

BUILDING
AN
INDUSTRIAL

2020

INDUSTRY
IN
MINNESOTA

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FOREWORD

Minnesota Hemp Value Chain Analysis

AURI is pleased to present this Minnesota Hemp Value Chain Analysis report to the growers, government, supply chain sectors and end users who are engaged in the emerging hemp industry in Minnesota.

With the interest in industrial hemp growing both nationally and internationally, along with the passage of the U.S. 2018 Farm Bill allowing cultivation of the crop, AURI decided to create this comprehensive report, which provides an overview of the industrial hemp industry.

The report provides a summary of the primary value-add opportunities for hemp in Minnesota, including food, fiber, CBD, fuel and feed. Additionally, the report discusses the challenges that lie ahead in connecting growers and end users to the processing infrastructure to deliver value-added products to the marketplace.

AURI would like to thank the growers, state officials, industry value chain experts and scientific professionals who contributed to this report.

AURI is committed to working with the hemp industry by providing value-added ag research, laboratory analysis, business and technical services, and a network of science and business professionals. Please connect with us via our website at: www.auri.org.



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PRODUCTS INCLUDING, BUT NOT LIMITED TO, TEXTILES, AUTOMOTIVE PARTS, FURNITURE, FOOD AND BEVERAGES, PAPER, CONSTRUCTION MATERIALS AND PERSONAL CARE ITEMS.

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OVERVIEW

HISTORY OF INDUSTRIAL HEMP

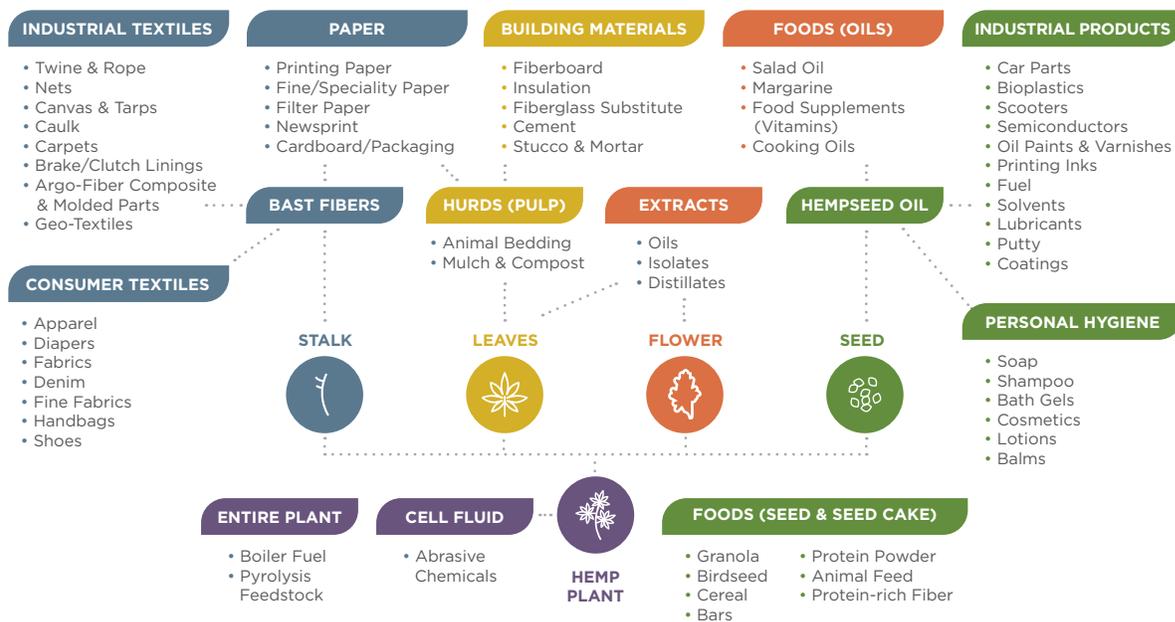
Until the recent passing of the 2018 Farm Bill, or Agriculture Improvements Act of 2018 production of industrial hemp within the United States was limited by regulatory restrictions due to its association with marijuana.³ With the passing of this bill, hemp has been officially reclassified for commercial use, distinguishing the crop from marijuana and removing it from the Controlled Substances Act.⁴ Because of the limitations in place prior to this passage, however, the market for industrial hemp in the United States has been primarily dependent upon imports from countries with an established industry.³

Contrary to marijuana, industrial hemp (*Cannabis sativa* L), contains no more than 0.3 percent delta-9 tetrahydrocannabinol (THC). Grown for industrial, non-drug purposes, the crop lends itself for use in a large variety of products including, but not limited to, agricultural, textiles, automotive parts, furniture, food and beverages, paper, construction materials and personal care items.²

The hemp industry has not always faced such strict regulations. Hemp was believed to have been brought to North America in 1606⁵, where it was grown primarily for fiber as a cash crop in settlements in Canada and the United States.³

The market ultimately began to suffer due to the development of synthetic fibers such as nylon, as well as the improvement of technology for making paper from trees.⁶ Regulatory action also had a significant impact.

USES FOR HEMP



Source: "The State of Hemp: 2014-2022," New Frontier Data derived from Hemp Business Journal¹

In the early 1900s, there was an effort to ban marijuana and hemp, beginning with the outlawing of the THC-containing component in several states. The Harrison Act of 1914 defined the use of marijuana as a crime and, by 1915, California had become the first state to ban the crop. Confusion surrounding the issue arose with the 18th Amendment to the U.S. Constitution in 1919, suggesting the drug as an attractive alternative to alcohol as the prohibition era began. Nonetheless, following the statewide ban in California, 28 additional states adopted this restriction by 1929.^{7,8}

In 1937, Congress passed the Marihuana Tax Act, which effectively began the era of industrial hemp prohibition. The tax and licensing regulations of the Act defined it as a narcotic drug and made hemp cultivation difficult for American farmers.⁹ As a result, farmers were required to hold a federal registration and special tax stamp to continue growing the crop.³ While this did create a more regulated market, it did not cause a decline in hemp production on an immediate basis.

Global events weighed in next. The Japanese attack on Pearl Harbor ended foreign supplies of "manila hemp" fiber from the Philippines. The U.S. government formed the War Hemp Industries Department and subsidized hemp cultivation, producing a film called "Hemp for Victory" to encourage U.S. farmers to grow hemp. During the war, U.S. farmers grew approximately a million acres of hemp across the Midwest as part of that program. After a product peak in 1943, hemp production began its steady decline, eventually ceasing to exist to any magnitude in the United States.⁶ Following the war, the government quietly shut down all hemp processing plants and the industry faded away again.⁹

The crop was not entirely ignored, however. From 1937 through the 1960s, the U.S. government acknowledged that industrial hemp and marijuana were distinct varieties of the cannabis plant. This changed when hemp was no longer officially recognized as distinct from marijuana after passage of the Controlled Substances Act (CSA) of 1970. This occurred despite the fact that a specific exemption for hemp was included in the CSA under the definition of marijuana. The recent federal court case HIA vs. DEA has reestablished acknowledgement of distinct varieties of cannabis and supported the exemption for non-viable seed and fiber, as well as any products made from them.⁹

While strict regulations dramatically impeded industrial hemp growth in the United States, many other countries did not face such obstructions. In fact, hemp grows naturally throughout Central Asia and has been a part of many cultures' history, being traced to as early as 2700 BC in ancient Chinese writings as well as in ancient tombs. Hemp production in foreign countries continued to evolve over the years, allowing for further advancements in processing and development of the industry. Since the Second World War, the main areas of hemp production have been India, China, Germany, Hungary, Poland, England, Holland and France.⁶

Today, roughly 30 countries grow and export hemp, with China at the forefront. In fact, approximately 20 percent of global production of industrial hemp can be credited to China. Because the cultivation and export markets of these countries continued while the United States restricted production, some questioned whether the U.S. could competitively re-enter this market. Even Canada, while following similar regulatory policies of the United States for some time, now represents a far more established market.² [A list of countries that produce and export hemp can be found on the National Hemp Association website.¹⁰]

The growth of competition has not discouraged industrial hemp advocates. In 1994, Canada began issuing licenses to allow research on industrial hemp. Beginning as early as 1999, the United States began to pass laws governing hemp cultivation, assisted by the support of the American Farm Bureau Federation.¹¹ Prior to the 2018 Farm Bill, 41 states had passed legislation related to industrial hemp, such as defining hemp and removing barriers, and 39 states permitted hemp cultivation and production programs.¹²

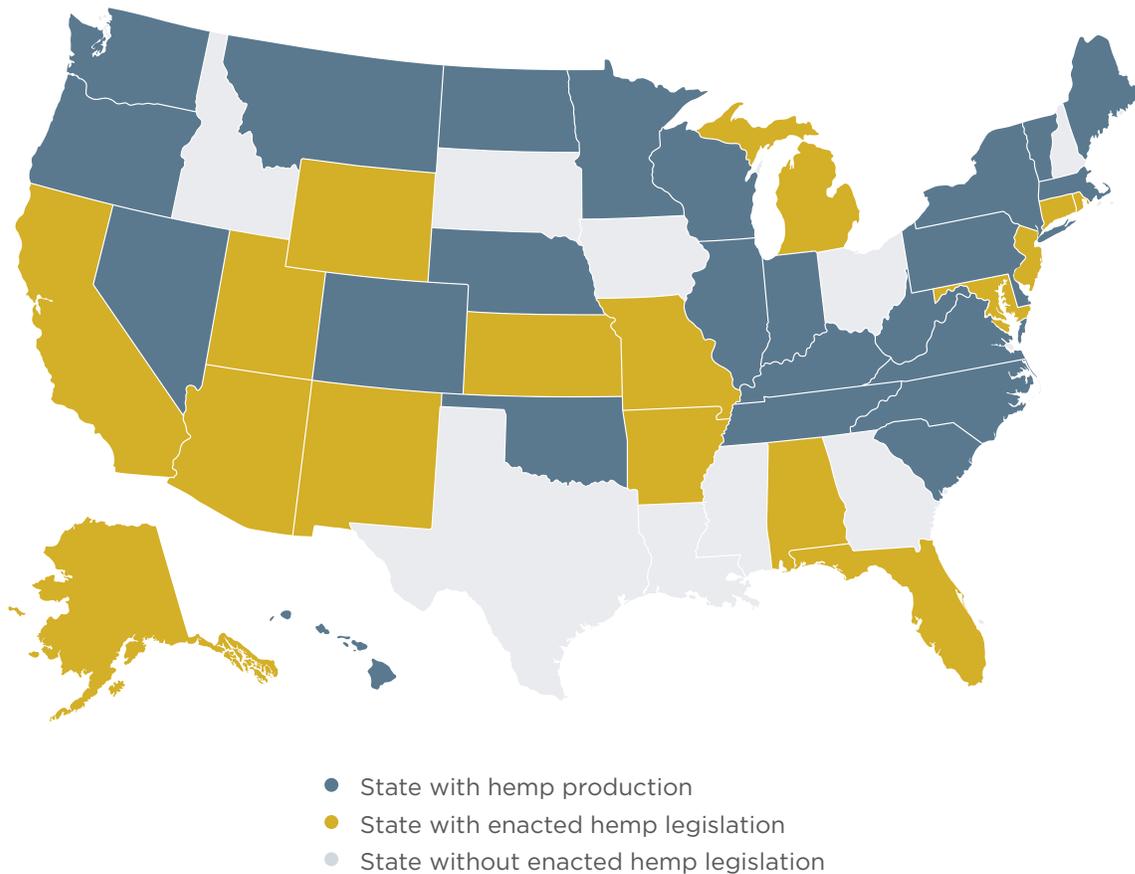
As a result, interest in industrial hemp as a cash crop resurfaced in several states. Both economic and market studies were conducted and used as catalysts to initiate or enact legislation to expand resources and production at the state level. In the 109th Congress, the Industrial Hemp Farming Act was first introduced. This has since been expanded upon, recently achieving the ultimate goal of expediting hemp production in the United States and amending the Controlled Substances Act (CSA) to no longer include industrial hemp under the marijuana umbrella definition.³

Even though domestic hemp production faced restrictions over the years in the United States, there has been an active movement to legalize industrial hemp production over the past two decades.¹³

Hemp advocacy made large gains in 2014, when the newly passed farm bill allowed research institutions and state departments of agriculture to grow the crop under an agricultural pilot program. The bill declared that industrial hemp could not contain a concentration of tetrahydrocannabinol (THC) that exceeded 0.3 percent on a "dry weight basis." This bill did not eliminate all regulations, however. Certain aspects of industrial hemp production were still subject to oversight from the Drug Enforcement Agency (DEA), including importing seeds, which required registration under the Controlled Substances Import and Export Act.³ Nonetheless, with the passing of the 2018 Farm Bill, regulation and enforcement of this crop has been moved from the DEA to the USDA.⁴

Even though hemp was still classified as a Schedule 1 controlled substance under the CSA, section 7606 of the U.S. Agricultural Act of 2014 legalized state departments of agriculture and certain research institutions to grow hemp via pilot programs for research purposes. Colorado and Kentucky were especially known for their pilot programs with planted acres at 5,922 and 2,525 acres, respectively, in 2016.¹³

2018 STATE OF HEMP INDUSTRY



Source: PanXchange Hemp Report, 2019¹⁴

Nationally, 32 states¹⁵ allowed hemp production per the 2014 Farm Bill. Vote Hemp — a Washington D.C.-based grassroots nonprofit organization working to bring back hemp farming in the U.S. — estimated that in 2015, 9,650 acres of hemp were planted in 15 states, 30 universities conducted hemp-related research and 817 state hemp licenses were issued. The status of state hemp production and legislation by state as of 2018 is shown above.

Concerns have been expressed by the DEA that legalization efforts for industrial hemp could be a front for those advocating for the decriminalization of marijuana, and could complicate surveillance and enforcement efforts.² Nonetheless, this crop is no longer restricted due to its relation to marijuana, which remains under the Controlled Substances Act.

While there is enthusiasm surrounding the potential economic benefits that industrial hemp could bring, some experts say that this could be a common reaction to the possibility of a “new, novel” crop. Throughout the past 50 years, optimism surrounding several crops has surfaced and subsequently subsided based upon unfulfilled expectations.¹¹

Industrial hemp has the capacity to produce a broad variety of both industrial and consumer products. Many experts say, however, that the controversy surrounding the crop has overshadowed progress.¹⁶

RECENT CHANGES

The 2018 Farm Bill, which went into effect January 1, 2019, sets the stage for greater expansion in an industry already seeing explosive growth. According to industry experts at New Frontier Data, a cannabis market research firm, federal legalization could triple the overall hemp market to \$2.5 billion by 2022, with \$1.3 billion of those sales from hemp-derived CBD products.¹⁷

“It’s a huge deal because it’s a domino effect. Banks can get involved now and, if banks get involved, then credit card processors get involved – and, if that happens, then big box stores like Target and Walmart get into it,” said Sean Murphy, a data analyst who has tracked the industry since its infancy in 2015. “All these big players are going to come in.”¹⁷

The farm bill does not open all doors to hemp commerce, however. There are still restrictions. Hemp cannot contain more than 0.3 percent THC. Secondly, there will be significant, shared state-federal regulatory framework for hemp cultivation and production. State departments of agriculture must consult with the state’s governor and chief law enforcement officer to devise a plan and submit it to the USDA. Licensing and regulating hemp will begin once plans are approved.¹⁸

Hemp farmers will eventually be able to buy crop insurance, apply for loans and grants, and write off their business expenses on their taxes like any other crop. Those who sell dried flower or CBD-infused products made from hemp can now ship across state lines without fear of prosecution, as long as they are in compliance with the U.S. Food and Drug Administration. Also, Section 12619 of the farm bill removes hemp-derived products from its Schedule I status under the Controlled Substances Act, but the legislation does not legalize CBD in general.¹⁷

ENVIRONMENTAL BENEFITS

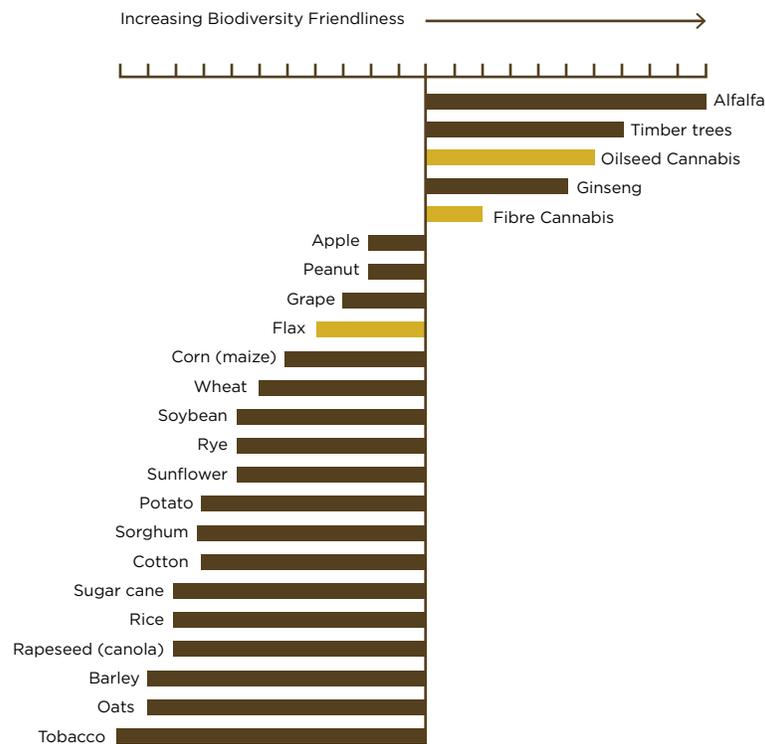
One of the many documented attractions of industrial hemp is the environmental benefits it can provide. In comparison to some other crops, industrial hemp does not deplete the soil of nutrients as quickly. It has been reported that hemp can return up to as much as 60 percent of the nutrients it detracts from the soil. A Kentucky report stated industrial hemp was grown on the same land for 14 consecutive years before soil depletion or a reduced yield occurred.¹⁹ Planting hemp on hemp over time like this, however, can lead to diseases taking over and reducing yields. While this crop has low requirements regarding crop rotations, it can also contribute to healthier soil for other crops.²⁰

In fact, hemp has even been referred to as a “pioneer plant,” meaning it can be used for land reclamation.²⁰ With a deep rooting system, the hemp plant provides soil aeration and fertilization, leaving optimal conditions for the next crop.¹¹ In a study conducted in 1999, hemp along with many other crops were tested and ranked for their “biodiversity friendliness.” Hemp for both seeds and fiber ranked among the top five crops, outperforming major crops including wheat, maize and rapeseed.²⁰

Hemp plants provide significant shade, limiting weed growth. Because of this, and the natural disease resistance of the plant, industrial hemp can technically be grown without the use of herbicides, pesticides or fungicides — making this an easy crop to comply with organic farming requirements.²⁰

In addition to being a relatively beneficial crop to the land on which it is planted, products made with hemp are found to be more efficient and less taxing on the environment. Over a 20-year timespan, one acre of hemp can produce as much pulp for paper as roughly four acres of trees.

FIGURE 1: CRUDE MEAN EVALUATION OF BIODIVERSITY FRIENDLINESS OF SELECTED MAJOR CROPS AND FIBRE CANNABIS



Source: Monford and Small, 1999

Hemp paper can also be recycled up to seven or eight times, as opposed to the typical three times with wood pulp paper. With higher production and recycling rates, industrial hemp could play a key role in reducing deforestation, while creating more durable and environmentally friendly paper.¹⁹

Paper is not the only industry that could benefit from regular access to industrial hemp crops. Hemp fibers are lightweight with a higher than average weight-to-strength ratio.¹¹ Hemp fiber also has very high insulating potential, offering a “greener” solution than currently used raw materials.¹⁶ When compared to cotton, one acre of industrial hemp can produce two to three times the fiber from the same area of land. Additionally, the fiber produced from hemp breathes and is recyclable, unlike petroleum-based fibers.¹⁹

Another significant environmental benefit of industrial hemp is the production of biomass for renewable fuels, which could reduce dependency on fossil fuels. Biomass fuels offer an alternative to fossil fuels, eliminating the release of sulfur oxides into the atmosphere. Not only does biomass provide a cleaner alternative, it could be more efficient when considering hemp is the leading crop of biomass production per acre.¹⁹

With respect to other oil seeds, hemp is fairly mid-range in terms of oil content at around 30 percent. Second only to whale oil in quality, hemp seed oil has similar burning qualities to that of heating oil, while avoiding sulfur-based pollutants.¹⁹ With more emphasis on utilizing renewable resources such as these, industries could consider transitioning away from dependence upon fast-disappearing resources and begin building sustainable, environmentally friendly economies and products.¹⁶

PRODUCTION

Potential yields and processing methods, along with the cost and return of growing hemp, are important considerations when evaluating it as a potential U.S. crop. Revenue is dependent upon yields and market prices. Generally, the lower the market price, the greater the yield must be for producers to break even or make a profit.²⁰

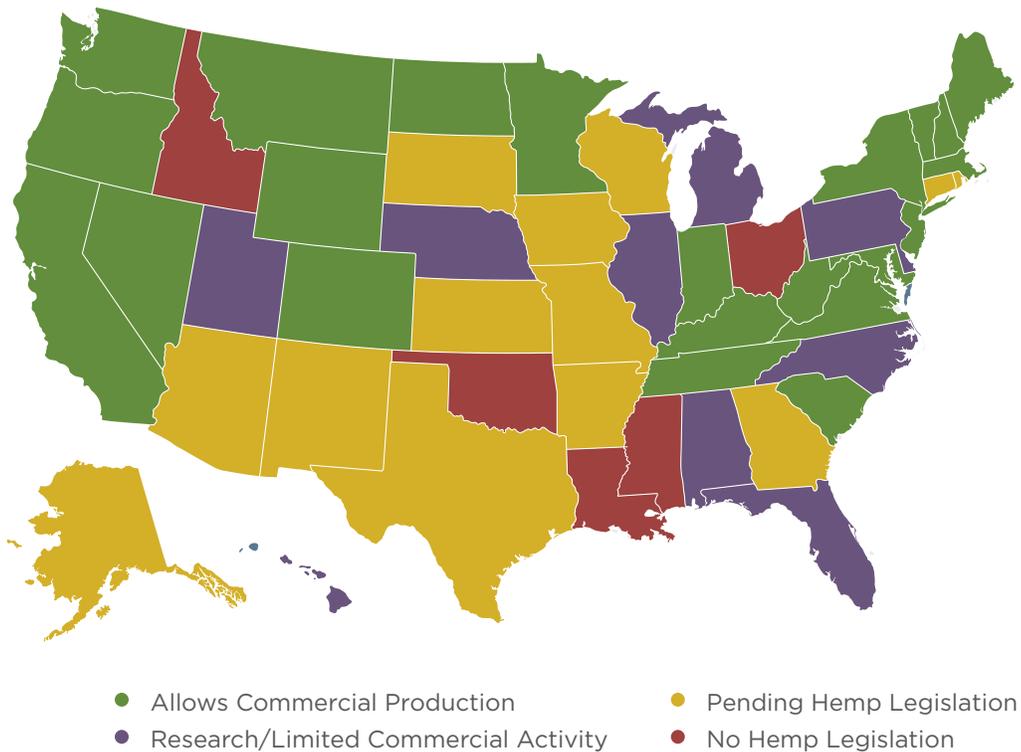
Industrial hemp is a member of the Cannabaceae family, as is marijuana.⁶ However, production, development and uses of industrial hemp have taken a largely different path through years of cultivation. Beginning with the enactment of the 2014 Farm Bill, growing hemp was once again permitted in the United States under restricted circumstances.³

Some research institutions and state departments of agriculture began growing the crop and, as of 2017, there were reported to be more than 25,000 acres of hemp production in the United States — up from just 9,770 acres in 2016. There were 1,420 registered or licensed growers, and more than 30 universities nationwide conducting research. As production increases so does the need for proper processing facilities. Currently, several states incentivize investments in processing capacity, including Kentucky, Tennessee, North Carolina and New York.³

Some still question whether hemp fibers can be profitably processed in the United States. The technologies used to process hemp fiber have not changed much, and require capital investment and knowledgeable workers. Research is underway to streamline harvesting, retting and fiber separation, but those technological breakthroughs have yet to occur.

U.S. INDUSTRIAL HEMP STATUS BY STATE

as of August, 2017



Source: National Hemp Association²¹

Traditional retting and fiber-separation processes — both labor and resource intensive — could limit the ability of U.S. hemp producers to compete against major suppliers such as China, Hungary, Poland and Romania.²⁰

Technological advancements in production and processing have not necessarily carried over to the hemp industry. For example, developments made in the wood pulping process vary greatly from those relevant to the hemp plant. Wood fiber is dense and can be transported long distances, whereas hemp fiber is lightweight and cannot be economically transported over long distances.

2019 AURI HEMP ACTIVITY MAP

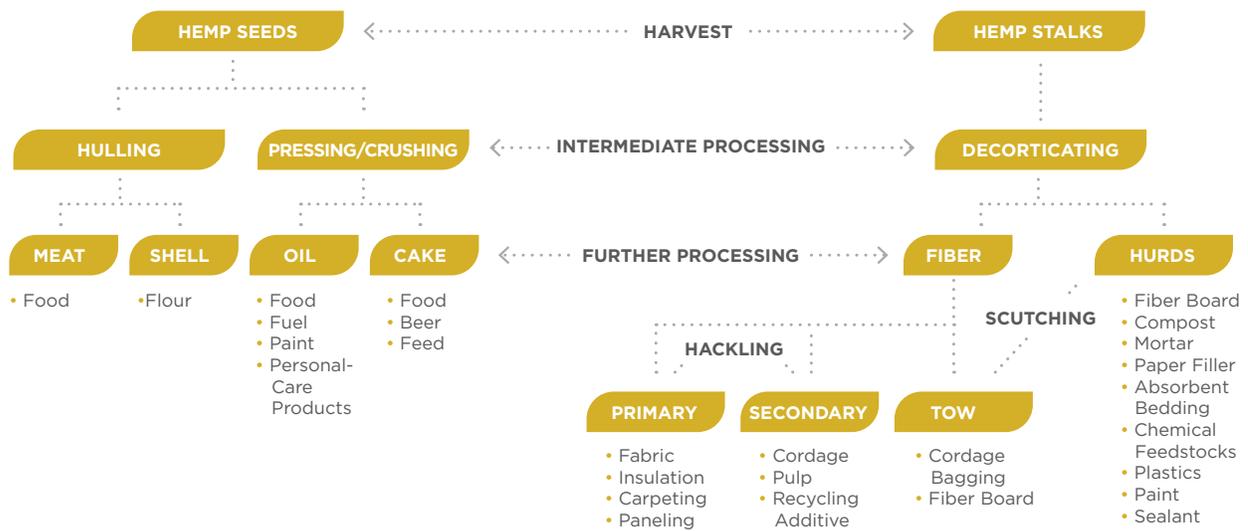


Currently, there are several new lab scale processes being tested for hemp pulp that are yet to be implemented for commercial businesses. The success of the industry not only depends upon the implementation of these advancements at the processing level, but also on the development of the market for these fibers.⁶

As Ken Anderson of Prescott, Wisconsin, who operates Legacy Hemp in Minnesota, Wisconsin, Kentucky and North Dakota, observed in *The Land Online*, “There is a need to expand the market so more American farmers can grow hemp . . . The better job that we do of expanding the market, the sooner it will be that it (hemp) will be treated as a commodity. Right now, it’s not the reality,” he said. “If you grow, you better know who your buyer is at the end of the day.”²²

The growth and production process required for hemp used for fiber differs from that of hemp utilized for oilseed.¹¹ Processing of the crop is therefore driven by end use. Processors of hemp seed, for instance, desire raw material that is of good food-grade quality; dry and sound; and meets acceptable standards for variety, color and appearance, flavor, purity, grade, toxins and moisture. Industrial hemp can also be intended for use within the categories of grain, fiber and dual purpose (grain and fiber). Processing – and eventually harvest and storage practices – will vary depending upon final use.²⁴

INDUSTRIAL HEMP



Source: North Dakota State University²³

HARVEST AND STORAGE

Hemp is a venerable, versatile crop.²² Historically, there have been many uses for this plant species; however, there are currently two variations that have the potential to make it a thriving cash crop in today’s world. Hemp plants can be used for both its fiber (from stalks) and seeds. The fibrous stalks offer an environmentally friendly alternative to a large variety of products, including insulation and paper, while the seeds produce oils that are increasingly popular in the food industry, personal care products and pharmaceuticals, as well as for a potential replacement for fossil fuels. Although both the fiber and seeds come from the same plant, aspects of the planting and harvesting process are different depending upon the intended use of the crop.⁶

For fiber crops, seeds are planted closer together to promote height, while preventing branching out and flowering.² This plant is also light sensitive, so early plantings will yield taller, more desirable output. The taller the crop, the more fiber produced; this is ideal considering fiber makes up only 25 to 35 percent of stem dry matter.⁶

The fiber is typically ready to harvest when the first seeds begin to develop. If left much past this point, the fiber will get too coarse.⁶ In the process of harvesting, the stems cannot be broken up or chopped if producing long fibers is the desired result. The outside tissue of the plant must be removed, and the fibers softened through a process called retting, in preparation for separation.²



There are different types of retting that can be done, depending upon the end use of the fibers. At the time the hemp stalks are baled, the moisture content must be below 15 percent. As the stalks continue to dry through the processing stages, the moisture content must eventually reach levels of 10 percent or less. Currently, there is no existing equipment made specifically for harvesting hemp for fiber in the United States. This poses another obstacle that must be overcome as interest in developing a profitable industrial hemp industry increases.²

Unlike hemp intended for fiber production, flowering and branching are desirable for hemp crops with the end goal of seed production.² Male plants die shortly after the flowering stage, leaving only the female and monoecious plants as seed producers. A monoecious plant can be defined as a plant with both male and female flowers. It is not a genetically stable plant and requires ongoing maintenance from the plant breeders, making for a very hands-on crop. Hemp that is intended to produce seeds as an end product is harvested much later in the season than those used for fiber. This harvest begins approximately six weeks after flowering occurs. Fiber from the stalks that is grown specifically for seed production is stiff, brittle and coarse, ultimately limiting its use.⁶

Hemp can be harvested using a combine, but not without challenges. The resin is sticky and the hemp stalks are easily wound around moving parts, causing a need for a cleaning process after harvest. To store hemp seeds, proper aeration is required. Seeds can quickly overheat and are highly susceptible to damage. Damage to seed coat can be minimized if seed is unloaded slowly and cautiously. Similar to the fiber crop, hemp seed must be properly dried before being stored – ideally reaching a moisture content of eight to nine percent.²

There are numerous factors to be taken into consideration during the growth and production stages. One significant threat to hemp seed production in the United States is birds.

Temperature is also a factor. Hemp can tolerate mild frost down to 23°F for a short period without harm to mature seeds or crop growth. A killing frost can hasten maturity and harvest is recommended within a few days to prevent yield loss and difficulties due to dry stem fiber. For taller, later-maturing hemp varieties, frost can be desirable, as it can help expedite harvesting.

While the harvesting process varies depending upon the end use of the crop, ideal conditions prior to planting are similar. Industrial hemp plants prefer semi-humid conditions with air temperatures averaging between 60 and 80°F. During the first six weeks of cultivation, the crop needs water. Hemp has higher demands for water and nutrients than that of grain crops. Although hemp crops are drought resistant a mere few weeks after planting, a lack of initial moisture can greatly reduce the mass produced by the plant as well as the maturity levels reached.⁶

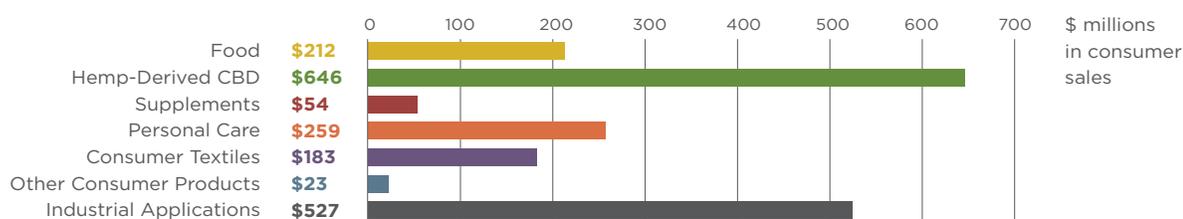
This crop does best in well-drained loam soils versus heavy soils. The nutrient requirements are similar to that of corn, and a lack of nitrogen in the soil can severely reduce fiber production.⁶ Like most crops, proper planting conditions and maintenance throughout the growing season impact overall yield and production.²⁴

ECONOMICS

Industrial hemp can be utilized in a wide variety of products, with approximately 25,000 currently in market.³ Hemp-derived oil, or CBD, is quickly gaining popularity as a potential new method to treating a vast range of medical ailments. Various market research groups estimate the market value for this type of oil will range from \$646 million to \$22 billion by 2022.^{1, 76}

While sales data can be used to identify the contribution of hemp products to the retail industry, there is very little information from other sectors. Statistics on hemp use in construction, biofuels and other manufacturing uses, for instance, are not widely available.³

\$1.9 BILLION U.S. HEMP-BASED PRODUCT SALES BY CATEGORY IN 2022E



Source: "The State of Hemp: 2014-2022," New Frontier Data derived from Hemp Business Journal'

Import statistics from 2017 show nearly two-thirds of U.S. hemp imports were hemp seeds, used mostly as ingredients of hemp-based products. Hemp imports totaled \$67.3 million in 2017 and, while this was not an all-time high, U.S. hemp imports have shown a steady increase since 2005.³

While economic data is limited due to the early stages of industry development within the United States, current data reflects growth in U.S. hemp retail sales, suggesting an increase in demand.² This may imply a promising economic outlook for the crop, supported by studies conducted by researchers in Canada as well as several state agencies.

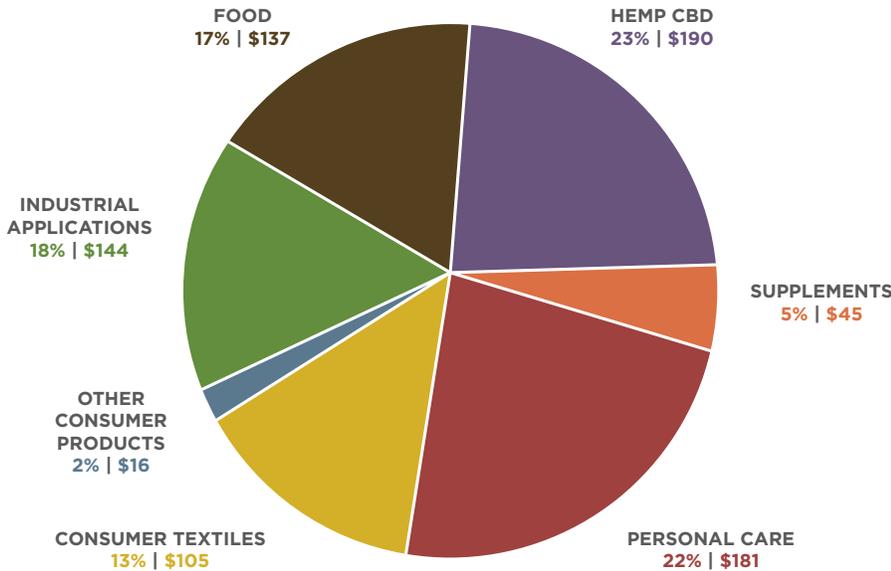
Rising acceptance for hemp and CBD – combined with easing regulations at the state level – caused U.S. hemp production to surge in 2017. From 2016 to 2017, the number of hemp acres in the U.S. increased by 166 percent, while the number of state hemp licenses issued grew by 78 percent over the same one-year period.²⁵

The U.S. hemp industry grew 16 percent in 2017 amidst continued domestic legal and regulatory challenges – a landscape that is mollifying by the day – with the growth led by hemp-derived CBD, food, personal care and industrial products. In fact, as legal and regulatory barriers are removed and consumer education spreads, *Hemp Business Journal* estimates the U.S. hemp industry will grow to \$1.9 billion.¹



Total sales for the U.S. hemp industry in 2017 were \$820 million. The top three product categories that contributed to this total are hemp-derived CBD products at \$190 million, personal care products at \$181 million and industrial applications reporting \$144 million. The remaining total included food, supplements, consumer textiles and other consumer goods.¹

**\$820 MILLION U.S. HEMP-BASED PRODUCT SALES
BY CATEGORY IN 2017**



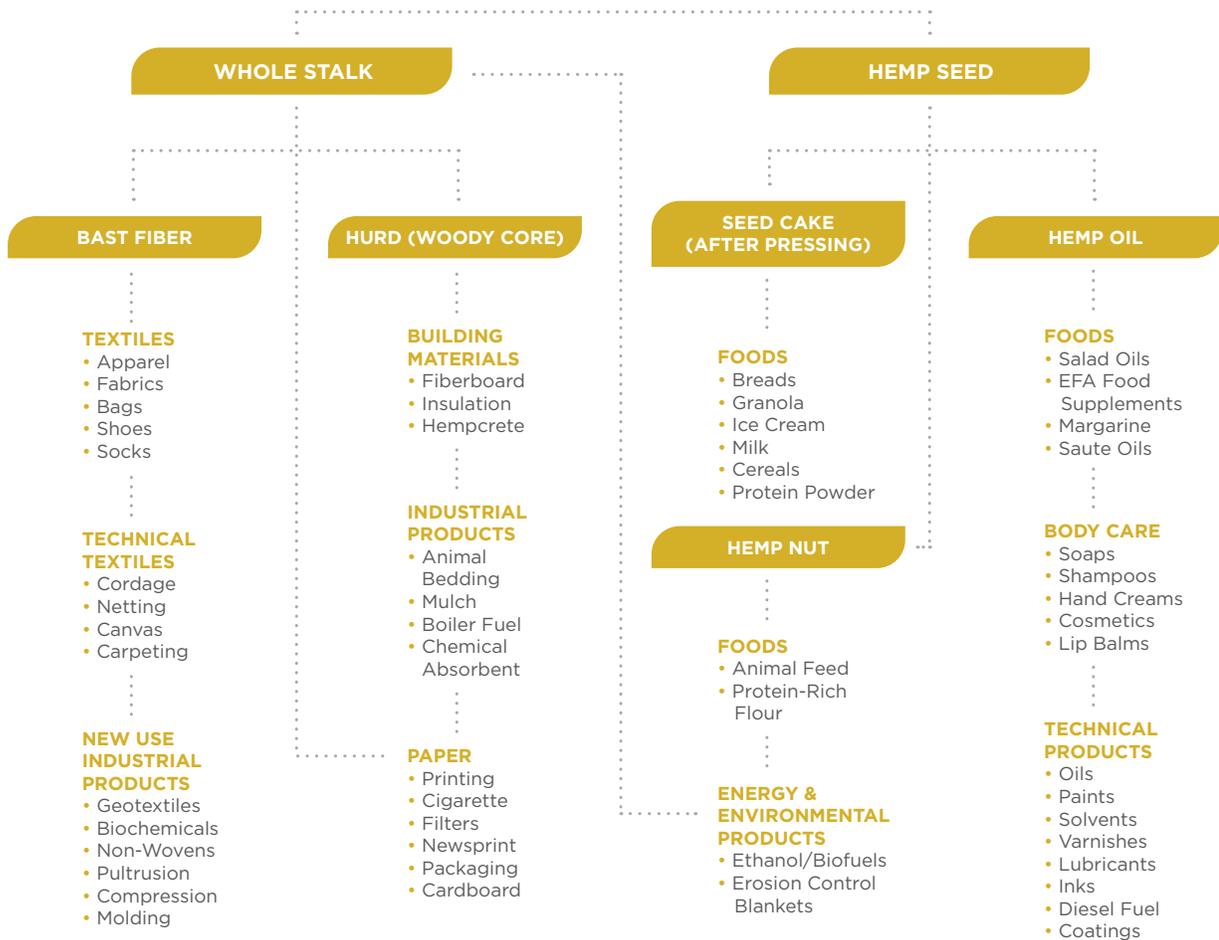
\$ millions in consumer sales

Source: "The State of Hemp: 2014-2022," New Frontier Data derived from Hemp Business Journal¹

SUPPLY CHAIN

As noted, it is no secret that hemp has an impressive list of uses. The fibers can be incorporated in fabrics and textiles, yarns and spun fibers, paper, carpeting, home furnishings, construction and insulation materials, auto parts and composites. Hurds, another material derived from the stalk, are used in building materials, papermaking and oil absorbents. Hemp seed and oilcakes contribute to a range of foods and beverages, and can provide an alternative source of protein for feed. Oil from the hemp seed is used in a range of body products and cosmetics.

MODERN USES OF INDUSTRIAL HEMP



Source: Vote Hemp, Inc., September 2018¹⁶

Hemp can also be found in nutritional supplements and medicinal products, including pharmaceuticals. It can be used in composite products such as “hempcrete,” a hemp-based alternative to concrete; insulation; hemp plastics; and fiberglass alternatives.³



Because of the evolving government regulations regarding growth and transportation, entry into the hemp industry is still a somewhat complicated and unclear process. Currently, hemp processing is unable to keep up with investor and consumer enthusiasm for the crop.¹⁹ While this industry is in the early stages of development, there arises an increasing need for a full supply chain to bring this crop from field to market. Lingering uncertainty surrounding regulatory issues, supply and demand, and profitability have impacted industry growth, however.

In Minnesota, hemp growers have pointed to difficulties in processing delays and regulatory confusion, as well as natural pests. These barriers have not greatly discouraged the small and growing hemp industry in Minnesota. Producers of the crop have expressed interest in developing this industry further for the variety of uses mentioned above, and optimism and enthusiasm about the potential for a profitable industry continue.¹⁹

Unfortunately, the enthusiasm and motivation of growers is still met with a lack of processors within the state.¹⁹ With the 2018 Farm Bill, opportunely, transporting the crop between states for commercial production is now legal along with interstate commerce.²⁶ Attention is needed to develop this emerging industry supply chain from field to consumer.



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WHEN HEMP IS NO LONGER A CONTROLLED SUBSTANCE, IT CAN BECOME A TRADED COMMODITY.

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- Ken Anderson,
Legacy Hemp

MINNESOTA OPPORTUNITIES

Minnesota hemp production has grown dramatically thanks to industry interest, introduction of a successful pilot program and a geographical latitude favorable to varieties already successful in Canada. While growers in the state report processing delays, pest issues and legal/regulatory challenges, enthusiasm for establishing a profitable industry has grown.²⁷

But, as an article by *StarTribune* reporter, Jennifer Brooks, noted, “There’s a steep learning curve when you’re resuscitating an industry that’s been dormant in this state for six decades.”²⁸

MINNESOTA HEMP SNAPSHOT

AS OF DECEMBER 2017

.....
Licensed Growers: 38
.....

Licensed Processors: 0**
2,000 outdoor acres
.....

Products allowed:

There are no formal rules, but hemp is reported to be grown for CBD extraction, seed or seed oil and fiber
.....

** Minnesota does not require processing licenses

Source: *Hemp Industry Daily*, 2018¹⁹

A COMPLEX ENVIRONMENT

Hemp and marijuana may look similar – a factor that has slowed industry growth. Visual appearance is where the similarities end, however, yet both have been caught in a legal tug of war.

The regulatory environment for hemp is complex, controversial and changing literally by the day. Hemp is used in thousands of products spanning multiple manufacturing and retail industries, thanks in part to state legislatures promoting industrial hemp as an agricultural commodity in recent years.

President Obama signed the Agricultural Act (or Farm Bill) of 2014, which included Section 7606 allowing for universities and state departments of agriculture to grow or cultivate industrial hemp within an agricultural pilot program or other agricultural or academic research; and if such is allowed under state laws in which “the institution of higher education or state department of agriculture is located, and such research occurs.”

The law required growers to be certified and registered at the state level.

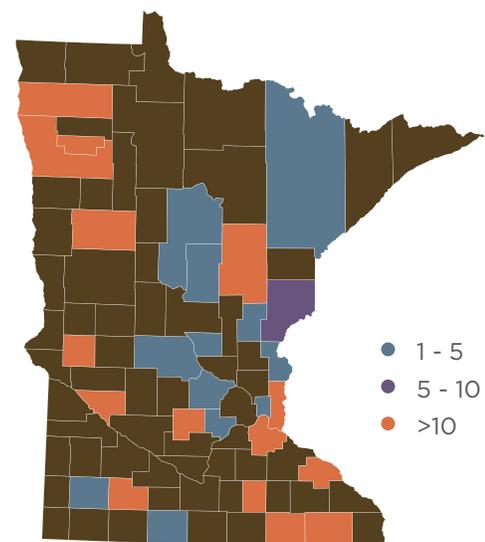
It must be noted, however, that the federal Controlled Substances Act previously did not recognize a distinction between the different varieties of *Cannabis sativa* – industrial hemp and marijuana – and considered them both a Schedule 1 controlled substance.

After the passing of the 2014 Farm Bill, 41 states passed legislation related to industrial hemp, and 39 states allowed for hemp cultivation and production programs. Numerous states considered legislation related to industrial hemp in 2018, including clarifying existing laws and establishing new licensing requirements and programs. Requirements for registration, licenses and permits can include such actions as criminal background checks; periodic renewals; and reporting sales or distributions, including to whom it was sold or distributed, as well as processors.¹²

In 2015, the Minnesota Industrial Hemp Development Act (IHDA), outlined in Minnesota Statutes 18K.01 to 18K.09, became law, creating an initiative to study the growth, cultivation and marketing of the crop. This law directed the Commissioner of Agriculture to make program rules, determine a fee structure, and perform testing and other regulatory activities.³⁰ This allowed the Minnesota Department of Agriculture (MDA) to create an industrial hemp research pilot program to study the growth, cultivation and marketing of industrial hemp.¹²

All first-time applicants to the program were asked to submit an application, fingerprints and an informed consent form, a federal/state criminal background check, payment and a detailed map of the field(s) to be cultivated. Pilot participants were – and still are – required to provide reports regarding seed varieties planted, agronomic findings and any processing, distribution and sales of products.³¹

2017 Industrial Hemp Pilot Program Locations



Source: “Industrial Hemp Pilot Program Annual Report,” Minnesota Department of Agriculture²⁹

Participation and support for the program has grown. In 2016, there were six pilot program participants in Minnesota who harvested approximately 40 acres of hemp for the first time since the 1950s.

In 2017, MDA received 47 applications for its pilot program; 40 became certificate holders. Of those, 33 were licensed hemp growers, and there were 56 total fields. Participants cited a range of goals, including gaining economic viability from an alternative crop to corn and soybeans; testing varieties for seed, grain, fiber and CBD production; expanding crop rotation; exploring food, fiber, and/or CBD markets; and researching and testing hemp processing methods to create products such as food, hemp seed oil, essential oils, fiber products and CBD extracts.³⁰

MDA also issued pilot program certificates to two testing laboratories, a hemp seed dealer, a researcher and three processors.

Of the 1,210 acres planted in 2017, 1,100 acres were harvested, primarily for hemp seed or grain. Four pilot participants harvested the hemp fiber, or the fiber in addition to the grain. The average plant height at maturity was 52 inches, with an average grain yield of 790 pounds per acre.³⁰

Costs for hemp production were reported between \$170 and \$1,000+ per acre, not including land rent. The cost for seed was about \$120 per acre. There were no profits reported within the 2017 pilot program report.³⁰ The remaining unharvested acreage suffered from extremely heavy rains after planting, improper planting methods and excessive weed pressure.²⁹

Applications for the 2019 Pilot Program began in October and surpassed 2018 participation.

But, as one grower commented, “The most difficult predicament facing every Minnesota hemp grower is cleaning and processing the seed,” due to the lack of places to sell the hemp grain or fiber. There are growers that see opportunity on the value-added side, but acknowledge it will take time and additional funding to get an industry established.³⁰

The foundation for dramatic changes began with the passage of the new farm bill in December 2018. As Rick Weissman, founder and president of High Falls Extracts in New York, predicted in *Money Morning*, passage was a game changer.

“There are two primary trends in the hemisphere that are going to continue to gather more steam in 2019. The first is the health and wellness movement, which will be spurred by the proliferation and adoption of hemp-based CBD products, which are starting to go mainstream. Hemp-based CBD products will continue to supplant synthetically derived pharmaceuticals. The second trend will be the revitalization of the agriculture/farming communities in states that have allowed their farmers to grow hemp.”³² That could jumpstart the Minnesota hemp industry.

“

SOYBEANS, MANY YEARS AGO, [WERE] NEVER HEARD OF, AND NOW IT’S A HUGE CROP FOR MINNESOTA AND THE ENTIRE WORLD. WE LOVE CANADIANS, BUT WE WANT TO BE MAKING THAT STUFF HERE. WE KNOW WE CAN GROW IT IN MINNESOTA.

”

- Andrea Vaubel, Assistant Commissioner, Minnesota Department of Agriculture, *StarTribune*, 2018

As Harold Stanislawski, project development director at AURI, stated just prior to passage, “If the farm bill passes, it will get industrial hemp on the playing field for commercial production. It opens the door for crop insurance, it opens the door for federal crop research grants and it really opens the door for banking. When that happens, things get a lot easier to move forward. Right now, it’s really entrepreneurship at its best and risk-taking at its best.”³³

A CHANGING LANDSCAPE

With the 2018 Farm Bill signed, MDA experienced a surge in hemp interest. “We’ve been inundated with calls from people wondering what it (bill passage) means, and if they need to get a license anymore. The short answer is yes, they still need a license – and not much is changing in Minnesota, at least in 2019,” explained Margaret Wiatrowski, industrial hemp program coordinator with MDA, referring to the fact that this will allow for uninterrupted production and processing of industrial hemp in Minnesota while the USDA develops its processes.³⁴

MDA is required to prepare a state plan for USDA approval on how it will regulate hemp and license growers. In the meantime, the hemp pilot program will continue until commercial hemp licensing begins. MDA is still required to license growers and test the fields to ensure THC compliance. Hemp will be removed from the Controlled Substances Act (CSA) and be recognized as an agricultural crop by the federal government. In addition, the farm bill allows interstate movement of hemp seed, plants and processed hemp products, and creates a path for farmers to be eligible for crop insurance and grants through USDA.³⁵

The Food and Drug Administration (FDA) will continue to regulate ingestible and topical hemp products, including CBD, and will not automatically allow hemp-derived CBD to be sold in any and all forms. It should be noted that the MDA Industrial Hemp Program does not have authority to make any determinations for the legality of food, beverage, cosmetic or animal feed products.

As the *StarTribune* editorial board noted, “Hundreds of millions of dollars of goods made with hemp – everything from hand lotion to teas and supplements – are sold in the United States, but rely on imported hemp and hemp byproducts. That’s been a boon for Canada, where hemp is already legal. Hemp could have strong potential in Minnesota . . . Already there are estimates that the U.S. cannabis industry could go from \$800 million now to \$20 billion within four years.”³⁶

HEMP FOR HUMAN CONSUMPTION

Hemp food products can be made from seed or grain in Minnesota. The FDA considers THC (tetrahydrocannabinol) and CBD (cannabidiol) to be regulated drugs, however; meaning they cannot be found in any traceable amount in food. Also, there are requirements regarding retail and wholesale food-handling licensure. If hemp is to be utilized within a product intended for human consumption, it’s important to contact MDA’s Food and Feed Safety Division to fully understand the legalities of hemp food products.

This hasn’t stopped some Minnesota entrepreneurs from trying to offer hemp-infused food products. Cosmic Beans Dispensary in Minneapolis announced in October 2018 that it would begin selling coffee and tea “energy drinks” made with CBD oil, a popular nutritional supplement derived from hemp. The owner’s plans received legal pushback, according to *Minnesota Daily*. Doing so would be a “critical violation” of the Minneapolis Health Department food codes, Daniel Huff, environmental health director with the health department, was quoted as saying at the time. Until CBD oil is FDA-approved, or generally recognized as safe (GRAS), business owners cannot add it to food or drinks.³⁷

CBD represents a complicated issue from a legal standpoint. The regulations set by various departments, like the Minneapolis Health Department, can differ from those set by the FDA. As the hemp industry is still in its infancy, the laws and regulatory agencies haven't necessarily kept pace.³⁷

CBD oil can be found on the shelves of natural food stores and head shops — stores that sell Cannabis paraphernalia — across the Twin Cities. Although it hasn't been approved for medical use, many claims have been made about CBD products that have not been through clinical trials, but that are still often purchased to treat everything from anxiety to restless leg syndrome.



As demand grows for the oil, farmers and entrepreneurs in Minnesota want a piece of the market. But, according to a report in October 2018 on Minnesota Public Radio (MPR), the murky legal status of the CBD supplement is a challenge for an industry that already brings in an estimated \$700 million a year nationally.³⁸

Cody Wiberg, executive director of the Minnesota Board of Pharmacy, was quoted as saying that state authorities have been aware of CBD oil for months. He believes that the 2014 federal law to allow hemp farm pilot projects does not provide for the sale of CBD oil. Wiberg said federal agencies “have issued this statement basically saying that they believe Congress intended this for research in pilot projects, but not for mass commercialization. The FDA has further specifically stated that CBD cannot be sold as a dietary supplement.”³⁸ Board of Pharmacy officials are reportedly not planning enforcement actions against manufacturers or stores that sell CBD oil.³⁸

According to an article in *The Land*, certified organic hemp grain is preferred over conventional in the food market. Achieving food-grade purity is difficult for Minnesota hemp farmers, hence growers have been somewhat frustrated with difficulty selling their grain.²² Due to the ever-changing nature of the hemp industry, MDA advises growers to secure a contract before they plant.

Also, thus far, hemp is not an approved ingredient for pet food. Including phytocannabinoids in animal feed, such as livestock, swine and equine diets, will be a potential market; however, these products will have to achieve AAFCO (American Association of Feed Control Officials) certification before being marketed.³⁰ [For more information, contact the MDA's Pet Food Program within the Commercial Feed Program.]

IS THERE MONEY IN HEMP?

Prices for hemp grain fluctuate in the United States – and particularly in Minnesota – due in part to the infancy of the industry. In 2015, the average hemp grain price in Alberta was \$0.54 USD per pound.³⁹ Typical returns for hemp grain in the United States have been between \$0.40 and \$0.70 per pound for conventional, and \$0.75 to 1.00 per pound for organic.⁴⁰

MDA pilot program growers reported a contract price of \$0.50 a pound for conventional and \$1.08 to \$1.18 per pound for certified organic in 2017. Across the 1,100 acres harvested, the average yield of cleaned grain was 790 pounds per acre, but some growers reported 2,000 pounds on the high end.²⁹

In Minnesota, hemp seed prices vary based upon the variety and whether it is domestic or imported. In 2016, hemp producers in Minnesota reported costs per acre between \$970 and \$2,500 per acre, according to MDA. In 2017, reports indicated production costs of between \$300 and \$600 per acre, not including land investment.³¹

While demand for hemp is growing, the need for processing facilities remains a challenge. “We lack a significant amount of processing in the state; that limits the participation of farmers,” observed Anthony Cortilet, MDA.⁴¹

“I think the processing is coming. We see some people that are in the program that are spending money, and there are people from all over the country and other countries that have inquired about coming to Minnesota to build a big processing facility. My guess is, with that kind of buzz, this is only going to grow.”⁴¹

FROM FIELD TO SALES

As within any new industry, entrants often need basic information, such as when do you plant hemp in Minnesota? With Minnesota’s growing conditions, planting too early can cause seedling mortality, therefore, ideal seeding dates for hemp production in the state are between mid-May and mid-June. Soil temperatures should be at least 45 to 50 degrees Fahrenheit.⁴⁰

Where can you buy hemp seed? Only hemp license holders are legally allowed to possess industrial hemp seeds in the state of Minnesota. MDA pilot program participants can obtain industrial hemp seed from in-state, domestic or international sources.⁴⁰

How do you sow it? Most conventional drills and seeders will work for hemp, but experts advise using lower air volumes to avoid seed cracking. Seed should be planted shallowly (0.5”-1” maximum) into a firm seedbed, and one should avoid soil compaction as well as not seed before a large rain event.⁴⁰

Hemp grain is generally harvested by straight combining, however, swathing is also used. Industrial hemp seed is harvested when approximately 75 percent of the seeds are ripe; it starts to shatter about 90 to 120 days after planting, depending upon the variety and local climatic conditions. High winds and bird predation can be major problems. Harvest is recommended at 18 to 20 percent moisture, with immediate drying to reach eight to 10 percent moisture for storage.⁴⁰

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THE MOST DIFFICULT PREDICAMENT FACING EVERY MINNESOTA HEMP GROWER IS CLEANING AND PROCESSING THE SEED.

”

- Minnesota Industrial Hemp 2017 Pilot Program Participant

As Anthony Cortilet from MDA pointed out, “It’s a different form of agriculture. You have to think and engineer things a little differently. But, just fly over Canada. They have giant farms that are harvesting and producing hemp, whether its fiber, CBD or you name it. It’s new, so American farmers have to get up to speed. There is a learning curve to growing anything new.”⁴¹

Harold Stanislawski agrees. “One of the things we’ve looked at within AURI is the resources needed in the state. The easiest path forward is to get mobile decortication here first. Then we can better characterize and understand the type of fibers that are coming out and start providing some of those fibers to end users in Minnesota for testing and, eventually, adoption. To obtain decorticated fiber today, fiber has to either go to Nebraska or Kentucky where decortication facilities operate.”³³

Another option is a collaborative approach, such as the Colorado Hemp Processing Cooperative, organized to provide seed to sale harvesting and processing services to the industrial hemp industry. With this model, Minnesota farmers could belong to the co-op or LLC and share risk as well as profits. This framework has already been established within Minnesota for other commodity industries to gain legitimacy, quality assurance and return on investment. Such a concept would allow farmers to work together rather than everybody trying to do it themselves.

Growers are, of course, responsible for locating their own buyers, but can contact a hemp trade association to learn more about marketing opportunities, such as the Hemp Industries Association or the National Hemp Association.

RESEARCH STILL NEEDED

As the industrial hemp industry matures in Minnesota, simultaneously, there is a need to continue expanding the knowledge behind it. Questions that need further exploration include these, among others:

- What’s the best method of sowing?
- What’s the best method of weed control?
- What herbicides are allowed and best for use on hemp?
- Where does hemp fit into a crop rotation?
- What are the major pest issues?
- How can seeds be tested for reliability and THC level?
- What diseases are going to be issues in Minnesota?
- What are the best extraction methods for CBD? What’s the anticipated yield?

PROFILE: MINNESOTA HEMP FARMS INC.

When the Minnesota Department of Agriculture approved the Industrial Hemp Pilot Program, John Strohfus was the first farmer to apply for, and be granted, a license to grow industrial hemp. That was not by accident.

"I wanted to be first. I knew that being first doesn't guarantee success, but it helps and gives you a jumpstart," Strohfus said. "I knew it was going to be difficult, but I knew I was going to be able to figure it out. It was a good decision. And it's been a lot of work."

Strohfus runs Minnesota Hemp Farms Inc., the largest producer of hemp products in Minnesota, located near Hastings. In 2018, Strohfus harvested his first certified organic hemp crop.

The business focuses on growing the plant for food, fiber and CBD nutraceutical markets. Minnesota Hemp Farms also offers consulting, seed sales, planting and harvesting services in addition to "Field Theory," a food brand available for sale online and in retail stores.

When he started farming hemp, his knowledge of the plant, its history and its potential was limited.

"I thought hemp was the stalk of the marijuana plant. I didn't know anything. I probably wasn't even as smart as the average consumer is now," he said.

He also admits to doing everything backwards. He planted hemp, grew it and then tried to process the crop and find a market.

"We probably violated the first rule of farming which is don't plant a crop unless you have a market for it. Instead, we did basically the opposite," he said.

Since that first harvest, Strohfus has learned a lot and he has become one of the state's

leading hemp authorities. He took his product and found customers and new uses. He sells planting seed, hulled seed, cold press oil and hemp protein. He developed new products like hemp oil, hemp seeds for salads and smoothies, and a warming muscle balm, which are available in 65 grocery stores across the Twin Cities. He is a frequent speaker on hemp issues, an informal resource for hemp growers and entrepreneurs as well as an organizing force for the larger Minnesota hemp industry.

Strohfus worked for many years with the Agricultural Utilization Research Institute (AURI) and credits the organization with helping him improve both his farming and his business. The "hemp prohibition" is ending, Strohfus said, and there are a lot of players ready to dive into food, health and beauty products, fibers and for medicinal purposes.

He will always grow hemp, but Strohfus says his future is in the business side. He enjoys marketing, networking and coming up with ideas. He looks for ways to put the right people together to discuss hemp and he wants to open doors to Minnesota's agricultural economy and agribusiness industry. He travels the state speaking to scientists, farmers, educators, legislators and entrepreneurs. He wants to work with producers to connect them to processors, packagers, labelers and eventually consumers.

"The future is everything. There is explosive growth everywhere," he said. "We have figured out this innovative product that actually gives people a lot of amazing benefits. It would be like discovering ibuprofen essentially."



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**HEMP'S USE
WITHIN
THE FOOD
INDUSTRY IS
PROJECTED
TO GROW.**

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FOOD LANDSCAPE

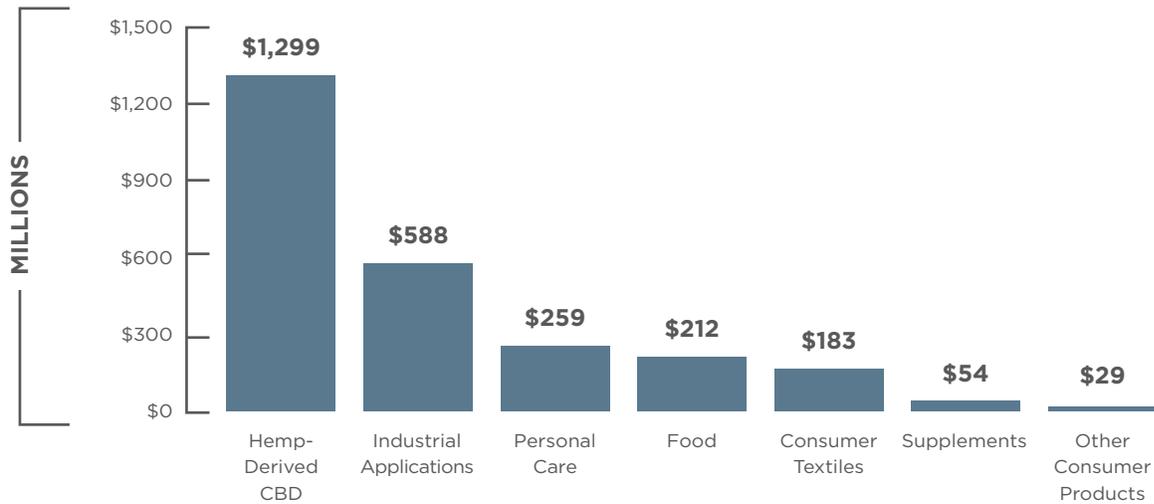
The versatility of hemp as a food source has long been recognized. With regulations and product awareness evolving, hemp's use within the food industry is projected to grow.

HEMP AS A FOOD PRODUCT

Hemp-derived ingredients such as seeds, “hearts” (the shelled seeds of the industrial hemp plant) and oils are appearing with more frequency in global food markets, including Europe and North America.⁴² As CBD popularity grows in the United States, the FDA continues to have regulatory authority over its use in food and beverages. In a December 20, 2018 statement⁴³ following the signing of the farm bill, FDA Commissioner Scott Gottlieb said three ingredients derived from hemp – hulled hemp seeds, hemp seed protein and hemp seed oil – are GRAS (Generally Recognized as Safe) foods and will not require additional approvals if marketers do not make claims that they treat disease. He did restate his agency's stance, however, that CBD is a drug ingredient and therefore illegal to add to food or health products without approval from the FDA.⁴⁴

Lack of FDA guidance over past years has not prevented successful introduction of hemp food products to the market. In 2018, U.S. hemp-based food sales totaled \$150 million.⁴ The following graphic illustrates the expected growth of the hemp industry by category total in 2022.⁴⁵

\$2.6 BILLION U.S. HEMP-BASED PRODUCT SALES BY CATEGORY IN 2022 (estimated)



Source: "The Global State of Hemp: 2019 Industry Outlook," New Frontier Data, Hemp Business Journal⁴⁵

Industrial hemp can be used both for its seeds and oil content. Hemp seeds offer a high nutritional appeal, containing between 25 to 30 percent protein, insoluble fiber, omega-3 fatty acid and traces of lesser-known beneficial fatty acids.⁴⁶ Contrary to popular belief, hemp seeds do not possess the same psychoactive properties as its biological cousin, marijuana. Industrial hemp crops are required by law to be destroyed if tetrahydrocannabinol (THC) levels exceed the legal amount of 0.3 percent.⁴²

In addition to the fiber, protein and essential fatty acids hemp seeds contain, they offer a plethora of micronutrients including thiamin, zinc, vitamin E, phosphorous, potassium, magnesium and calcium.⁴⁷ Technically, the seeds are achene fruits, consisting of a single seed with a hard outer shell.⁴⁸ Seeds can be consumed raw, cooked or roasted.

Below is a breakdown of the nutritional content by percentage found within the hemp seed.

TYPICAL NUTRITIONAL CONTENT (%) OF HEMP SEED

	WHOLE SEED	SEED MEAL
Oil	35.5	11.1
Protein	24.8	33.5
Carbohydrates	27.6	42.6
Moisture	6.5	5.6
Ash	5.6	7.2
Energy (kJ/100 g)	2200	1700
Total dietary fibre	27.6	42.6
Digestible fibre	5.4	16.4
Non-digestible fibre	22.2	26.2

Source: NSW Parliamentary Research Service, March 2016⁴⁷

Hemp seeds must go through additional processing to be converted into hemp seed oil, which can be used in a variety of food and non-food products. First, the seed must be thoroughly cleaned to prevent contamination from other crops, as well as removing any possible leaf matter. The cleaned seeds are then loaded into hoppers that extract oil by pressing the seeds into a “hemp cake” and separating out the oil. While chemical extraction of hemp seed oil is also a possible method, cold pressing is currently the most common process for producing hemp seed oil. As the oil cools from the extraction process, it is filtered into a holding reservoir to begin the next phase, a cold-filter filtration process. This filter removes any remaining solids from the oil and leaves processors with high-quality, food-grade hemp seed oil.⁴⁹

Much like hemp seed, consuming hemp seed oil has its nutritional benefits. Hemp seed oil has the second-highest omega-3 fatty acids content compared to other common plant-based oils,⁴⁷ and the fatty acid profile is a balanced ratio of approximately a 3:1 omega-6 to omega-3.¹¹ Competitors such as chia or flax seeds typically have a 1:3 or 1:4 ratio of omega-6 to omega-3.

Fresh hemp seed oil is green in color due to the presence of chlorophyll in the seeds.⁴⁸ It can serve as a substitute for olive oil, walnut oil or butter when stir frying and sautéing meats and vegetables on the stove, but since it has a relatively low smoke point, experts don’t advise using it for deep frying or high temperature cooking. Hemp oil does work well as a salad dressing or additive to smoothies or shakes.⁵⁰

TECHNICAL PROPERTIES

Hemp can be a great source for several necessary macro- and micronutrient properties, whether in seed or oil form. Depending upon the variation of hemp product consumed, the nutritional benefits will differ. Whole hemp seeds are the best option when looking to increase fiber intake.⁵¹ With levels reaching nearly 17g of fiber in every 56g serving, a few handfuls will meet daily minimum fiber requirements.⁵⁰ These seeds contain both soluble and insoluble fiber due to the high fibrous content within the shell. Soluble fiber aids in digestion and can help regulate blood pressure spikes, as well as cholesterol levels. Insoluble fiber also plays a role in a healthy digestion cycle and has been linked to reducing risk of diabetes. Once hemp seed has been de-hulled, the outcome being commonly referred to as a “hemp heart,” most of the fiber content has been lost with the shell.⁵¹

Another form of hemp that boasts high levels of fiber is powder. Both hemp flour and hemp protein powder offer a high fiber content. Hemp flour, which is produced by milling and sifting hemp seed cake – a product made after crushing hemp seeds for oil – is nearly 50 percent fiber.⁵⁰ One serving of hemp protein powder can contain up to 52 percent of daily required fiber value for women and 43 percent for men.⁵²

With plant-based proteins on the rise, hemp has become a viable option. In addition to the fatty acids, fiber and other minerals, hemp contains roughly 25 percent protein. These levels are comparable to yellow field peas, but lower than that of soybeans.⁵³ The digestibility of hemp seed protein is equivalent to, or better than, a variety of other grains, nuts and pulses.⁴²

Protein digestibility-corrected amino acid score (PDCAAS) is regularly utilized by the FDA to evaluate the quality of a protein based upon the



Source: The World of Food Ingredients, September, 201542

amino acid requirements of humans and their ability to digest it – a method which has determined hemp to have a score of approximately 0.66 for hulled seeds. While this is higher than some of the aforementioned grains, nuts and pulses, this score is lower than most standard protein sources including soy, whey, milk and beef.

By definition, hemp is also considered to almost be a complete protein source, due to the fact that it is low in L-lysine and leucine.⁴² These lower levels of lysine are the main cause for the lower PDCAAS score.⁵³

Hemp proteins can be used most effectively as emulsifiers, foaming agents and moisture retainers. The way in which hemp is processed can impact the characteristics of resulting protein ingredients. Proteins obtained through a process called membrane filtration have higher solubility, foaming capacity, water-holding capacity, oil-holding capacity and digestibility than those obtained through pH extraction.⁵³

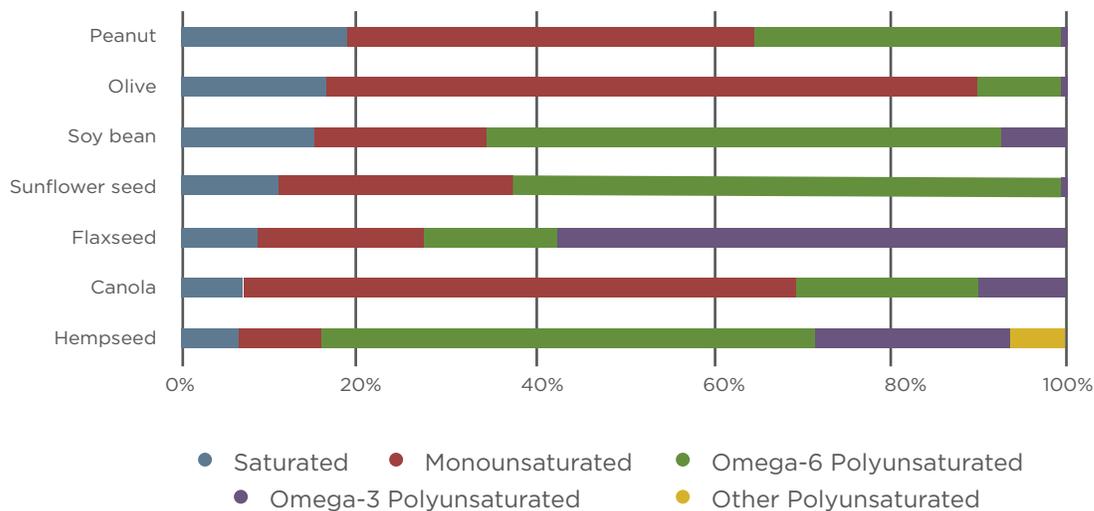
When using the pH extraction method, hemp proteins can have decreased levels of functionality in comparison to their plant-based protein competitor, soy. In addition to the inferiority to the properties of soy, another barrier to the adoption of hemp as a regular source of protein is a lack of an established supply chain to process the crop.⁵³

Although hemp may not possess all the nutrients one can obtain with other plant proteins, some experts say it is rich in iron, magnesium and zinc, elements many Americans are lacking in their diet. Additionally, hemp is high in arginine. Arginine is a precursor to nitric oxide, a gas released within the body that expands the blood vessels and increases blood flow, decreasing the likelihood of blood plaque and clotting.⁴⁶

While a popular assumption is that foods high in fat are unhealthy, it is important to identify what kind of fat the food contains. Hemp is a high-fat plant, but 80 percent of its fatty acid profile is polyunsaturated fat, otherwise known as the “healthy” type. This includes the essential fatty acids such as omega-3 and omega-6. These fats contribute to important biological processes within the human body, including immune response and heart rate, and are essential for normal growth and development. They are also believed to have positive effects on rheumatoid arthritis, heart disease, diabetes and even cancer.⁴⁷

Below is a comparison of the fatty acid profile of hemp seed to other similar crops. As the graph indicates, hemp seed boasts one of the highest percentages of polyunsaturated fats.

TYPICAL NUTRITIONAL CONTENT (%) OF HEMP SEED



Source: NSW Parliamentary Research Service, March 2016⁴⁷

HEMP: A MARKETABLE FOOD PRODUCT

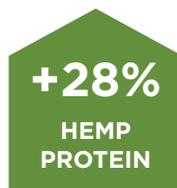
The many forms in which hemp can be processed lends itself to versatility as an ingredient in food and beverage products. Hemp can be an additive in powdered or seed form to nearly any food product, but is most popular in snacks, smoothies, juices, infused waters, baked goods, nutritional bars, granolas and cookies.⁵⁴

In recent years, popularity of hemp as an ingredient for baking has seen the largest growth in comparison to other food and drink categories. Currently, food is the primary use of hemp in the forms of seed, protein and oil.⁵⁴

The following table demonstrates the growth of hemp use by market category.

CEREALS, SPORTS & SNACKS ARE KEY FOR HEMP NEW PRODUCT DEVELOPMENT

GROWTH FOR LEADING MARKET CATEGORIES FOR HEMP APPLICATIONS
(GLOBAL, 2016 VS. 2015)



PLANT-BASED HEMP PROTEIN SURGE

+28% increase in product launch activity containing hemp protein (Global, 2016 vs. 2015).

Source: Food Ingredients 1st, July 24, 2017

Hemp seeds are small and round with a light nutty flavor. They can serve as additives to practically any dish, offering numerous nutritional benefits. Common uses for hemp seeds include topping salads, mixed in with desserts or yogurt, sprinkled on cereal and baked into bread.⁵⁴

Hemp seeds can be purchased as either whole seeds or dehulled as hemp hearts. Although hemp hearts still have nutritional value, removing the hull of the seed does impact the integrity of the seed's overall nutritional benefits. The hull, or shell, is an excellent source of minerals as well as insoluble fiber. Another benefit of whole hemp seed is the stability of the product. Hemp seeds become more fragile - and tedious to store or transport - once they are dehulled.⁵⁵

There are still many barriers to overcome, but some early adopters are already hitting the market and making waves with homegrown hemp crops. At a natural foods exposition in early 2018, Nutiva®, a California-based company producing natural organic snacks, oils and supplements, introduced the first certified organic hemp seed grown in the United States.⁴⁶

Nutiva is not the only company on board with the inclusion of hemp in its products; an example being Manitoba Harvest, which produces healthy hemp food products. It was purchased by Tilray⁵⁶ – a Canadian pharmaceutical and cannabis company incorporated in the United States in 2019, and is one of the largest and most sophisticated producers of premium medical cannabis in the world. Currently, its biggest seller and fastest-growing product is hemp hearts. Snacks, cereal and protein powders, however, all have potential for strong future growth.⁴⁶

As previously mentioned, hemp is a great source for vegetable-based protein.⁴² It is a complete protein comprised of all 21 known amino acids and nine essential amino acids that cannot be produced within the body.⁵² As plant-based alternatives to meat have been rapidly gaining in popularity over the last few years, so has an interest in more healthful, natural ingredients.

NEW ITEM LAUNCHES WITH PLANT-BASED PROTEINS HAVE GROWN BY 37.3 PERCENT OVER THE PAST FIVE YEARS IN THE UNITED STATES

PLANT BASED PROTEIN TYPE	# PRODUCT LAUNCHES 2016	2016 % CHG	5YR CAGR	5YR % OF LAUNCHES
Soybean Protein	799	(15.6%)	32.5%	70.1%
Wheat Protein	475	(18.5%)	26.3%	42.1%
Pea Protein	129	(40.2%)	8992.3%	6.1%
Vegetable Protein	58	(49.6%)	(29.3%)	8.0%
Potato Protein	13	0.0%	225.0%	0.3%
Hemp Protein	10	11.1%	233.3%	0.7%
Sacha Inchi Protein	2	(71.4%)	0.0%	0.2%
Quinoa Protein	1	0.0%	0.0%	0.0%
Pumpkin Protein	1	0.0%	0.0%	0.0%
Rapeseed Protein	0	0.0%	(100.0%)	0.0%
Cranberry Protein	0	0.0%	0.0%	0.1%
Barley Protein	0	(100.0%)	(100.0%)	0.1%
Artichoke Protein	0	0.0%	0.0%	0.0%

On average, 70.1 percent of product launches with plant-based proteins have contained soybean protein in the past five years, but it has seen declines in 2016

 New items with pea, potato and hemp proteins are the fastest growing in food and drink product launches in the U.S

 On average, 6.1 percent of product launches with a plant-based proteins have contained pea protein and its share of product launches has grow by 9.1 percent over the past five years

Source: "U.S. Plant-Based Proteins Market Report," Mintel GNPD, May 2017 (Updated 2019)⁵⁷

The table above illustrates the market growth of a variety of plant-based proteins. As noted, hemp is among the top three fastest-growing in the United States.⁵⁷ This can likely be attributed to the fact that it is considered one of the best and most complete plant protein sources.⁵⁴ One common and suggested use for hemp protein is to blend into shakes and/or smoothies for a post-workout protein boost.⁵² Nutiva has recently introduced a new plant protein blend combining hemp, pea, sunflower and pumpkin.⁴⁶ In 2015, a protein powder blend was launched by a company called NP Nutra®. This became the best-selling plant-based protein powder and included ingredients such as hemp powder, brown rice and pea protein.⁵⁴

Another common use of hemp in the food industry is for hemp seed oil, which can provide a healthy dose of essential fatty acids. Studies have indicated the polyunsaturated fats within hemp seed oil possess anti-inflammatory properties, and can be beneficial for heart and brain function. The daily recommended dose of omega-3 fatty acids, as well as vitamin E, can be reached with just one to two servings.⁵⁸

Not only is this considered by some to be one of the healthier options on the market, hemp seed oil is an exceptional alternative to blended oils, which can separate. With hemp seed oil, no further blending is required, eliminating the need for a balanced ratio of oils and preventing separation on the shelf. The product can be used in salads, spreads, dips or drizzled on top of a dish to add flavor. It is not suggested for cooking or a substitute in baking in sweet dishes, as the strong flavor profile can be overpowering.⁴⁹

Hemp seed oil is different from CBD oil in that it comes from a different part of the plant. The Drug Enforcement Agency has declared that quantifiable amounts of CBD are not found in the hemp stalks, seeds or oils but, in fact, are in the flowering tops, resins and leaves — parts of the hemp plant that are technically classified as marijuana, despite the inability for CBD to produce any psychoactive effects.

Companies that currently make products including CBD must make manufacturing determinations carefully within this regulatory environment. Currently, dietary supplements are regulated under the Dietary Supplement Health and Education Act of 1994 (DSHEA), covering dietary ingredients that consist of one or more vitamins, minerals, herbs, amino acids, concentrates, metabolites, constituents or extracts. Any new dietary ingredient that meets the definition above and was not sold prior to the passing of the DSHEA in 1994 is subject to pre-market notification and review for safety by the FDA. Existing CBD supplement companies are operating under the premise that these supplements were on the market before 1994 and before any clinical investigations for CBD had been conducted.⁴²

The FDA continues to be concerned at the number of health claims being made about products that contain CBD or other cannabis-derived compounds. According to a statement by FDA Commissioner Scott Gottlieb, MD on December 20, 2018, “. . . the FDA requires a cannabis product (hemp-derived or otherwise) that is marketed with a claim of therapeutic benefit, or with any other disease claim, to be approved by the FDA for its intended use before it may be introduced into interstate commerce — the same standard to which any product marketed as a drug for human or animal use is held.”⁴²

Cannabis and cannabis-derived products claiming they are intended for use in the diagnosis, cure, mitigation, treatment or prevention of diseases must go through the FDA drug approval process for human or animal use before they are marketed in the United States.”⁵⁹

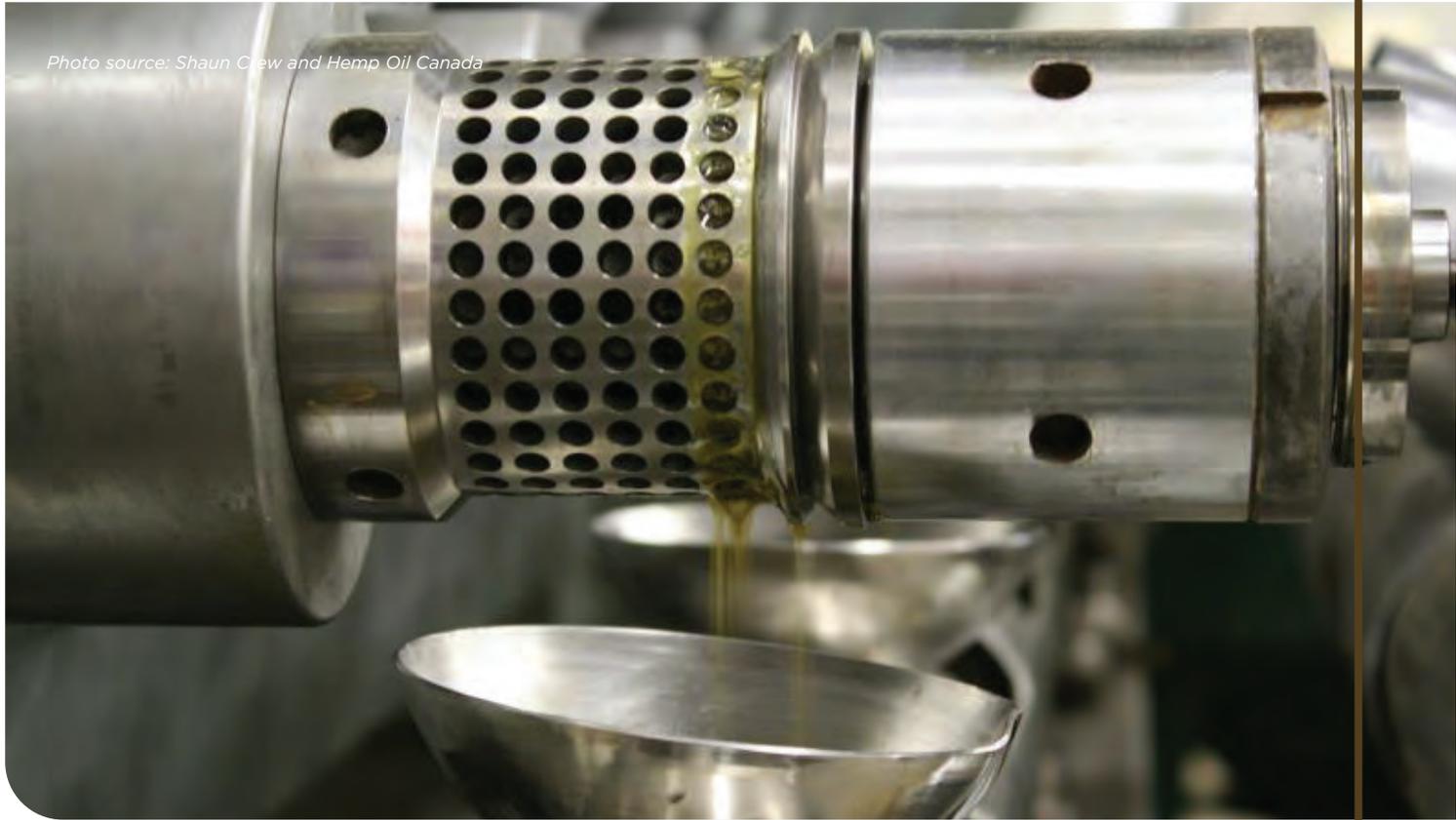


Photo source: Shaun Crew and Hemp Oil Canada

COMPETITIVE OVERVIEW

Industrial hemp and its use in the food industry presents a plethora of benefits. While hemp seeds can offer a viable source for plant-based protein, as well as fiber and other essential nutrients, there are other crops that can offer similar properties with much less stigma.⁴²

The table below provides a snapshot into the nutritional profile of hemp hearts in comparison to some of its top competitors: chia seeds and flaxseed.

**NUTRITIONAL VALUE OF HEMP VS. CHIA VS. FLAXSEED
PER OUNCE (28G OR – 2-3 TABLESPOONS)**

CHIA SEEDS (DRIED)	FAT	PROTEIN	DIETARY FIBER	OMEGA-3: OMEGA-6	MAJOR VITAMINS/MINERALS
Hemp Seeds (shelled or de-hulled)	13g	10	3g	2,200mg: 6,600mg (approximate,calculated)	20% of iron, also 45% of magnesium, 21% zinc, 110% of manganese
Chia seeds (dried)	9g	4g	11g	4,915mg: 1,602mg	18% calcium, also 27% of phosphorus, 30% of manganese
Flaxseed (ground)	6g	2g	4g	6,400mg: 1,655mg	4% of calcium 4% iron, 7% magnesium, 9% manganese, plus other minerals

Source: Food Ingredients 1st, September 2015 ⁵⁴

What this table does not take into consideration is the many ways hemp can be processed and used in the food industry. Hemp seed meal, hemp seed oil, sprouted seeds, hemp milk and butters can all vary in the nutritional profiles. As seen above, the hemp seed has more than two times the amount of protein of chia or flax seeds.⁴² Additionally, and to reiterate, hemp is a complete protein source. Complete protein sources are rare among plants, as most typically lack an important amino acid — lysine.⁵¹

Unfortunately — even with the many health benefits offered — the stigma, uncertainty and regulations surrounding industrial hemp are preventing Fortune 500 food manufacturers from regularly including it in their products. What is referred to as “corporate conservatism” protects brands from breaking potential regulations, and avoiding negative consumer perceptions and legal consequences.

Additionally, there has not been enough evidence regarding health benefits of industrial hemp for these businesses to prefer this crop over the less controversial — and less costly — crops such as soybeans, chia, pea and flax. This poses one of the largest hurdles to the adoption of industrial hemp as a key player in the food industry. Hesitance due to the potential impact on consumer perception, as well as greater cost, stands between industrial hemp and market shelves.⁶¹

The barriers to entry into the food industry that industrial hemp faces are most prevalent in the U.S. market. While there is no existing source of aggregated data for worldwide industrial hemp production, data from various countries has indicated an upward trend.⁴⁷

In Europe, hemp cultivation has been increasing since 2001. The majority of hemp seed from these crops is used for both animal feed and human food. Because of the history of the cultivation and consumption of hemp in Europe, they are not subject to novel food regulations. While vitamins and minerals are regulated, the inclusion of plant extracts in food supplements are not specifically restricted.⁴²

The nationwide adoption of industrial hemp as a legal crop in Canada allows hemp to be used as a food ingredient without any pre-market clearance beyond that of the crop requirements. Canada currently has a large number of hemp products available within the market as food.⁴²

Hemp products used as ingredients in natural health products (NHPs) are subject to regulations in addition to those of the industrial hemp crop. A license must be obtained prior to market entry and, in order to obtain a license, applicants must submit a detailed description on the safety, quality and efficacy of the finished product. NHPs can vary from topical skin creams to vitamins and mineral supplements to protein powders. Currently, there are 60 licensed NHPs on the Canadian market containing hemp as an ingredient.⁴²

Manitoba Harvest, recently acquired by Tilray, contracts with Canadian hemp farmers for their supply, but recognizes a strong opportunity to expand into the U.S. market. The U.S. market penetration is one-tenth of the current Canadian market and has ample room to grow and flourish. The company is committed to educating consumers and retailers about what industrial hemp is and how beneficial it can be for a multitude of reasons. Showing consumers how to best use hemp products and/or incorporate it into existing products are two ways the company hopes to slowly introduce this ingredient to the masses.⁴⁶



PROCESSING

Not only does industrial hemp face an abundance of barriers regarding perception, regulations and market adoption, the crop also faces issues when it comes to processing. Because this plant was not legal for decades, there have been few advancements made nor extensive research done on how to most effectively and efficiently harvest this crop. Less uniformity than other crops and uncertainty on the best processing protocol can make for a difficult path to commercialization.⁵⁶ Growers have reported that a draper header combine works well to harvest the seeds, while leftover stalks from a hemp grain variety crop could be retted and run through a decorticator to separate the outer bast fiber from the inner hurd for several end uses.

Furthermore, processors need to account for the high expenses associated with the ideal protein production process that generates the best results — membrane filtration.⁵³ As demand and market acceptance increase, equipment and costs will likely evolve but, in the beginning stages, this is a current obstacle.

The way in which hemp is processed is also determined by the end use of the seed. Cleaning steps are required for all forms, but the extent is dictated by the end use.⁵⁶ Actual guidelines for food-grade cleaning practices have been difficult to define due to the illegal status of the crop. Canadian standards for grain purity are currently being followed in Minnesota. Canada's standards are to 99.99 percent purity for food grade processing, or less than 0.01 percent foreign material, according to a paper from the government of Alberta.²⁴

Riley Gordon, an engineer with AURI, states that food processing equipment essentially includes the following: seed huller — to make hemp hearts; screw pressing — to make hemp oil and meal; oil filter — to clean impurities from hemp oil; milling — to powder hemp cake; sifting — to turn hemp cake into flour or protein powder; and CBD extraction — to make CBD oil. Other food-related considerations could include equipment needed for making hemp milk (which would also require a blender and filter cloth), and for Hemp Beer, which is generally made from the hulled seed added in as an ingredient to the traditional brewing process; although including some of the resins and/or terpenes found in the flower material to make new products may be another opportunity for the brewing industry, as these compounds have similarities to those found in a traditional hop. Common hemp grain cleaning equipment used to meet Canadian standards include air screen cleaners, indents, graders, gravity tables and, in some cases, a color sorter may be necessary if there is a significant amount of ergot or sclerotia affected grain.⁶²

HEMP AS A FOOD PRODUCT

Hemp-derived ingredients such as seeds, hearts (the shelled seeds of the industrial hemp plant) and oils are appearing with more frequency in global food markets, including Europe and North America. In conjunction with the signing of the 2018 U.S. Farm Bill, former Food and Drug Administration (FDA) Commissioner Scott Gottlieb stated the classification of these three ingredients is “Generally Recognized as Safe” (GRAS) as food products, or for use in food products. This means additional approvals are not required if marketers do not make health claims. A fourth hemp-derived ingredient, cannabidiol (CBD), is gaining popularity as a wellness product and food ingredient, though the FDA has clearly communicated that CBD is not legal for use in food and beverage product as of mid-2019.

Opportunities

Hemp protein is a non-allergenic, plant-based protein. There will be a potential opportunity to blend hemp protein with other non-allergenic plant based proteins.

Hemp derived ingredients like seeds, hemp hearts, and oil are the most common forms of hemp found in food. The United States imports hemp products primarily from Canada. As such, U.S. companies are beginning to work with hemp as a processed food ingredient given the public interest.

Because of hemp’s relatively high protein content (25%), it is a viable alternative to other high protein, emerging plant-based sources. Hemp protein concentrates and isolates are available and can fortify products, such as bars or cereal. Another possibility is hemp-based protein beverages, though the solubility of the protein may limit the amount incorporated.

Dietary fiber supplementation in snack products is another opportunity for hemp. The seed contains both soluble and insoluble fiber making it a good option for fiber fortification.

Finally, hemp oil presents an opportunity to take advantage of the nutritional benefits of the plant. The fatty acid profile of the oil is 80 percent polyunsaturated, including the essential omega-6 and omega-3 fatty acids.

Hemp ingredients could also represent a unique opportunity in the craft brewing industry. Brewers could utilize the flour or hemp hearts in the mash or add the terpenes as a flavor or aroma compound.

Hurdles

Hurdles to the use of hemp-based ingredients include functionality shortfalls, market competition from a multitude of other plant protein options, lack of food grade processing capabilities, and lack of local sourcing for the raw ingredients. Regarding functionality, limited research has resulted in unfavorable comparisons to other, more established plant-based proteins. However, additional research into processing methods combined with breeding and genetic efforts, such as those at the University of Minnesota Plant Protein Innovation Center, should improve the understanding of hemp’s perceived shortcomings and result in higher usage in food products as these challenges are overcome.

With the introduction of the Minnesota Department of Agriculture’s Hemp Pilot Program in 2016, Minnesota has seen a steady increase in the total acreage of industrial hemp. While the total acreage has increased over the past three years, the processing capabilities required to transform the raw agricultural commodity into viable food ingredients have lagged. This lack of viable food grade processing, along with the limited acreage of hemp, has led to the need for importing the majority of food grade hemp ingredients from either Canada or the European Union.

Hemp Food Landscape - Market Overview



Figure 1

US Hemp-based Product Sales in 2017 (\$795 mil)
Source: *Hemp Business Journal*

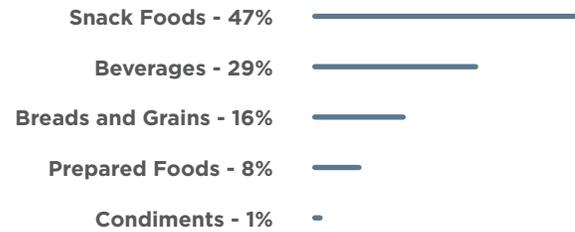


Figure 2

US Hemp-based Food Sales in 2017 (\$112 mil)
Source: *Hemp Business Journal*

Hurdles

- Hemp protein functionality limited vs other plant proteins
- Market-relevant differentiation from other plant proteins
- Lack of processing for food grade hemp ingredients
- Competition from well-established international supply chains

Product Opportunities

- Hemp protein beverages
- Hemp-based milk replacements
- Hemp protein concentrate and isolates
- Hemp protein blends
- Hemp protein bars
- Hemp as a fiber source
- Hemp oils
- Hemp flour
- Hemp as a brewing or distilling ingredient
- Non-GMO ingredients

Existing Infrastructure

Minnesota is a hub for food companies and processors. With the steady growth of Minnesota hemp acreage, expectations are that investment in food grade hemp processing will also increase.

Processing capability investment opportunities include:

- Seed defatting (cold-press and chemical extraction)
- Protein concentration (concentrates and isolates)
- Protein functionalization
- Flour milling
- Fiber processing

Forecasted Market Potential

There appears to be a strong path forward for hemp oils and proteins in the food market. More regulatory and science-based information is necessary to understand the true market of food products containing CBD. Minnesota is well suited to be a market player in the hemp food sector.

AURI Involvement

AURI expertise:

- Shelf life and packaging guidance
- Regulatory compliance
- Chemical analysis
- Nutrition labeling
- Product development guidance and troubleshooting

AURI can assist clients interested in hemp-based foods to commercialize their products. AURI scientists use analytical and food labs to aid companies with nutrition labels, optimize protein powders, analyze cold pressed oils for essential fatty acid content and provide food product development guidance.

Reach out to AURI to learn more about how AURI can help move your hemp food idea forward!



PROFILE: HEALTHY OILSEEDS

Roger Gussiaas farmed for many years before starting Healthy Oilseeds LLC in 2002. The company grows, processes and exports organic and non-organic grains and oilseeds. Located in Carrington, North Dakota, the company sells flax, borage and, increasingly, hemp to clients across the globe, including Algeria, China, Columbia, Kazakhstan, Malaysia and Taiwan.

Gussiaas, president of Healthy Oilseeds, said the hemp market is growing by the day. The growth is fueled both by consumers looking for healthier, organic options in their diet and by companies recognizing the many uses of the plant. Hemp has many nutritional advantages and it can be grown with less environmental impact compared to other crops. Consumers are also willing to pay more for a premium product.

He recently attended SupplySide West, one of the industry's largest food and beverage trade shows. Hemp was one of the hottest topics of discussion, and since the passage of the farm bill the calls from across the country have increased steadily.

"I wanted to get into hemp, but I always thought it would be a secondary product and it would never be that big," he said. "But it has taken off and now much of our business is hemp seed. It has really surprised me. It is amazing how many people are asking for it."

Healthy Oilseeds is one of the larger processors in the United States, Gussiaas said, but the company is still very much a small business. It is one of the few companies in the industry to be certified organic by the International Certification Services and kosher certified by Seal K.

"I think there is as much opportunity with hemp as any other well-balanced oil seed," he said.

Another growing segment is older people looking for an alternative to pharmaceuticals and prescription medications.

"People from 55 up to 80 years old are all asking about hemp (CBD). They know it is a very healthy product and may be able to get them off some of their medications and make them feel better," he said.

Whatever the use and whatever the product, Gussiaas is happy to supply it. He said there are plans to expand Healthy Oilseeds to be able to increase production.

"We are getting larger equipment almost every month. We have seven employees right now. We are small, but we have the potential to really grow," he predicted.



BIOBASED LANDSCAPE

MARKET LANDSCAPE/COMPETITIVE OVERVIEW

The adoption and use of hemp-based materials has been steadily increasing in the United States over the past decade due to the increasing interest and capabilities of farming, processing and manufacturing globally.⁶³ Both the oil and fiber found in the industrial hemp crop can be used in the production of material goods. The utility of hemp is not a recent discovery. Evidence from Chinese archaeologists suggests hemp fibers have been used as far back as 4,000 years ago.

There are a large variety of biobased hemp products available today with the number of products continuing to increase as the crop gains popularity and new uses are discovered. The green bark-like stem of the hemp plant contains long, strong fibers, referred to as bast fibers. These fibers are commonly used in products such as clothing, rope, paper, textiles, yarn, carpeting, home furnishings, composites and biobased plastics.

“

**THE UTILITY
OF HEMP
IS NOT A
RECENT
DISCOVERY.**

”

The definition of a biobased good is not necessarily a product composed entirely of unaltered resources, but rather comprised of materials that are renewable.⁶⁷ Biobased plastics obtained from renewable resources, such as industrial hemp, aid in the reduction of fossil fuel consumption and CO₂ emissions.⁶⁸ In addition to providing cleaner alternatives, fibers obtained from natural resources are among the most ample of natural polymers. Products made using these fibers have been shown to have a low cost and increased-impact strength, along with other desirable mechanical properties.⁶⁶

As hemp fibers make their way into a large variety of plastic-based applications, more and more manufacturers are beginning to explore this opportunity. It provides a “greener” alternative to traditional materials, reducing the use of petroleum and synthetic materials.⁶³ While fibers from plants such as hemp — referred to as fiber-based biocomposites — are being considered as a potential replacement for both synthetic and biodegradable films, further exploration and development is required before determining whether this provides novel products with improved properties.⁶⁴ The increasing importance of creating these materials from renewable resources, however, is driving these advancements.⁷⁰

With demand increases for resource-efficient models for construction, renovation and maintenance, sustainable building practices such as the use of hemp fiber continues to rise in popularity. Building materials that are traditionally wood- and petroleum-based products are now being created from hemp, offering an environmentally superior alternative.⁶³ Hemp and natural fibers are lightweight and have a high strength-to-weight ratio are more recyclable than traditional building materials.¹¹ Shifting priorities of this market and growing appreciation for these benefits led to the use of industrial hemp gaining traction against alternate resources.⁶³

Another common and historic use of hemp is in the production of paper. The strength of hemp fibers lends itself to the production of high-quality papers for a variety of uses. The development of mechanical and chemical pulping in the early 19th century, coupled with the restrictions of the industrial hemp crop in the 1930s, however, led to the rise of using wood pulp for paper. In countries where hemp production has continued through the 21st century, plant-based pulping remains a common practice.⁶⁴

Although the development of wood-based pulping techniques has nearly eliminated hemp from the papermaking process in the United States over the last 100 years, it is starting to make a comeback with specialty papers and new processing techniques.⁶³ A variety of manufacturers and business entities are beginning to incorporate hemp materials into paper products, including fine-art paper, packaging board stocks, soft tissue products, rolling papers and commercial-grade printing paper in varying weights. Using a wood-based pulp mill to pulp hemp at a smaller scale could provide mills with the opportunity to explore new markets with minimal additional costs by capitalizing on the existing infrastructures.⁶⁴

An early adopter, a paper company in California, has been producing commercial-grade hemp paper since the 1990s.⁶³ If the U.S. market reflects the European market, however, further developments will need to be made before this approach becomes common practice, as hemp pulp is roughly five times the price of wood pulp.¹¹ Hemp paper can also be produced from the hurds, the end product having less strength than paper produced from the fibers, but being softer, thicker, easier to make and more desirable for most everyday paper purposes.⁷¹



The fiber from industrial hemp can also be used to make other consumer goods. As an example, the first hemp-based sunglasses have been recently developed by an eyewear company dedicated to hemp products. The fibers are durable and long-lasting, providing an ideal material to be used in production. Another eyewear company is selling a plant-based, urethane frame with a hemp ventilation system and 100 percent recycled cushioning ski goggle. It is the first of its kind to make it to commercialization with hopes to lead the next market trend with its green approach.⁶³

Additionally, automobile manufacturers are wise to the benefits of using hemp-based composites and plastics in their vehicles, with some doing so for over two decades. High-end companies such as BMW, Mercedes, Jaguar and Volkswagen have been experimenting with the use of these plant-based materials in various parts of the vehicle, including interior door paneling, dashboards, body molding and interior upholstery. Introducing hemp and natural fiber products into the production of automobiles, and even aircrafts, has brought a new way to lighten, strengthen and make products more fuel-efficient, not to mention environmentally friendly.⁶³

Another use of hemp fiber that is quickly gaining speed in today's market is that of fabric production. Similar to cotton, hemp can be processed into a variety of fabrics, including high-quality linens. In fact, compared to cotton, hemp provides a stronger, longer-lasting end product while achieving the same levels of quality and softness. When combined with other fibers, the strength of the hemp fibers easily incorporates with the desirable qualities of the other fibers, such as the elasticity of cotton or the smoothness of silk. Aside from the minimal elasticity properties of hemp fibers, has beneficial characteristics superior to cotton in that it is moth-resistant, more durable, less prone to fading and more absorbent.

Hemp fibers also have insulation properties that are not found in other natural fibers which includes the ability to screen out harmful UV rays. While there are nearly 30 varieties of hemp fiber, only those possessing high-tensile strength, fineness and luster have commercial value in the fabric market. Hemp materials with these attributes are a plausible substitute for cotton. Different processing techniques can be used in converting hemp fibers into textiles, one of which is referred to as "cottonized" hemp fibers, which can be processed on cotton spinning machines.

Chinese textile industries have recently started exploring the replacement of cotton with hemp fibers, and countries in Europe have experimented with "cottonized hemp" as a serious alternative to imported cottons. Not only can these fibers be used in apparel, but because of the high-absorbency properties, they work well in items such as bedcovers, table linens, bath towels, padded seats, baby clothing and diapers.⁷² Unfortunately, until there are more established processing facilities or technological advancements to develop this industry further, non-hemp alternatives will continue to be a more economical route, limiting its market share as a natural fiber crop.¹¹

One of the most exciting innovations in the last few years is the development of graphene-like nanosheets used for supercapacitor electrodes created from industrial hemp bast fiber. This material exhibits excellent electrochemical performance at a significantly lower cost to that of industry standard graphene materials.¹⁰² Researchers in Canada have been producing favorable data that indicates hemp-based supercapacitors offer an affordable next-generation energy source to replace rechargeable batteries for applications such as electric cars, power tools and mobile devices.¹⁰³

SUPPLY CHAIN BARRIERS IN THE UNITED STATES

While industrial hemp is slowly working back into the marketplace in the United States, hemp fiber textiles have been used for thousands of years in China, which remains the leading producer of these fiber textiles today.⁶⁴ China has established spinning facilities for natural hemp fibers in addition to possessing a lower-cost labor force, creating obstacles for other nations looking to enter the hemp textile industry competitively.

Additionally, Chinese processing regulations allow for water retting, a cost-effective but environmentally detrimental approach. This has created challenges for the resurgence of the hemp textile industry in Europe. New technologies are not as cost effective, allowing China to remain the industry leader for the foreseeable future in the production of high-quality hemp textiles for apparel.¹¹

Although China has an established industry, this has not prevented Europe from finding alternative ways to use the fiber from the industrial hemp crop. Aside from apparel, hemp fiber has become a popular material in the production of pressed fiber, insulation products, and plastic. The largest industrial applications for hemp fibers in the European market have been in the automobile, construction and agriculture industries. While there are certain benefits to using hemp fibers, market success has largely been driven by government programs related to “green support” policies. Should this support diminish, the future of this market is uncertain.¹¹

With European subsidies and lowest cost production in China, it will continue to be difficult for other countries such as Canada and the United States to compete. The technological advancements, established processes and general industry support are not as strong in these markets, posing further barriers to entry. Additionally, biomass has yet to prove itself as a sustainable investment value in North America. Lumber waste and residue from already established and regulated crops create strong competition for those crops cultivated specifically for biomass.¹¹ The interest in environmentally sustainable natural fibers is on the rise, however, creating business opportunities to be further explored in North America. As this market gains popularity, a demand for more local processing facilities to supply sufficient quantities of quality materials will surface.⁶⁴

PROCESSING REQUIREMENTS

Some hemp crops are grown for both oilseeds and fiber. These dual-purpose crops produce modest seed yields and relatively low-quality fiber, limiting the profitability of both end products.⁶⁴ Hemp that is grown solely for fiber production is typically harvested in the early flowering stage to maximize the fiber volume; however, harvest timing may vary depending on the requirements of the processor. This type of industrial hemp crop is expected to reach heights in excess of eight feet, and has been reported to reach upwards of 12 feet.²⁴

The end use of the fiber may determine the ideal length of fiber for processing.⁶⁵ For example, if the fiber is used in the production of textiles, processors may prefer the stalks be as long as possible. Shorter stalks may be desired for other applications. Unfortunately, traditional equipment used to reduce the size of other stalks could struggle with hemp because of the tough fibers and tendency to wrap around moving parts.⁶⁴

Additionally, cutting taller stalks will pose difficulties because the equipment used requires the ability to accommodate large volumes. On the following page is an image showcasing the cutting process with a sickle bar and swather, ideal for cutting hemp used for fiber only.²⁴



Additional processing steps are end use dependent. The stalks can either be baled and used directly or may go through a retting process. As explained in the Harvest and Storage section, on pages 12 and 13, the retting process is conducted to allow the separation of bast fibers from the hurd. The degree to which the stalks are retted makes mechanical processing easier, reduces impurities between the fiber and hurd, and contributes to desirable qualities in the final product, color being one example.²⁴

There are various ways retting is conducted, including field, winter, water and enzymatic retting. Enzymatic retting has the potential to enhance the separation process, given it is done in a controlled industrial environment. Unfortunately, this approach is more cost-intensive than others, requiring a high value proposition for the end product to remain sustainable.⁶⁴

After the retting process is complete, the hemp stalks must be baled. In order to prevent molding or rotting while in storage, it is best to bale at low stalk moisture levels. Bales are also best stored under dry conditions to reduce this risk.⁶⁴ Baling immediately after cutting can help minimize the possibility of fiber wrapping but, if retting is desired by the processor, it is ideal to wait a considerable amount of time between cutting and baling to eliminate this potential obstacle.²⁴ Unfortunately, one of the more significant concerns for this crop is the economic ramifications regarding cost of transportation to a processing center. Hemp is bulky and heavy, and is not cost-effective to ship far from a processing plant, with a maximum of 80 km (50 miles) away being the identified threshold by the Illinois Hemp Task Force.¹¹ As the demand for hemp fiber and hurds continues to grow, however, commercial investments into processing facilities are likely to follow.⁶⁴

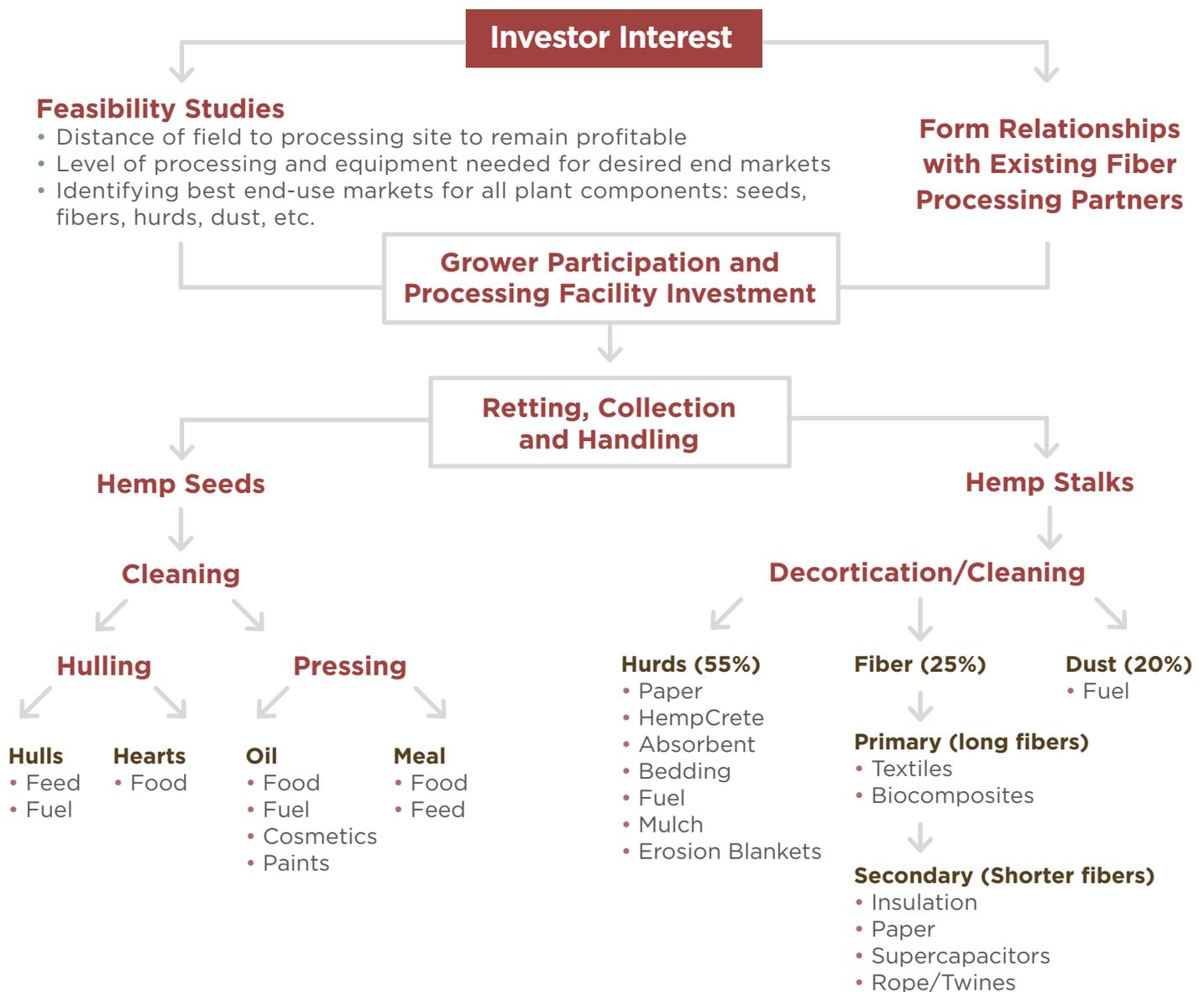
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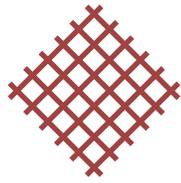
Hemp Fiber Value Chain

Forecasted Projections for Minnesota

OPPORTUNITY FOR HEMP FIBER

One of AURI's core objectives is to find new, reliable, biobased products. Hemp fiber's low weight and high tensile strength can provide increased performance in products including composites, textiles, insulations and more. Hemp hurd is the inner core of the hemp stalk and can be likened to an absorbent wood chip after processing. It can serve as a substitute or additive in building materials, composites, paper pulp, animal bedding and more. Additionally, hemp fiber and hurd are biobased materials which can improve performance when utilized in new and existing products. These raw materials come from the hemp stalk, where the bast fiber length and quality depend on the variety of hemp grown and processing method. Long fiber stalks can yield fibers for textiles and high-quality biocomposites, while the shorter fibers are better suited for insulations, paper, supercapacitors and lower quality biocomposites.





FIBER

Hurdles

- Lack of processing
- Feasibility studies on market potential
- Product development research for hemp fiber inclusions
- Lack of weed control in hemp fiber variety crops

Forecasted Market Potential

The market potential of hemp fiber remains unknown. End-user market assessments are currently underway and will set a path for fiber processing infrastructure. Minnesota is well suited to be a market player in this sector.

Existing Infrastructure

Hemp hurds and fibers are unique raw materials that have hundreds of potential applications. Many existing businesses and industries in the state could benefit from the use of these biobased materials as alternatives to their existing materials.

- Window companies
- Cabinet manufacturers
- Composite manufacturers
- Building companies
- Fiber in concrete applications
- Hurd and fiber in insulations
- Textile manufacturers
- Automobile companies

Product Opportunities

- Textiles (fiber)
- Biocomposites – automobiles, furniture, panels, etc. (fiber)
- Rope/twine (fiber)
- Supercapacitors (carbon-based hemp fiber nanosheets)
- Batt insulation (fiber)
- Animal bedding (hurd)
- HempCrete insulation (hurd)
- Fuel (hurd)
- Mulch (hurd)
- Paper (hurd/fiber)
- Erosion blankets (hurd)

AURI Involvement

- Coproducts facility in Waseca is a unique value-added facility in the Midwest.
- Coproducts lab is uniquely positioned to aid in product development involving hemp fibers or hurds.
- Capabilities include but are not limited to:
 - Pelleting
 - Milling
 - Aspiration
 - Mechanical separating
 - Mechanical and thermal dewatering
 - Cold oil pressing and filtration
 - Blending/mixing ingredients
 - Bedding development/ammonia testing
- The coproducts lab also plans to house decortication equipment in the future to do R&D work on the fiber from retting to utilization.
- Reach out to Harold Stanislawski, Al Doering or Riley Gordon at AURI to learn more about how AURI can help move your hemp fiber or hurd idea forward.

Sources:

Fiber – A modified graphic from: North Dakota StateCite Source: *Industrial Hemp as an Alternative Crop in North Dakota*, NDSU, 1998
Feed (Table 1) – *Crude Protein/TDN of Corn*: www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/400/400-230/400-230_pdf.pdf
Crude Protein/TDN of Alfalfa Hay – www.uaex.edu/publications/pdf/FSA-4000.pdf
Crude Protein/TDN of SBM – www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/400/400-011/400-011_pdf.pdf

PROFILE: C2RENEW

Dr. Chad Ulven is a professor of mechanical engineering at North Dakota State University. He is also the chief technology officer of c2renew, Inc., a material designer and custom compounder utilizing a variety of proprietary biocomposite formulations. From its 15,000 square foot operations center in Fargo, the company makes composite components for a wide-ranging list of products like a coffee mug made from coffee, sunglasses made from beer and a guitar pick made of hemp.

Hemp wasn't part of the original business plan, Ulven said, but in the past two to three years, the interest in hemp-based composites has really grown.

"We could make these products out of flax and no one would really know the difference," he said. "But people are really gravitating toward these products right now because of the hype surrounding hemp. Companies are coming up with some innovative and really cool products." c2renew manufactures compounds for applications to be used in specific products. They supply companies which make air fresheners, toothbrushes, coat hangers, backpacks and vinyl records for clients in Europe, South America and across the United States.

"One company, in particular, has approached us to look into drinking straws," Ulven said. "It's so broad; it's amazing who we talk to. Hemp has really taken off."

The company sources its hemp from two processors: one in Kentucky and one in Nebraska.

"One of our first companies has really exploded. We can't supply them with materials fast enough," he said.

To keep up with demand, c2renew plans to bring a second compounding unit online in 2019 with the plan to increase capacity tenfold. They have also explored adding a second facility.

AURI was a helpful partner in the company's evolution, Ulven said. The main benefit of organizations like AURI is knowledge sharing and bringing together thought leaders and experts in the industry to share and ask questions. For continued expansion of hemp to be successful, it will take the combined efforts of farmers, processors, lawmakers, scientists and entrepreneurs.

"The next big thing is improving the technology within our borders. Using hemp core as fillers in plastics or as animal bedding is the low hanging fruit. The real challenge, and opportunity, is how do we make woven textiles out of the fiber for advanced composites and clothing? That is a much higher value use of the fiber. But how are we going to get there?" Ulven said.

PROFILE: HEMP ACRES LLC

In 2017, Charles Levine participated in the Hemp Solutions of Minnesota LLC exhibit at the Minnesota State Fair to speak with people about hemp and his fledgling business, Hemp Acres LLC.

“About 80 percent of the people who came to the booth asked me if hemp would get them high. I said, ‘No. There is nothing psychotropic about this in any form,’” Levine remembered.

Today, thanks to efforts from the science, education and agricultural community, as well as organizations like AURI, the public has more knowledge about hemp. People are starting to recognize the plant’s untapped potential for use in a host of everyday products, Levine said, and this is only the beginning.

Hemp is ready to take off, he believes, and Levine plans to be in the center of the action. “As far as anything we can put in the ground, hemp has the most potential and so many different possibilities,” Levine said. “It is endless. From rope, to textiles, to food, plastics and medicine, hemp is one of the most versatile and exciting plants there is. I really believe there is going to be a paradigm shift and it is only going to become more popular as more people learn about how it can be used.”

In 2018, Levine grew and harvested approximately 70 acres of hemp at his family farm in Waconia, Minnesota. He processed the resulting grain into seed oil and protein powder.

Levine also converted his steel sheds, once used for black angus cattle, into a hemp processing facility. His long-term goal is to have the capacity to process 100,000 acres of hemp. By the summer of 2019 he wants to add CBD extraction to his facility. Getting the business up and running took a lot of work and a lot of learning, Levine said. Most learnings were self-taught because there wasn’t an established business he could lean on as a resource. He was motivated by the desire to become the first large scale hemp processing business in the greater Midwest.

“I saw the need on the processing side because everyone that was growing hemp had nowhere to go with their product,” he said. “I started Hemp Acres LLC because I wanted to be a source for local farmers who want to grow hemp. They need a viable outlet to buy and process their crop.”



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THE FUTURE MARKET FOR CBD OIL MAY BE A ROBUST USE FOR HEMP.

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CBD OIL LANDSCAPE

Cannabidiol, or CBD, is a non-intoxicating chemical compound derived from the cannabis sativa plant.⁷³ It is one of the 100-plus — and counting — known compounds called cannabinoids found in the cannabis or marijuana plant.⁷⁴

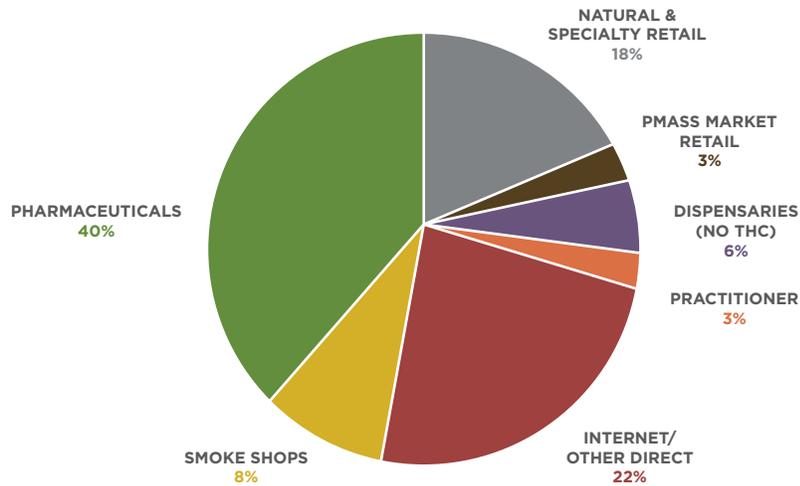
The main psychoactive constituent of medical marijuana is the narcotic delta-9 THC, which has been shown to provide relief from nausea and improve appetite in patients. Industrial hemp has less than 0.3 percent THC, but contains many other bioactive components such as the non-psychoactive cannabinoids. CBD does not have a psychoactive effect, however, it has several potentially beneficial pharmacological properties that are currently being researched in several countries.⁷³

Bioactive components are typically found in the trichome heads found mainly on the plant's female flowers or buds. Lesser amounts are also present on the leaves, grain varieties and seed coats. Supercritical extraction leveraging carbon dioxide, temperature, pressure and solubility differences between the various components is one of several processes that can be used to isolate components of interest.⁷³

The future market for CBD oil may be a robust use for hemp. The research firm, Brightfield Group, claims that CBD is growing faster than cannabis in the United States, and will be a \$22 billion industry by 2022. The legalization of hemp in the 2018 Farm Bill is fueling the growth of CBD, but it is not the only driving factor. Brightfield also highlighted increased investment, the popularity of hemp versus pharmaceutical products in the health and wellness movement, the evolution and improvement of distribution channels, and a steady stream of innovation and new products hitting the market.⁷⁵

Supporters claim that CBD treats a diverse array of ailments. In a study released in 2017, the World Health Organization’s Expert Committee on Drug Dependence said CBD may benefit people diagnosed with inflammation, pain, acne, insomnia, nausea, Alzheimer’s disease, anxiety, depression, psychosis, post-traumatic stress, arthritis, heart disease and even cancer.⁷⁴ The National Institutes of Health database lists approximately 150 studies involving CBD as a treatment for health conditions, including Parkinson’s disease and infant spasms.^{75,76}

\$450 MILLION U.S. HEMP-BASED CBD PRODUCT SALES BY CHANNEL IN 2020 (estimated)



Source: "The State of Hemp 2014-202," New Frontier Data derived from Hemp Business Journal¹

CBD oil can be administered by end-users orally through an eye dropper or added to food and beverage products. It can also be smoked through a vaping device. The future market for the product, however, may be in high-end food, coffee and beauty products, including shampoo and conditioners, eye serums, makeup, soaps, massage oils, lip balms, bath gels, face lotions and body creams.⁷⁷ By breaking CBD down into nanoparticles, it can substantially increase the bioavailability of the product, thus reducing the amount needed.⁷⁸

For example, The Chillhouse, a New York City café and spa, lists CBD honey and ricotta toast on the menu. New York City’s Standard Hotel stocks CBD oil gumdrops in guest room minibars.⁷⁷ Closer to home, Nothing But Hemp opened the first edible hemp store in the Twin Cities in late 2018. Two additional locations opened in early 2019 in south Minneapolis and Forest Lake. The company sells lotions, bath bombs, pain creams, cleansing oils, drops and edibles made with CBD oil.⁷⁹ CBD Hemp Dropz of St. Cloud sells oils for humans and pets, as well as face and pain creams, and gumdrops. Products range in price from \$45 to \$120.⁸⁰

In the fall of 2018, the Las Vegas-based CV Sciences, a supplier and manufacturer of hemp-derived phytocannabinoids including CBD oil, became the first U.S. company to receive the self-affirmed Generally Recognized as Safe (GRAS) status for their CBD products in accordance with stringent U.S. Food and Drug Administration safety guidelines. The designation recognizes an ingredient as presumably safe among experts under the conditions of its intended use.⁸¹ Manitoba Harvest also achieved self-affirmed GRAS status on its broad-spectrum CBD products in early 2019.⁸²

In June of 2018, the U.S. Food and Drug Administration approved Epidiolex, an oral solution for the treatment of seizures associated with two rare and severe forms of epilepsy — Lennox-Gastaut syndrome and Dravet syndrome in patients two years of age and older. This is the first FDA-approved drug that contains CBD oil. It is also the first FDA approval of a drug for the treatment of patients with Dravet syndrome.⁸³

LICENSING / REGULATORY

CBD oil has not been approved for commercial use, though 47 states allow sales of some form of CBD, and there are many states that have laws directly related to CBD oil. Different states also require different levels of prescription to possess and use CBD oil. CBD oil is legal to purchase in Minnesota without a prescription, if the THC concentration is below 0.3 percent.⁸⁴

While you do not need a prescription for it in Minnesota, officials in many states have shut down stores selling products containing CBD oil, mainly due to not having FDA clarification.

Many CBD oil advocates favor a regulatory framework where products that contain high doses of CBD would be placed in a prescription-only category, whereas lower-dose products could be sold over the counter at retail stores as food and health supplements.⁸⁵

PROCESSING

Industrial production of CBD oil is done by combining the cannabinoid-rich plant with other compounds like CO₂, butane, ethanol or even olive oil, which act as solvents to extract the cannabinoids from the plant. Auxiliary processes such as winterization, short path distillation and chromatography are utilized to further refine and concentrate CBD content. The crude extracted oil, whether it be ethanol or CO₂ extracted, etc., is often bound with a carrier oil like MCT oil or hemp seed oil to make a final product such as a tincture. CBD carrier oil represents one of the largest markets in the United States right now, said Riley Gordon of AURI, as there is a marketing benefit to having products that are “100 percent hemp-based.”⁶²

The most important part of CBD oil extraction is selection of the right plant for the extraction of oil. The cost of final product depends upon potency and purity, which is controllable only via oil extraction techniques.⁸⁶

CO₂ extraction is also among the cleanest techniques of extraction, utilizing carbon dioxide under different pressures to extract the oil. This is among the most expensive techniques of extraction due to use of hi-tech equipment that can be operated by trained personnel only. The advantage of this technique is that it captures the purest form of CBD oil that is highly concentrated and free of chlorophyll.⁸⁶ Decarboxylation is a complimentary process of applying heat to the cannabinoids in order to remove a carboxyl group and release CO₂. It transforms the naturally occurring CBDa into the active form, CBD. More research is required to truly understand the difference between the acidic and decarboxylated forms of cannabinoids. But it is likely that there is a place for both in products.^{87,88}

Carrier oil extraction is the most inexpensive method of extracting CBD oil, however, the resulting oil contains high levels of omega rich acids and lower chemical residue levels. Usually, hemp seed oil or olive oil are used as a carrier to extract resin from the plants and flowers. With this method, hemp seed oil is not evaporated away after the process, so users must consume much higher quantities than the higher-concentrated oil produced by other methods.⁸⁶



Extraction with solvents is a common, inexpensive, equipment-free and simple method preferred by small-scale producers of CBD oils. During extraction, this method uses solvents like butane, ethanol and alcohol derived from grains. Disadvantages include leftover residue of the solvents and, in rare cases, explosions and fires. These negative effects, however, can usually be countered by adjusting the process.⁸⁶

CHALLENGES

The challenges to businesses in the CBD oil market are similar to those found throughout the hemp industry. There is a supply shortage of the plant, limited processing options, an untested market chain, and confusing state and federal regulation. There are also no standardized regulations or accepted testing procedures for cannabinoid content in finished products.

Selling CBD oils that are used as dietary supplements or pharmaceuticals remains illegal. Growing hemp for CBD is also more labor-intensive than growing it for food or fiber. Following the designation of hemp as a legal agricultural crop in the 2018 Farm Bill, Scott Gottlieb, the FDA Commissioner, restated the agency's position that CBD is a drug ingredient and illegal to add to food or health products without approval from the agency. The FDA has specifically stated that CBD oil cannot be sold as a dietary supplement.⁸³

There are also financial constraints. Many farmers, especially, report that banks are hesitant to accept deposits, nor will they make loans to hemp-based businesses. Insurance companies do not cover CBD oil-based treatments or medications. Some retailers also report being unable to find a company to process credit card transactions, forcing their businesses to be cash-only.³⁸

CBD is poised to become the most valuable market within the rapidly emerging cannabis industry. With a rising number of various CBD products available in mainstream markets, consumers are spending more on such products than ever before. With the CBD market primed for expansive growth with recent regulatory developments and advancements in the hemp industry, farmers across the country are turning their attention to commercialization and profitability.

OVERVIEW: CBD OIL

Cannabidiol (CBD) is a non-intoxicating chemical compound derived from the *cannabis sativa* plant. It is one of the 104 chemical compounds known as cannabinoids found in the industrial hemp plant. Industrial hemp has less than 0.3 percent delta-9 tetrahydrocannabinol (THC) but contains many other bioactive components such as non-psychoactive cannabinoids. CBD does not have a psychoactive effect; however, several potentially beneficial pharmacological properties are currently being researched in several countries. Commonly reported benefits to using CBD include relief of seizures and epilepsy, anti-anxiety effects, pain relief or anti-inflammatory and digestive relief. Although CBD is technically legal due to the farm bill, which passed December 2018, the industry remains fragmented as a result of the federal regulatory status.

Hurdles

With the legalization of industrial hemp after the passage of the farm bill at the end of 2018, the U.S. Food and Drug Administration (FDA) has the authority to regulate all products that contain cannabis or cannabis-derived compounds under the Federal Food, Drug, and Cosmetic Act. Currently, the FDA's stance on CBD in food products is that it is not legal. However, the FDA will conduct analysis to determine if CBD products can be given Generally Recognized as Safe (GRAS) status and be allowed to as a food ingredient.

While CBD isn't a legal food ingredient, the FDA has allowed companies to use CBD in dietary supplements if they do not make therapeutic claims. The use in dietary supplements is allowed since the FDA does not consider them as food, but substances that supplement one's dietary needs. The biggest issue facing companies who put CBD into dietary supplements is the threat of false claims or misbranding. There are companies currently on the market who claim CBD can do things like improve Alzheimer's conditions, cure addiction and reverse cancer cell growth. Unsubstantiated claims, like these, are not compliant with FDA regulations. With time, the FDA will be able to set precedent in dealing with baseless claims and the market should stabilize. Another issue facing the CBD dietary supplement industry is misbranding. While CBD companies cannot make specific claims on their products, they can make claims such as contains "X" mg/mL or "X" mg/bottle. Some companies are finding out that the concentrates received to make their CBD products are not at the level claimed by the supplier. As a result, they can be adding much less to no CBD to their products. This leads to a misbranding claim and an eventual recall.

Technology/ Extraction Issues

CBD extraction choices include supercritical or cold carbon dioxide (CO₂), ethanol, butane, propane, or methanol. Much due diligence is essential to select any one piece of equipment.

AURI recommends obtaining testing and a performance guarantee from the manufacturer before making a purchase.

As of publication, there is currently no certified standard testing method for cannabinoids in hemp products (ex. AOAC, AOCS, etc.) and only one certified lab in Minnesota tests for cannabinoids in products. There is also a lack of standards and regulations on the production of products containing cannabinoids.



CBD

Product Opportunities

- Food
- Supplements
- Tinctures
- Medicine
- Beverages

Hurdles

- Lack of processing and ideal extraction capabilities
- Regulatory uncertainty
- False CBD concentration claims

Existing Infrastructure

Growing hemp in Minnesota has great potential. Some farmers are growing industrial hemp for CBD indoors in greenhouses, which may be a viable alternative to outdoor growing operations.

- Processors
- CBD extractors (CO₂, ethanol, and others)
- Diverse food ecosystem to introduce CBD products

Forecasted Market Potential

While there are many projections for the CBD market, true market potential remains unknown due to the ever-changing industry from technical, legal, political and regulatory standpoints.

Recent reports project the CBD markets will hit \$22 billion by 2022.

AURI Involvement

The AURI coproducts lab can help with research on harvest improvement, handling, and drying techniques for hemp as it is prepared for CBD extraction.

AURI can:

- Test THC levels of non-certified hemp flower and leaves throughout grow cycle.
- Test cannabinoid content pre-and post-extraction to understand processing efficiencies.



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WHILE THE HEMP SEED IS A GREAT SOURCE OF OIL AND NUTRITION, THE STALKS PROVIDE FIBER AND “HURD” THAT OFFERS VIABLE ALTERNATIVES TO COMPETING CROPS.

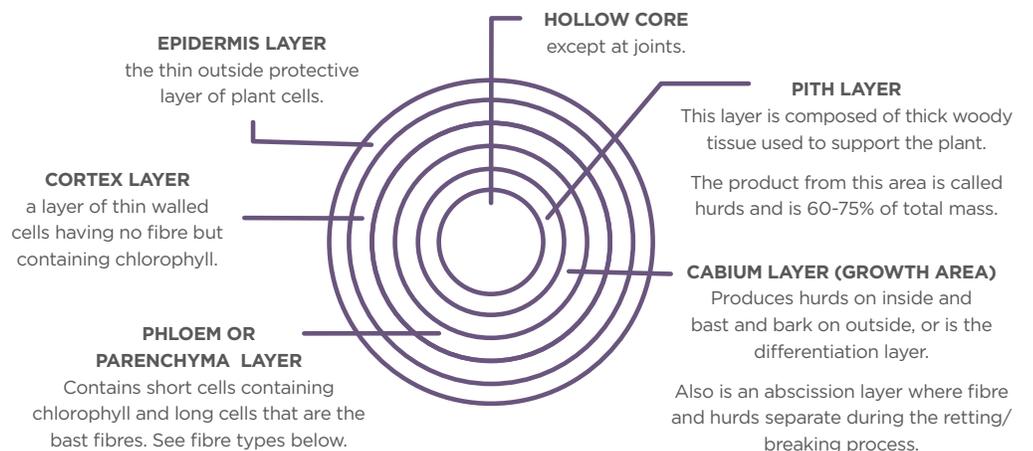
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FEED AND COPRODUCTS LANDSCAPE

MARKET OVERVIEW

Industrial hemp can be used for a large variety of goods and products. While the hemp seed is a great source of oil and nutrition, the stalks provide fiber and “hurd” that offers viable alternatives to competing crops. The byproducts remaining after the processing of fibers can offer value in and of themselves; products made with these residual parts are called “coproducts.” The inner core of the stem, white in color, is called the “hurd;” it is usually the main component of these products. Roughly 70 percent of the hemp plant is composed of the hurd.⁸⁹ Differing from the bast fibers, these fibers are light and short. They are used in materials such as animal bedding, oil absorbents and building supplies.⁶⁵

THE HEMP STEM (CROSS SECTION)



Source: British Columbia Ministry of Agriculture and Food, “Industrial Hemp Fact Sheet”⁶⁵

Hemp hurd can be used as an insulation and building material known as hempcrete. Hempcrete is made by mixing hemp hurd with a lime binder and water, creating a chemical-free and fire-, rot- and pest-resistant insulation. The use of hempcrete allows for untreated softwood to be used in structural frames, which further reduces the need for any chemical additives in the home.⁹⁰ Hempcrete used as insulation is also a cost-efficient, energy friendly alternative to traditional insulation. The hempcrete can be installed in irregular shapes and plastered, creating a high level of air tightness to the building.⁹¹ Interiors of buildings insulated with hempcrete are able to maintain a fairly constant temperature, creating lower demand on heating and cooling systems, and reducing energy costs. The ability to store heat within the material, as well as fill any structure to the edges, provides a competitive advantage for hempcrete over lightweight insulation options.⁹⁰

The use of hemp in building materials offers environmental benefits, not only because it is a natural material, but because it has strong temperature-regulating properties that reduce energy costs. It is non-toxic and allows for the accumulation of carbon dioxide within it, decreasing additional negative impacts on the environment.⁶³ It is considered a “better-than-zero-carbon material,” which means more carbon from the atmosphere is stored within the material for the lifetime of the building than was used in its production and use.⁹²

In addition to the environmental benefits of using hemp hurd in building materials, many companies use hurds for oil and chemical spill reclamation. Due to the porous, absorbent properties of hurd, it acts similar to a sponge. This offers a chemical-free, environmentally friendly way to reverse the effects of spilled synthetic materials. Hemp products of this nature are beginning to enter the market.⁶³

Another practical use of hemp byproducts is as a substrate for the production of engineered particle boards. Hemp hurds can be used as a stand-alone material or combined with wood to produce these boards. Because of the low density of hemp, the particle boards are lightweight. These boards can be used in a variety of ways, commonly including kitchen cabinets, door cores, ceiling panels and veneered furniture.⁸⁹ Offering an alternative to wood for these products can help eliminate resource fatigue that can occur with commonly used materials.

The absorbency of hemp hurd is a desirable quality in animal bedding products and has led to increased uses in this market. There is also little to no dust produced for the animal to inhale, and hemp bedding reduces harmful ammonia odors, making for a safer alternative to traditional bedding. Bacterial growth can occur in damp bedding, leading to a variety of illnesses that can quickly spread to both animals and humans. With hemp, the risk for this is reduced given the sponge-like absorbent properties. Additionally, it has the ability to retain heat, which will keep animals warmer, reducing energy costs. This bedding is non-acidic and biodegradable, providing an earth-friendly alternative to others on the market.⁹³

Compared to competitors such as pine shavings or straw, hemp is two times more absorbent, leading to higher salvage rates and cost savings, in addition to decomposing at a faster rate than other bedding materials.⁹⁴

Hemp paper can also be produced from the hurds, the end product having less strength than paper produced from the fibers, but being softer, thicker, easier to make and more desirable for most everyday paper purposes.¹¹

Other coproducts that result from hemp processing include the hulls from the seed when making hemp hearts, hemp cake or “press meal” after cold-pressing the oil from the grain and spent flower material after CBD has been extracted.

The AAFCO conducts scientific reviews of ingredients used in animal food in the United States before they are allowed to be sold or distributed. Currently, the hemp industry has yet to submit significant data indicating that ingredients derived from the crop are safe and useful in animal food.

Source: National Grain and Feed Association, May 2019

The hulls from hemp seed could have great value as an animal feed source, as would the press cake meal and extracted hemp flower. Work needs to be done yet in order to achieve AAFCO (Association of American Feed Control Officials) certification for hemp and its coproducts, however, in order for it to be legally marketed as an animal feed. This work is under way in states such as Colorado and North Carolina, where industrial hemp was approved as a pilot crop under the 2014 Farm Bill. Additional work also needs to be conducted in the pet food industry with hemp-derived products. The work currently is of significant importance, and needs to be done to achieve legality for the marketing of hemp byproducts as an animal feed. This will make a significant difference to the viability of the industry once achieved, according to Riley Gordon, AURI.⁶²

The press meal maintains its highest value in the human food protein market. The cake can be milled and sifted in order to create flours and high protein* cuts that make great plant-based food products. Depending on the market, the oil may also end up as the coproduct.

Even with some controversy surrounding CBD in the human food industry, there has been an increase in use of this extract within pet food and supplies. Treats and other pet products with both CBD and other forms of hemp are on the rise. Some companies are ignoring this lack of approval and marketing products as pet treats, while others are marketing their products instead as pet supplements, which are subject to a different set of regulations.⁶⁰

Supplements for pets are not regulated under DSHEA like they are for humans. This is one of many ways manufacturers can avoid these regulations and still place their products on the market. The naming of such products, as well as the terms used in the ingredients, can dictate to which regulatory laws these products are subjected. For example, as opposed to listing a main ingredient in a pet supplement as CBD, manufacturers in this category often refer to the additive as phytocannabinoid-rich, or PCR. Ensuring proper education for retailers as well as consumers is critical for these manufacturers to remain relevant. The consumer interest and demand in CBD products for both humans and pets will continue to increase.⁶⁰

AURI evaluated the spent flower material that is left over after the CBD oil and resin compounds have been extracted, from both an animal feed and fuel perspective.* The flower came back with a relatively high value as an animal feed. With around 25 percent crude protein on a dry basis and 20 percent aNDF (neutral detergent fiber), which are the carbohydrates, sugars and protein that would easily dissolve in a ruminant's stomach. The low aNDF value indicates a high level of digestibility when compared with grass hay or corn stover which generally ranges from about 40-50 percent aNDF.

*Refer to the renewable energy section of report to see the evaluation of the hurds and press cake coproducts as a fuel source.



Hemp coproducts are products made from the remnants of the crop traditionally after the fiber has been used in the production of other materials.⁶⁵ Similar to other parts of the crop, hemp hurds must remain dry in transportation and storage. This can create difficulties when loading and unloading material, along with the conditions in which it is kept. Ensuring the proper care in both transporting and storing hemp hurds can lead to increased total costs. Furthermore, any additional shipping that is required reduces the carbon-negative feature hemp boasts.⁹⁵ Processing and storing facilities are most effective when located within a reasonable distance to reduce costs and negative environmental effects.¹¹

PROCESSING REQUIREMENTS

Since hemp hurds are obtained as an end result of processing the stalks for fiber, the steps from field to storage are rather similar. After the retting process, the stalks are baled and transported to a processing plant. Once at the plant, a decortication process separates the stalks from the hurds. From there, the stalks continue through the processing steps needed to produce the desired product from the fibers, and the hurds remain to be used in whatever way possible.⁶⁵ In the production of hempcrete, hurds are mixed with a lime-based binder. The high silica content of the woody hemp core allows for ideal binding conditions with the lime, providing the hempcrete with desirable properties.⁹⁵

When using hemp hurd in particle board, the process is similar to that for wood particle board. The hurd is dried and screened, creating uniform particulate sizing. It is then sprayed with resin as it makes its way down a conveyor belt to a blending hopper. The resin used is determined by the intended end use of the product.

Once coated, the hurd is blended for consistency and piped into a press to form a sheet of particle board. The boards then undergo a process that places them under pressure to harden the resin. The final product is a particle board that can be used as is or veneered to replace natural hardwoods in furniture or cabinetry.⁶⁴ Hurds used for bedding and oil / chemical spills require little to no processing, with no chemical additives.*

*Refer to the renewable energy section of report to see the evaluation of the hurds and press cake coproducts as a fuel source.

AT A GLANCE

Hemp Feed Value Chain

Forecasted Projections for Minnesota

OPPORTUNITY FOR HEMP IN FEED AND PET FOOD

The livestock and poultry industries continue to be a growing market. With this growth comes the opportunity and challenge to provide highly nutritious and energy dense feedstuffs to these animals. Protein and energy are the main requirements for these diets. Identifying new feedstuffs that can supply these required nutrients at an economical cost is an on-going opportunity. Hemp coproducts such as hemp cake, hemp hulls, and the high protein hemp flower and stem can provide an excellent source of protein and energy to help support the growing livestock industry.

Product	TDN	Crude Protein
Hemp Cake	81%	33%
Hemp Flower	68%	25%
Hemp Seed Hulls	52%	14%
Corn	90%	10%
Soybean Meal	84%	44%
Alfalfa Hay	58%	17%

Table 1. Energy and crude protein comparison to main livestock feedstuffs.

Hemp coproducts Total Digestible Nutrients (TDN) and crude protein were compared to corn, soybean meal (SBM), and alfalfa hay to determine an equivalent market price for the hemp products at various market inflections.

** All values represented on a dry matter basis. AURI sent samples of locally sourced hemp cake and flower for TDN and crude protein analysis. Hemp hull values were taken from Evolve Hemp Hulls product. (<https://elitethree.com/products/e5-evolve-hemp-hulls>)

The table below provides an estimated market value for the various hemp coproducts samples at two different corn, soybean meal and alfalfa hay prices. These two sets of values show potential value based on the variability of commodity prices. Potential feed value may vary based on the targeted livestock species.

To evaluate feed value, comparisons were made between samples of each feedstuff and #2 corn, which is the primary source of energy in livestock diets; 44 percent protein soybean meal, which is the main source of protein in most North American livestock diets; and, lastly, 17 percent alfalfa hay, a key protein and energy source for ruminant livestock. Estimated values do not consider variability and nutrient requirements for individual ration, or rations balanced for amino acid levels. Least-cost livestock ration formulation software may apply slightly different feed values based upon protein and energy sources available within specific livestock rations.

Table 2. Hemp coproducts feed value fluctuations as compared with common US feed commodities

Product	Corn - \$3.50 / bushel 44% SBM - \$300 / ton 17% Alfalfa Hay - \$140 / ton	Corn - \$4.50 / bushel 44% SBM - \$400 / ton 17% Alfalfa Hay - \$170/ton
Hemp Cake	\$222.40/ton	\$294.33/ton
Hemp Flower and Stem	\$153.80/ton	\$203.00/ton
Hemp Seed Hulls	\$127.33/ton	\$168.85/ton

ADDITIONAL INFORMATION

aafco.org | auri.org/hemp | mda.state.mn.us/plants/hemp/industhempquestions

Hemp cake is a potential feed source for ruminants, poultry and equine. However, cold pressed hemp cake is not ideal for swine feed due to residual unsaturated fatty acids. If chemically extracted hemp cake was available, the defatted cake would be a good feed source for swine. Omega content in cold-pressed meal may be a good opportunity for poultry diets, with high omega eggs having a reliable market. Looking at the amino acid profile for hemp cake, it is deficient in the amino acid lysine. Although, those hurdles are surmountable with proper diet formulation, resulting in new blended feeds. Based on relatively high protein and fat content of the hemp seed cake, it could serve as a protein and energy source for the pet food industry. It appears pet owners have also shown interest in utilizing the active phyto cannabinoids in the hemp plant in their pets' diet.

Hemp flower after the extraction of cannabinoids provides an excellent roughage feedstock with high levels of protein and energy.

Hemp hulls are a coproduct from de-hulling hemp seed. They are the removed husk or seed coat, similar to soybean hulls, which could serve as a soluble fiber and protein feedstock in the livestock industry.



Hurdles
 Work is necessary to achieve American Association of Feed Control Officials (AAFCO) certification for hemp and its coproducts in order to be legally marketed as an animal feed. This work is ongoing in states such as Colorado, Kentucky and North Carolina, where industrial hemp received approval as a pilot crop under the 2014 Farm Bill. Additional work is necessary in the pet food industry with hemp-derived products. The latest update, based on information from a panel discussion at NOCO 2019 where AAFCO members were present, is hemp products marketed as animal feed are at least two years away from being a reality. Further discussion touched on the fact that it costs an estimated \$250,000 for the research required to gain an AAFCO approved feed number for each feed ingredient, and for each species of animal. When a feed trial is carried out or an ingredient receives approval for a specific animal in any state, the information is usable nationally. There are national companies known to be pursuing research to reach AAFCO certification for hemp cake.

Product Opportunities

- Hemp cake (Ruminants, Poultry, Pet food, Swine**)
- Hemp flower (Ruminants)
- Hemp hulls (Ruminants)
- Hemp protein processing byproduct (fiber cut)
- Off-specification seeds for wild bird feed

****Must be defatted, chemical extracted cake for swine diets**

Existing Infrastructure

Once products receive regulatory certification, the livestock and poultry feed industries in Minnesota have assets to efficiently incorporate hemp feed commodities into their livestock feed product lines.



Forecasted Market Potential

Estimated feed values for hemp coproducts will continue to be based on commodity price fluctuations. Feed value calculation conducted by AURI show the potential for hemp coproducts to be profitable in Minnesota. There will also be potential for hemp coproducts to be profitable in organic feed markets, which was not taken into account in the AURI feed value calculation. Regulatory and legal hurdles, namely receiving certification through the American Association of Feed Control Officials (AAFCO), will need to be overcome before hemp coproducts can play into animal feed markets. Minnesota will be well suited to be a market player in the feed sector.

AURI Involvement

- Coproducts facility in Waseca is a unique value-added facility in the Midwest.
- Coproducts lab is uniquely positioned to work on new feed products with a range of pilot scale equipment and animal nutrition expertise.
- Capabilities include but are not limited to:
 - Pelleting
 - Milling
 - Mechanical separating
 - Mechanical and thermal dewatering
 - Cold oil pressing and filtration- Blending/mixing ingredients
- Reach out to Harold Stanislawski, Al Doering or Riley Gordon at AURI to learn more about how AURI can help move your hemp feed idea forward.



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IN ADDITION TO USES IN FOOD, TEXTILES AND PLASTICS, HEMP HAS GREAT POTENTIAL AS AN ALTERNATIVE ENERGY SOURCE.

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RENEWABLE ENERGY LANDSCAPE

In addition to uses in food, textiles and plastics, hemp has great potential as an alternative energy source, both in automobiles and for heating. There are many reasons for further research and investment in hemp as the United States continues to explore ways to shift to cleaner energy sources and decrease dependency on fossil fuels.

The hemp plant is versatile as an energy source, can be processed in both biodiesel and ethanol energy, and exhibits superior fuel quality as shown in properties of various biofuels table below. Hemp is felt by some to provide a greater yield compared to similar crops, have a higher oil content (as high as 38%)⁹⁶ and be far more environmentally friendly than other plants commonly used for renewable energy applications.⁹⁷

BIODIESEL YIELD PER ACRE FROM SELECTED CROPS

CROP	FUEL YIELD (GALLONS/ACRE)	SOURCE
Palm Oil	508	Brown 2006
Coconut	230	Brown 2006
Rapeseed	102	Brown 2006
Peanut	90	Brown 2006
Sunflower	82	Brown 2006
Soybean	56	Brown 2006
Hemp	83	Alcheikh 2015

Source: University of Gavle Faculty of Engineering and Sustainable Development, June 2015⁹⁷

Hemp is resilient and can grow in most climates; around 70 percent of the plant's nutrients return to the soil during the growth cycle. It functions very well in crop rotations since it is an annual crop with a short growth cycle. Hemp can be cultivated on infertile soil, freeing up more fertile land to be used for food crops.

Environmentally friendly, hemp requires little to no pesticides and it has deep roots, which controls erosion of topsoil. Today there are no active ingredients or pesticides labeled for use on industrial hemp. Hemp needs only about 30 to 40 centimeters of water per growing season, compared to corn which requires around 56 centimeters per season. Hemp has strong resistance to pests and drought.

Capable of phytoremediation — a process by which the plant leaches pollutants from the soil, hyper-accumulates them and metabolizes them — hemp works well on sites contaminated with heavy metals, uranium and arsenic.⁹⁹

Further, hemp produces a cleaner fuel than some of its fellow oilseeds. It has a lower sulfur content and is safer for handling, storage and transport due to its higher flash point. Hemp seed oil has a lower freezing point than saturated oils, which makes it better for biodiesel engines operating in cold environments. Hemp also performs well in biodiesel blends.⁹⁷

PROPERTIES OF VARIOUS BIODIESEL FUELS

FUEL/ PROPERTY	HEMP BIODIESEL	SOYBEAN BIODIESEL	RAPSEED BIODIESEL	EM 14214 REQUIREMENTS (CEN 2012)
Flash point (°c)	162	138	96	101
Density (kg/m ³)	864	875	882	860 - 900
Sulfur content (ppm)	0.4	1.1	2.4	10
Kinematic viscosity at 40 °c (mm 2/5)	5.13	3.15	4.37	3.5 - 5
Cloud point (°c)	-4	0	-4.1	Maximum 0 - 2 for superior quality biodiesel
Pour point			-12	
Oxidization stability at 110 °c (hours)	poor	2.35 (poor)	5.6 (poor)	8
Sources: (Mahajan 2011) (He, Van Gerpen och Thompson 2009) (Li, Stuart and Parnas 2010)				

Source: University of Gavle Faculty of Engineering and Sustainable Development, June 2015⁹⁷

Biodiesel made from hemp seed can meet the ATSM D6751 and EN 14214 requirement for fuel quality, and surpass that of conventional diesel except in the area of oxidation stability as is the case with other biodiesel products. The oxidation stability, however, can be improved with the addition of antioxidants to the fuel, prolonging its shelf life.⁹⁷

PROCESSING

Hemp seed oil, pressed from the seed of the plant, can produce biodiesel through a process called transesterification. Processed correctly, biodiesel can be utilized in any diesel-powered automobiles, and can be stored and transported like diesel.⁹⁷ The remainder of the hemp plant can be made into ethanol using fermentation under low oxygen levels. Ethanol is traditionally used as an additive to gasoline, appropriate for “flex-fuel” vehicles.¹⁰⁰

Hemp seed has an oil content of 30 to 35 percent of the seed weight, giving it a fuel yield of approximately 207 gallons per hectare. Filtered hemp oil can be used directly to power diesel engines.⁹⁸

Researchers have also confirmed that physical and chemical properties of biodiesel derived from unrefined hemp oil meets the standards set by the American Society for Testing and Materials for biodiesel fuel. Additionally, the hemp hurd can be burned as is, or processed into charcoal, methanol, methane or gasoline through pyrolysis (destructive distillation). Hemp could be used to create cellulosic-based ethanol.⁶⁶

Under some scenarios, ethanol derived from hemp hurd could be practical. Conversion of hemp biomass into fuel or alcohol, however, is not ideal in areas where there are abundant supplies of wood, and energy can be produced relatively cheap from a variety of sources.¹⁰⁰

AURI has arranged short proximate analysis testing on hemp hurd, hemp meal and hemp spent flower as a fuel source. The results for energy content, ash, chlorine and sulfur contents for the respective materials are seen listed in the table below. One big challenge with using the hurd or flower as a fuel source, is the high chlorine content. Samples tested through AURI came in at 3605 and 4471 PPM, for the hurd and flower respectively, far exceeding the standard for residential biomass stoves set forth by the Pellet Fuel Institute (PFI) for chloride content in biomass pellets of less than or equal to 300 PPM. Currently PFI does not have standards set for biomass pellets used industrial scale biomass burners, however as chlorine content climbs there can be issues with equipment degradation as a result of pellet combustion. The ash content for these two materials is also very high when compared with industry standards. AURI recommends learning and following your biomass stove manufacturer fuel recommendations and guidelines.

HEMP BYPRODUCTS FUEL ANALYSIS

FUEL SOURCE	ENERGY (BTU/LB)	ASH (%)	CHLORINE (PPM)	SULFUR (%)
Hemp Hurd	7413	2.41	3605	0.077
Hemp Seed Meal	8599	6.48	392	0.907
Hemp Flower (Extracted)	6663	13.36	4471	0.314
Shelled Corn	7810	1.15	701	0.12
Wood Pellets	8298	0.35	471	0.01

Source: AURI-compiled data, July 2019

The hemp meal, aside from being above the desired maximum ash content outlined by the PFI as one percent, also has a chlorine content on the high end. While the energy content is quite high, there are a few challenges to using the meal as an energy source, as outlined above, not to mention that the product will more than likely maintain a higher value as a food or a feed source. According to Riley Gordon at AURI, the opportunity to blend hemp byproducts with other biomasses such as corn or even wood, may be a viable option to utilize these products as fuel sources and meet limitations.⁶² Cost of natural gas will largely influence the value as a pellet fuel. As discussed in the Coproducts section of this report, the hurd will likely find a higher value in other end uses such as beddings, absorbents or building materials, while the spent flower has excellent value as an animal feed.

As noted in the Biobased section of this report, hemp fiber can be used to create graphene-like carbon nanosheets for supercapacitor electrodes. The material displays excellent electrochemical performance for battery use and energy storage which could positively contribute to innovation in the battery and renewable energy storage areas.

CHALLENGES

There are a series of legal, financial and practical hurdles that must be overcome before hemp is a viable source of renewable energy. First, hemp is very much a niche crop. The worldwide hemp seed production rates declined significantly in the early to mid-20th century. The production rates are once again on the rise globally, but have not matched demand in the biofuel industry.^{103,97}

The main competitors for hemp are maize and sugar beets for biogas production, and the perennial crops willow, reed canary grass and Miscanthus for solid biofuel production.¹¹

According to research performed at Penn State University, hemp yields averaged about 1,500 pounds per acre, with a market value of 50 cents per pound. Based on these variables, oil from hemp is not as cost-competitive as a feedstock for biodiesel.¹⁰⁴

Most of the hemp grown in the United States and across the world is designated for the food market. Farmers can make a better profit selling hemp to food producers than companies using the plant to make biodiesel fuel.

Also, to use hemp and other biofuels, automobile manufacturers need to make significant modifications to their vehicle lineup to be compatible for biodiesel fuels. The higher blend rating for hemp-based fuel requires engine modification to ensure performance and maintenance standards.¹⁰³

Hemp may not be the be-all, end-all solution for green energy. If cultivated correctly, however, it can be a strong addition to energy production crops.

AT A GLANCE

Hemp Fuel Value

Forecasted Projections for Minnesota

OPPORTUNITY FOR HEMP HURD AS FUEL

Minnesota has been at the forefront of renewable energy for years. Programs supporting ethanol and biodiesel production in Minnesota illustrate the commitment this state has made to promote renewable energy.

The opportunity Minnesota has to offer biomass crops and renewable energy is evident through various programs supporting the use of renewable fuels along with industries within the state that already utilize solid biomass fuel. This analysis focused on renewable energy opportunities that may exist for hemp products.

Hemp coproducts such as the hurd, extracted flower and cake all have high heating values. Hemp seed oil can also serve as a feedstock to make biodiesel, with the end product competing with the properties of soy-based biodiesel. Utilizing hemp coproducts as fuel sources are a potential opportunity, however the materials will likely have higher values in other areas and there are a few hurdles to overcome, including meeting pellet fuel standards as well as its price competitiveness with other leading fuel sources.

Table 1.
Value of hemp hurd to be competitive with other fuel commodities on the market based on dollar per million BTUs.

Natural Gas \$8/therm ¹	Propane \$1.60/gal ²	Wood \$180/ton ³	Shell Corn \$3.50/bushel ⁴
\$101	\$227	\$139	\$80

Hemp hurd per ton comparative value

The values calculated in the table above are derived from accounting for the fuel value of each commodity and combustion efficiency variations to compare fuel sources on an equivalent cost per energy unit.

If you can source any of the hemp ingredients for less than the comparative value column shown in Table 1, hemp hurd may offer a competitive alternative to use as a fuel source. Note: The capital cost of biomass heating systems and potential pelleting cost of around \$90 per ton is not considered in the projections. Hemp oil may also be competitive with soybean oil for biodiesel production, providing another opportunity in the state for biodiesel plants.

Hemp flower and hemp cake both have high energy content which could serve as a good fuel source. However high protein and energy feed values show that these commodities will likely capture a greater value as livestock and poultry feed.

ADDITIONAL INFORMATION

pelletheat.org | auri.org/hemp | fpl.fs.fed.us/documnts/techline/fuel-value-calculator.pdf

Sources for Commodities Prices

¹ Natural Gas Price - eia.gov/dnav/ng/hist/n3010mn3m.htm

² Propane Price - eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_EPLLPA_PRS_SMN_DPG&f=W

³ Wood Price - bankrate.com/mortgages/how-much-does-a-cord-of-wood-cost/

⁴ Corn Price - markets.businessinsider.com/commodities/corn-price

Hurdles

While the energy value of many hemp plant components is substantially high, in order to contend as a pellet fuel some challenges need resolving for hemp to play a role as a marketable fuel. For example, blending the hurd with shelled corn or wood to reduce chlorine levels in the final products could be a great opportunity to make a blended hemp fuel product. Chlorine levels will be more important to focus on when considering home pellet fuel burners. However, larger industrial scale systems should be able to handle higher chlorine contents. However, as the chlorine levels begin to reach the thousands of parts per million (PPM) levels, one should expect equipment degradation. **AURI recommends learning and following your biomass stove manufacturer fuel recommendations and guidelines.

Product Opportunities

- Hemp hurd pellet fuel blends with other natural fuel commodities such as wood or corn for use in residential or industrial pellet burner systems
- Hemp cake or hemp flower fuel pellets
- Biodiesel

Existing Infrastructure

Existing Minnesota infrastructure and products that could utilize hemp products as fuel:

- Biodiesel plants to utilize hemp oil in their process
- Biomass boiler companies with systems capable of combusting hemp hurd

FUEL



Forecasted Market Potential

Estimated fuel values for hemp coproducts will continue to be based on commodity price fluctuations.

Citing the Minnesota Department of Agriculture's (MDA) 2017 biodiesel study Economic Impact of the Minnesota Biodiesel Industry: Minnesota currently ranks 10th among the US states in biodiesel production.

In 2016 the total economic impact of Minnesota's biodiesel production, including direct, indirect and induced impacts, was about \$1.7 billion.

AURI Involvement

- Coproducts facility in Waseca is a unique value-added facility in the Midwest.
- Coproducts lab is uniquely positioned to aid in product development involving hemp byproducts utilized for pellet fuel blends.
- AURI has worked on numerous pellet fuel development projects in the past.
- AURI's Marshall facility also has the capability to make small batches of biodiesel from hemp oil.
- Capabilities include but are not limited to: pellet mill, hammer, mill aspiration, mechanical and thermal dewatering, cold oil pressing and filtration, blending/mixing ingredients
- Reach out to Harold Stanislawski, Al Doering or Riley Gordon at AURI to learn more about how AURI can help move your hemp fuel idea forward!



MDA INDUSTRIAL HEMP PILOT PROGRAM

The Minnesota Department of Agriculture administers an industrial hemp research pilot program to study the growth, cultivation and marketing of industrial hemp.

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RESOURCES

AURI

Offers resources to assist hemp growers, processors and manufacturers to provide the research and quality assurance best practices to produce commercial products. AURI works to develop commercial markets for hemp products and collaborates with growers, economic developers, processors and regulators to identify the hurdles and opportunities hemp presents and to help Minnesota's industry capitalize on the market potential.

BIOBASED PRODUCTS

Biobased products enable the transition from traditional petroleum-based materials to agricultural resources in the production of a variety of products including plastics, consumer goods, building materials and chemicals. AURI can support clients through hands-on technical assistance in the form of sample analysis in the AURI analytical laboratory, product development in its pilot facility, and by working directly onsite with client specific topic areas.

Confidentiality is a high priority for AURI staff as projects routinely involve elements that involve intellectual property and trade secrets. In the AURI bioproducts laboratory, processes are developed, improved and/or validated for producing increased value materials using such techniques as fractionation, chemical conversion and purification. Additional capabilities include: chemical processing, extraction and characterization of oils and high-value components, distillation and evaporation for process development.

COPRODUCTS

Nearly every agricultural processor generates residue or coproducts – including hemp. Creating new uses for what could seem like waste byproducts can create significant new revenue streams for Minnesota agriculture producers and processors. AURI can assist in several key areas:

Applied Research

Identify emerging, value-added opportunities to help entrepreneurs and businesses generate ideas for new products and processes.

Hands-On Scientific Assistance

Scientists provide consulting and technical services in the areas of product and process development; product evaluation and testing; and sourcing materials, equipment and services. The AURI coproduct lab is a unique value-added facility of its kind in the Midwest with capabilities that encompass pellet and hammer mills, an aspirator to separate products of different densities, an oil press and filter, and a vibrating fluid dryer.

Innovation Networks

When deciding the feasibility of a new product or process, it is critical to have access to industry experts and a science-based network of people. With a broad range of networks, AURI can assemble the right people at the right time to assist.

INDUSTRIAL HEMP

AURI is working with farmers and businesses to help build a framework of shared knowledge and a market in Minnesota. AURI also partners with the University of Minnesota and the Minnesota Department of Agriculture to help develop new markets for Minnesota-grown hemp and other agricultural products and to provide additional resources and funding opportunities for farmers and businesses. As industrial hemp production continues to grow across the United States, AURI is poised to lead the value-added efforts to help Minnesota and neighboring states.

RENEWABLES

AURI's Analytical and Bioproducts Laboratories provide support in chemical technologies and processing of value-added agricultural products. Processors, growers and researchers utilize AURI's services within hemp for such work as CBD and THC testing. Utilizing high-performance liquid chromatography, or HPLC scientists are able to extract and test cannabinoids as a way of monitoring crops.

Seeds and other components of the plant can also be tested for fat or oil content. The labs can do small-scale pressing of the oil seeds as well. AURI can analyze the amount of carbohydrates available in the seeds, stocks or other parts of the plant, as well as look at protein content and minerals. The labs are also capable of studying biodiesel made from hemp through small-scale biodiesel production and, of course, test food made with hemp.

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CONCLUSIONS

THE END OF THE PROHIBITION OF INDUSTRIAL HEMP IN MINNESOTA CREATES POSSIBILITIES FOR GROWTH AND DISCOVERY IN SEVERAL KEY SECTORS OF THE STATE'S ECONOMY. TO FULLY CAPITALIZE ON OPPORTUNITIES WILL REQUIRE COLLABORATION, INGENUITY AND CURIOSITY AMONG MANY STAKEHOLDER GROUPS.

Throughout this report, AURI has identified five categories that present the most promising economic development prospects for growers and processors. Those are feed, food, fuel, fiber and CBD oil. In each sector there are hurdles to overcome and questions to be answered in areas such as supply chain, processing and federal regulation.

Despite these challenges, the possibilities for hemp are exciting and tangible. Minnesota and the upper Midwest is well positioned to play a key role in shaping the future of the hemp industry.

Hemp coproducts such as hemp cake, hemp hulls, and the high protein hemp flower and stem can provide an excellent source of protein and energy to help support the livestock industry.

The fatty acid profile of hemp is 80 percent polyunsaturated, including the essential omega-6 and omega-3 fatty acids, making it an attractive ingredient for food products. Hemp protein is non-allergenic and can be blended with other plant-based proteins. It is also used in bars, cereals and protein beverages. The beer industry is also exploring the use of the flour or hemp hearts in the mash or adding the terpenes as a flavor or aroma compound.

Hemp coproducts can be utilized in the renewable energy market. Hemp flour and cake have high energy content. Hemp hurd pellet fuel blends with other natural fuel commodities such as wood or corn for use in residential or industrial pellet burner systems.

In addition, hemp hurds and fibers are unique raw materials that have hundreds of potential applications. Many businesses in the state could benefit from the use of these biobased materials as alternatives to their existing materials in the construction, manufacturing, automobile and textile industries.

Many in the hemp industry say the CBD oil sector is the largest growth area. Consumer demand for CBD oil is driving development and investment. Industry analysts predict that by 2020 CBD oil will be a \$22 billion-dollar industry in the U.S. for food, supplements, beverages, medicine and tinctures.

The hemp market is global, and the regulatory climate is changing rapidly. AURI's role is to form connections and provide the resources necessary to help Minnesota's economy capitalize on these existing opportunities and to identify new ones. The organization has the infrastructure and on-staff expertise to help businesses overcome challenges to help create the economic benefits connected to hemp and bring their ideas to reality.

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