometimes it is a question of being able to secure adequate supply of a specific ingredient, such as soy stalks, for example. Other times it's a larger problem of non-availability which means the specific type of raw soy material needed for a product simply doesn't yet exist in the desired form.

Other

Odour has been identified as a concern with early bio-product development. Items made from bio-based ingredients often have a different smell than those with the traditional petroleum base, one that consumers have not yet become used to. To address this issue, Soy 20/20 is involved with industry, academia and researchers to facilitate a solution to the concern of odour in bio-products.

We can help

But in spite of the challenges, the bio-products sector is full of opportunity and potential. Soy 20/20 and its partner organizations in the Agri-Technology Commercialization Centre (ATCC), located in Guelph, Ontario, can play a key role in connecting researchers with industry or in bringing together suppliers and manufacturers. In addition to Soy 20/20, ATCC members include:

- **Ontario Agri-Food Technologies**
  Capturing new markets and accessing new technologies for Ontario's agri-food sector
  www.oaft.org
- **BioEnterprise**
  Building Ag-Bio Based Businesses
  www.bioenterprise.ca

For more information:
www.soy2020.ca

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The Soy 20/20 Project brings government, academic and industry partners together to stimulate and seize new global bioscience opportunities for Canadian soybeans. The Project assists researchers, industry, producers and policy makers in focussing on key opportunities and working together to achieve them.

Soy 20/20 works to build linkages among researchers and guide their studies towards markets where opportunities await. Improving teamwork among soybean researchers across the country increases their effectiveness and adds to the creation of new knowledge and technology.

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