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ARTICLE

The Usage of Flax as Biodiesel and Biomass

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Flax is an ancient plant that was originally cultivated in Ancient Babylon. This plant has many food, medicinal, and industrial uses. Flaxseed and flaxseed oil are common ingredients in many foods such as cereals, whole grain bread, pasta, energy bars, and snack foods.

An exceedingly dependable energy source is flaxseed oil. Flaxseed oil is one of the vegetable oils utilized to create clean energy sources. Biomass, biodiesel, and linseed oil can all help to reduce pollution on the planet. Because flaxseeds contain 35–45% oil compared to soybean seeds' 18–20% oil content, flaxseed oil should be used to manufacture biodiesel. 17–27% of the oil in palm seeds is also oil. This indicates that flaxseed would be a superior option because it produces more oil. Also, soy is more commonly consumed as food than flax, particularly in Asia. This would imply that using flax would be preferable because it isn't as commonly consumed as food. The importance of this work is that the Earth is getting polluted increasingly every year and flax may be the miracle and answer we are looking for.

INTRODUCTION

Flax is a plant in the Linaceae family that is grown for its fiber, which is used to make linen yarn and fabric, as well as its nutritious seeds, known as flaxseed or linseed, from which linseed oil is extracted. Flaxseed has risen in favour as a healthy food, even though it has lost part of its value as a commercial fiber crop due to the advent of synthetic fibers (Flaxseed | Complementary and Alternative Medicine | St. Luke's Hospital, n.d.). This project was done because of its importance in clean energy and crops in general, especially in Saskatchewan where most of the flax in Canada is produced.

Flax has been consumed for thousands of years. Flax production grew across Europe, Africa, and North America over the ages, becoming the first oilseed to be widely produced in Western Canada (Saskatchewan Flax Development Commission, n.d.). Each year, about 3 to 4 million tons of flaxseed are produced in the world. The largest producers are Canada, USA, Kazakhstan, and Russia. With yearly exports between CAN$150-180 million, Canada is the world's top flax producer and exporter and 40% of all flax productions come from Canada. As a result, market circumstances in Canada have an enormous impact on flax prices around the world (Saskatchewan Flax Development Commission, n.d.). Flax in Canada is grown using between 300,000 and 700,000 hectares, 70% of which is in Saskatchewan. The average yield per hectare is around 2000 kg (Rowland, 2013). All the flaxseed farmed in Western Canada is used to make flax oil, flaxseed meal, and flax fiber for export. Saskatchewan produces four times as much as Manitoba on average and has been the leading producer since 1993-1994. Manitoba is Canada's 3rd flax producer trailing to Saskatchewan and Alberta. Flax is grown in about one out of four farms in Saskatchewan.

Flax demand has shifted dramatically during the previous century. Since the 1950s, technological advancements such as greater usage of water-based paints and petroleum-based floor coverings have reduced industrial need for flax. However, in the late 1990s, the movement for ecologically friendly and health-oriented goods gave flax a new purpose. Linoleum's non-allergenic and biodegradable properties, along with quality improvements, have resulted in a revival of demand in some regions of Europe (Saskatchewan Flax Development Commission - Industry Overview, n.d.).

Flaxseed is also used as a medicine. It helps cure many different diseases, while it is also good for the prevention of dangerous diseases like cancer. Flax was originally used as a medicine for the digestive system as a laxative, but it was later found out that it could help people with so many more diseases.

And finally, flaxseed oil is an exceptionally reliable source of energy. Many vegetable oils are used to produce clean sources of energy and flaxseed oil is one of them. Flaxseed oil biodiesel and biomass can decrease the pollution on the Earth. The reason that flaxseed oil should be used to make biodiesel is that flaxseeds are composed of 35-45% oil, while soybean seeds are composed of 18-20% oil and palm seeds are composed of 17-27% oil. This means that flaxseed gives more oil for production. Also, soy is used more than flax as a food, especially in Asia. This would mean that using flax would be better since it is used less as a food. The importance of this work is that the Earth is getting polluted increasingly every year and flax may be the miracle and answer we are looking for.

METHODS AND MATERIALS

The methodology of the study in this project is based on a research analysis on the topic by:

Several interviews with Prairie Clean Energy and Dr. Hussameldin Ibrahim, several articles, several webpages and websites, and charts and graphs.

RESULTS

Composition of Flax

Flax seeds come in two basic varieties: brown and golden. The brown seeds have a little stronger flavor than the golden seeds, according to most individuals (Gavin, 2019). Mucilage is found in around 15% of the seed's envelope or Testa. As seen in Figure 1, flaxseed is high in omega-3 fatty acids, protein, and dietary fiber. Brown Canadian flaxseed had an average fat content of 41%, 20% protein, 28% total dietary fiber, 7.7% moisture, and 3.4% ash in a study. The seed's protein content falls as the oil content rises. Flaxseeds are well-known for their high amount of polyunsaturated fatty acids (Katare et al., 2012). Flaxseeds also include 534 calories per 3.5 ounces (Bjarnadottir, 2019). The nutrient content of brown and yellow (Omega) flax cultivars is comparable. The nutritional differences are minor and are due to variances in growing conditions. As previously stated, the amount of pigment present determines seed coat color, which is a trait that can be altered by conventional plant breeding procedures, because the nutritional value of brown and yellow flax is similar (Morris, 2007).

Protein

There are 18 grams of protein in 100 grams of flax. Flax is a gluten-free grain. Gliadin, which is high in the amino acids, proline, and glutamine is the specific component in gluten that causes 'celiac illness (Katare et al., 2012).

Figure 1. Krona chart showing the proximate composition of flaxseed. Source (Danish et al., 2020).

Carbohydrates

Flaxseed has a low carbohydrate content. As a result, flax contributes little to total carbohydrate consumption (Katare et al., 2012).

Fiber

Dietary and functional fibers combine to make total fiber. Nondigestible carbohydrates taken from plants, purified, and added to foods and other items make up functional fiber. In full-fat flax seeds, total fiber accounts for around 28% of the weight. Flax seeds are high in both soluble and insoluble dietary fiber. Dietary fiber aids in the regulation of hunger and blood glucose levels, as well as the promotion of laxation and the reduction of blood lipids. Heart disease, diabetes, colon cancer, obesity, and inflammation may all be reduced by eating a diet high in dietary fiber (Katare et al., 2012).

Phenolics

Phenolics are plant-derived chemicals that serve a variety of purposes, including giving color to the plant and attracting pollinators such as bees and other insects. Flax includes at least three forms of phenolics, including phenolic acids, flavonoids, and lignans (Katare et al., 2012).

Vitamins

Flaxseed is high in both water-soluble and fat-soluble vitamins. Gammatocopherol is the most abundant form of vitamin E in flax. Vitamin K is found in flax in the form of phylloquinone, which is the plant version of the vitamin. Vitamin K is required to produce specific proteins involved in blood clotting and bone formation. One tablespoon of milled flaxseed has 34 mg of magnesium. Flax is also low in sodium (Katare et al., 2012).

Fatty acids

Flax has long been prized for its high fat content, which delivers a unique blend of fatty acids. Fatty acids are chemical molecules that can be found in almost any food (Morris, 2007). Flax is made up of a variety of fatty acids. It is high in polyunsaturated fatty acids, especially the necessary omega-3 fatty acid ALA (Alpha-linolenic acid) and the essential omega-6 fatty acid linoleic acid (LA). We require these two polyunsaturated fatty acids because our bodies are unable to produce them, they must be received from fats and oils found in food (Morris, 2007).

Oil

Flaxseed oil extracted from flax plant seeds and included a high amount of omega-3 fatty acid alpha-linolenic acid. Because omega-3 fatty acids have been demonstrated to have anti-inflammatory properties in the body, they are used as a dietary supplement to treat inflammatory disorders such as allergies, heart disease, arthritis, epilepsy, renal disease, diabetes, and some types of cancer (Gellner, n.d.). Flaxseed oil's alpha-linolenic acid and other compounds reduce swelling. That is why some people use it to treat inflammatory disorders like rheumatoid arthritis. There is no solid scientific evidence to support the use of flaxseed oil for high blood pressure, high diseases, elevated levels of cholesterol, and many other illnesses. While research suggests that omega-3

fatty acids may help to avoid coronary heart disease, no studies have established that alpha-linolenic acid is the cause. Diarrhea and gastrointestinal symptoms are side effects (Cleveland Clinic Wellness, 2013).

Biodiesel

Biodiesel is a fatty acid alkyl ester (Chen et al., 2018). It is a clean and safe type of fuel that is made from waste cooking oil, vegetable oils, animal fats, and yellow grease. It can be used in diesel vehicles directly or blended with petroleum diesel (Alberta Education, 2009). The composition and structure of the fatty acids from which biodiesel is made determine its functional properties (Barhum, 2018). Biodiesel is made using a variety of ways using diverse feedstocks. Pyrolysis, microemulsification, dilution, and transesterification (Alam & Tanveer, 2020). Biodiesel is produced from flaxseed oil utilizing a transesterification process using catalysts such as potassium hydroxide (KOH). During the process of transesterification, the viscosity of the liquid decreases, which makes it suitable to perform well in engines.

In order to convert flaxseed oil into biodiesel, one needs to perform these few steps:

1. Pour 200 ml of methanol into a glass blender pitcher.
2. Turn the blender on and add 3.5 g of KOH. This will produce sodium methoxide.
3. Mix the methanol and potassium hydroxide together until the potassium hydroxide has fully dissolved and then add 1 liter of flaxseed oil to this mixture.
4. Continue blending the mixture for about 30 minutes.
5. Then, pour the mixture in a jar. The liquid will separate into two layers.
6. Finally, allow a couple of hours for the mixture to separate. The top layer is the biodiesel fuel. The bottom layer would be glycerin.

The operating independent variables of methanol oil ratio, which is 4:1 to 6:1, KOH weight of 0.40–1.0%, temperature which should be 35 to 65°C, and reaction time which is 30 minutes–60 minutes were tuned using biodiesel production as the response. At the optimum methanol oil ratio of 5.9:1, KOH weight at 0.51%, a reaction temperature of 59.2 °C, and reaction duration, the maximum yield of 98.6% of biodiesel from flaxseed may be reached in 33 minutes (Danish et al., 2020).

Biodiesel provides a variety of advantages over petroleum diesel, in addition to being sourced from a renewable resource. There is no sulphur or aromatic chemicals in biodiesel, and the presence of oxygenated functional groups reduces carbon monoxide and particulate matter emissions. Blending 5–20% biodiesel with petroleum diesel provides some of these benefits to the blend, while adding lesser amounts of biodiesel to low-sulfur petroleum diesel has been found to restore lubricity (Chen et al., 2018).

In the presence of a catalyst, typically potassium hydroxide, approximately 100 pounds of oil or fat are reacted with 10 pounds of a short-chain alcohol, usually methanol, to produce 100 pounds of biodiesel and 10 pounds of glycerin (or glycerol). A co-product, glycerin, is a sugar that is extensively utilised in the production of medications and cosmetics (Alternative Fuels Data Center: Biodiesel Production and Distribution, n.d.).

The reason that makes flaxseed oil an exceptionally good option for the production of biodiesel is that flaxseeds are composed of 35-45% oil, while soybean seeds are composed of 18-20% oil. Palm seeds are also composed of 17-27% oil. This means that flaxseed gives more oil for production and would be a better deal. Also, many other vegetable oils, such as soy, are used more than flax as a food. This would mean that using flax would be a better option since it would have less effects on the food system.

Although biodiesel fuel has been shown to be a more environmentally friendly source of fuel in diesel engines than traditional petroleum-based fuels, it may still be more expensive than traditional fuels. The cost of mass-producing biofuels is predicted to decrease with time, bringing them closer to the cost of other, more frequently accessible fueling sources.

Biomass Fuel

Any organic material that has stored sunlight in the form of chemical energy is referred to as biomass. It is made from the decomposition of plants and animals, and it is a renewable resource. Manure, wood waste, sugarcane, and straw are examples of it as a fuel.

After the crops are cut, they go through a process where they are combined. Next, the seeds are separated from the chaff. Then, the bales are shredded using an industrial size shredder. After that, they go through a pellet mill which forces fine powders into manufacturing die and pushes them out. Finally, heat comes out of extrusion. After this process, solid biomass fuel is produced as pellets. These pellets can be burned in a home boiler, cooking smokers, or biomass power plants. The reason that flax straws are being used for this is that flax biomass generates more BTUs per pound than other leading forms of biomass, making it one of the most efficient and environmentally responsible biomass fuels on the market.

As a staple of Canadian agriculture, flax is an important part of farmers' crop rotations every year. The straw has no nutrient value after the flax has been harvested. It also has no marked to be sold in, so the straws are just burned in the field.

As tested, flax straw meets ISO standards. Flax straw's ash content has low moisture levels. The chemical composition of these straws are appropriate for generating power. Also, flax straw has a superb heating value, which is able to generate more than 8,500 BTUs/lb as seen in Figure 2. There is a shortage of wood fiber used to make biomass fuel in the world and 670,000 tonnes of flax straw gets burned on the prairies every year. Flax straw has a higher BTUs/lb than wood fiber. Also, the usage of flax straws is more appropriate than the usage of wheat straws since flax straw is more of a woody fibre while wheat straw is more like a plant. This means that wheat straw will have more ash content. Another

reason is that wheat has many more uses than flax does in the food we eat, so it would affect our food supply.

CONCLUSION

To conclude, flax is a very healthy choice in a person's diet. It has many medicinal uses and can prevent dangerous diseases. Besides its nutritional values, flax is a great source of clean energy. Biodiesel is produced from flaxseed oil by a process called transesterification. Flax straws, that have no other uses, can also be used to produce biomass fuel. Flaxseed would not affect the food chain as much as using other competitors would, so it could be an open door for a world of clean energy.

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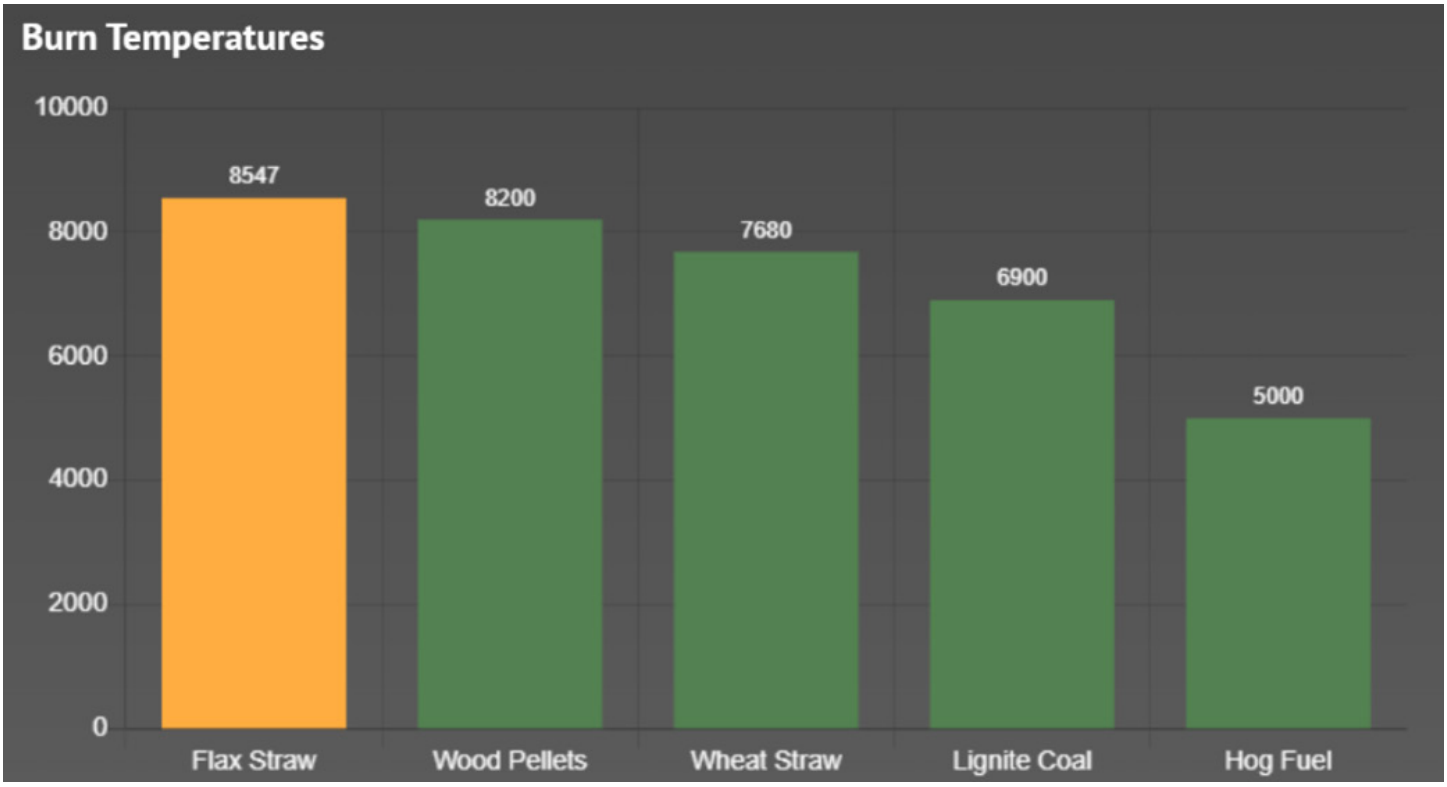

Figure 2. Flax Straw Burn Temperature vs. Competitors. Source ((Prairie Clean Energy, n.d.))

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My name is Parham Golshenas. I am currently a high school student in Saskatoon, Saskatchewan. Some of my hobbies include playing many sports and musical instruments. My favourite sport to play is tennis, and I have been playing it for about six years. My main musical instrument is the violin; I have played it for almost ten years. I have been doing science fair projects since I was in the first grade, and I highly enjoy the process. I am incredibly interested in the STEM field and am planning to follow a career in this field. I am always eager to learn more about energy, agriculture, and medicine.