

# Feedstock Fact Sheet

Although the biodiesel industry has experienced tremendous growth, raw material supplies have served as a natural brake and created a strain on margins for biodiesel producers. The surge in commodities prices is a result of numerous factors including a weak dollar, expanding domestic and global biofuel production capacity, low commodity stocks due to global weather situations, increased energy and transportation costs, and the strength of global food demand.

The National Biodiesel Board was formed during a time period of record inventories of fats & oils and extremely low feedstock prices. However, achieving the industry vision of replacing 5% of diesel demand by 2015 calls for additional focus on new raw materials sources for biodiesel production. New feedstock opportunities vary significantly; both in terms of potential impact on the market in terms of volume and timing to commercialization.

The following summary will highlight a limited number of near-term and longer-term opportunities to add to the U.S. supply of raw materials for biodiesel production. Existing feedstock supplies with a limited supply response or feedstock supplies that are primarily imported are not addressed in the summary.

Near-term opportunities exist with the creation of “virtual acres” (greater yields of oil per acre), capitalizing on growth in the ethanol industry, and additional acres of high oil content crops such as winter canola and camelina.

## **Corn Oil—Changing biofuels landscape creates opportunity to benefit from increased ethanol usage**

Ethanol producers may offer the biodiesel industry its nearest term opportunity for additive supplies. Historically, corn oil has not been a viable biodiesel feedstock due to its relatively high cost and high value as edible oil. In current dry grind processes, the corn oil essentially passes through the process and remains in the resulting distillers dry grains with solubles (DDGS). Ethanol firms are investigating fractionating technology to remove corn germ (the portion of the corn kernel that contains oil) prior to the ethanol process. Furthermore, some ethanol plants have already made public their intention to employ technology to remove the remaining vegetable oil from dried distillers grains, a co-product of the ethanol process. In addition to the various extraction technologies, the quantity of corn oil could also be increased in the long term by producing more high-oil corn varieties.

All of these technologies could add to the biodiesel raw material supply in a meaningful way. Corn oil could help to meet feedstock market demand in two ways. First is for edible corn oil to displace other edible oils that could then be diverted to biodiesel production. Second is for non-edible corn oil to be used directly for biodiesel production. For example, reaching the proposed goal of 15 billion gallons of ethanol production from corn could generate almost 400 million gallons worth of vegetable oil if only ½ pound of oil was extracted from each bushel of corn.

## **Soybean Virtual Acres—New technology will add to the U.S. raw material supply**

“Virtual acres” is a term for generating additional feedstock from the same acre. Monsanto plans to introduce new technology that can increase soybean yields 9 to 11 percent. DuPont is commercializing soybean varieties that increase yields by as much as 12 percent. These technologies are set to have an impact in 2010. If 90% of U.S. soybean acres adopted the new technology, more than 60 million acres could benefit from a 10% increase in yield. This equates to more than 250 million additional bushels of soybeans (the equivalent of 380 million gallons of

biodiesel) without increasing acreage in the U.S.

The same benefit can be achieved by increasing soybean oil content. Current industry genetic programs suggest 10% oil increases are achievable within the next few years. New approaches for achieving even higher oil levels in plants are needed. Previous efforts focused on increasing the flow of carbon into the oil biosynthesis pathway. However, downstream bottlenecks appear to reduce the value of this approach. The National Biodiesel Board (NBB) has teamed up with The Donald Danforth Plant Science Center to look at the potential to enhance the oil production in soybeans and other oilseeds, although this is a longer-term endeavor. At the heart of the Danforth Plant Sciences strategy is the hypothesis that the ability to utilize available carbon limits oil production. Therefore, their work will focus on engineering carbon sinks that will pull metabolites through the oil production process in plants. This is a three-year program, initiated in 2008.

### **Camelina, Winter Canola, & Brassica Juncea—Crops with higher oil content**

The production of oilseeds on new acres may also offer additional raw material supplies to the biodiesel industry. Private firms are offering camelina contract opportunities in the Pacific Northwest and the U.S. Canola Association has established an initiative to increase canola acres by 2010. Although interest in these oilseeds is high, global wheat consumption has surpassed production in six of the last eight years. The resulting price spike in wheat has negatively impacted the current opportunity for expansion of winter canola and camelina acres.

**Camelina**—Just as biodiesel producers like to say that biodiesel can be used in any application that diesel fuel is used, camelina is said to be adapted to any region in the Upper Midwest where wheat can be grown. According to Montana State University, camelina is a short season crop (85 to 100 days) that is well suited for marginal soils and has a lower break-even cost than wheat or canola. It performs well under drought stress and can yield up to 2,200 pounds per acre (1,200 to 1,500 lbs/acre typical) in areas with less than 16 inches of annual rain, although reported yields are still highly variable in different regions. Camelina is said to be a good fit for cool regions where canola production is difficult. In 2007 there were a reported 50,000 acres of production in Montana with limited acreage in surrounding states.



Camelina is an annual or winter annual crop that researchers say can be planted on marginally productive cropland from eastern Washington to North Dakota. Long considered a weed in northern states, camelina is a member of the mustard family and also known as false flax, gold of pleasure, and leindotter in Germany. Researchers and producers indicate the crop can be grown in arid conditions, prefers lower humidity levels, does not require significant levels of inputs such as fertilizer, and the oil will produce a high quality biodiesel. Typical varieties of camelina are approximately 38 to 40% oil.

At least two firms are offering contracts to producers with stated goals of achieving two million acres of production. Depending upon the type of extraction technology used, more than 100 million gallons of oil could be added to the market.

**Canola**—Canola is a type of rapeseed that was first developed in the 1970s. Canadian plant breeders developed canola explicitly for its nutritional advantages compared to industrial rapeseed. Original rapeseed's nutritional content has always been questioned due to their high levels of elcosenoic and erucic fatty acids, which is a fatty acid that has been shown to be related to heart disease. In the 1960s, Canada began researching rapeseeds by isolating specific lines that were low in erucic acid to produce an oilseed that could be considered safe for human consumption. The result of their efforts was “Canola,” defined as oil that contains less than 2% erucic acid.

Canola is a popular crop throughout the world because of its variety of uses and the nutritional value compared to competing crops. Canola can be produced in some countries where similar crops are not able to grow because of short growing seasons. In the U.S., North Dakota is the leading producer of canola. Canola oil has been increasing its market share in the United States, because of its nutritional advantages compared to other competitive vegetable oils. Although canola oil would primarily move into edible markets, increased U.S. acreage will have positive impacts on the overall vegetable oil supply.

The U.S. Canola Association has established goals and programs to expand canola acreage to 2 million acres by 2010. Significant to a portion of this goal is expansion of winter canola acres. Canola in the U.S. is almost exclusively grown as a spring crop. Expansion of winter canola acres in the Great Plains and mid-South would add to the vegetable oil supply.

**Brassica Juncea**—Mustard is the common name for multiple species in the *Brassica* genus. The species of which most people are aware is yellow mustard, referred to as white mustard in Europe, and is grown primarily for condiment mustard seed. As a result, it does not have as high oil content as the other commonly known Indian mustard referred interchangeably in commerce as brown or oriental mustard. This mustard's botanical name is *Brassica juncea*. *Juncea* varieties are grown for edible leaves or greens or for condiment mustard, and have been and are increasingly grown as an oilseed crop.



The crops commonly called rapeseed and canola in commerce are also in the *Brassica* genus, and are *Brassica napus* species. As a result, they are closely related to *juncea*. Because canola is not a botanical term, but one used to describe compositional qualities, the term is often used with *juncea* when discussing cultivars that have been developed for the oilseed market. Canadian plant breeders have developed *Br. juncea* cultivars with canola characteristics. As a result, canola varieties of *napus* and canola-type *juncea* have similar compositional characteristics but different crop or agronomic qualities. In theory, oils from both species have the same acid profiles (high in monosaturates and low in saturates) and oil characteristics (lower pour and melting point and better cold flow properties) and similar meal properties (35 to 40% meal protein content with low glucosinolate levels). The key differences between *napus* and canola-type *juncea* lie in their agronomic characteristics. Both are an annual, cool season crop. However, *juncea* tolerates high temperatures and drought better than *napus*, and thus is better suited for the warmer, drier climates of the Upper Plains of the U.S.

Cultivars of *juncea* have been or are being developed in the private domain for commercial use, and at least two companies are currently marketing *juncea* varieties in Canada and the U.S.

Pioneer Hi-Bred has released 45J10 to be commercially available in 2008. Viterro Proven Seeds is marketing two *Juncea* canola varieties – Proven Estlin and Proven Dahinda. In addition, Pacific Seeds began marketing their first *Juncea* canola variety in 2007 in Australia in limited quantities. Research is ongoing to create *juncea* cultivars that are more “canola-like” to increase oil content. Other varieties have been developed by public entities such as Arid and Amulet (developed by the Agriculture and Agri-Food Canada Saskatoon Research Center, and Saskatchewan Wheat Pool) and the University of Idaho’s cultivars, Kodiak.

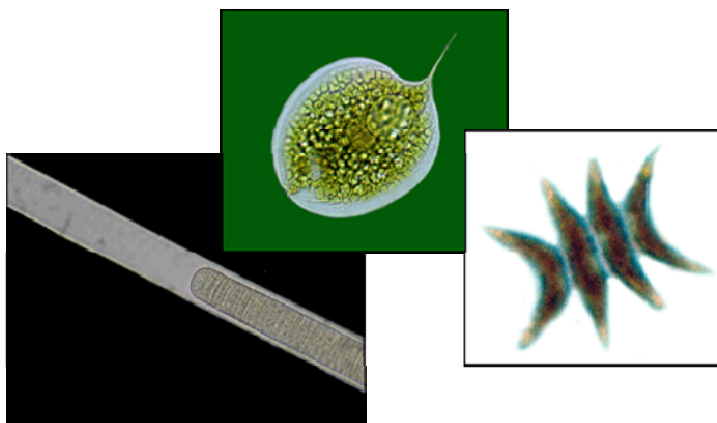
*“The greatest service which can be rendered any country is to add a useful plant to its agriculture.”*

*Thomas Jefferson, ca. 1800*

The current feedstock supply situation has sent numerous signals to the market to invest in new technologies and methods to increase raw material supplies. Investment in new, non-edible raw materials sources such as algae, jatropha, mustard, brown grease, and seashore mallow continues at an aggressive rate. The list is not short for potential avenues to generate raw materials; however we must remain realistic relative to the amount of time required to fully benefit from these investments. A number of opportunities are highlighted in the following text.

## **Algae**

Lipid production from algae holds much promise for the biodiesel industry. Microalgae are microscopic aquatic plants that carry out the same process and mechanism of photosynthesis as higher plants in converting sunlight, water and carbon dioxide into biomass, lipids and oxygen. However, algae production does not require fresh water or arable land used for cultivation of food crops.



Large scale production of these algal lipids is still a few years away but many companies and universities are working to unlock the potential of these single-celled plants, which can contain up to 50 percent oil by weight and double their numbers in a single day. Once realized oil yield per acre is expected to be the highest of any triglyceride source currently available. Yield projections in the medium term are estimated to range from 2,000-5,000 gallons per acre as compared to 61 gallons per acre for soybeans.

There are two algae production paths that are being pursued: open ponds or bioreactors. The open pond method involves growing the algae in open ponds of water, much like it grows in nature. Open ponds are generally less capital intensive than the other production methods, but they require a reliable supply of water to replenish that lost from evaporation. The lack of temperature, weather and algae species control can decrease yields from the theoretical potential.

Closed loop or bioreactor systems grow algae in a controlled environment using a wide variety of production processes like plastic bags, tubes or fermentation reactions. Closed loop systems provide the advantage of additional control over seasonal temperature changes, evaporation losses and contamination by undesired algae strains. However, the capital costs of bioreactors tend to be higher than for open pond systems.

Locating algae processing plants intelligently can add to their efficiency. Locating algae facilities next to carbon producing power plants, or manufacturing plants, for instance, the plants could sequester the CO<sub>2</sub> they create and use those emissions to help grow the algae, which need the CO<sub>2</sub> for photosynthesis.

Very little biodiesel to date has been from algal lipids. Several algae production companies have indicated that the biodiesel has been produced will meet the ASTM D6751 specification. The wide range of algae species will differ in the oils they produce.

#### Links

[University of New Hampshire Biodiesel Group](#)

[DOE Aquatic Species Program Report](#)

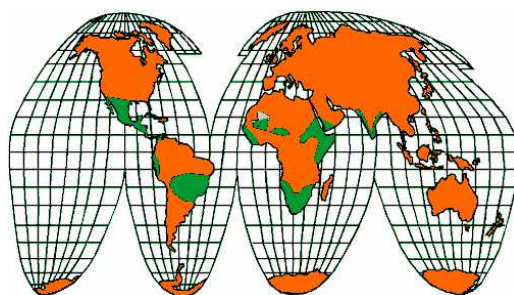
[Pure Energy Systems Wiki – Directory: Biodiesel from Algae](#)

### **Jatropha**

Jatropha is a small but versatile bush/tree from the Euphorbiaceae family. The tree flowers and produces clusters of about 10-15 fruits with a seed containing high concentrations of oil. *Jatropha Curcas L.* is gaining a lot of attention as a potential feedstock for biodiesel production due to its high oil content and ability to grow in less than ideal conditions. However, harvesting and logistical challenges have kept the plant from being grown in large scale production in places where there is not an abundance of low cost labor.



Historically, most of the Jatropha has been grown in tropical areas including Africa and Asia, especially India. More recently, it has been grown on most continents around the world. The green shading on the map below indicates the primary areas where Jatropha is grown. These areas are mainly inside the tropics and are not known to have land of good quality.



This low maintenance plant has generally proven to be resistant to local pests under common cultivation practices and can produce seeds containing up to 40 percent oil. While Jatropha is touted as being able to survive in poor soils with very little fertilizer and water, the fruit (and thus oil) yields increase significantly with increased soil fertility and water. For example, adding small amounts of magnesium, sulfur, and calcium have a significant impact on improving yields. Jatropha can survive in areas with annual rainfall of 8-12 inches. In extreme conditions, plants will survive drought by dropping its leaves to reduce transpiration loss. In fact, this resilient plant can survive three full years of drought before it would die. However, fruit production is very low during these drought years. While Jatropha is most commonly grown in low altitude regions that are relatively warm, it can grow at higher altitudes but can only handle a slight frost.

Since Jatropha can grow in arid areas that are not suitable for traditional grain crops, there could be a potential market for growing Jatropha in portions of the United States. Such areas

could include much of the dry southern states including Arizona, Texas, and New Mexico, and other arid grounds. Literature has also suggested that *Jatropha* could grow very well Florida, California, Alabama, Mississippi, and Louisiana. In order to be economically viable in these states, *Jatropha* would need to be grown in a manner that it does not compete with existing crops or alternative competition such as urban sprawl.

### **Seashore Mallow**

Many land areas are presently not arable because freshwater is lacking, the soils are naturally saline, or the soils are salty as the result of previous agricultural practices. Many of these areas have abundant saline water available either as surface or ground water. Seashore mallow is a novel salt-tolerant perennial crop, derived from a salt marsh plant. With an oil content of approximately 18% and residual meal that contains 30% protein, this crop can be grown on saline land and produce vegetable oil on underutilized or non-arable land.



As reported by researchers at the University of Delaware, seashore mallow has a productive life of about a decade and the oil is very similar in fatty acid composition to the oil from cottonseed. There are few reported insects or diseases that impact the crop, breeding efforts have been almost non-existent. Due to limited breeding efforts, yields of seashore mallow are low compared to other oilseeds. Researchers envision at least four ways that seashore mallow may fit into agronomic scenarios:

- Grown on salinized farmland,
- Grown on dry farmland with brackish water wells,
- Grown on sandy coastal deserts, or
- Grown on farmland or aquatic ecosystems in transition.



### **Peanuts**

Today, seven states account for approximately 99% of all peanuts grown in the U.S. Georgia grows the major proportion of all peanuts followed by Texas, Alabama, North Carolina, Florida, Virginia, and Oklahoma. With the 2007 Farm Bill making major changes in many aspects of the agriculture industry, many special incentive programs were cut. Some of those include charging the farmer for storage and handling and assigning crop base to growers and not land owners, causing less acreage for peanut production.

Georgianic—or similar varieties—may be the future of peanut biodiesel because it can be planted and grown with just one herbicide application for weed control, compared to the three to four applications typically sprayed during a growing season for edible peanuts. Additionally, these fuel peanuts are grown without fungicides, which are the greatest input cost in traditional peanut production.

Currently, there are 24 peanut varieties being scrutinized in this biodiesel screening project, including Georgianic, which was developed by ARS breeders in Tifton, Ga. Promising varieties also include DP-1 and Georgia-04S, a new high-oleic-acid, Spanish-type peanut ([ars.usda.gov](http://ars.usda.gov)).

Production of these peanuts would be limited to the southern regions of the U.S. where growing conditions are more suitable.

### **Chinese Tallow Tree**

The Chinese Tallow Tree (*T. sebifera*) is a plant native to central China. The tree is most favorably grown in warm climates with well-drained soils, with the fruit being harvested in early winter after the leaves have fallen off.



It was first introduced into the United States in 1776 by Ben Franklin. Since then it has become an invasive species, growing on canal banks, steep mountains, granite hills, or sandy beaches. The Chinese Tallow Tree is shade, sun, drought, flood, freeze, and salt-tolerant, making it a plant that is very hard to control.

According to studies done on the plant properties of the Chinese Tallow Tree, one seed contains about 20% oil, 24% tallow, 11% extracted meat, 8% fibrous coat and 37% shell. The oil keeps well and probably does not need refining. In plantations, when trees are planted about 400 trees per hectare and if pruned would yield 14 MT seed/ha, containing 2.6 MT oil. Some reports yield of 4,000 to 10,000 kg/ha, and cite estimates of 25 barrels of oil per year as a sustained energy yield.

Since the Chinese Tallow Tree is very hard to control making it seem as if there are no impediments to its growth. Although it has been an invasive species in many states, California uses the tree as a street and ornamental plant and it does not interfere with the other plant life. Many scientists have speculated that it does not spread as quickly in California because of the lack of rain in their climate. With some tolerance to salt, the tallow trees could be investigated as energy crops for saline situations.