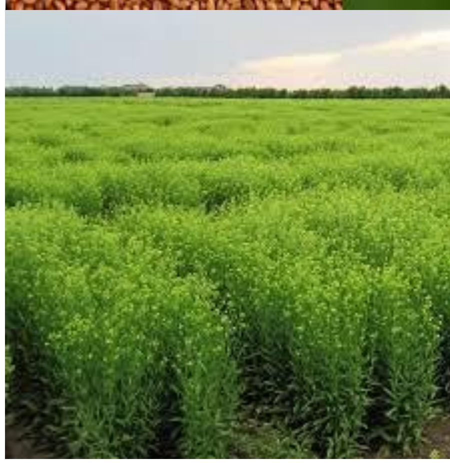
CAMELINA

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Project Summary

This **Farm – to – Factory project** involves all the aspects of growing and using Camelina for bio-diesel production.

Camelina

PROJECT SUMMARY

Introduction

Camelina oil is edible oil that comes from seeds of *Camelina Sativa,* commonly known as false flax.
Camelina oil has been used in Europe and North America for a few centuries as an oilseed and for lighting lamps. Camelina oil has been found to contain high amounts of omega – 3 fatty acids, like flaxseed oil, which make it suitable for use as a nutritional supplement and general purpose oil.

The association of Camelina with human civilization reaches back to prehistoric times. Archaeological records suggest that it has been grown in Europe for at least 3,000 years. Very early findings indicate that Camelina seed was a substantial part of the human diet and consumed in porridges and the like, and it seems the Romans appreciated the pleasant aroma of the oil as cooking, lamp, or massage oil. As fuel, Camelina oil historically was used in many parts of Europe as the lamp oil of choice until the advent of gas and electricity in the 19th century. Camelina continued to be quite commonly grown all across Europe, particularly Russia, until – ironically – the onset of the large-scale production of hydrogenated vegetable oils in the mid-1950s (hydrogenation creates trans-fatty acids which are today known to cause adverse health effects). But because the hydrogenation of Camelina oil is more difficult and more cost-intensive than, for example, hydrogenation of canola oil, it became economically unfeasible to grow Camelina and acreages dwindled. Today, Camelina is sporadically grown in Europe as a source for culinary oil.

But while Camelina is an oilseed with a long history in Eastern Europe and Russia, it is a relatively new crop in North America where it has sparked interest as a non-food, low-input, feedstock for the production of biofuel and bio-based industrial products such as lubricants, hydraulic fluids and polymers.

Camelina sativa is a member of the mustard family, a distant relative to canola, and an exciting new player on the biofuels scene. Camelina plants are heavily branched, growing from one to three feet tall producing seed pods containing many small, oily seeds. It's proof that good things really do come in small package.

Camelina oil is obtained by extracting oil from seeds of Camelina sativa. This is a hardy crop that grows well in cold and arid climate, even in very cold environments like in Canada. Although it has not been as popular as other common edible oils, however archaeological studies confirm that it was a major oilseed crop in ancient times in Europe. Historic settlements in some places in Switzerland and Greece show signs of cultivation of this crop. Today, it is grown mainly in Canada for commercial oil extraction.
Just like other oils, Camelina oil too can be extracted by a few ways.

- Cold pressed oil – It retains most of the original nutrients in the oil.
- Solvent extraction – It yields better extraction, but it contains harmful solvents.
- Supercritical fluid extraction.

Cold pressed Camelina oil is quite healthy and exerts a few health benefits.
Camelina oil is also used as a nutritional supplement for dogs.

Camelina oil has some more interesting uses.

As cooking oil – There is growing interest in Camelina oil as cooking oil, especially for deep frying. It has the highest smoke point of 475 ° F which is much higher than olive, coconut, canola, grapeseed and most other cooking oils. That is why one can use it for stir frying, deep frying and sautéing. Camelina oil has a nutty flavor, which makes it excellent for fried food and other delicacies. Camelina oil is a popular ingredient in paleo recipes.

As biofuel – Camelina oil is also a source of fuel. It is being studied for its viability as an alternate fuel.
It has been used as a jet fuel on number of occasions. In Japan, it is being studied for its potential to generate electricity.

Growing Camelina

Camelina has many names: gold-of-pleasure, false flax, wild flax, German sesame. One of our favorites is Siberian oilseed; it's such a hardy, cold-tolerant plant it seems to deserve that name.

Camelina is an annual plant with prolific small, pale-yellow flowers with four petals, attains heights of 1 to 3 feet and has branched stems that become woody at maturity. Leaves are arrow-shaped, sharp-pointed and about 3 inches long with smooth edges. Seed pods are the size and shape of a small pea. The seeds are very small, amounting to about 400,000 seeds per pound, and they are 40 percent oil, compared to 20 percent with soybeans.

Camelina, also known as false flax or gold-of-pleasure, is an oilseed belonging to the Brassica (mustard) family. It is native to Europe and naturalized in North America where it grows well under a wide range of climatic and soil conditions. The crop originated on the steppes of southeastern Europe and in southwestern Asia. This is an area characterized by a climate very similar to the Canadian Prairies with short, hot, summers, long cold winters and relatively low average yearly precipitation. This makes Camelina a natural fit for the Prairies.

If every drop of moisture is precious, you may want to consider Camelina. It can produce seeds with less moisture so you're assured of something to harvest. Plus, by maturing earlier than most other crop options, it's not as dependent on rain later in the summer when Mother Nature can be more fickle. And since Camelina can be harvested early, it allows ground to absorb later-season rainfall so it can enter the New Year in a better position.

The remaining meal is a protein-rich feed source for cattle, poultry or swine.
Camelina typically contains 35-38% oil, which is high in omega-3 fatty acid. This makes the oil fit for biofuels production and the meal a good option for livestock feed.

Camelina as renewable fuel

The emerging green fuel industry is turning Camelina into a new crop rotation option and consistent income source for farmers. The seeds are easily crushed with oil being used for biodiesel or aviation biofuel that performs similar to fuels from other sources but can be more efficient.

Camelina oil is a low-cost feedstock for biodiesel production that has received a great deal of attention in recent years. Four main process conditions in the transesterification reaction for obtaining the maximum biodiesel production yield (i.e. methanol quantity, reaction time, and reaction temperature and catalyst concentration) were investigated. It was found that the order of significant factors for biodiesel production is catalyst concentration > reaction time > reaction temperature > methanol to oil ratio. Based on the results of the range analysis and analysis of variance (ANOVA), the maximum biodiesel yield was found at a molar ratio of methanol to oil of 8:1, a reaction time of 70 min, a reaction temperature of 50 °C, and a catalyst concentration of 1 wt.%. The product and FAME yields of biodiesel under optimal conditions reached 95.8% and 98.4%, respectively. The properties of the optimized biodiesel, including density, kinematic viscosity, acid value, etc., were determined and compared with those produced from other oil feedstocks. The optimized biodiesel from Camelina oil meets the relevant ASTM D6571 and EN 14214 biodiesel standards and can be used as a qualified fuel for diesel engines.

Here are some basic values to crude Camelina oil:

FFA < 3%

Iodine Value > 90

M&I < 1%

Saponification Value: 170-180

Density: 0.92 g/ml

Calorific Value: 38,000 MJ/Kg

Unsaponifiable: 1.2-1.5

CSB – Camelina Sativa Biodiesel

Table 1. Standard requirements, Camelina *sativa* biodiesel properties and test methods.

Property	Units	ASTM D6751-12	UNE-EN 14214:2012	CSB	Test Method
Density at 15 °C	kg m^{-3}	-	860 – 900	888	EN ISO 12185
Kinematic Viscosity at 40 °C	mm^2 s^{-1}	1.9 – 6	3.5 – 5	4.3	EN ISO 3104
Cold Filter Plugging Point	°C	-	According to climate zone	- 4	EN 116
Cloud Point	°C	According to climate zone	-	0	ASTM D 2500
Cetane number	-	≥ 47	≥ 51	42.76	EN 15195
Methyl ester content	wt.%	-	≥ 96.5	97.5	EN 14103
Distillation temperature AET, 90 % recovered	°C	≤ 360	-	369	ASTM D 1160
Flash Point	°C	≥ 93	≥ 101	152	EN ISO 3679
Sulphur content	mg kg^{-1}	≤ 15	≤ 10	0.57	EN ISO 20846
Carbon residue	wt.%	≤ 0.05[a]	-	0.019[a]	EN ISO 10370
Sulphated ash content	wt.%	≤ 0.02	≤ 0.02	0.0013	ISO 3987
Water content	mg kg^{-1}	-	≤ 500	120	EN ISO 12937
Total contamination	mg kg^{-1}	-	≤ 24	7.3	EN 12662
Copper strip corrosion (3 h,50 °C)	classification	3	1	1A	EN ISO 2160
Oxidation stability, 110 °C	hours	≥ 3	≥ 8	1.3	EN 14112
Acid value	mg KOH g^{-1}	≤ 0.5	≤ 0.5	0.15	EN 14104
Iodine value	g I_2 g^{-1}	-	≤ 1.2	1.52	EN 14111
Cold Soak Filterability Test	seconds	≤ 360	-	246	ASTM D 7501
Linolenic acid methyl ester	wt.%	-	≤ 12.0	34.2	EN 14103
Polyunsaturated (≥ 4 double bonds) methyl esters	wt.%	-	≤ 1	2.08	EN 15779
Methanol content	wt.%	≤ 0.2 or flash point ≥ 130 °C	≤ 0.2	0.0121	EN 14110
Monoglyceride content	wt.%	0.4	≤ 0.7	0.579	EN 14105
Diglyceride content	wt.%	-	≤ 0.2	0.171	EN 14105
Triglyceride content	wt.%	-	≤ 0.2	0.107	EN 14105
Free glycerol	wt.%	≤ 0.02	≤ 0.02	0.006	EN 14105
Total glycerol	wt.%	≤ 0.240	≤ 0.25	0.189	EN 14105
Group I metals (Na+K) Group II metals (Ca+Mg)	mg kg^{-1}	≤ 5.0 ≤ 5.0	≤ 5.0 ≤ 5.0	0.11 0.16	EN 14538
Phosphorus content	mg kg^{-1}	≤ 10	≤ 4.0	< 0.1	EN 14107
Water & Sediment	% volume	< 0.2	-	0	ASTM D 2709

[a] (on 100 % sample)

Aviation opportunities

The jet fuel market has emerged as a strong business opportunity for Camelina producers. Airlines and the military are looking for new, greener ways to fuel their planes. Camelina fits the bill.

A life cycle analysis of the carbon footprint of Camelina-based bio jet fuel concludes that the renewable fuel reduces CO_2 emissions by 75 percent compared to traditional petroleum-based jet fuel, according to a peer-reviewed paper published in the journal **Environmental Progress & Sustainable Energy**. The study also found that "green" diesel made through the same process reduces CO_2 emissions by 80 percent. The research, in collaboration with UOP , a Honeywell company, was conducted at Michigan Tech University, and based on Camelina grown in Montana and processed into bio jet fuel using UOP hydro processing technology.

Camelina-based bio jet fuel is well positioned to be the renewable fuel of choice for airlines and the U.S. military once the American Society for Testing and Materials (ASTM) approves a specification for renewable jet fuel, known as Hydro treated Renewable Jet (HRJ). The standard is expected to be fully approved in 2011.

Camelina-based jet fuel has been among the most, if not the most, heavily tested of any renewable jet fuel, with successful tests by the U.S. Air Force, the U.S. Navy, the U.S. Army and Japan Airlines. These groups have conducted multiple tests of the fuel on different aircraft types, engines, and at different speeds. Camelina-based fuels have passed every test.

Taking to the skies

Between 2009 and 2012, the US Air Force and the US Navy successfully test flew the A-10 Thunderbolt II, F-22 Raptor and F/A-18 Super Hornet fighter jets on a blend of standard jet fuel and camelina-based jet fuel. By 2016, the US Navy intends to have a carrier battle group 100% powered by camelina-based bio- fuel. The army has also set a target of 50% renew-able fuels for its entire domestic jet fuel consumption. Commercially, KLM Dutch Royal Airlines and Japan Airlines have also performed successful test flights using a blend of standard jet fuel and Camelina.

In 2009, Japan Airlines used a fuel derived from the oils of Camelina (84%), Jatropha (16%) and algae (one percent), blended with traditional kerosene fuel in one of the plane's four engines. After the flight, they confirmed that the biofuel was more fuel efficient than the 100% kerosene fuel, indicating that biofuels may be both carbon neutral and cheaper to run, benefiting both the environment and the airline. KLM Airlines flew a passenger-carrying Boeing 747 jet in 2009 with one of its four engines running on a 50/50 mix of Camelina-based biofuel and kerosene. In June 2011, a Gulfstream G450 business jet flew across the Atlantic on a mix of 50/50 biofuel from Camelina and petroleum-based jet fuel.

<u>Camelina production bonus</u>

Depending on the process done using the seed and the oil we can have byproducts that can open more markets for different clients.

Process	Feedstock	Output	market
Harvesting	Straw	Bio-fertilizers Syngas Electricity	Own use + Government
Crushing	Seed	Meal Cake	Animal feed Solid biofuel

Adding to that the byproducts from the refining and distillation processes we can have also:

1. Acid oils
2. FFAs
3. Soap stock from the acid oil
4. Lecithin
5. Tocopherols (Vitamin E) from the distillation of the fatty acids