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FUTURE OF INDUSTRIAL HEMP

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<p>Abstract</p> <p>Environmental issues are growing all around the world and the manufacturing industry is one of the largest contributors to the emissions and waste created. New eco-friendly manufacturing practices, processes and the use of environmentally friendly raw materials need to be created and used for the preservice of earth. The thesis seeks to find out how industrial hemp can be an eco-friendly raw material for several manufacturing industries and what beneficial applications can be processed and manufactured from hemp. The goal is to find out which hemp applications and products have the best potential for market value growth and building new businesses around.</p> <p>The global hemp markets of North-America, Europe and China were researched on the goal of finding how hemp products and applications are currently utilized and what is their potential for growth in the near future. Smaller European markets of Finland and Estonia were also looked into to compare how the smaller and newer hemp markets differ from the more established larger ones. New hemp applications from Cannabidiol or CBD oil was researched in those markets to conclude if the market growth of CBD products were beneficial to the whole hemp industry. Some of the currently companies in those markets was also researched for information on how they have built a business around hemp and its applications and what different business models they have found to secure profits from cultivating, harvesting and processing hemp or manufacturing products and application for hemp.</p> <p>The aspects considered when concluding the future of the industrial hemp market are the current status of industrial hemp markets, potential of hemp applications and products in those markets, current businesses and the potential for new businesses, environmental aspects, processing and manufacturing needs, possible need for investments into the industry and the current volumes of hemp cultivation. The results of the research concluded that industrial hemp has many environmentally beneficial applications and products but not all of them can be fully implemented to their respective industries because of the lack of hemp cultivation and the need of investment into better manufacturing infrastructure. The applications and products with the most potential for market growth found were the products processed from the hempseed for the food market. Fiber industrial applications had the second most potential for hemp in the form of animal bedding, bio-composites for the automotive industry and hemp concrete for the construction industry. For future growth estimations the applications from CBD oil were the highest and show the best potential for new businesses. However, the CBD oil market is not regulated well enough yet in most markets to build a sustainable business around CBD products. Most other hemp applications mainly from the fiber have benefits in their industries but don't have the potential for growth outside of the current smaller application used. One of the more interesting future possibilities from hemp found was the biomass conversion into energy. However, the bioenergy application from industrial hemp would need more investing, better infrastructure and more hemp cultivated to be a potential mass energy producer.</p>	
<p>Keywords</p> <p>Industrial Hemp, Cultivation, Fiber, Seed, CBD, Harvesting, Hurds</p>	

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1 INTRODUCTION

Industrial hemp has been used for centuries for manufacturing thousands of products and was once said to be the next billion dollar crop. The early predictions made in the year 1920 about industrial hems future did not come to fruition and now in the 21st century hemp products are being used globally in low numbers and crop is underused as it has potential to be a more environmentally friendly option for many industries.

The resurgence of hemp started in the 1990's as people gained interest in hemp cultivations again with new technology making hemp farming and processing more efficient. Hemp cultivation and manufacturing has gained popularity steadily ever since and in 2020 there is a growing demand for environmentally friendly hemp based products and industrial applications.

The thesis researches how hemp is cultivated and harvested and what products can be made from the different parts of the plant. The environmental benefits of hemp cultivation and products are explained and how the different hemp applications can benefit the manufacturing industry by using hemp as an environmentally friendly raw material. The thesis also discusses the benefits of hemp cultivation compared to other industrial crops used as manufacturing raw materials and how the different manufacturing processes of hemp products and applications are more environmentally friendly than the current popular ones competing with the hemp industry.

Processes and manufacturing methods behind the products are researched with the goal of understanding how the difficulty of processing and number of processes can effect the potential of the hemp applications market growth and investment opportunities. Questions about the environmental impact of hemp applications are sought and how different hemp products market growth can be beneficial to farmers, manufacturers, companies and the consumer.

The main goal was to understand the hemp industry from cultivation to end product and how the global industrial hemp markets can grow in the future. The markets researched were the North-American market, The European market and the Chinese industrial hemp market. The market research into these larger markets includes already existing hemp applications and their potential market growth in the future.

Smaller industrial hemp markets of Finland and Estonia were also researched to understand how the large global hemp markets differ from the newer growing markets of small European countries. One of the key application for growth researched is Cannabidiol of CBD oil that has exponentially accelerated the cultivation of industrial hemp and the hemp industry around the world. Research is also done on companies which are currently building businesses on hemp applications inside these markets and what kind of business models they have implemented for market growth and sales.

Another key element of the thesis is to understand the business side of industrial hemp. The thesis researched which of the hems application are the most promising ones to start a new business in or for current industries to start investing in the hemp business. Possible hurdles for the growth of hemp application can include too high investment amount for starting, complicated processing that needs skilled and experienced individuals and the complications in implementing hemp processing into the current manufacturing infrastructure by acquiring new machinery or competing with the current manufacturing methods and infrastructures already in place.

2 RESEARCH IMPLEMENTATION

Research for this topic started from collecting information about the benefits of industrial hemp crop and the possibilities for its use. The research was conducted by collecting the information from the internet by searching the potential for different hemp applications and products.

The research included the cultivation and harvesting of industrial hemp as well as the environmental aspects of the hemp cultivation. The next aspect of research was the possible application and products from hemp and how they are processed and manufactured. Current competing raw materials and manufacturing processes were also researched to compare them to industrial hemp in order to find out how and if industrial hemp was beneficial as a raw material for manufacturing industries.

The application and products research was done to conclude the potential future market value of the industrial hemp application or products with taking in consideration the environmental benefits of cultivation, possible benefits of manufacturing and processing and the benefits on the end products for businesses and consumers. Literature used to form the conclusions were blogs, internet sources and theses written on industrial hemp.

The next step in the literature research after the best potential application and products from industrial hemp were found was to find how they are utilized in different markets around the world. The potential size and future of the markets were concluded from the research as well as the best application for industrial hemp fibers, seeds and CBD in those markets. The research was done by reviewing research articles and reviews into those markets. Research was also done to several companies in different hemp markets to find out their business models and usage of industrial hemp for cultivation, processing and manufacturing of products. The research was conducted by searching company websites, reading articles written on the companies and interviews from company leaders.

All the research and literature review was concluded into an understanding of the industrial hemp market as a whole, the most potential future applications from hemp and which industrial hemp markets those applications can be best used. The research also brought the conclusion on business opportunities around industrial hemp and how the different industrial hemp markets differ from potential applications, cultivation and the potential for introducing new products from industrial hemp. To find the potential for growth of the industry all of the negative factors were also researched that included lack of industrial hemp cultivation, lack of investment and difficulties around creating a sustainable processing and manufacturing infrastructure for industrial hemp.

3 WHAT IS INDUSTRIAL HEMP

Hemp is a crop that has a variety of industrial uses by producing fibers, seeds, pharmaceuticals and hurds. The plant is sustainable and versatile as all of its parts can be utilized in manufacturing products or recycled. Hemp farming is also considered environmentally friendly and so are the products derived from it. Products made from hemp can give several industries a more environmentally friendly option for manufacturing raw materials and be a way to move towards reducing the carbon dioxide emissions done by the manufacturing industry.

Hemp has many advantages over its current competitors such as cotton and the paper industry. One acre of hemp produces as much fiber as two to three acres of cotton. Hemp also has a stronger fiber than cotton so it won't mildew over the years. Hemp also is regarded as having softer outcomes on the end products than cotton making it perfect for manufacturing clothes.

Compared to the paper industry, one acre of hemp will produce as much paper as two to four acres of trees. Maturing time of hemp to harvesting age for hemp is around 90-120 days, compared to tens of years for trees. Paper manufactured from hemp can last for decades without degrading and can be recycled more times than paper made from trees. Substituting hemp for wood can limit the need for deforestation even more by transitioning fiberboard production to hemp based. Hemp fiberboard is stronger and lighter than its wood based counterpart.

When comparing growing hemp to trees and cotton cultivation, it is more beneficial for the environment and sustainable. Cotton growing only in moderate climates and needs more water, pesticides, herbicides and fertilizer. Hemp can grow on most land suitable for farming and is frost and weed tolerant making it not require pesticides or herbicides. Currently 50 % of the world's pesticides and herbicides are used in cotton production. On the other hand, forest and tree farms require more land, time and space with it also adding to land erosion and water pollution due to logging (Hempbasics s.a.)

With environmental issues rising all around the world and plastic and the fuel industry being the worst contributors. Hemp can be manufactured to produce durable and environmental-friendly plastic substitutes. Petroleum-based plastics can be changed to hemp based bio-composites thus lightening the load of plastic recycle and waste management. The oil pressed from the seeds can be processed into biodiesel that powers any unmodified diesel engine thus lightening the need for petroleum based fuels for manufacturing machinery and dual motor cars that run both on electricity and fuel.

3.1 Cultivation and Harvesting

Hemp is a robust plant that grows fast and can be planted densely in diverse soil conditions. It can be grown in most environments but the best conditions are warm areas with well-drained soil that is not acidic and rich in nitrogen, potassium and phosphorus.

When growing hemp it is best to avoid climates with heavy rain fall because it keeps the soil too wet but for the best natural water conditions there should be at least 65 cm of rainfall in the area per year (Joyorganics s.a.). The time it takes the plant to fully mature depends on the growing conditions as well as for which application the plant it is harvested for.

Normally hemp grows from seed to full bloom in 120 days, but for high quality fiber the plant is ready to harvest when it starts to shed pollen. This means for fiber the harvesting time is around 90 days and when harvested for seeds the time is several weeks later. Letting hemp grow too long will also rise the psychoactive THC (Tetrahydrokannabinoli) content of the crop which classifies it grown for medicinal use and not the intended industrial use.

Planting hemp in a dense manner makes it resistant to weeds by having a better root system which removes the necessary water away from weeds that could inhibit the growth of the hemp plant. Hemp also grows tall which suppresses light from the weeds. In conclusion the cultivation of hemp gives a perfect combination of dense, tall and rapid growth that minimizes weed growth by taking away growth space, water and light.

3.2 Environmental impact

Since hemp plant suppresses the nutrients out of the weeds there is very limited amount of need for herbicides and pesticides. Energy requirements for pesticide production are high and pesticides are potentially harmful for the environment and humans. Low amounts of pesticide use in hemp cultivation makes it a potentially high yielding energy crop as hemp biomass can be turned into energy in the form of biogas.

Cultivating and harvesting hemp improves soil health and adds diversity to the soil. The retting method where the stalks are left on the field to rot allows nutrients extracted by the plant during the growth cycle to return to the soil and leaves to decompose. When crop rotation is utilized in hemp cultivation it improves the weed suppression effect by reducing the possibility for weeds on the next harvest. Furthermore, hemp cultivation suppresses soil pathogens which can lead to improved soil health.

Hemp cultivation and use has very low overall environmental impact. The environmental impact of a crop can be measured by calculating the sum of all emissions caused during the lifecycle of the crop including cultivation, harvesting, transport, manufacturing and storage. From cultivation, harvest and transport the emission balance supports hemp as an environmentally friendly crop as hemp cultivation uses carbon dioxide for growing thus removing greenhouse gases from the atmosphere.

The manufacturing impact for emission depends largely on which part of the plant is processed and the manufacturing methods used to achieve an end product. For food purposes such as seed and oil the emission impact from the manufacturing is fairly low because of the low amount of processes needed to provide an edible hemp food. Processes that need more energy such as biogas production can have a disadvantageous emission balance as heat production is needed in the process. However, when comparing to hemp biodiesel production from hemp seed oil to fossil fuels it has been shown to have a much lower overall environmental impact. (Prade 2011, 66-68.)

3.3 Different sexes of the plant

Hemp is a dioecious plant meaning it can be male, female or hermaphrodite. When farmers buy hemp seeds there will inevitably be a mix of male and female plants that grow from them. When those seeds are planted the sex of the plant must be determined in order to identify the female plants which produce more resin that can then be processed into valuable CBD.

Possible ways of identifying the sex of the plant is by DNA testing of a seedling that is a couple weeks old. Other option is to wait until the seed has grown six weeks and reached the pre flower stage. At this time it is

possible to tell the sex of the plant by looking at the crux of the plants branches. Male hemp plants will have grown a small pollen sack and female one will grow bracts. Whispy hair-like stigma will star to grow out of the female plants bracts that can then catch the pollen released by the male plant. The third possibility is that a seeds sprouts a plant that has both pollens sacs and bracts. This hemp plant is called a hermaphrodite.

A hermaphrodite having both the sacs and bracts can also pollinate the female plants and should be removed from the harvest with the males if pollination is not wanted. Hermaphrodite plants can be caused by poor seed genetics or trauma to the plant. some possibilities for trauma and stress for the plant is disease, bad weather and nutrient deficiencies.

In some cases the pollination of the female plant is not wanted. To prevent this from happening it is crucial to identify the males as early as possible and remove them from the field before they pollinate the females. If the male plant successfully pollinates the female plant it will grow seeds in their buds that take energy out of creating the wanted resin on their leaves. Moreover, the pollinated female plant are smaller than the unpollinated ones and as a consequence produce far less resin.

However, this way of farming hemp is time- and labor-intensive for larger growers. In some cases it causes elimination of half of the harvest by culling the male plants after six weeks of cultivation in order to preserve the quality of the female plants. This can be prevented from happening by lab testing the the sex of the plants pre planting but it is very costly and not currently practical for large scale industrial hemp farmers.

Another way to prevent the need of removing the males plants is for the growers to invest in feminized hemp seeds that are selectively bred to grow exclusively female plants. A feminized seed batch is more expensive but it saves labor on labor costs as all of the cultivated plants can be harvested.

As currently hemp farmers don't get subsidies they need to grow hemp for the most profitable end product which is currently CBD. That is why for most farmers the male hemp plants have no place in their fields but the male plant can still be used for crossbreeding purposes to create new and better strains of hemp (Highgradehempseed s.a.).

3.4 Different parts of the plant

As an industrial variant of its species hemp is best grown for its fiber, flower, seeds and leaves. Most of the plants weigth comes from the hurd that refers to the inner core fibers. Hemp hurd fibers have been used throughout history to make hemp paper which is the oldest known application from hemp. To this day hemp hurds are used for making smaller paper applicatios from mechanical hemp pulp.

Hemp fibers coat the inner core and stalk of the plant and are commonly called bast fibers. The fiber is a strong natural fiber that is durable and water resistant. The fiber can be used for industrial pulp and paper making and consumer textiles that include clothes, rope, canvas and clothing. Some newer industrial uses for hemp fibers include bio-composite plastics for the car manufacturing industry and concrete called hempcrete that is used for building houses.

The processing of hemp bast fibers creates by-products such as the shorter bast fibers that can be used in the manufacturing of animal bedding. Another by-product of fiber processing in the shivs that come from the

woody core when the stalk of the hemp plant is crushed for fiber separation. The shivs can be utilized to make construction materials such as hempcrete that is an environmentally friendly concrete substitute.

Seeds of the plant can be used for food that is extremely nutritious and contain omega-6 and omega-3, two essential fatty acids. Seeds can also be made into a protein source that contain high amount of vitamins such as magnesium, iron and zinc. The seed can also be pressed into an oil that contains the same nutritional benefits and can be used for human consumption, beauty products and fuel manufacturing.

Leaves and the flower can be processed into pharmaceutical medicine. Most commonly known by consumers is Cannabidiol or CBD oil that is sold to alleviate inflammation, pain, arthritis and migraines. All of the parts of the plant can also be used for animal feed and organic composting making hemp sustainable and recyclable.

The hemp plant can also be modified by selective breeding for characteristics that are better suitable for an individual parts cultivation and harvesting. Some possibilities include a variety for fiber where the stem is longer and less branching. This type of selective breeding gives the best yield for fiber harvest and the strongest quality as the crop is harvested earlier.

Another possible variety is for growing the seed, where the breed yield the best amount of seed and is harvested later when the seeds have matured. Latest breed modifications to hemp came from the need to harvest it for medicinal purposes. With the latest CBD oil demand, farmers and agricultural scientists have come up with a strain of hemp where the crop produces the best yield of resin from the leaves. As the hemp strain is left to mature to right age and not let to pollinate seed it is the optimal breed to harvest for high-quality CBD oil production.

4 INDUSTRIAL HEMP PRODUCTS

Hemp can be made into thousands of products by using different refining and manufacturing methods depending on which part of the plant is used and what the end product is. The products have a strong variety and can be found in most popular markets today ranging from food, health, beauty, clothing, housing, fuel, energy and the automobile industry.

The goal is to research the best applications for hemp and how they are manufactured. Aspects of the manufacturing process include cultivation of the hemp plant, harvesting, processing and the environmental impact of the whole process from seed to end product. All these variables will determine the potential of the hemp applications future market share and popularity with the manufacturing industry.

The manufacturing industry has been blamed for the increase in environmental issues for years. The environmentally friendly nature of hemp is one of the reasons it has peaked the interest of large companies and corporations to implement more hemp raw materials in their products. Hemp products have an edge on their competitors because of the environmentally friendly qualities they pose from cultivation methods to replacing currently used manufacturing processes and raw materials that pollute the environment.

The current low amount of hemp cultivation is the biggest issue for growing the hemp industry and hemp applications. Business opportunities with hemp applications are not viable with no sustainable flow of hemp raw materials. Increasing the amount of hemp cultivation would increase job and business opportunities in the industry and increase the availability of hemp products and applications for several industries. For applications needing complicated processing the problem for future market growth is investments for efficient processing machinery and infrastructure.

4.1 Hemp Seeds

Hemp seeds are one of the best products available from the hemp plant. The recent increase in popularity has made them easily accessible for human consumption. Hemp seeds are rich in protein, fiber and essential fatty acids omega-3s and omega-6s. The seeds protein is a complete protein source containing all nine essential amino acids that are building blocks for all proteins.

The body can't produce essential amino acids or fatty acids so eating hemp seeds are a great way to make sure you are getting them from your diet. Hemp seeds are especially high in arginine that turns into nitric oxide which is essential for artery and vein dilation and beneficial for the heart. Hemp seeds also contain high amounts of fiber that is healthy for the gut. The benefits of hemp seeds go even further by being high in vitamins and minerals. They are rich in vitamin B-6 and E, magnesium, potassium and also contain iron and zinc. (Bjarnadottir 2018).

Hemp seeds are also shown to have neuroprotective, anti-inflammatory and immunity system benefits. Reducing inflammation in the body can improve skin and joint health and help manage some of the issues for people suffering from autoimmune conditions. According to (Crichton-Struart 2018), the neuroprotective compounds found in hemp seeds may help with Parkinson's disease, Alzheimer's disease and multiple sclerosis.

Hemp seeds being one of the best super foods on the markets right now the expectations for its market value growth is high in the coming years. The market was valued at 350 million U.S dollars in 2020 and it is

expected to reach 480 million USD by 2024 (Market Watch 2020.). The potential growth of the hemp seeds industry stems from more countries starting to implement more hemp cultivation and seeing the benefits of hemp foods for human consumption. Specialized hemp breed for seed cultivation have been on the market for decades making the possibility for hempseed cultivation easy for countries with mass amounts of farmable land and farmers who want to make more profits from their harvest.

4.1.1 Seed harvesting and processing

According to (Singh s.a.), the seed yield per acre on hemp specifically bred for seed cultivation is about 10 kilos. The seeds near the ground mature faster so harvesting should be done when the seeds near the top get a hard shell. This usually means that the seeds are harvested at 16 weeks old. The harvesting happens after the retting process of leaving the stalks to ret on the field is done. Hemp seeds can be harvested by hand in low quantities but in a large scale business a mechanical thresher is used to separate the seeds from the stem.

After harvesting the seeds must be winnowed or cleaned from the stalk remnants. This can also be done manually by using two buckets or stainers with a mesh. Large crop sizes should be processed through a mechanical winnower. Mechanical threshers and winnowers come in various sizes so they can be scaled depending on the yield size of the harvest.

Hemp seeds are edible with the shell or without but for dietary purposes the seeds should be dehulled because of the hard exterior of the hemp seed. Dehulling machines also come in various sizes and can scale with company needs. After harvesting the processing of the seed varies depending on the end product. If for example the seed is made into a hemp coffee the whole hemp seeds can be used and no dehulling process is needed.

4.1.2 Market potential of hempseeds

The potential for hempseeds market growth is one of the best of any hemp applications. The hemp seeds need minimal processing to be ready for human consumption. Minimal processing leads to low cost and hempseeds nutritional values bring it potential to be a higher priced food. The dehulled seed has become a popular food for human consumption and hempseeds are known by mass amounts of people as a nutrition rich additive to foods.

Key markets where growth potential is the highest are the North-American and the European markets. Canada being the leading cultivator of hemp seeds with over 20 years of experience. Canada currently produces around 90% of the worlds hemp seeds and exports them to the U.S and Europe.

Hemp breeds cultivated for seed harvesting are becoming more popular by hemp farmers because of the higher earnings from selling the seed. The combination of being beneficial to hemp farmers, minimal need of processing and health benefits to the consumer gives hempseed market a significant potential in being one of the leading industrial hemp applications in the future.

4.2 Hempseed Oil

Hempseed oil is oil pressed from the hemp seeds. Hempseed oil has the same nutritional content as the seed meaning it contains great nutritional and health benefits. For human consumption it can be used in cooking for preparing salads, dressings, sauces and marinades.

The cosmetic industry can utilize hempseed oil in their products because it is great for the skin and can be used to treat acne. Because of its strong lubricating property it is used in products for rough, irritated or scaly skin. The high fatty acid content in hemp oil also prevents moisture loss, dehydration and help reduce redness of the skin. The benefits of hemp for skin and hair give it a wide range of possible products such as massage oils, shampoos, soap bars and creams. Hempseed oil also helps to protect the skin from inflammation. The properties of hempseed oil can be used to treat a variety of skin issues including eczema, dermatitis, psoriasis and acne. (Johnson 2019.)

With hemp being environmental friendly and growing it reduces pesticide and herbicide use the beauty products made from it can be marketed as natural products. The skin health and environmental benefits give an edge for marketing purposes to hemp beauty products over many competitors. This is why even the biggest beauty brands like Kiehl's have a cannabidiol based product in their line because of its great properties that include being anti-inflammatory, not clogging pores and superior moisturizing compared to other products (Kiehl's s.a.).

For industrial use hemp oil serves as a resource for the production of detergents. Through various of chemical processes such as saponification, ethoxylation and sulfation hemp oil can be produced into soaps, emulsifiers, solvents and surfactants for the cleaning industry. Another industry application for hempseed oil is biodiesel that is manufactured from the fat and oil content with a process called transesterification. Biodiesel is an alternative fuel source for running any unmodified diesel engine and it has been used in Europe for over two decades. (WayofLeaf Staff 2020.)

Hempseed oils biodiesel applications market potential will be discussed later in the text alongside other bio-fuel applications and energy production from hemp.

4.2.1 Processing of hempseed oil

Hemp oil is pressed from the hemp seeds after harvesting and they go through a mechanical pressing process in order to produce high quality hempseed oil. The seeds are processed through a mill with the aid of an oil press. To get the best end result and cold press is used because the temperature of the oil during processing should be between 40 and 60 celsius (florapower s.a.). Keeping the oil temperature low makes sure that the oil quality is not reduced and damaged through the heat.

Oil pressed have variabilities in their shape and sizes but the method stays the same. The seeds are put into the machine where the seeds are crushed and then the pressed oil runs through where the pulp separates from the oil. Processing hemp seed into oil results in a pure and unprocessed end product.

Some of the processing variables include moisture content of the seed. Incorrectly stored seeds can gather higher moisture content than wanted which will lead to the moisture to tie up the oil within the seeds during pressing. Too low moisture levels are problematic too as that will increase pressing temperature. Too high

pressing temperatures lead to lesser oil production and potentially exceeding the cold pressing temperature limit or 120 celcius. (Pickering 2019a.)

4.2.2 Market potential of hempseed oil

The hempseed oil market coincides with the seed market as both can be sold to human consumption by themselves or added to food. The hempseed oil market differs from the seed market by its potential in being used by the beauty industry. Hempseed oil processing for beauty products is simple compared to other hemp applications. The oil pressed from the seeds can be added into beauty products such as oils and creams because of its benefits for skin health and moisturizing components.

The beauty industry is one of the largest industries in the world and hempseed oil is already being used in beauty products by some of the largest companies in the industry. This would indicate that the benefits of hempseed oil for skin health are proven to be true and the market will keep growing. The potential for market growth for hempseed oil in the beauty industry is the largest from any hempseed oil application.

However, new business opportunities from hempseed oil in the beauty industry are unlikely as the competition is already too high. The hemp beauty product applications growth will likely come from current beauty products manufacturers implementing hempseed oil into their products. If the quantity of hempseed oil demand rises for beauty products, the benefits can be acclaimed mostly by the farmers who cultivate hempseeds and sell them for hempseed oil processing. Aside from the beauty industry, hempseed oil can be sold by itself as a food additive like any vegetable oils. The hemp food market growth is inevitable and the future will show can the hempseed oil compete with the already existing vegetable oils in the supermarket shelves.

4.3 CBD Oil

Currently various hemp products are on the market but their impact is low and they are considered to be a niche in their field such as hemp based foods. CBD oil on the other hand is one of the fastest growing industries and products on the market today. When hemp cultivation was legalized in the U.S in 2018 CBD products came to market and started growing rapidly.

Reason for the rapid growth was a combination of CBD oil being highly marketable and more research coming out as it was easier to study its medical benefits. CBD oil is not sold for dietary uses everywhere in the U.S only in some states and in Europe only a couple of countries have classified it as a dietary supplement. Some obstacles for CBD being classified for dietary uses is the uncertainty of its benefits or side-effects for humans.

CBD oil and hempseed oil share the same plant family so they often get categorized as the same thing but the difference depends on the CBD content of the product. CBD is also derived from the plants leaves and flower contrary to hempseed oil being pressed from the seeds and does not contain CBD. CBD oil also costs more and only way to know what you are getting is if the bottle informs the CBD content of the hemp oil. The hemp plant contains around 12 % - 18 % CBD with no more than trace amounts coming from the seeds (Murray 2020). CBD oil is not just sold and marketed as oil but as an add-on to many products. It can be added to products like creams, edible foods and tea with all marketed as having the great health benefits that come with ingesting CBD oil.

4.3.1 Benefits and side effects

The medical benefit claims about CBD oil and products containing CBD oil vary a lot. Some of the CBD oils alleged medical benefits include anxiety relief, anti seizure, neuroprotective, pain relief And even cancer cell growth prevention. Medical studies have been done on its anti seizure effect on the childhood epilepsy syndromes. Strongest scientific evidence for CBD oils effectiveness come from it treating Dravet syndrome and Lennox-Gastaut syndrome where CBD oil was shown to reduce the number of seizures and stop them complete in some cases. (Grinspoon, MD 2018.) Since those studies the FDA has proves its first cannabis derived medicine that contains CBD.

CBD oil can also be used as an anti inflammatory to treat chronic pain with applying CBD cream to problem areas of the body to alleviate pain. The human body contains a endocannabinoid system which is involved in regulating sleep, appetite, pain and immune system response. Studies have shown that CBD may reduce chronic pain by impacting the endocannabinoid receptor activity. Endocannabinoids are neurotransmitters that interact with CBD by binding the cannabinoid receptors into the nervous system.

CBD oil has shown promising signs of reducing anxiety, depression and post-traumatic stress disorder. CBD may also relieve symptoms related to cancer treatments and inhibit the growth of cancer cells but more human studies have to be done until these claims can be fully substantiated.

Side effects of CBD can include nausea, low blood pressure and irritability. This is why most CBD products are sold as an supplement and not medicine and there are concerns about regulations in the supplement industry with active ingredient and dosage. CBD products still need to be studied before they can be listed as a health supplement and the consumer should always be careful of what they buy because of the many unknowns. (Kubala 2018.)

4.3.2 Selective breeding and processing of CBD oil

The hemp plant that CBD is refined from is bred specifically to have attributes that give the highest quality and quantity of leaves that contain the resin that can then manufactured into CBD oil . After the plant is harvested for the leaves and flower that sits at the top the next step is to do a process called extraction where the valuable compounds of the plant are pulled into an oil called crude extract. The process includes passing of a solvent through the dried plant material to separate out the active compounds.

The extraction results in a dark oil that contains cannabinoids and other plant compounds such as fatty acids and chlorophyll. The crude oil is then processed further in several processing methods to make CBD oil. CO2 extraction is considered to be one of the best methods to create CBD oil and the method puts carbon dioxide under high pressure while maintaining a low temperature. Then the gas gets transformed into liquid due to the high pressure and passed through the plant material with up to 90% efficiency. The final product is highly concentrated and pure and this is why the process requires expensive equipment and experienced operators.

Ethanol extraction is another method used that utilizes an alcohol solvent ethanol. Ethanol mixes with water and dissolves water-soluble molecules in addition to the wanted CBD compounds. One of the compounds ethanol will co-extract is chlorophyll and it can be removed from the oil using secondary filtering methods

which can also remove some of the CBD content of the oil resulting in a lower quality product. Some of the water-soluble component extraction can be minimized by using cold temperatures during the extraction.

When comparing ethanol and CO₂ extraction methods, ethanol is the cheaper option and used by many companies but results in a lower quality end product than the CO₂ method. Ethanol extraction can still produce a high quality product with an experienced extractor that matches the levels of a CO₂ method but may need several processes. Also as the expertise needed for this method is high the quality of the end product may vary a lot.

Hydrocarbon is an early extraction method created by using a light hydrocarbon solvent to extract the oil. Hydrocarbons with a low boiling point such as butane, pentane, propane, hexane, isopropyl alcohol or acetone are used as solvents in the method. This extraction method is easy and cheap so it comes with a lot of issues. The final result contains lower amounts of CBD and higher levels of THC. There can be unsafe compounds still left on the product after processing that might negatively affect immune function. The method is rarely used because of these quality and safety concerns.

Another lesser used method for extraction is called lipid extraction where fats that often come from organic coconut oil are used to absorb and encapsulate the hemp compounds. The method does not require any use of solvents or CO₂. Even though it is not a popular method many smaller companies still use it.

After the extraction process comes activation where the raw form of the cannabinoids that contain acid need to be activated. Activation happens by decarboxylation where heat is applied to the raw extract. The process removes the acid molecules and produces the active compound sought. Natural hemp contains CBDA (Cannabidiolic acid) and the decarbing process that can be done before or after extraction produces the wanted CBD.

Now that the processing has created crude oil it needs purifying because extraction methods still leave many unwanted compounds such as plant material, fatty acids with the cannabinoids. The purifying process is called winterization and it further purifies the crude extract and removes all those unwanted materials. The process mixes the CBD extract with 200 proof alcohol that is then frozen overnight. Next morning a filtration process is done by running the liquid through a filter into an extraction jar. The remaining alcohol is removed from the end product by heating it until it evaporates because it has a lower boiling point than the oil.

Processing up to this point will create an end product but further processing can be made for alternative demands from pharmaceutical companies and for consumer use that requires the use of isolated CBD compound that is THC free. CBD isolate is created by using a method called short path distillation to separate the compounds. With rising consumer demand for CBD products there needed to be a THC free alternative that could be sold to consumers as a dietary supplement or a prescription medicine. This need brought broad-spectrum CBD to the market where the THC is removed from the product by chromatography where the extract is pushed through a column compound that binds to THC and lets the rest go through. The result is a consumer friendly product that can be sold in various forms on the market such as oils, soap, tea, coffee and creams. (Arnone 2018).

4.3.3 Market potential of CBD oil

Currently CBD oil has the largest market potential of any hemp application. The medical benefits of CBD oil seem to be backed by studies that support the fact that CBD oil can alleviate inflammation, pain and be a cure for neurodegenerative diseases. The market growth potential comes also from the demand of the consumer. Even with the products high price, the demand and sales keep increasing. The U.S is the largest hemp market currently and the demand on CBD oil is the largest there. CBD oil is added to more and more products and the estimates on market growth go up every year.

The European and Chinese markets are not on the same level of production quantity of CBD oil as the U.S. The market potential in Europe is as high as in the U.S but there are problems with legislation of hemp cultivated for CBD oil production, the safety of the product and categorising CBD oil as a health supplement instead of a prescription medicine.

For business opportunities, CBD oil is also a top potential product. With its high price it brings the whole production chain the most profit. Farmers change the cultivation of more traditional crop to hemp just for the extra earning from selling the harvest for CBD oil production. The high profit margin bring the businesses that process and sell CBD oil high earnings which brings notoriety and business opportunities to new people. With more CBD oil businesses forming, there is a higher demand of hemp cultivation which leads to the growth of the hemp industry.

Negatives from CBD oil can include bad press from faulty processing practices that lead to an unpure product. Creating high quality CBD oil is complicated and it needs an someone with experience in processing. Bad quality product leads to unhappy customer and a harvest gone to waste from the farmer. If CBD oil is not legislated correctly with clear quality control on processing it can negatively affect the hemp industry by it being associated with bad CBD oil. The hemp farmers that cultivate it for CBD oil production will also steer away from the CBD oil business if the market is unreliable and harvest can go to waste with inefficient processing.

4.4 Hemp protein

Hemp protein is an edible protein source that is made by grinding the left over seeds after oil extraction to powder. It is a high-quality protein that contains all nine essential amino acids that are the building blocks of protein making hemp protein highly bio-available. The human body can't make these amino acids by itself and they are needed from food sources making hemp powder a great daily supplementation for us.

Hemp protein also comes with a high fiber content that is linked to many health benefits such as healthier gut bacteria and improved blood sugar levels. The fiber content depends on the seed processing whether they were hulled or unhulled seeds when made into powder. 30 grams of hemp powder contains 18% of the daily fiber need for men and 28% for women which adds to the amazing nutritional benefits of it.

The benefits of dietary uses of hemp seed continue as after the oil is extracted from the seeds they keep roughly 10% of the original fat content meaning the powder has unsaturated fats that are great for health and an ideal 3:1 ratio of omega-6 to omega-3 fatty acids. Hemp protein also comes rich in minerals such as phosphorus, magnesium, calcium, iron, manganese, zinc and copper. It also has high levels of antioxidants

because it contains compounds called lignanamides that protect the body from oxidative damage that can lead to chronic illnesses like heart disease and diabetes.

When comparing hemp protein to other proteins sources it has no dairy making it easier to digest for most people and making it friendly for vegans and vegetarians. Whey protein has more protein per serving but lacks the beneficial nutrients that hemp protein provide and is also more processed which can lead to more protein going to waste as it is harder for the body to break down. (Julson 2018.)

Hemp protein and hemp foods are sold for dietary and supplementation uses and is available all over Europe and the U.S. for consumer use. Hemp protein powders and foods are also manufactured in Finland by an organic food company called Foodin (Foodin s.a.). Hemp proteins market share is still low and it can be more expensive protein choice than whey protein but makes up for it being higher-quality, environmental friendly and less processed which leads to it being all around cleaner product.

4.4.1 Processing of hemp protein

Hemp protein meal is one of the protein product that can be processed from hemp. The hemp protein meal comes from the oil extracton process of crushed hempseeds by cold-pressing or with solvent. The protein content of the meal ranges from 30 % to 50 % depending on the variety of hemp used and processing methods.

Hemp concentrate is another product from hemp protein processing with removing the water-soluble and non-protein matter from the dehulled and defatted hempseed. Hemp protein concentrate contains atleast 65 % protein on dry weighth basis. Third most purified form of hemp protein is hemp protein isolate which is over 90 % protein. Most common method of hemp protein isolate processing is alkaline extraction followed by isoelectric precipitation.

This method can produce an protein isolate with purity up to 94% depending on extraction conditions such as pH, temperature and extraction time. To improve protein solubility and maximize yield in the isolate, some researchers use elevated extracting temperatures of 35 to 40 degrees celcius in the processing of hemp protein isolate. (Wang & Xiong 2019.)

4.4.2 Market potential of hemp protein

The hemp protein market faces a lot of competition from other animal based protein sources such as whey protein. Hemp protein is more costly and has less protein by serving making it not the optimal source of protein supplementation for the average consumer.

The biggest potential for hemp protein coincides with hemp seeds and hempseed oil in the food market. Hemp protein can be added into protein bars and other foods. Even with the hemp food market growing hemp proteins value is the lowest because of the competition it faces. Every protein food source has already existing products with a cheaper protein option which will always make food containing hemp protein the higher priced option.

Even with all the benefits and high quality of hemp protein, it is highly unlikely that it will own a larger share of the protein market in the future. Smaller application in the form of hemp protein bars are the more likely niche market option grouped up with the other hemp foods such as hempseed meals and dehulled

hempseeds. Hemp foods in general seem to be one of the most likely application from hemp to gain popularity in the future. The growth of the environmental and the health movements support the growth of hemp foods. Consumers are more conscious about their decision on choosing the healthier option and having a positive impact on the environment because of their purchases.

4.5 Hemp paper

The earliest paper made by the Chinese was made from hemp nearly 2200 years ago. Hemp remained the main source of paper making until it was substituted for wood pulp in the 20th century. Recently hemp has been again looked as a possible addition for paper manufacturing to reduce the deforestation that is one of the leading causes of global warming and climate change. As the paper demand increases the load goes on the wood pulp industry that requires mass amounts of wood for pulp making which creates the problem of deforestation by trees not being as regenerative as the need would require. Hemp pulp paper manufacturing is more expensive than wood pulp which is one of the reasons for its reduction of use. To reduce deforestation, hemp has been looked as an alternative to take of the load from the wood pulping industry by being the raw material for smaller paper applications.

Between the years 1990 and 2016 the world has lost 1,3 million square kilometers of forest cover. Destroying forests also releases CO₂ to the atmosphere as hemp farming on the other hand removes carbon dioxide as a result of cultivation. Deforestation also harms the natural water cycle and results in the loss of natural habitat for animals and plants that then leads to them being more likely to go extinct. Currently 70-80% of Earth's land animals and plants live in forests. Scientist estimate that we are losing species at 1000 to 10000 times the original rate each year because they lose their homes due to deforestation. With these rates 30-50% of all species could be facing extinction by 2050.

Hemp paper is one of the only eco-friendly options outside from the current wood pulp paper making as hemp paper needs no bleaching so it eliminates the possibility of water contamination by the paper mills dioxin and chlorine use. Hemp also grows fast and can be harvested often compared to trees which makes it more sustainable in the long run. As an added benefit hemp farming also regenerates soil because of the retting harvesting method where nutrients used by the plant can return to the soil.

Hemp is more efficient for paper making because of the high cellulose content and lower ligning content than trees. The paper yield per hectare of hemp is also higher when compared to paper made from trees. As trees have only a 30% cellulose content the other 70% needs to be removed with the use of chemicals and trees grow time to harvesting is over 20 years making hemp clearly the more suitable option. The end product is also stronger and longer lasting as hemp paper does not yellow or deteriorate in use. (O'Connell 2020a.)

4.5.1 Processing of hemp pulp paper

In its core papermaking is the rearrangement of elementary fibres to a flat thin sheet from any source such as trees or hemp stalk. The fibers are chains of cellulose molecules that form a rigid structure when assembled. The average paper making fibre is 2 millimeters long and 20 micrometers thick. Elementary fibers are building blocks of plants that are then glued together with other components such as lignins and pectins. This gives the fibers strength and flexibility to withstand forces applied to it. As hemp fibers are

the strongest natural fibers they make a great raw material for pulp paper and manufacturing high-quality paper.

Converting the hemp fiber to pulp is a multiple step process that starts with cleaning all the non-fibrous material from the fibres. Non-fibrous material that can include dirt and small rocks need to be removed from the fibers before the clean raw material can be chemically processed. Fiberizing is the next process where fibers are take apart by mechanically tearing the fibers apart or chemically breaking down the bonds that hold the fibers together. For hemp fibers to be suitable for paper making they need to be cut down as they are naturally too long to give a homogeneous paper sheet. The fibers need to be classified after separating and cutting by their attributes. Fibers suitable for paper making are selected by the right size, thickness, age and how straight and strong the fiber is.

Bleaching is an optional step of the process if a whiter paper is wanted. Modern pulp manufacturers use oxygen-based bleaching and hemp pulp can be bleached with hydrogen-peroxide which is harmless to the environment. The bleaching is usually applied for writing paper for better contrast and application such as packaking paper and board do not require it.

A separate possible process that can be done to the fibers is refining them by roughening their surface. The greater the surface roughness of the paper, the greater it adheres to other fibres in the paper. Surface roughness also gives the paper greater strength.

After the pulp processing is done it can be made into paper. The process starts with diluting the pulp with water. Diluting makes it possible to lay the fibres into a homogeneous sheet of paper. The fiber-water mix is then poured on a fines mesh where most of the water falls through leaving the fibres into a flat sheet. The flat sheet of fibres need to be dried next which can be done by pressing and steam heating. The process is done when the fiber pulp is dry and it can be cut into required sized of paper sheets. (Van Roekel jr. 1994.)

4.5.2 Technical aspects of hemp pulp and paper

Industrial hemp bast fibers have an wide range of potential application in modern paper making as the reported properties of unbleached alkaline mechanical pulps made from hemp bast fiber were sufficient for linerboard production. When comparing the unbleached hemp bast fiber mechanical pulp with softwood thermomechanical pulp, it was found to have higher tear strength, but higher density. The properties of bleached bast fiber mechanical pulp were found to have properties that it could be used to replace bleached semi-thermochemical softwood pulp in printing and writing grade papers.

When evaluating the pulping of both bast and hurd fibers of industrial hemp using the autoclaved organosolv pulping it was found to have high yield, fiber strength, and high tear strength with the bast fiber pulp. This type of bast fiber hemp pulp would be ideal for manufacturing paper products requiring high tear strength, stiffness, or bulk. The investigation into hemp pulps made from its woody-core concluded that the brightness, burst, and crystallinity values of it were comparable with hardwood pulp. The woody-core pulp was comparable to hardwood pulp when used in printing paper grades and the hemp core could be a suitable option for producing pulp mixes for printing paper if production was optimized.

With all the research on hemp pulp making being done by separated bast of core fibers from the stalk it leaves the question if its technically possible to pulp the whole stalk while obtaining acceptable paper properties. Using the whole stalk for hemp pulp would bring the issue of hemp fibers being needed for other application but certain hemp breeds that grow a tall stalk could be harvested for only paper making. As further research was done with the whole stalk pulp making with the orgasolov process it was found that the paper strength from the pulp were intermediate between commercial chemical hardwood and softwood pulps. All the research eventually concluded that separate pulping of core and bast fibers was recommended. (Bowyer 2001, 22-24.)

4.5.3 Market potential of hemp paper

Hemp paper cannot replace the current paper industry overnight because of the changes that would be needed to make to the infrastructure of paper making. Changing manufacturing of paper to fully hemp based would be costly because the machinery would be needed to be switched to ones that support hemp pulp and paper manufacturing. The current inefficient hemp pulping process leads to a high price of hemp pulp which. Another reason for hemp paper mills inefficiency is that hemp is harvested once a year and needs to be stored and handled which leads to high raw material cost.

To assist the wood pulp industry better, the hemp paper industry would need to create high-quality pulping techniques that utilize both long bast fibers and short inner hurds that make over half of the stalks fiber volume. Nothing happens over night and the benefits from hemp paper start by making small changes towards creating more hemp paper applications thus lowering the need of trees for paper.

The smaller application of speciality paper made from hemp pulp include cigarette paper, filter paper, coffee filters, insulating papers, greaseproof papers and various speciality art papers. These paper can mostly only be produced from special fibers including hemp, flax, cotton and other non-wooden fibre sources. (Van Roekel jr. 1994.)

In conclusion, growth potential of the hemp paper market remains slow even with it being the oldest known application from hemp. The current processing technologies are too costly for efficient manufacturing and hemp paper will remain a subsidy to the cheaper more sustainable wooden pulp industry.

4.6 Hemp Clothing & Accessories

Hemp fiber that comes from the stalk of the plant can be processed into clothes and any accessories that are currently made from cotton. Hemp fiber is stronger and softer than cotton with also hemp yielding more-fiber than cotton per acre. Another benefit of hemp compared to cotton is that it requires less water to grow, it grows faster and does not require pesticides like cotton cultivation does (Greenmarketreport s.a.). Benefits in clothing that are made by using hemp fiber are its great insulating and anti-bacterial properties, resistance to mold and mildew, high abrasion resistance and it retains color better and stretches less when washed (Hempgazette s.a.).

Only in recent years has hemp clothing gained popularity and seen as a option for clothing manufacturers because of the increased push for cultivation of industrial hemp everywhere. Throughout history hemp has been used to make clothing in China, Europe and North America. The disappearance of the hemp clothing market came from other crops such as cotton being cheaper and less labor intensive to harvest in the past.

The recent resurgence of the hemp clothing market came from the environmental movement gaining popularity which made manufacturers rethink the raw materials they use to manufacture their clothes. Clothing and accessories that can be made from hemp fibre include shirts, hoodies, wallets, shoes, belts, hats, socks, jeans and underwear.

4.6.1 Processing of the hemp fibers

Everything starts from the harvesting as the quality of the hemp fibre depends whether the crop has been bred specifically to have qualities that produce high-quality fibre that can be used in textiles. Some harvests are used for dual-usage meaning the crop is harvested for the fiber and seed. This can lower the quality of the fibre as seeds are harvested much later. The best quality fiber for textile manufacturing is harvested at 70-90 days after seeding.

After harvesting the hemp stalk needs to go through a retting process. Field retting is a process where the crop is left on the field to naturally decompose with the help of bacteria, fungi and mold. Retting breaks down the pectins that bind the hemp fibres together for easier fiber separation. This retting process can take from 4-6 weeks and sometimes winter retting is used where the late autumn harvest is left on the field over winter to rot and harvested when the weather starts to get warm again.

Other types of retting are called water retting where the stems are soaked in water for 10 days and dew retting where the stalks are laid on the field after cutting for three to six weeks with turning then occasionally for even retting. Dew retting is a natural process where dew falls on the crop each morning and with the help of bacteria and fungi the pectins break down allowing the fibers to be separated from the stem. Dew retting is done when the stalk bundles laid on the field are white and dry.

After retting the hemp stalks fibers need to be separated for further processing into textiles. The woody core of the stalk needs to be removed from the coating fibers. The process is called breaking where the fiber is separated by passing the stalk through mechanical rollers that crush and break it. Commonly used machine for this separation method is a decorticator that come in commercial sizes as well as portable types for smaller farmers and manufacturers. The decorticator also allows the leaves to be left on the stalks during the breaking although this makes the fiber separation process messier. The fiber separation process can also be done manually by cutting the leaves and beating the stalks with sticks but this is more labor intensive and not viable for large harvests.

After the separation the fiber goes through another process called scutching that beats and scrapes the fiber bundles thus separating them into short fiber and long fibers. The fiber quality and size can also be altered in the growing phase where the plant is bred for fiber production with having less flower and leaves and a longer stalk that yields a longer stronger fiber. The short fibers produced are called tow fibre and the long fibers are called line fibre. The longer line fibre is used for higher end products such as clothing fabrics and accessories and the short tow fibers are commonly used for stuffing and insulation.

The long separated fibers need to be softened by using a hemp softener or roller that softens the decorticated fibers for a combing machine that removes the final woody core particles from it and aligns the fibers for the spinning process. The spinning process can involve wet or dry spinning where the fibers are spun into hemp yarn. The best quality yarns are obtained by passing the fibers through hot water before they

are spun which produces a finer softer yarn. After the fibers are spun into the yarn they are ready to be manufactured into textiles such as any other fiber. (Mahapatra 2018.)

4.6.2 Market potential of hemp clothing

Large clothing manufacturers such as Patagonia are coming out with special edition hemp products but they are a small majority of their yearly production and seen as a niche market currently (Patagonia s.a.). The hemp clothing market is at the top when it comes to potential new businesses for hemp based products with style and fashion being one of the biggest markets today. The transition to large scale hemp clothing business would need a manufacturing line that supports hemp fiber processing into clothing. The raw hemp fibre would need to be acquired by working with current hemp farmers to produce high quality fibre for production. China already produces massive amounts of hemp for fibre and could be the future exporter for hemp fibre for fabrics as they already have an existing infrastructure. Currently China does not export much hemp fibre but if large companies start producing hemp clothing this might change due to demand and business opportunities.

The current clothing market is mostly dominated by cotton based fabrics which cultivation is harmful to the environment because of the pesticides needed in the growth cycle. Hemp has many advantages over cotton as clothing made from hemp fibers are higher quality from fibers strength to softness. These characteristics make hemp clothing user friendly and long lasting. Furthermore, hemp clothing are also an environmentally friendly product as cultivating hemp removes carbon dioxide from the atmosphere and does not require pesticides. These characteristics give hemp clothing an great opportunity to be marketed as an higher quality and environmentally friendly choice for a fashion statement or for daily confortability and long lasting sustainable option.

4.7 Hemp plastics

Hemp can be processed into environmentally friendly plastics that are clean, sustainable, renewable and biodegradable. Currently plastic is made from non-renewable petrochemicals that is polluting the planed and its oceans at a rapid phase. Switching the current fossil fuel based plastic manufacturing to hemp based plastics would also help with the emission of carbon dioxide to the athmosphere as biodegradable plastics do not produce them.

Plastics completely made from hemp is currently almost non-existent but plastics made from combining hemp and other plant sources are already in use at low amounts. These plastics are strong, inflexible and light making their use great for cars, boats, musical instruments, construction and design.

Problems with moving towards completely hemp based bio-plastics is that the technology isn't quite ready for it. Companies have experimented changing polyethylene terephthalate (PET) based plastic bottles to 100% plant-based bottles but still 70% of commercially available products are made from traditional fossil fuel sources.

Switching fully to 100% hemp based plastic still come with its issues such as not being able to biodegrade in a landfill and possibility of hemp microplastics ending up into the ocean but as the world is moving to recy-
 cleable manufacturing it's a step in the right direction. More commercial composting facilities need to be build

near all major cities and communities for efficient disposal of bioplastics and people still need to take responsibility on how they dispose every day plastics (O'Connel 2020b.)

4.7.1 Processing of hemp plastics and technical aspects

Hemp contains 70% cellulose and can be extracted to make cellophane, rayon and celluloid and cellulose can be manufactured into variety of plastics. The cellulose is extracted from the hemp hurd fibers by crushing them into powder first and then hydrolyzing the raw pulp by adding 50-90 celcius water to it that separates the wanted compounds out of it.

Immersing cellulose into weak acid can also be used to separate the crystalline sections from the amorphous ones and creating cellulose nanocrystals. A gel like substance called nanocellulose can be produced if extra pressure and heat is applied to the cellulose nanocrystals. Nanocellulose is can be added as a reinforcing material in plastics and can also be manufactured into sanitary products.

Currently hemp is mostly utilized as an reinforcement material in composite plastics that are based on cellulose and other natural of synthethic polymers. Composites reinforced with hemp fibers have high tensile strength when the fibers of a female plant is used. A 2003 study of natural fibre-reinforced polypropylene composite material showed that hemp had a tensile strength comparable to traditional fiberglass composites and hemp outperformed all competitors in impact resistance. Another 2007 study on polypropelyne composites reinforced with hemp fibres showed that overall stress and mechanical properties were increased up to 80 % when compared to traditional glass fibre composites. (Sensi Seeds 2020a.)

4.7.2 Market potential of hemp plastics

Hurdles to overcome for hemp plastics is that hemp has been popularized only partially in the western world and the infrastructure for hemp farming and manufacturing is still at its infancy and will take a few years or even decades to build to the levels of other agriculture and the fossil fuel industry. Hemp also is labor intensive to harvest and lacks a sustainable infrastructure in most markets. For hemp plastics to make up a larger share of the market it simply needs to be cultivated more which opens business opportunities around hemp-based bioplastics.

Building technology and infrastructure that supports hemp cultivation and manufacturing of hemp plastics to the three largest markets China, United States and EU is one of the only was to help reduce current plastic waste. Issues on building hemp infrastructure for bio-plastic production are the cost of initial investment. Mass amounts of hemp need to be cultivated and harvested to create large amount of bio-plastic products which needs machinery for harvesting and processing. Smaller application need less investment and are the probably future for hemp based bio-plasctics.

However, plastic pollution is one of the worst problems in the world right now and will only get worse if better and more bioplastics products are not manufactured. The hemp plastic market has a lot of potential for positive environmental impact but investment into the industry will likely remain the largest issue. The disposal of current plastics is a major environmental issue already so if bio-plastics are wanted to help the issue it is crucial that a disposal system are also created for them which creates more need for investment if ways to turn hemp plastic into profitable solution such as energy production are not created.

Hemp plastics have not reached its potential even with there being is more interest towards hemp being used more as bio-plastic raw material. The biggest application currently is biocomposites used as by big autocompanies taking the initiative to add hemp based car panels in their products because of the light weight benefits. Some of the largest automobile manufacturers such as BMW, Mercedes and Bugatti are incorporating hemp plastics in their cars and even the latest Porsche model 718 Cayman GT4 has hemp fibre panels.

4.8 Hemp housing

Hempcrete was originally created in France in the mid-1980s and since its discovery its use has been growing in Europe because of the legalization of industrialized hemp in several countries that have now adapted the growth of hemp and use of hemp products including hempcrete. Currently 5000 tons of hemp material is used in construction yearly in France.

4.8.1 Manufacturing of hempcrete

Hemp can bring new manufacturing methods to the construction industry as the shivs of the hemp stalk that is mainly a waste product of fiber farming can be used to make a lighter concrete substance called hempcrete. Hempcrete can be then used to manufacture walls and roof insulation. It is made by combining the hurds, water and lime which is powdered limestone. After the ingredients are added the slurry compound is pored inside the wall structure that is supported by woden beams and over time the compounds react together to form a solid compound.

The only disadvantages that hempcrete has is the length of the materials curing process which take up to three months making it a less reliable material for weigth bearing walls. During the time if it is exposed to harsh weather conditions is can delay the process or damage the structure. The workaround this long curing process is to make the hempcrete into bricks that are formed by pressing machines and left to cure. When the brick cures it is thicker but lighter than relular cinderblock but require no supporting frame as they have a petrified rock like feature that lasts a hundred years

Another way is to build wooden structures where the slurry hempcrete form can be placed to cure while the wooden beams work as supporting structures. The second downside comes from the fact that lime is sensitive to low temperatures building the house during the winter months is difficult. Hempcrete is best to be used in places with reliable weather conditions and no real winter (National Hemp Association 2016.)

4.8.2 Technical aspects of hempcrete

Benefits of hempcrete in construction are that it is fire and water resistant. It is also mold resistand due to the fact that combining hemp and lime hinders the growth of fungi and bacteria. The hempcere wall is breathable because of the materials great vapor permeability. The material is is not solid like regular concrete but porous so it drains excess moisture by accumulating it in the hemp cellulose. As humidity of the room decreases the fibers emit it back to the room thus proving air quality.

The material is durable and strong because of the materials low density making it harder to crack under load. In movement the hempcrete creates microcrack instead of larger ones as relugar concere would and as the material goes in contact with moisture the fiber stick back together. Such properties make hempcrete an great material for building in places where earthquakes are common.

Hempcrete works great as a thermal insulator because less heat can flow through it than other insulating materials. In the winter time the outer walls of a hemp house can be around 5 Celsius lower than in regularly insulated houses meaning less heat leaves the interior of the building. With comparable heating intensity hemp houses can maintain a higher average temperature by 2 Celsius because hempcrete can also absorb and emit heat depending on the surrounding temperature. All these insulating properties make hemp houses significantly better with energy efficiency. (Obluska 2020.)

4.8.3 Environmental benefits of hempcrete

Hempcrete is light and weighs 1/8 of the weight of concrete and also does not negatively affect the carbon footprint as hemp absorbs carbon dioxide to the tissue of the plant and when made to hempcrete it does not return to the atmosphere. Regular concrete on the other hand makes 900 kilograms of carbon dioxide per ton because of the chemical reaction used in the manufacturing process. (Bedliva & Isaacs 2014, 1.) According to Mukherjee (2012, 1), the building and construction industry accounts up to 40 % of the world's energy use and approximately 40 % of the world's raw material use. Therefore, sustainable building materials such as hempcrete have potential to positively impact the global environmental problems. Manufacturing hempcrete creates some emission but the cultivation process of hemp taking carbon dioxide out of the atmosphere balances the emission to zero or in some cases hempcrete can be referred as carbon negative. A maximum of 325 kilograms of carbon dioxide can be stored in one tonne of dried hemp and hempcrete sequesters 110 kilograms of carbon dioxide for every cubic metre of material when the emissions from manufacturing are taken into account. (6 Advantages of Building With Hempcrete 2017).

The low weight of hempcrete gives it environmentally friendly qualities as the manufacturing and transportation of materials emits less CO₂ than the cultivation of hemp removes from the atmosphere. Hempcrete can even be recycled if the house needs to be demolished leaving behind plant biomass that can be turned into energy. Each of the components of it are biodegradable, sustainable, non-toxic, require no solvents and can even be composted making it the most environmental friendly building material.

4.8.4 Market potential of the hemp construction industry

The hemp construction market in the form of building eco-friendly houses from hempcrete has a strong base in several countries in Europe including France and The UK. Other European countries that have homes built on hemp construction materials include, Finland, Sweden, Ireland, Czech Republic and Spain. Hempcrete is also used in Canada, The U.S and Australia (International Hemp Building Association s.a.).

Hemp housing seems to have most interest of hemp application after the hemp foods market. With hempcretes technical aspects it can be used to build houses all around the world with minor inconveniences from cold weather in some cases. The benefits compared to regular concrete have strong environmentally friendly implications which can positively drive the popularity of hemp housing in the future.

The manufacturing process of hempcrete is simple and cost efficient. With pre-casting, hempcrete can be used for manufacturing houses where the weather conditions are not optimal. The hempcrete building techniques have been optimized for building since its discovery in the 1990's. The research and development done to the building techniques has created a strong possibility for hempcrete to have a large impact in the

construction industry in the near future. The only disadvantage holding the growth of the industry back currently is the low amount of hemp cultivation. With low amounts of hempcrete available the companies constructing hemp houses cannot meet the demand and grow accordingly.

4.9 Hemp fuel

Biofuels processed from the hemp is an environmentally friendly application where the oil and the fibers can be refined into hemp based fuels called bioethanol, methanol and biodiesel. Ethanol is currently used as an additive to petrol but regular cars can only withstand 10% ethanol content. New flexible fuel cars can use up to 80% ethanol and the use of biofuels could be a viable option to lower the amount of regular petrol cars that are polluting the environment. Electric cars will help with the lowering of petrol car need in the future but there still will be a need for liquid fuel vehicles for transport or manufacturing machinery so biofuel sources like hemp need to be invested in.

A hectare of hemp can produce up to 800 liters of biodiesel per year which is a greater yield than other crops used for biofuel production such as soybean, sunflower or rapeseed. Hemp biodiesel also is superior to other plant based products and outperforms regular diesel in all other areas other than oxidation stability that can be mitigated by adding anti-oxidant to the mix. Biodiesel can be used to run in any typical unmodified diesel engine and is currently used as a blend in regular diesel.

Fuels like coal, natural gas and oil are harvested from the earth and are not renewable compared to a hemp crop that can be harvested yearly. Petrol and diesel also are made by using crude oil that consists of hydrocarbons that create energy and toxic chemicals when burnt. Hemp on the other hand removes CO₂ from the atmosphere when grown and when harvested for cellulostic content the other parts of the plant can still be utilized to manufacture different products. After the oil is pressed from the seeds for biofuel manufacturing the remaining hulls can be pressed into nutritious animal feed. The leaves that fall from the crop during harvesting return the nutrients back to the ground and replenishes it for the next harvest making hemp a sustainable option. The stalk can still be used for hurds and fiber that can be produced into many useful products such as paper, insulation and hemp based building materials.

Hemp is the most environmentally friendly biofuel raw material when comparing it to the current popular crops used in biofuel manufacturing such as soybean and palm oil. Palm oil harvesting creates massive amounts of deforestation because of the space needed to harvest palm oil and deforestation kills the natural habitat of several species in the rainforest which lead to them becoming endangered.

Soybean harvesting also destroys the natural habitat for several species in the rainforests because of the deforestation done for the space needed to harvest soy. Soy cultivation also leads to soil erosion which leads to more deforestation by needing nutritious soil where more soy can be harvested in. Soy farming also contaminates rivers and forests as they need large amounts of fertilisers, pesticides and herbicides which of hemp farming in most cases require none. These fertilizers are nitrates from oil and gas and once they are introduced to land cause distress to the ecosystem by running into water sources. Fertilizers can also enter the atmosphere and become nitrous oxide which is a greenhouse gas worse than carbon dioxide.

Even though switching all motor vehicles for hemp biofuel won't solve the issue of future transportation problems or climate change it would be a helpful and quite simple way to reduce environmental harm. If hemp farms had hemp biofuel processing plants near them could the whole process become carbon neutral

by creating a sustainable and effective process chain as the hemp farmed would remove CO₂ from the atmosphere and there would be less transporting emissions. Building an infrastructure around hemp biofuels would also cut the need for all the other crops used for biofuels thus adding to the environmentally friendly nature of the industry.

Some negative aspects of hemp growing for biofuel that might halt its popularity is that it takes several processes to convert hemp into fuel which can be more costly. Other sources of biofuel such as sugarcane only requires to be fermented and corn that needs to undergo hydrolysis on top of the fermentation. Before hemp material can go through these processes it needs to be pre-heated and made into a cellulose pulp or the seeds have to be pressed into hempseed oil first which takes energy and time. (Sensi Seeds 2020b.)

4.9.1 Processing of biofuels from hemp

Biofuels can be made from grains of several plants but in hems case the high cellulose content of its fibers make it a great plant to produce cellulosic ethanol. Hempseed oil made from the seeds can also be processed into biodiesel for cars through a process called transesterification where by mixing fatty acids, alcohol and a strong acid catalyst produces raw biodiesel.

Unlike other biodiesel applications, hemp can also be used to produce bioethanol and methanol. Bioethanol is manufactured by processing the starched and sugars of a plant and the process to make ethanol out of hemp is called cellulolysis. There are several stages of processing in order to make ethanol from hemp. Firstly a pre-treatment needs to be made to the cellulose content in hemp suitable for hydrolysis. After the pre-treatment the molecules are broken down into sugars by an enzyme that converts cellulose into glucose. Next step is to separated the sugar materials from the lignin and the fermentation of the sugar solution. Then the separated sugars go through distillation to extract the ethanol out of them and to increase the ethanol concertration it is put through a molecular sieve. The Final product is a hemp based ethanol that can be used in cars for fuel.

Methanol is the other alcohol manufactured from the pulp matter of plants and methanol can be created from hemp by a process called dry distillation. Heating the hemp pulp material creates gases that can be then condensed into methanol. Coal is a by-product of the dry distillation process and that can be reused as fuel. Another possible way to produce methanol is by a process called pyrolysis. Pyrolysis is a new way to make hemp biofuels and it involves the intense heating of the fibrous cellulose mater that hemp contains. The process is very economical as any waste biomass can be used in it such as the left over parts of the hemp plant.

As the hemp movement grows larger globally there will be more biomass waste coming from manufacturing processes and pyrolysis can be a way to capitalize on that waste by using the biomass left from harvesting hemp and processing it to other products. Currently one of the issues for hemp biodiesel becoming popular is that hemp is being cultivated for the use of other industries and products. This leaves little harvest for bio-diesel manufacturing and the industry stays stagnant as business possibilities need high funding to start. (Industrial Hemp's Energy Potential – Biofuels s.a.).

4.10 Hemp biomass for bioenergy and biogas

Bioenergy is produced from biomass which includes plants such as hemp. Commercial bioenergy comes in the types of residues and cultivation of agricultural crops for the purpose of energy production. Residues include any type of residual material that originated from an industrial manufacturing processes. This can include the manufacturing of foods, fuels or building materials.

Hemp biomass for bioenergy can cover both types as it can be solely grown for biomass production as it has a comparable or even higher yield of biomass energy than other crops depending on the harvest. Hemp residues can also be used for bioenergy production as many other industry application from hemp that require processing leave biomass waste product that can be converted into bioenergy.

Converting biomass into bioenergy from hemp can be done by a process called anaerobic digestion that is based on a microbial degradation of biomass in a oxygen-free environment. This process can be done wet or dry and energy crops such as hemp are often co-digested with manures in a digester with applying the wet processing of the crop.

The main energy carrier product produced by anaerobic digestion is methane which is a biogas that can then be combusted into gas boilers for heat production. Methane produced from hemp can then act as a heating source for district heating devices used by family homes or municipality buildings. Upgrading raw biogas into high methane content can also be utilized as a fuel for vehicles. The nutrient-rich mass that remains after the conversion of biomass into biogas can be then used as a biofertilizer for field crops thus creating a sustainable circle of biogas production from hemp. (Prade 2011, 16-19.)

4.10.1 Market potential for the biofuels and bioenergy from hemp

In Europe, hemp has been rated as one of the best crops available for energy production. Europe has done continuous development of possible crops that can convert biomass to energy by subsidizing the research. It has been proposed that hemp is notably a superior to most crops when it comes to biomass production. However, observations on the annual dry matter yield of hemp that rarely approaches 20 tonnes per hectare is not exceptionally higher compared to corn, beet or potato. The main current competitors for hemp are maize and sugar beets for biogas production. In North America, the hemp biomass to energy industry has not been proven sustainable enough to grant large investments towards it. Most notably because of the competitors such as lumber waste and other crop residues present considerable competition for hemp being cultivated specifically for biomass production.

The biomass to bioenergy market coincides with the bio-fuels market as in Europe there has been interest in the application of turning hemp hurds into methanol, methane and gasoline through pyrolysis. The conversion of hemp hurds into cellulosic-based ethanol has also been shown to be practical. However, converting hemp into biomass into fuel is not optimal in areas where there is massive amounts of wood which can be turned into energy cheaper. The conversion of hempseed oil into biodiesel by transesterification with ethanol and methanol currently is not competitive with other fuel sources because of the high price of processing. The main current competitors for hemp are maize and sugar beets for biogas production. Hemp current competitors for solid biofuel production are willow and reed grass. Despite all the hurdles of the

hemp bioenergy market it has been shown to be an above-average energy crop which gives it large potential for the future if improvements are done for the yield and better processing infrastructure is build for sustainable and cheaper processing. (Cherney & Small 2016, 14.)

In conclusion, for the hemp fuel industry to grow it needs more investments to create a better infrastructure with superior technology and equipment in order to create hemp fuel effectively and with low cost. Another issue is the whole hemp industry not being large enough for hemp growing becoming the better choise for farmers in order to supply the hemp biofuel industry. If more hemp would be farmed more in general would there be more hemp cultivated just to produce biofuels out of it. This would lead to more research of the field from the effectiveness of hemp based biofuels in vehicles to being able to invest in a biofuel business that has a sustainable revenue source.

5 INDUSTRIAL HEMP IN FINLAND

Despite being located in northern Europe, Finland has a long history of hemp cultivation. Earliest signs of hemp dates back to the Viking era (800-1050 AD). Hempseeds also were found when several excavations were done in southwestern Finland. Those finding show that hemp was used in a long continuous period from 1100-1500 AD. During those times hemp was used as a commodity and was traded for fiber not seed even though the finding of seeds indicated that hemp was cultivated and not imported.

The research on hemp cultivation shows that in Finland the use of hemp goes back further than originally though and has been used in the southwestern agricultural regions of Finland for atleast 1000 years, maybe even 1500 years. Hemsps cultivation increased heavily during the 18th century and kept rising until the early 19th century. By that time hemp was cultivated and used all over Finland.

Hemp use in Finland was high in the 19th century as Eastern Finns wore primally hemp clothing back then. Coarce yarn was spun from the fibers of hemp and categorized by fineness and was then made into every-day items such as towels, cloths, work cloths and linen. Fishing nets and sacks were made from hemp twine by knitting and it was also used to make sails for boats and lamp oil pressed from the hemp seed has also been used in Finland. During and before the second world war hemp was the best material to make rope and as mechanical twinning machines were introduced could rope be made more efficiently for Finns to use for home needs.

Even though hemp was vastly utilized in Finland for hundreds of years, its cultivationg basically stopped during the 1950's. By beginning of the 1960's hemp was only grown in private farms for domestic needs. The decline started much earlier with flax passing hemp as the most important fiber for industrial and home use. Flax was cultivation needed less labor and eventually it was replaced with cheaper cotton imports. Decline of hemp was also hit by the commercialization of agriculture as more wood was sold for money and the labor intensive crops such as hemp was not appealing anymore. Having more money ment that clothes imported to Finland could be bough rather than made (Laitinen 1995.)

Cultivation of hemp in Finland has always been legal by law and today in the 21st century hemp is still being farmed in over 20 locations all over Westerns and Eastern Finland. After the steep decline of cultivation in the 1950's the hemp industry saw a revival in the 1990's and is a part of the economy again. Currently there are several companies farming and manufacturing hemp products in Finland.

Hemp strain cultivated in Finland has it own name Finola that was developed in 1995 and added to the EU's subsidized crop list In 2003. The special nature of this strain comes from the varying weather conditions in Finland. The long days in the summer with long periods of sunlight makes the strain grow tall which gives the fiber strength. The harvest is also always winter retted meaning it is left on the fiel during winter and harvested in spring. The cold temperatures detach the fibers from the inner core of the stalk making it easier to process by mechanical means. In spring when the sun comes out again it warms the fiber up and it goes through a natural process that removes most of the pectin and gives it the resilient quality needed in processing.

5.1 CBD in Finland

The use of CBD products is currently very low in Finland and can be bought in health stores and ordered online. Its potential benefits are currently being researched for medical use and the future for hemp oil derived products in Finland look promising. A Finnish company called Hamppusampo started developing an industrialized strain of hemp in 2018. Their intentions were to create CBD products from it and sell them in Finland and abroad.

The company obtained a permit from Evira the Finland's food and safety agency but then got revoked of that licence since then Evira decided that the hemp plants grown by Hamppusampo did not meet the industrial standards. The miscommunication happened when Hamppusampo understood that Evira would consider flowering hemp as food but Evira stated later that they had not authorized the flowering of hemp and creating products from it. Since this decision Hamppusampo had to stop selling their products.

Since the setback Hamppusampo has continued its research and development into hemp and expect the full commercial cultivation of hemp to be legal for medical purposes in the next few years. Currently they are building their infrastructure and working with half a dozen small-scale farmers in areas near Oulu and Jyväskylä, and also in eastern Finland near Lieksa and Rautavaara. The world has a growing need for CBD products and with the expansion of their businesses Hamppusampo strives to have the cultivation and processing skills needed when the legalities of hemp growing get sorted in Finland. Hamppusampo has the permit to import hemp seeds currently and uses them for research to find the right strain that CBD can be processed from.

CBD products are currently classified as pharmaceutical drugs in Finland and that complicated the cultivation licence for hemp in order to process CBD from it. In other countries such as Switzerland and the U.S. CBD is classified as a dietary supplement and can be bought by anyone over the age of 18. Finland is hoped to follow suite but the The Ministry of Social Affairs and Health says that deregulating CBD to non-prescription sales requires extensive studies to prove product safety (Finnish entrepreneurs cultivate 'cannabis light' with eye to export 2018).

5.2 Hemprefine

Hemprefine Ltd. is a Finnish company that cultivates hemp on Finnish soil in several locations mainly in Western and Eastern Finland. Their business model revolves around creating an energy-efficient and eco-friendly production technology and production chain for hemp. They are doing continuous research and development into the industry and created the world's first industrial scale movable decortication machine that separates the fibers from the stalk. Transporting costs involving raw material lowers the profitability of a business of any biomass production and their decortication machine can be moved by road modules thus being able to operate it close as possible to the production areas. This reduces the cost of biomass transport and increases the profitability of cultivation and manufacturing processes.

The company's products include hemp pellets that are made for small animals, hempcrete for the construction industry, hemp hurds for the gardening industry and hemp fibre for domestic and foreign bio-composites industry. Their hemp pellets are used for animal bedding and litter products and have antibacterial properties that reduce the need for antibiotics.

Hemprefines main research and development goal is to support the manufacturing of high performance bio-composite material and composite products for hemp fibre. Their hopes are that these new bio-composites offer the Finnish industry a new portfolio of high value products that come from domestic sources. Finland has always been seen as an environmentally friendly country and the rise of environmentally friendly hemp products in Finland could be beneficial to several Finnish manufacturing industries.

They are also on the forefront of research and backing for hempcrete being popularized by the Finnish construction industry as they make demonstrations on how hemp building materials are beneficial. Their goal is to be the main supplier of high quality and environmentally friendly building materials in Finland. As hemp building materials have special manufacturing process needs in colder climates Hemprefine provides valuable information for their clients during the design process in order to get the best end outcome (Hemprefine s.a.).

5.3 Finola

Finola is a Finnish company that produces their own strain of industrial hemp called FINOLA. The hemp is mostly cultivated and harvested for seed production. The seeds are processed into edible food sources for humans and animals. Their products include whole seed, hulled seed and seed meal. The company's business model revolves around exporting and selling their seeds for hemp cultivators worldwide. The seed buyers then have the right to harvest the hemp and produce FINOLA certified hempseed oil and hempseed food products from it.

The hemp strain called FINOLA originated in Finland in 1995 under the breeder code FIN-314 and currently is well known outside of Finland for its quality. FINOLA is OECD certified and has also been certified by the European Union to the list of accepted industrial hemp strains. As the strain is selectively bred to produce seeds it is most commonly sold for the Canadian market where it has been used by hemp cultivators since 1998. Some characteristics that the strain possesses are strength and resilience to wind and low temperatures because it was originally bred for the northern climate. The crop also grows short and matures early which is optimal for producing the biggest yield of seeds per harvest. (Callaway 2013.)

5.4 The Finnish industrial hemp market

The hemp market in Finland is relatively small but it still has a good base for growth as it has grown slowly but surely since the 1990's. As Finland has their own breed of hempseed with a long history it creates possibilities to be a large export when hemp based foods gain more mainstream popularity and the demand grows.

There was an effort to start CBD oil businesses in Finland but those efforts died down as the regulation on CBD oil and CBD products were unsure at the time. There inevitably will be hemp grown for CBD in Finland because of the popularity and business opportunities but as of today CBD is in its infancy in Finland.

Most of the hemp in Finland is cultivated for the seed and fiber and the hemp market currently consists of hempseed oil, hemp seeds and processing the stalk to fiber. Finland has a lot of farmable land and if hemp farming gets more popular the demand for Finnish hemp will also rise and new opportunities will come from the hemp market for farmers and new business owners that sell hemp based products.

6 INDUSTRIAL HEMP IN ESTONIA

The European country of Estonia is taking big leaps to solidify themselves as a major player in future hemp farming and product manufacturing. Hemp cultivation is legal in Estonia and over 6000 hectares of hemp is farmed there annually. Estonia is Europe's second largest hemp producer after France and mostly exports the cultivated hemp in the form of hempseed and oil.

There are shops selling a variety of hemp products including CBD products in the country's capital Tallinn. CBD oil is currently a growing business in Estonia as the demand has grown in the last few years. More people are getting into the industry and building new businesses because of the popularity CBD oil has gotten and made it an expensive commodity.

CBD oil is the most profitable product you can manufacture from hemp and that is why it's driving the hemp market forwards and is one of the main reasons for popularizing the idea of hemp products. More farmers are looking into cultivating hemp for profits and manufacturers are improving refining methods and quality of the product rapidly.

CBD oil production is still in its early stages in Estonia due to its potential as a major market for new businesses and exporting possibilities. More research is being done on the medical benefits of CBD oil all over the world with positive results coming out of the trials. Growth of the CBD oil industry is seen as a great new business opportunity at the moment and more people are looking into becoming cultivators of hemp or manufacturers and sellers of CBD products in Estonia.

6.1 Hemp Futures

Hemp Futures is an Estonian based company that produces CBD products. It was founded in 2019 and currently operates in more than 68 hectares of organically certified land. Estonia's clean environment that includes clean waters and organic soil makes it the perfect place to grow organic hemp. There are also no native pest insects so growing hemp needs no pesticides on Estonian soil.

The company makes the product in house from the ground up and through research and experience thrive to provide high quality CBD products. With growing their own hemp and producing the CBD themselves they have an advantage to have quality control of the product from start to finish. Currently the company uses the CO2 extraction method to produce the CBD.

Their products are hand crafted as everything is done by hand after the field has been ploughed for seeding. To ensure product quality the company carefully controls the harvesting process by selecting the right time to harvest depending on flower maturity. The whole process is logged and records are kept on which strain produces the best yield and quality.

To further ensure the quality of their product the company uses two master growers that have several years of experience in cultivating and growing hemp. Through research and development the growers are working towards new innovative products. The farmers use crossbreeding to create new strains of hemp that is better suitable for CBD and hemp oil refining.

By autumn 2020 the company is expected to begin bottling and selling its full spectrum CBD oil via online store. Their plan is to cover the EU market and expand to countries under the European Union because of

the easy customs between nations and unifying common laws that regulate CBD. A part of their expanding goals is to break down the myths and stereotypes considering CBD oil and work towards a legislative change so the laws are more favourable towards hemp growing, manufacturing and selling to consumers (Hemp Futures: a growing hemp producer in Estonia 2020).

6.2 Estonia Industrial hemp market

The Estonian industrial hemp market is an example of a new market that mainly saw any growth after the CBD oil market started gaining momentum. The market consists mostly of CBD oil and CBD related products which are sold in stores around the country's capital Tallinn. The cultivation of industrial hemp has been growing in Estonia for over a decade and originally it was grown for the hemp seed and oil.

The market started to shift in the year 2018 as the CBD market started to grow in the U.S and it was seen as a possibility for new business opportunities. The hemp cultivated in Estonia doubled from 3,500 hectares in 2017 to over 6000 hectares in 2018, mainly for the production of CBD oil. Since then more companies have been built around CBD oil production and stores selling CBD products have started to emerge. The products sold at the stores containing CBD have a wide variety ranging from CBD oil, CBD for pets, CBD tea, CBD lotion and CBD creams.

Smaller application from the fiber can also be found from the stores such as t-shirts, hoodies and other wearable accessories but their main target is to be advertising merchandise for the shops. Another smaller hemp application for hemp in Estonia is the hemp foods market. The volume and market size of hemp protein powders, protein bars and other hemp foods are not large. The hemp foods market growth is slow and the demand for them is not growing rapidly. Even with the hemp foods market being potentially one of the biggest applications in the future their market share stays stagnant in smaller European markets such as Estonia.

One reason for the stagnant growth of other hemp applications in Estonia can be that the CBD oil market has taken over the cultivation of hemp and not enough is left for other hemp applications to grow and be seen as a profitable opportunity for the farmers. The growth of the CBD market has positively affected the amount of hemp cultivated but possibly hindered the market growth of other beneficial hemp applications such as hempseeds and fiber. If the future of hemp relies on the CBD market it can hurt the entire industry. In 2020 six CBD stores were raided in Estonia and they were shown to be selling CBD products containing too high amounts of THC thus making them illegal. (Baltic Times 2020.)

An unregulated CBD oil market makes it possible for stores to sell CBD products that are not pure. Bad press about CBD products hurts the entire hemp industry. Hemp is already not cultivated enough for all its beneficial applications and hemp being associated with bad quality CBD oil only hurts the possibility of more farmers changing their crops into hemp cultivation. With less hemp, there are less possibilities for growth of the potential hemp markets of hempseeds, hempseed oil and fiber application. The market will stay stagnant and the hemp industry will stay a niche market as it has been for over two decades.

7 EUROPEAN INDUSTRIAL HEMP MARKET

Industrial hemp has had a long history and importance in Europe. Countries such as the UK, France, The Netherlands, Germany, Spain and Italy have been cultivators of hemp for ages with the most important application being strong hemp fiber for fabrics, canvas and ropes. In current days the main cultivators are France and The Netherlands but in recent years more European countries have started to expand their infrastructure for hemp cultivation and processing especially for hemp seeds.

The European hemp industry is heavily subsidized and initially the production was focused on hemp fiber and its applications. Application from the fiber have build niche markets around Europe during the last 20 years including hemp textiles and hemp pulp and paper that is used to manufacture cigarette paper. High quality bast fibers are used to manufacture bio-composites for automobiles. 15 % of the total hemp fiber production goes to automobile applications in Europe and hemp's total market share in the automobile bio-composite industry is about 15 %.

Other notable markets for hemp in are the construction industry where hempcrete is used throughout Europe for building houses because of the high insulating properties of it. Hempcrete is made from combining hemp hurds and lime to produce a lightweight concrete that has great strength to weight ratio. The use of hemp hurds for construction materials competes with the animal bedding market which uses half of the hurds produced in Europe. The animal bedding market is very lucrative and can be one of the best applications for hemp in all the major markets. More hemp needs to be cultivated in Europe for all the possible applications to grow as currently they compete with each other for the low amount of total hemp available which leads to the markets staying stagnant for the most part. (Cherney & Small 2016, 4-5.)

7.1 Fiber market

Hemp fibers have been used all around Europe because of their properties of being a strong natural fiber with many applications. Hemp fibers are mainly processed into insulation material, for bio-composites in automotive applications. Before the rediscovery of industrial hemp in the 1990's, hemp fibers were mainly used for pulp and paper but the applications were limited because of the high price of production compared to the wood pulp. Hemp pulp and paper market is still alive and has been stable in recent decades as in 2013 it still was the most important market for hemp fiber in Europe. With hemp paper being used only in small applications, the market has stayed stagnant for years with no expected expansion due to wood pulp being still dominant.

Due to hemp research and development financed by the European Commission and Member States in the 1990's new applications were developed for hemp fibers. Such applications included hemp based biocomposites mainly for the automotive industry and insulation materials. Today insulation material is the second most important application for hemp fibers, accounting for 26% and biocomposites that account for 14% of the applications. (Carus & Sarmiento 2016, 3.)

7.2 Hemp shivs and hurd market

Hemp shivs are a by-product of fiber processing that bring added value to the European fiber producers as each kilogram of fiber production brings around 1,7 kilograms of hemp shivs. Most important markets for hemp shivs and hurds today are bedding material for horses and other animals in farms such as chickens.

Hemp shivs and the hurd fibers are great at absorbing moisture and they are effective for much longer in animal use than other materials thus saving working time. Horse bedding accounts for 45% of the market share of the total hemp shiv and hurd applications and other animal beddings 18%. Remainder of the hemp shiv market goes to the construction industry for the hempcrete application where hemp shivs and lime is mixed to create construction material for building houses. Hempcrete is a growing market with many countries such as France and Finland looking to expand the use of hemp based construction materials. (Carus & Sarmiento 2016, 5.)

7.3 Hemp seeds and oil markets

In Central and southern Europe, hemp seeds have been mainly a by-product of fiber production. Only in recent years has the exclusive cultivation of hemp seeds gained popularity among producers around Europe. One reason for this change is the increased demand from the food market for hemp based foods. From 2010 to 2013 the production of hemp seeds increased from 6000 to 11500 tonnes and for the first time more than half of the hemp seeds went to the food market. The hemp foods market is increasing in Europe and expected to increase in the coming years which will inevitably raise the share of hemp seeds in the European production. The seeds are sold for human consumption because of their great nutrition density but also hemp seeds can be utilized as animal feed for birds and fish. The oil from the seeds has great nutritional value with high unsaturated fatty acids and can be used for culinary uses. Both the seeds and oil coincide with the current trends and science in the food industry with being health foods that are environmentally friendly. If the quality and marketing of the hemp foods are managed correctly it is possible they will soon be found on every supermarket and hold a bigger share of the whole foods market. (Carus & Sarmiento 2016, 7.)

7.4 CBD oil market

In recent years CBD oil and products containing CBD have gained popularity in the pharmaceutical and supplement industries in Europe. In 2013, 240 tonnes of flowers and leaves went to the production of medical applications, food supplements and essential oils for food and beverages. Comparing to the 7,5 tonnes in 2010 a clear exponential increase can be seen and even more recently in 2020 the CBD market is seeing monumental increase of demand in Europe as most countries habitants are in favor of CBD products being readily available.

With the major business opportunities surrounding the CBD market there is no definitive numbers on how big of a share it has on the total hemp market in Europe as it is growing exponentially every year. Some estimates states that the market will grow five times what it is currently in four years with the current CBD market in Europe being approximately 400 millions euros. Many events and circumstances can affect the CBD market over the next few years so estimates can only be estimates but what seems to be certain is that the demand is there which should lead to the growth of the market. (Carus & Sarmiento 2016, 9.)

7.5 Hempflax

Hempflax is a company originally founded in the Netherlands by Ben Donkers in 1993 when hemp cultivation became legal there. The aim was to create a proper hemp industry and since then they have successfully done that by becoming Europe's largest independent grower and processor of hemp. Hemp flax has operations all over Europe with over 2,200 hectares of hemp expected to be harvested in 2020.

Hempflax as an industrial hemp provider is focused beyond just CBD production. They use innovative technology to process hemp into the many hemp-based products gaining popularity in Europe. Their products include hempfoods, biofuel, hemp plastics and fibre production for textile and construction industries. Their main goal is to provide products that are sustainable, environmentally friendly and cost-efficient to their customers. Hempflax also has patented technology for a specialized harvester that they developed. The harvester is able to combine the harvesting operations of seeds, stems and leaves at the same time.

The company's first facility was opened in Oude Peleka, the Netherlands on 450 hectares of land and hemp cultivation and processing has taken place mainly there since then. In 2015 the company decided to expand their operation outside of the Netherlands and acquired 550 hectares of land in Germany and 700 hectares in Romania. Hempflax also invested 5 million euros to the Romania hemp market and has gotten positive recognition of their efforts to grow the industry only a year after opening their facility (Sensi Seeds 2020c).

7.5.1 Business Model

When it comes to processing hemp, Hempflax strives to use every part of the plant. That is why their line of products have a wide range and possible customers are endless. When the cultivated hemp goes into the factory it is separated, processed and refined into forms that produce several revenue streams for the company. Even the mechanized processing "waste" that comes from the hemp stalks is resold as flour that is used to make pellets.

The revenue streams that come from processing hemp include construction materials, animal bedding and industrial applications such as doors panels and boat fiber made from hemp plastics. The company also has a genetics business that sells their breed of sowing seeds and also their specialized harvesting equipment that is efficient for hemp harvesting.

The food and supplement industry is also a focus in their business model as they sell hemp seed oil, protein powder and also CBD oil. As hemp cannot be farmed for the leaves in order to produce CBD the company has found a solution for that. With their investment into hemp cultivation areas outside the Netherlands they are now able to grow and process hemp for CBD in Germany. (Baum 2020.)

7.5.2 An environmentally friendly high quality option

Aside from business, Hempflax has an alternative goal to be the provider of environmentally friendly products to as many industries as possible and be a carbon neutral company as a whole. When adding the whole infrastructure of the company from processing, harvesting, manual labor and transportation it still has a negative carbon dioxide balance. This is possible with the thousands of hectares of hemp they are farming taking more carbon dioxide from the air that they are emitting throughout their processes.

With the infrastructure that Hempflax has build in Europe they are getting noticed by big companies that want to work with them. A lot of times companies reach out to them with a product that is manufactured with glass fiber or synthetic fiber for example and questioning if its possible for them to change these raw materials to more environmentally friendly hemp based materials.

This is how Hempflax got in business with several car companies. With hemp fiber quality being dependent on many factors such as weather and harvesting time there was a learning period in order to produce high quality fiber at a sustainable rate for there car manufacturers.

With the company's success in this process they are currently supplying fiber for door panels for the Mercedes F,C and A type. For BMW their fibers can be found in the 3 and 5 series and even high end car manufacturers Jaguar, Bugatti and Bentley use Hempflaxes fibers to strengthen their car door panels. Hemp fibers in cars is not just used as a marketing gimmick to seem more eco-friendly but as a performance booster with hemp giving weight reduction over carbon fiber. Although, producing carbon fiber is a major contributor to the growing CO2 emissions every year so hemp wins on both ends.

All in all the company's future looks bright as they continue to expand their business and infrastructure. As a leader in the field the next steps are to educate and help the industry and farmers that might be interested in changing their lands to hemp cultivation. Also with the company's new harvests there is an opportunity to expand the business to the U.S where the big hemp boom is going on currently after the 2018 farm bill that legalized hemp cultivation. (Baum 2020.)

8 NORTH AMERICAN INDUSTRIAL HEMP MARKET

Hemp is the fastest growing crop in North-America and most of the crop farmed goes into CBD production with the recent surge in demand of CBD products. The growth and research of CBD products is great for pushing hemp farming forward and creating better infrastructure for hemp processing but it might also hinder the manufacturing of other hemp derived products.

With most of the crop farmed for the high-priced CBD oil it leaves out the possibility to grow the industry from other hemp applications that are manufactured from the bast fiber, hurd and seeds of the plant. Farmers and companies that are in the business of CBD oil are breeding new strains of hemp plant that is specifically good for growing resin on the leaves and flower that can then be refined into CBD oil. This type of breeding leaves the crops fiber quality and seed yield lower than what is needed to manufacture high quality products.

Selective breeding of hemp for the flower and leaves gives the best quality of CBD oil but subpar quality on bast fiber, seeds, hurds and shivs. Most of the high quality applications from hemp need special breeds for each individual part of the plant. With farmers cultivating mostly CBD breeds of hemp, it lowers the quantity of high quality fiber and seed harvests which hinders the growth of those applications and their markets.

The growth in demand of cultivating hemp specifically for CBD oil started rising only after the year 2018. As North America has a long history on hemp cultivation it has been cultivating hemp for other applications way before the growth of the CBD market. The CBD market has slowed down the growth of those markets involving hemp fiber applications and the hemp foods market from the seeds. The growth of the CBD oil market has positively affected the amount of hemp cultivated but if it all goes to CBD production it makes the hemp economy volatile by being mostly dominated by one product.

8.1 The U.S market

Hemp market is the biggest in the U.S and it is growing exponentially every year because of the growth of demand for CBD oil that brings new people and companies to the industry. The CBD oil market is seen as the most profitable hemp market for farmers and businesses selling hemp products in the U.S and as more research comes out of the benefits for using CBD oil the industry will keep growing.

Currently industrial hemp is planted in 37 states in the U.S and the increase of hemp plantations has skyrocketed since the new farm bill in 2014 that opened up the hemp cultivation by states being able to control their own pilot programs into the industry. As the US already had massive amounts of good farm land to begin with it was an easy shift for the farmers to start farming hemp instead of the commodities such as soy, corn and cotton. Across those 37 states, hemp is planted on over 150,000 acres of land with Montana being the biggest cultivator of the crop.

With the booming CBD market most of the hemp cultivated in the U.S is going to CBD oil production. Since the CBD market is fairly new and untapped there are many possibilities for quick profits for people starting new businesses by selling high-priced CBD oil with large margins. With no previous expertise in agriculture or the manufacturing industry new people open CBD oil businesses without research and provide a subpar product. This will have unwanted side effects by bringing negative press to the hemp and slowing the growth of the industry.

The same shady business owners contracting farmers to produce hemp for them has also had a negative effect on the hemp industry since farmers have gotten the bad end of the deal and waste crop and resources on promises of quick riches. This has led many farmers to harvest hemp for the fiber and seed instead of the leaves which is a positive sign as there are other large industries that buy hempseed oil for their products such as the beauty industry. The profits that is left for the farmers from the fiber and seed harvest is more modest than for CBD oil. Seed farming is much more sustainable and reliable way for them to keep their farm going by bringing in some profits instead of none with the harvest gone to waste for CBD. (Avins & Kopf 2019.)

8.1.1 CBD market

The recent growth in demand of CBD oil and CBD products in the U.S indicates that most of the hemp cultivation is steering towards hemp based CBD production. Further estimates couple years into the future also support the fact that the CBD industry is going to grow even more and the demand requires more hemp to be farmed for CBD production. Indicators on the positive growth of the CBD market include medical research done on its benefits and effectiveness and its possible classification as a health supplement.

The future of industrial hemp market seems to rely heavily on the effectiveness of CBD oil and its benefits in the U.S. As the market drives hemp production and research forward it is still a very volatile base for the future of hemp as the demand might go down despite the estimates. The causes for the downfall can come from multiple factors such as negative research results on CBD oil health benefits or restrictions for dietary uses for CBD oil.

As there is already some negative side effects on CBD market being the driver of hemp industry it is probable that it would set the future of industrial hemp and its other applications back if the CBD boom is not successful. Other industrial uses for hemp such as fiber and seed production are the real beneficial application for the environment that hemp cultivation brings. Products manufactured from the fiber and seed are going to be the stable in the growing U.S hemp market and bring the most potential for long term business investing as the hemp food market is expected to grow in the future.

Growing hemp regardless of what is produced from hemp it is always an environmentally friendly option and even farming it for CBD is beneficial because of the carbon negative results but hemp's benefits can mostly be noticeable by cutting down the deforestation and pesticide use by other crops. If the CBD production from hemp gives a negative connotation for hemp in the next few years it can change the view of many large companies that are already beginning to produce and support hemp based products. Companies still rely on the view of the public for their marketing and companies would not want to be associated with hemp products if the consumer would see all hemp based products as bad.

8.1.2 Fiber market

The fiber market is one of the most stable markets for hemp throughout history and is one of the potential large hemp markets in the U.S. With its many uses the fiber market has potential for current manufacturers starting to implement hemp based products. The clothing industry can benefit from hemp's strong natural fibers for softer and stronger clothing with the added benefit of cutting down the cotton use which cultivation lies heavily on pesticides. Cotton will likely remain the main fiber source for clothing but the hemp clothing industry has a growing niche market that supports environmentalism and higher quality clothing. Major

clothing manufacturers have already started adding hemp fibers with cotton to create a hybrid of strong quality and affordable prices. This cotton-hemp hybrid clothing is the most probable option for hemp appearing in clothing for the masses in the near future.

Hemp pulp can be an application used for manufacturing niche paper products that support the current wood pulp industry and cuts down the need of wood pulp for smaller paper applications thus cutting down the deforestation problem even if it is by smaller increments. As hemp fiber has so many applications, the benefits start adding up as many industries start using hemp as a source of cutting down the load for the environment. Industries like the wood pulp industry has a long history and massive infrastructure so it is unimaginable that hemp fiber pulp can replace it fully in the next decades.

The bast fibers of hemp can be used along side with other natural fibers to create fiber composites for the growing automobile industry in the U.S. Currently European countries such as Germany has already implemented hemp bio-composites in their car panels which gives them validity as the German autoindustry is the biggest in the world. More cars are being manufactured in the U.S and people prefer American made cars. American made hemp in an American made car gives the autoindustry a sustainable infrastructure to manufacture car panels and please the customer by assuring the support for domestic industry and workers.

8.1.3 Hemp shivs and hurd market

The by-product of fiber processing is the shivs and hemp hurds that can be made into a hemp-lime concrete for building materials. Hemp building materials are relatively inexpensive and considered carbon negative. Hempcrete is already used in Europe where it was originally invented and it surely has implementation possibilities in the U.S building material market too. Massive increases of any applications from hemp in the U.S market is unlikely at this moment as current infrastructures do not support fully switching to hemp based products. Hemp will always have a niche market in all its fiber application that will grow slowly but surely. Most likely application from hemp that can grow the most is the animal bedding market that has already a large share in Europe. The hemp hurds that can be made into animal bedding do not need a massive manufacturing infrastructure with several processes and are fairly easy to make. They also appear to be beneficial for animal and their care takers as they provide a long lasting moisture absorbing products. (Cherney & Small 2016, 4-5.)

8.1.4 Hempseed and oil market

In recent years hemp cultivation for the seed and hemp oil has gained popularity largely due to then being sold to human consumption. The large demand for hemp seed and oil has also made farmers to start selectively breeding hemp for the best yield of seed. U.S hemp farmers have also switched to hemp farming from other crops such as corn and soy due to hemp being more profitable now.

The oil and seed market has the most potential of any hemp market in the U.S because of their benefits to the farmers, manufacturers and consumers. With the increased demand of hemp food products the farmers can rely on hemp cultivation for sustainable and higher income. Hemp seeds and oil production do not need heavy processing so it does not need a large investment to start a business in selling hemp seeds. With profits from the seeds the business can grow organically with adding more products such as the oil or hemp food like energy bars or protein. The hemp seed meals and hemp foods have health benefits due to the seeds and oils nutritional content which creates the increased demand by the customer.

Hemp based foods can already be found in supermarket in the U.S and their market share is only expected to grow in the coming years. The growth of the hemp seed market in the U.S can also be seen in the growth of hemp seed imports as it increased from \$29 million in 2014 to \$54 million in 2015, and the hemp oil cake imports doubled over that period to \$16 million. The total USA imports of seed, oil and oil cake products exceeded \$75 million in 2015. (Cherney & Small 2016, 6-7.)

Another possible market for the hempseed oil is the beauty industry where it can be utilized in beauty products. Hempseed oil has great benefits for the skin and can be used in the production of facial cleansers, oils and shampoos. The beauty industry has a reoccurring trend on eco-friendly products where hemp based beauty products fit in perfectly. The beauty industry has a large variety of products so hemp products will likely stay a niche in the market at best as the industry seems to keep growing and changing at a fast rate. The potential for hemp based beauty products still remain high with one of the biggest companies in the beauty industry, Kiehls already incorporating several hemp oil based products in their line.

8.2 Canadian market

The Canadian hemp market differs from the U.S market as it has a longer history of hemp cultivation. The re-introduction of hemp came to Canada in 1998 before the CBD oil market started growing and it shows in their hemp production. Initially hemp was re-introduced for fiber production and the food market. Currently about 80,000 acres of hemp is planted yearly across Canada and most of the hemp is harvested for the seed. The most widely cultivated breed of hempseed in Canada is called FINOLA, which comes from Finland.

The hemp industry is subsidized by the government in Canada as in 2018, the federal government announced that they will be investing funds to the Canadian Hemp Trade Alliance. The reason for the investment was to develop industry-wide grading standards for Canadian hemp to be recognized globally for the quality of their product and consistency of production.

8.2.1 Hempseed and hemp oil market

Canada is currently the biggest producer of hemp seeds in the world and in 2018 it exported nearly 5,400 metric tons of hemp seed. Over 70% of the seeds cultivated in Canada are exported to the United States with rest of the export volume going to European and Asian countries. The Canadian market is the dominant force when it comes to hempseed production as up to 90% of the seed harvested for hemp cultivation is produced there. (Industrial Hemp Production Trade and Regulation, Canada 2019). Hemp has more potential from its oilseed application than fiber. As Canada has become the leading country of hempseed production it has potential to become one of the largest hemp product markets in the world. The dietary benefits of hempseed and hempseed oil are gaining acknowledgement in North America and the sales of hemp foods are increasing rapidly and the market is expected to grow larger in the following years.

8.2.2 Fiber market

Canada also produces some hemp fiber but it cannot compete with China's production and infrastructure that results in low cost hemp textiles. Canada's hemp fiber industry also lacks the processing technology compared to the heavily subsidized European market which makes the fiber market unlikely to grow. Dual purpose crops for fiber and seed are grown in Canada to some degree but dual crops lack the yields of specialized breeds for fiber and seed. The fiber quality of the dual purpose crops is also lower which makes them

an unlikely major application in the Canadian market. One reason for the mass amounts of hempseed production by the Canadian market is the greater profitability of it compared to fiber. This encourages businesses and farmers to focus on the hempseed market to secure sustainable profits. (Cheney & Small 2016, 13-16.)

8.2.3 CBD market

As the Canadian market grew organically with slow advancements over the years it has a great infrastructure for producing hemp for other applications than CBD oil. Most of the hemp harvest goes to food and supplement production from the hulled hemp seeds and products containing hempseed oil in the cosmetic industry. In 2018 the Canadian hemp growers were licenced to harvest the crop for flower and leaves in order to produce CBD out of them. Even with the growing CBD market the Canadian hemp harvest that goes into CBD production is still a minority and farmers prefer other more sustainable options such as the seed harvest.

CBD has medicinal benefits and recreationally it can be labeled as a supplement for aiding sleep and alleviating pain. The market potential is the largest of any hemp derived products because of the high profit margins of CBD oil. In Europe alone the potential annual CBD market has been estimated of being in the billions. Canada has great potential for being and CBD oil producer as oilseed cultivators produce more flowers than fiber cultivators. As the flowers can be processed into CBD oil the cultivators of large amounts of hempseeds are the logical source for CBD oil manufacturers for their raw material. Cultivating industrial hemp for CBD production has not received much growth yet in Canada but with the commercial interest and demand of CBD products going up it is likely that the cultivators of hempseed will look to secure more profits from their harvest from the CBD oil market. (Cherney & Small 2016, 14.)

Even with the inevitable growth of the CBD market, the fact that the Canadian hemp market has taken a different route for business gives potential to the possibility that the CBD market will not completely take over the hemp production. Other eco-friendly hemp products such as hemp based foods and the possible biofuels made from the hempseed oil will be the more likely applications from the Canadian harvest. With the subsidies from the government it is even more likely that the Canadian market will be one example on how hemp can be best utilized to grow hemp foods market and how an infrastructure and businesses can be build around them.

9 CHINESE INDUSTRIAL HEMP MARKET

China is the largest producer of hemp in the world with nearly 165,000 acres planted in 2019. Currently China produces more than half of all the worlds hemp supply most of it coming from the provinces of Yunnan and Heilongjiang. China has the longest history with hemp cultivation and at one time it was responsible for 70% of the worlds hemp. The oldest known paper comes from China and it was made from hemp and throughout history hemp has been used in China to manufacture textiles, paper and medicine.

There have been ups and downs in the Chinese hemp market throughout the years but with the recent growth in demand of hemp products there was more pressure to continue mass producing hemp and start to export it to the growing hemp economies. China does not currently export much hemp considering the volume of production but the potential for hemp exporting is massive for China as they have the agricultural infrastructure ready to supply the growing U.S and European markets.

China also has natural advantages for growing hemp as the country has a lot of farmland and the weather conditions in most of Chinas provinces are favourable for hemp cultivation. Hemp growing also becomes a way to earn a living for a large amount of farmers as they can make up to 300 dollars per acre of hemp. With the majority of Chinese population living Eastern coast where the best farmlands reside it is possible that industrial hemp becomes one of the major job markets and industries if hems popularity keep growing at current phase.

The Chinese hemp market has some disadvantages of being highly regulated by the government. The large amounts of capital and high quality production technology capabilities compared to the Western manufacturers make the market still a interest for many investors. As the industry keeps growing the regulations considering hemp cultivation are expected to be loosened in China and this gives the market a lot of potential for growth.

With China having a long history with hemp cultivation it is unlikely that the it shifts to dominantly CBD oil based as it is mostly harvested for fiber production currently. The hemp fiber gives many industries possibilities to manufacture environmentally friendly products from it thus diversifying the hemp product market. With the massive farmable landmass China has the potential to be one of the main providers of hemp fiber for the U.S and European markets if government regulations allow it. If the demand of hemp products grow high enough many countries do not have the infrastructure ready for hemp production and the Chinese hemp cultivation could be the sustainable revenue of raw material they need. (Pickering 2019b.)

9.1 Industrial hemp applications in China

With China being a mass producer of hemp it is also responsible for 1/3 of the worlds total hemp sales. Textiles make up most of the sales and the rest comes from other products such as CBD, food and supplements. Recently China allowed to farm hemp to produce beauty products which saw a increase of hemp sales in the cosmetic industry which will increase the share of hempseed oil production from hemp in the future.

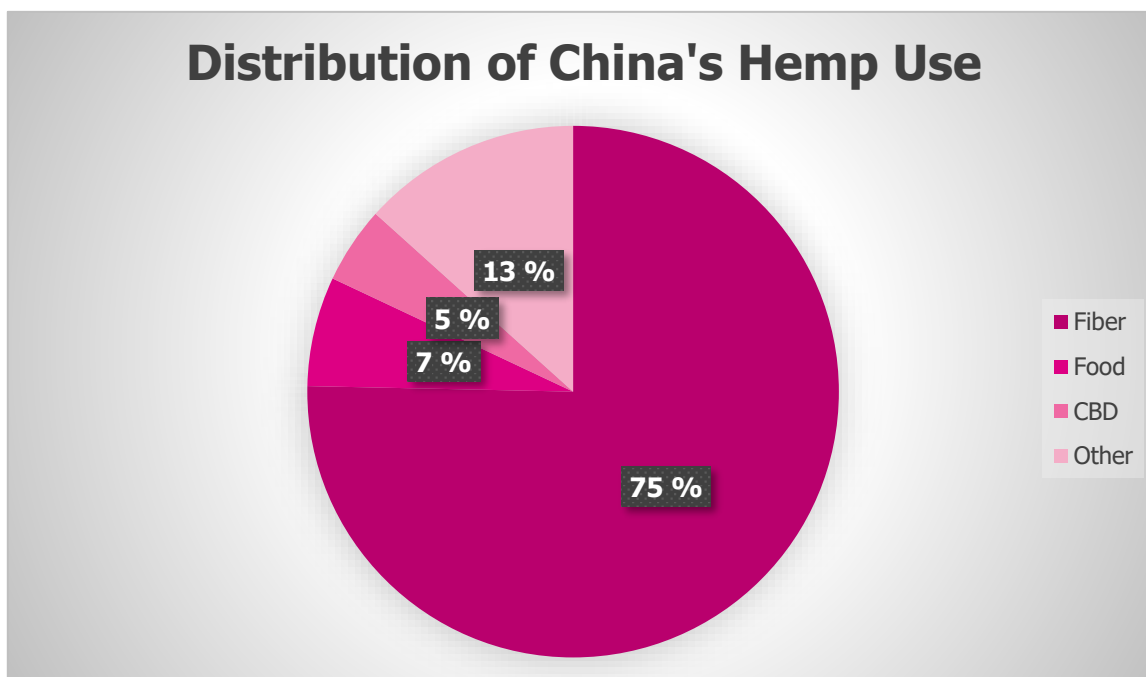


FIGURE 1. Distribution of China's Hemp Crop: 2017 (U.S Department of Agriculture's Foreign Agricultural Service)

For most of the years the hemp sales have been dominated by fiber sales for the textile industry but the recent demand for CBD products has increased the amount of hemp demand to produce CBD oil in the western world. In 2018 the estimated sales from the Chinese hemp fiber were at 1,2 billion. As the government does not release official cultivation production or sale data it is not clear how big of an impact has the CBD market had on the Chinese market. Some estimates state that China only accounts for 11% of the global CBD market but that is expected to grow as more provinces are legalizing hemp growing for CBD production (Overview of the global hemp market: CBD to Fiber 2020).

9.2 The Chinese industrial hemp market

The Chinese industrial hemp market differs from the other large markets by being mostly focused on one fiber application of textiles. Other applications in comparison are small when considering the size of the market. However, what the Chinese market lacks in variety it makes up for it in volume as the hemp cultivation is a stable in their agriculture. Currently China does not import industrial hemp and much data is not given out on the industry of hemp because of government regulation.

With the combination of mass amounts of potential cultivation land for industrial hemp and the fiber processing infrastructure, China has the potential to be a mass exporter of industrial hemp. Companies in the European market that have the demand for hemp applications but lack the cultivation volume and industrial hemp raw materials would benefit from the cultivated hemp from China if it could be exported.

If hemp applications and products demand increases but the cultivation volume of hemp cannot be increased at the same rate it can cripple the industrial hemp market. The industrial hemp market would benefit greatly if China started exporting hemp and the Chinese agricultural industry would benefit from the sales. Currently China produces hemp for its own applications and usage but the biggest business opportunity and market potential will be exportation of industrial hemp if the demand increases in the future.

10 CONCLUSION AND DISCUSSION

The future of the industrial hemp market is on a positive path as hemp applications and products gain popularity every year with the manufacturing industry and the consumer. From an environmental view, the industry of hemp won't save the earth from the manufacturing industry as changing the manufacturing practices of several industries to fully support hemp based raw materials is costly and inefficient at this point. However, with the increase of industrial hemp popularity it has made a positive change in several industries as a load bearing and supporting raw material for manufacturing eco-friendly products. Industries such as the paper, plastic, construction, fuel and energy production industries can utilize hemp in smaller applications that support the current manufacturing processes thus lessening the emission load.

From pure cultivation standpoint, hemp is one of the most environmentally friendly industrial crops. The combination of fast growing, needing less pesticides and removing carbon dioxide from the atmosphere leaves no competition when environmental aspects are taken into consideration. However, the cultivation of industrial hemp can only be done annually in markets where there are winter months and harvesting it needs specialized equipment to be efficient and not labor intensive. The harsh regulations on growing industrial hemp in Europe and the U.S have also been a detriment for the crops growth in popularity among farmers. This has slowed down the growth of cultivating industrial hemp in key large markets thus slowing down the growth of businesses relying on hemp raw material for their applications and products.

All the other aspects aside, the industry of industrial hemp is in the end driven by the popular products and applications that create revenue for the whole supply chain from farmers, manufacturers and businesses selling them. The products and applications also need to be seen as beneficial by the customers and consumers which has been done by educating the public on the benefits of hemp.

One of the best applications that has been positively received by the farmers, manufacturers and consumers is the hempseed and the possible products for human consumption from it. Hempseed bring the farmers an sustainable income and the manufacturers a raw material that can be made into edible seeds and hempseed oil which processing leaves the edible seed cake. The consumer benefits from the health benefits coming from the great nutritional content of the seeds. Hemp foods are seen as a health food in all the major markets and the market share of hemp foods are growing by the millions every year. The success of the hempseed market and the foods processed from it comes from the easy processing that does not need major investments compared to other hemp applications. The other benefit for hempseed market is that Canada, one of the largest cultivators of hemp has been growing mainly hempseeds for two decades and created a sustainable flow of hempseeds for The U.S and Europe. The cultivation of hempseed is one of the most important application for the future of the hemp industry and it is the most sustainable one of them all.

The hempseed oil pressed from the seeds has another growing industrial application as the beauty industry has started to add hempseed oil into their beauty products because of the benefits it has on skin hydration and skin issues. The beauty product market includes a variety of products containing hempseed oil and they can be found in the products of some of the biggest beauty and cosmetic brands today. Hempseed oil in the beauty industry is a sustainable market for hemp and has the potential to grow large in the future as the product variety of hemp beauty is vast. The most likely large scale applications for hempseed oil in the

beauty industry is current large brands implementing it by creating new products or products line that contain hempseed oil. The increase in demand of hempseed oil beauty products is beneficial for hempseed cultivation as more volume is needed to support the demand of another large application besides hempseeds for food. As the number of hemp popular hemp applications grow it makes hemp cultivation appear more interesting for farmers as they can grow hempseeds and sell them for several revenue streams for a sustainable income.

The applications from the fibers come as the next best for future industry growth. The long bast fibers have shown to be great for manufacturing clothing and they are already used as an addition along side cotton in clothes. As the current fiber industry is dominated by cotton it is unlikely that hemp fibers will completely replace them but as with other industries they are used as a addition to current raw materials to enhance the properties of the end product. China is the most dedicated market for utilizing the fibers for textiles as most of the hemp grown there goes into textile production. In other markets the popularity of other hemp applications might hinder the growth of the textile applications as hemp cultivated for the seeds and flower leave a mediocre quality on the bast fibers that is not optimal for production of clothing.

The hurd fibers have the potential for larger growth in the future in other markets with along side the shivs that are a by-product of fiber processing. The fiber applications of bio-composites by the automotive industry has already been used in Europe by the largest car manufacturers in the world. The bio-composite applications are not large considering the whole automotive industry but they have been deemed beneficial and have the potential for growth even as hemp is only an additive in the bio-composites. Other applications used for the hurds is the animal bedding industry and using them for their insulation properties that are successful in Europe.

The shivs that come from the fiber separation process are used all around the world to manufacture construction materials that has potential to be one of the largest industrial hemp applications as its popularity is growing rapidly. Currently hempcrete has a lot of demand but the low amount of hemp cultivation is slowing down the progress of growth as companies cannot meet their customers demands. The construction industry also can benefit from the hurd fiber as it can be used for fiberboard and insulation materials. For hemp applications that are currently used but in relatively low amounts, the construction materials from hemp poses the most future potential growth of any hemp fiber applications. The interest in hempcrete is all over the world and the manufacturing techniques for hemp housing are improving. The properties of hempcrete are beneficial to most markets and it has many environmental benefits when comparing it to regular concrete.

Other fiber applications are small and their potential for growing large markets is unlikely. Applications such as plastics from hemp for mass production are not plausible with the current amount of hemp cultivated and their manufacturing infrastructure would need massive amount of investments to grow to the level where it would make a difference against the current plastics made from fossil fuels. The hemp paper industry has stayed stagnant for years and the most likely outcome for the future is smaller application made from hemp paper assisting the current wooden pulp paper industry.

The last application from hemp that has potential and maybe the most potential is CBD oil and products containing CBD oil. However, for the market to reach the estimations of billions annually it has to be regulated

beter in several markets. The benefits of CBD oil in research conditions are substantiated and have the potential to reduce the symptoms of many severe illnesses. CBD oil is classified as a prescription medicine in some markets and a health supplement in others which makes it seem that there is still uncertainty about the product for daily use for the masses.

Since the growth of CBD oil started rapidly increasing in 2018, the market has seen developments with research into the benefits and risks of CBD oil and it has been deemed beneficial and not harmful for the consumer as it has seen new markets since then in Europe and the U.S. The problems for the CBD oil industry come from many concerns about products quality. The manufacturing of CBD oil needs heavy processing and can be done with several different processes which can lead to a variety of quality outcomes. The processing of CBD oil needs trained professionals with experience to produce the best quality and a safe product. Because the CBD oil has been seen as a high earning business it has seen businesses sell mediocre quality CBD oil with high price. With bad processing practices the quality of the CBD oil is lower and can still contain unwanted substances. Regulations about the purity of CBD oil are already in place in most markets and the finding of unpure CBD products have had a negative effect on the market and industrial hemp's image. For the CBD oil market to grow to the largest application from industrial hemp it needs to be regulated in a way that processing sees quality control that the products coming to the market are high quality CBD oil.

The growth of CBD has positively affected the cultivation of hemp as more the demand of hemp increases with the increase of the CBD market. However, the hemp cultivated for CBD oil is a special breed that grows the best flowers and leaves for the processing of CBD oil. Other parts of the plant such as the fiber are of lower quality and does not compare to a breed that grows tall for long and strong fibers. The industrial hemp breed that CBD is processed from does not also want seeds to pollinate on it as the seeds take nutrients away from the leaves and the flower thus lowering the resin content that CBD oil is processed from. Dual crops have been tested for cultivation in several markets but they have not been deemed beneficial for the most part as the quality cannot match special breeds. With more industrial hemp cultivated for CBD oil, it leaves no raw material for the other applications which can lead to other hemp markets staying stagnant as CBD oil is dominating the harvests. CBD oil also brings the farmer more potential for profits from the hemp harvest as it is a high priced product. However, uncertainties on the industry's regulations have negatively affected the image of CBD among farmers also as faulty deals have gone wrong and the farmers lost their entire harvest of hemp that was meant for CBD production.

For the CBD oil market to reach its full potential it needs more time for all of the major markets to accept CBD oil as a health supplement that can be sold in general stores. Before that happens the business opportunities of hemp cultivators and selling CBD oil can be risky as large investment to processing machinery and infrastructure can turn no profits with no clear way to sell mass amounts of products. There are several businesses doing research and development into CBD oil and industrial hemp breeds for producing the best quality CBD oil. Those businesses are doing the groundwork needed for producing large amounts of CBD oil when the market clears. CBD oil is at its early stages still even though products are being sold in several markets. The companies building their business around CBD oil will most likely see success in a couple years when CBD oil is regulated better. For any industrial hemp application, CBD oil has the largest potential for increasing cultivation, building new businesses and turning in profits in the future. However, if the whole industry of hemp starts relying on CBD oil it can hurt other applications growth and suppress the growth of

the whole industry if the CBD oil market does not succeed as it has been expected to. Many factors can lead to the failing of the CBD market such as governments regulating CBD oil as a prescription medicine only which would make it hard to sell mass amounts of products as companies producing medicine would be the only revenue stream for CBD oil. The public image of CBD oil is also a possibility for the falling of CBD oils market growth. If more bad news comes out about CBD oils quality and legality in the coming years it can lead to the consumer not wanting anything to do with CBD oil products.

One of the more interesting applications for industrial hemp is the bio-fuels and biomass into energy conversion. Industrial hemp converted into biofuels is an environmental friendly way to produce ethanol, methanol and biodiesel which can help the distancing from fossil fuel in the future. The industry has potential in the sense of being one of the best applications for saving the environment from hemp. In reality the investment needed to the production of mass amounts of bio-fuels and the amount of hemp raw material needed to supply cars and manufacturing machinery with hemp biofuels make the application not likely to grow substantially in the future. The biofuel application will likely be small and used in small application such as manufacturing machinery but biodiesel for cars seem out of the reach for now.

The energy production from hemp biomass has some potential for more growth in the future as hemp has been found to be better than average biomass for energy conversion. However, again for producing energy from hemp biomass in large scale needs mass amounts of hemp cultivation. As the technology is already there the applications potential can grow alongside the growth of the hemp industry. By-products of other hemp applications processing can be turned into energy from the biomass and be used to power the processing of hemp applications again. The hemp biomass conversion into energy substantiated hems environmentaly friendly idea even more as the plant is sustainable and nothing goes to waste in processing. In the future it is possible to build hemp manufacturing infrastructures that process hemp for all its applications and the left over biomass is converted back to energy used by the manufacturing processes thus creating a sustainable cycle. As the industrial hemp plant is so diverse in its applications and usage the possibilities for manufacturing technologies in the future for hemp are endless.

The final takeaway about the future of the industrial hemp market is that with so many beneficial applications from it, some of them will certainly grow large industries behind them. Many of the beneficial applications will stay small as hemp cultivation cannot provide raw material for all of them. The most beneficial ones that have an already existing base for and industry will continue to grow and likely exponentially in the next few years. As simple as it sounds, the future of industrial hemp lies with the amount of hemp cultivated in the world. Many of the applications need better processing and manufacturing technologies to have a sustainable industry which cannot happen if there is no industry to build with the lack of raw materials. The possibility for investments is not there for many hemp applications as they cannot currently provide profits. With low amount of raw materials, inefficient processing and infrastructure and lack of investments some of the more complicated hemp applications will be stuck for years to come. The potential is always there as many industrial hemp applications have small scale businesses researching and developing better manufacturing and processing methods. There is not much unknown about hems potential which gives it a good base for growth but the biggest unknown will be the best business opportunities around hemp applications and products which will in the end move the whole industry forward as profits are the most important things for the manufacturing industry.

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