

Defining *Hemp*: A Fact Sheet

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Botanically, hemp and marijuana are from the same species of plant, *Cannabis sativa*,¹ but from different varieties or cultivars.² However, hemp and marijuana are genetically distinct forms of cannabis that are distinguished by their use and chemical composition as well as by differing cultivation practices in their production. While marijuana generally refers to the cultivated plant used as a psychotropic drug (whether used for medicinal or recreational purposes), hemp is cultivated for use in the production of a wide range of products, including foods and beverages, personal care products, nutritional supplements, fabrics and textiles, paper, construction materials, and other manufactured and industrial goods. *Hemp* and *marijuana* also have separate statutory definitions in U.S. law.

Despite these differences, growing hemp has been restricted in the United States until recently, and the U.S. market has been largely dependent on imports for finished products and as an ingredient for use in further processing. Hemp's association with marijuana placed its production under U.S. drug laws wherein all cannabis varieties, including hemp, were considered Schedule I controlled substances under the Controlled Substances Act (CSA).³ Since the late 1950s, the U.S. Drug Enforcement Administration (DEA) has strictly controlled and regulated hemp production. Prior to the late 1950s, hemp in the United States was considered an agricultural commodity, and the U.S. Department of Agriculture (USDA) supported its production.⁴

Restrictions on U.S. hemp production and marketing were relaxed by changes enacted in the 2014 farm bill (Agricultural Act of 2014, P.L. 113-79) and were further relaxed in the 2018 farm bill (Agriculture Improvement Act of 2018, P.L. 115-334). These changes provide further differentiation between hemp and marijuana in terms of farm policy and federal regulatory oversight.

The Food and Drug Administration (FDA) maintains oversight of hemp-derived consumer products under the Federal Food, Drug, and Cosmetic Act (21 U.S.C. §§ 301 *et seq.*). FDA's jurisdiction includes hemp and hemp-derived products as a food and food ingredient, as well as an ingredient for use in body products, cosmetics, dietary supplements, and therapeutic products.

Hemp and marijuana are distinct in several key ways: (1) statutory definitions and regulatory oversight, (2) chemical and genetic compositions, and (3) production practices and use. This fact sheet describes these differences, which are summarized in **Figure 1**.

¹ In this report, *cannabis* refers to the plant species *Cannabis sativa* and all of its industrial, medicinal, and recreational varieties. The terms *industrial hemp* and *hemp* are used interchangeably, and the term *marijuana* refers to the plant used as a medicinal or recreational drug unless otherwise specified. The terms *Cannabis sativa* L denote use of the Linnean system of taxonomy.

² *Plant varieties* and *cultivars* both refer to unique characteristic of a particular plant, but they differ overall: Varieties often occur in nature, and most varieties are true to type, meaning that seedlings grown from a variety will also have the same unique characteristic of the parent plant. Cultivars are cultivated varieties and not necessarily true to type, since certain traits have been selected by growers. See Cindy Haynes, "Cultivar versus Variety," Iowa State University, February 6, 2008, <https://hortnews.extension.iastate.edu/2008/2-6/CultivarOrVariety.html>.

³ 21 U.S.C. §§801 *et seq.*; Title 21 C.F.R. Part 1308.11.

⁴ Strictly speaking, the CSA does not make growing hemp illegal, but makes it illegal to grow without a DEA permit.

Figure I. Differences Between Hemp and Marijuana

	Hemp	Marijuana
Botanical Name	<i>Cannabis sativa</i>	<i>Cannabis sativa</i>
Statutory Definition	“the plant <i>Cannabis sativa</i> L. and any part of that plant, including the seeds thereof and all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers, whether growing or not, with a delta-9 tetrahydrocannabinol [delta-9 THC] concentration of not more than 0.3 percent on a dry weight basis” (Section 297A of the Agricultural Marketing Act of 1946 (AMA)).	“all parts of the plant <i>Cannabis sativa</i> L., whether growing or not; the seeds thereof; the resin extracted from any part of such plant; and every compound, manufacture, salt, derivative, mixture, or preparation of such plant, its seeds or resin. Such term does not include the mature stalks of such plant, fiber produced from such stalks, oil or cake made from the seeds of such plant, any other compound, manufacture, salt, derivative, mixture, or preparation of such mature stalks (except the resin extracted therefrom), fiber, oil, or cake, or the sterilized seed of such plant which is incapable of germination” (21 U.S.C. §802(16)).
Content Threshold for Psychoactive Compounds	No more than 0.3% delta-9 THC on a dry weight basis (THC is one of the leading psychoactive cannabinoids in cannabis)	No THC threshold specified
Other Cannabinoids	Reportedly more than 60 cannabinoids (including CBD and other nonpsychoactive compounds)	Reportedly more than 60 cannabinoids (including CBD and other nonpsychoactive compounds)
Psychoactive Properties	Nonpsychoactive	Psychoactive
Primary U.S. Laws	Agricultural Marketing Act of 1946 (AMA, 7 U.S.C. 1621 et seq.) Federal Food, Drug, and Cosmetic Act (FFDCA; 21 U.S.C. §§ 301 et seq.)	Controlled Substances Act (CSA, 21 U.S.C. §§801 et seq.) Federal Food, Drug, and Cosmetic Act (FFDCA; 21 U.S.C. §§ 301 et seq.)
Primary Federal Agencies with Regulatory Oversight	U.S. Department of Agriculture (USDA) Food and Drug Administration (FDA) (U.S. Department of Health and Human Services (HHS))	U.S. Drug Enforcement Administration (DEA) (U.S. Department of Justice (DOJ)) Food and Drug Administration (FDA) (U.S. Department of Health and Human Services (HHS))
Plant Part Used	Fiber, seed, and flower	Flower
Types of Products	Food and food ingredient; ingredient for body products, cosmetics, dietary supplements and therapeutic products; textiles and fabrics; other manufactured and industrial products	Recreational and medicinal products
Plant Height at Harvest	10-15 feet (fiber), 6-9 feet (seed), 4-8 feet (flower)	4-8 feet (flower)

Source: CRS from various governmental and industry sources.

Statutory Definition and Regulatory Oversight

Congress expanded the definition for *hemp* in the 2018 farm bill (amending the 2014 farm bill definition of *industrial hemp*), further distinguishing hemp and marijuana under U.S. law. *Hemp* is codified in Section 297A of the Agricultural Marketing Act of 1946 (AMA, 7 U.S.C. 1621 *et seq.*) as follows:⁵

the plant *Cannabis sativa* L. and any part of that plant, including the seeds thereof and all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers, whether growing or not, with a delta-9 tetrahydrocannabinol concentration of not more than 0.3 percent on a dry weight basis.

As defined in statute, hemp must contain no more than a 0.3% concentration of delta-9 tetrahydrocannabinol (delta-9 THC)—marijuana’s primary psychoactive chemical. In general, a level of about 1% THC is considered the threshold for cannabis to have a psychotropic effect or an intoxicating potential.⁶ Some suggest that cannabis with a THC level of greater than 1% be considered a drug varietal (e.g., marijuana),⁷ with some suggesting that marijuana plants often have a THC level of 5% or more.⁸ In the United States, hemp varieties or cultivars having less than 0.3% THC may be cultivated under USDA-approved license as hemp, while plant varieties or cultivars having higher amounts of THC may not be cultivated as they are considered to have too high a potential for drug use.⁹

By contrast, *marijuana* (or “marihuana,” as it is spelled in the older statutes) is more broadly defined in the CSA and does not specify a permissible limit for THC or any other cannabinoid:

(16) The term “marihuana” means all parts of the plant *Cannabis sativa* L., whether growing or not; the seeds thereof; the resin extracted from any part of such plant; and every compound, manufacture, salt, derivative, mixture, or preparation of such plant, its seeds or resin. Such term does not include the mature stalks of such plant, fiber produced from such stalks, oil or cake made from the seeds of such plant, any other compound, manufacture, salt, derivative, mixture, or preparation of such mature stalks (except the resin extracted therefrom), fiber, oil, or cake, or the sterilized seed of such plant which is incapable of germination.¹⁰

Marijuana is a Schedule I controlled substance under federal law, and, as such, the unauthorized manufacture, distribution, dispensation, and possession of marijuana is prohibited.¹¹ Cannabis

⁵ A definition of *hemp* was originally established in the 2014 farm bill and amended by the 2018 farm bill (P.L. 115-334, §10113). The 2014 farm bill defined *industrial hemp* to mean “the plant *Cannabis sativa* L. and any part of such plant, whether growing or not, with a delta-9 tetrahydrocannabinol concentration of not more than 0.3 percent on a dry weight basis” (7 U.S.C. §5940(b)(2)).

⁶ See, for example, E. Small and D. Marcus, “Hemp: A New Crop with New Uses for North America,” in *Trends in New Crops and New Uses*, ed. J. Janick and A. Whipkey (Alexandria, VA: American Society for Horticultural Science Press, 2002).

⁷ F. Grotenhermen and M. Karus, “Industrial Hemp Is Not Marijuana: Comments on the Drug Potential of Fiber Cannabis,” nova-Institute, <http://www.internationalhempassociation.org/jiha/jiha5210.html>.

⁸ See, for example, M. Shipman, “Is Hemp the Same Thing as Marijuana?,” North Carolina State University, February 15, 2019, <https://phys.org/news/2019-02-hemp-marijuana.html>; and D. Donnon, A. T. Kearney, “The New Green Rush,” presented at a Food Institute webinar, January 31, 2019.

⁹ E. Small and D. Marcus, “Tetrahydrocannabinol Levels in Hemp (*Cannabis sativa*) Germplasm Resources,” *Economic Botany*, vol. 57, no. 4 (October 2003); and G. Leson, “Evaluating Interference of THC Levels in Hemp Food Products with Employee Drug Testing” (prepared for the province of Manitoba, Canada), July 2000.

¹⁰ 21 U.S.C. §802(16).

¹¹ Generally, all cannabis varieties are commonly considered to be of a single species. However, not all researchers

that exceeds the 0.3% delta-9 THC concentration limit falls under the definition of *marijuana* and the CSA. THC levels in marijuana reportedly average about 10%, with a high of 30% concentration.¹² However, advancements in cannabis breeding have introduced plant varieties with even higher levels of THC and other cannabinoids.¹³

The definition of *industrial hemp* enacted in the 2014 farm bill allowed for hemp cultivation under certain narrowly prescribed circumstances—namely, for research purposes by research institutions and state departments of agriculture in states with laws allowing for hemp production. Although hemp production was allowed in accordance with the requirements of the 2014 farm bill provision, other aspects of production were still subject to CSA regulations and DEA oversight, including the importation of viable seeds, which still required DEA registration according to the Controlled Substances Import and Export Act (21 U.S.C. §§951-971). This and other requirements were reinforced in a 2016 joint Statement of Principles on Industrial Hemp issued by DEA, USDA, and FDA.¹⁴ The 2016 guidance also clarified DEA’s contention that the commercial sale or interstate transfer of hemp continued to be restricted. A May 2018 internal directive by the DEA later clarified that certain “products and materials that are made from the cannabis plant and which fall outside the CSA definition of marijuana (such as sterilized seeds, oil or cake made from the seeds, and mature stalks) are not controlled under the CSA.”¹⁵ Accordingly, such products may be sold and distributed throughout the United States without restriction under the CSA or its implementing regulations. The 2018 directive, however, does not apply to cannabis extracts and resins.¹⁶

The 2018 farm bill further expanded upon hemp policies in the 2014 farm bill by amending the CSA and removing *hemp* from the CSA definition of *marijuana* (21 U.S.C. §802(16)).¹⁷ Removing *hemp* (as defined in AMA Section 297A) from the CSA—and thus removing it from being considered a controlled substance—effectively permits the cultivation, processing, marketing, and sale of hemp and any cannabinoid derived from hemp that is produced by an authorized grower in accordance with the 2018 farm bill, associated federal USDA regulations, and applicable state regulations. The 2018 farm bill also excludes THC in hemp (as defined) from Schedule I of the CSA.¹⁸ All other cannabis and cannabis-derived products remain a Schedule I substance under federal law and are thus subject to CSA regulations and DEA oversight, except for certain drug products approved by FDA. Regardless of whether a substance is hemp-derived, it is FDA’s view that it is unlawful to market food or dietary supplements

agree on a single taxonomy. Other cannabis species may include *Cannabis indica* (meaning from India) and its known subspecies. See, for example, R. C. Clarke and M. D. Merlin, “Cannabis Taxonomy: The ‘Sativa’ versus ‘Indica’ Debate,” *HerbalGram*, vol. 13, no. 4 (April 2016).

¹² Based on sample tests of illegal cannabis seizures from December 2007 through March 2008. National Institute of Drug Abuse, “Quarterly Report, Potency Monitoring Project,” University of Mississippi, 2008.

¹³ See, for example, M. A. ElSohly et al., “Changes in Cannabis Potency over the Last Two Decades (1995-2014): Analysis of Current Data in the United States,” *Biological Psychiatry*, vol. 79, no. 7 (April 1, 2016): pp. 613-619.

¹⁴ 81 *Federal Register* 156: 53395-53396, August 12, 2016; also DEA/USDA/FDA joint “Statement of Principles on Industrial Hemp,” August 2016.

¹⁵ DEA, “DEA Internal Directive Regarding the Presence of Cannabinoids in Products and Materials Made from the Cannabis Plant,” May 22, 2018.

¹⁶ 81 *Federal Register* 240: 90194-90196, December 14, 2016. See also DEA, “Clarification of the New Drug Code (7350) for Marijuana Extract,” https://www.deadiversion.usdoj.gov/schedules/marijuana/m_extract_7350.html.

¹⁷ P.L. 115-334, §12619(a).

¹⁸ P.L. 115-334, §12619(b).

containing cannabidiol (CBD) or other cannabinoids, as well as any products making therapeutic claims without FDA approval.¹⁹

The 2018 farm bill also established a new regulatory framework to monitor compliance and regulate production under USDA's jurisdiction.²⁰ The 2018 farm bill also contains an "interstate commerce" provision that prohibits states and Indian tribes from interfering with the transport of hemp or hemp products produced in accordance with the new USDA requirements through their jurisdictions.²¹ Hemp is now also eligible for federal crop insurance programs, as well as USDA research and development programs.²² These changes returned U.S. hemp production to the status of an agricultural commodity and thus eligible for USDA-supported farm programs, similar to the status it had in the United States before the late 1950s.

Chemical and Genetic Makeup

There are many different varieties of cannabis. Although industrial hemp and marijuana are both varieties of cannabis, they have been bred for different uses and can be distinguished by their chemical and genetic compositions.²³

Differences in Chemical Composition

The term *industrial hemp* dates back to the 1960s and generally refers to cannabis varieties that are grown primarily as an agricultural crop, such as seeds and fiber, and byproducts, such as oil, seed cake, and hurds.²⁴ Hemp is generally characterized by plants that are low in delta-9 THC, the dominant psychotropic compound in *Cannabis sativa*.²⁵ In addition to its low THC content, hemp generally has high levels of CBD, the primary nonpsychotropic compound in *Cannabis sativa*.²⁶ Accordingly, a high ratio of CBD to THC might also be a metric used to differentiate hemp from other cannabis varieties.²⁷

¹⁹ FDA, "Statement from FDA Commissioner Scott Gottlieb, M.D., on the Signing of the Agriculture Improvement Act and the Agency's Regulation of Products Containing Cannabis and Cannabis-Derived Compounds," press release, December 20, 2018.

²⁰ P.L. 115-334, §10114.

²¹ P.L. 115-334, §10113.

²² For more information, see CRS In Focus IF11088, *2018 Farm Bill Primer: Hemp Cultivation and Processing*.

²³ See, for example, S. L. Datwyler and G. D. Weiblen, "Genetic Variation in Hemp and Marijuana (*Cannabis sativa* L.) According to Amplified Fragment Length Polymorphisms," *Journal of Forensic Sciences*, vol. 51, no. 2 (2006).

²⁴ See L. Grlic, "A Combined Spectrophotometric Differentiation of Samples of Cannabis," United Nations Office on Drugs and Crime, January 1968. Hurds are soft inner core fiber of the hemp stalk. Hurds are woody in texture and mostly used in nonwoven items, including hempcrete and animal bedding.

²⁵ R. C. Clarke and M. D. Merlin, *Cannabis: Evolution and Ethnobotany* (University of California Press, 2013), p. 255. A psychotropic drug is capable of affecting mental activity, behavior, or perception and may be mood-altering.

²⁶ U. R. Avico et al., "Variations of Tetrahydrocannabinol Content in Cannabis Plants to Distinguish the Fibre-Type from Drug-Type Plants," *UNODC Bulletin on Narcotics*, January 1985; C. W. Waller, "Chemistry of Marihuana," *Pharmacological Reviews*, vol. 23 (December 1971); K. W. Hillig and P. G. Mahlberg, "A Chemotaxonomic Analysis of Cannabinoid Variation in Cannabis (Cannabaceae)," *American Journal of Botany*, vol. 91, no. 6 (June 2004); and A. W. Zuardi et al., "Cannabidiol, a Cannabis sativa Constituent, as an Antipsychotic Drug," *Brazilian Journal of Medical and Biological Research*, vol. 39 (2006).

²⁷ Continued advancement in breeding and plant genetics, however, are resulting in cannabis varieties or cultivars that have more equal parts THC and CBD, making previous generalizations about the inverse relationship between THC and CBD concentration less relevant.

THC and CBD are among the subclasses of cannabinoids and their 66 known variants in *Cannabis sativa* (see **text box**).²⁸ *Cannabinoids* refer to the unique chemical compounds produced in the plant, which are known to exhibit a range of psychological and physiological effects.²⁹ These compounds exist in both hemp and marijuana in varying amounts. THC is the primary psychoactive compound in cannabis; however, the plant contains multiple THC isomers and variants.³⁰ While some cannabinoids are psychoactive, others, such as CBD, are not considered to be psychoactive.³¹ THC and CBD are considered to be among the most abundant cannabinoids in cannabis, and some consider both to be medically valuable. THC and CBD are also the most well-known and researched cannabinoids. Among the isomers of THC, properties may vary and not all have been well characterized.³² The interaction between THC and other cannabinoids in the cannabis plant is also not well known.

Cannabinoids

More than 480 natural components are found within the *Cannabis sativa* plant, of which 66 are classified as cannabinoids. Cannabinoids are separated into the following subclasses.

Delta-9 tetrahydrocannabinol (delta-9 THC)	Number of known variants: 9
Delta-8 tetrahydrocannabinol (delta-8 THC)	Number of known variants: 2
Cannabigerol (CBG)	Number of known variants: 6
Cannabichromene (CBC)	Number of known variants: 5
Cannabidiol (CBD)	Number of known variants: 7
Cannabinol (CBN)	Number of known variants: 7
Cannabinodiol (CBND or CBDL)	Number of known variants: 2
Cannabicyclol (CBL)	Number of known variants: 3
Cannabielsoin (CBE)	Number of known variants: 5
Cannabitriol (CBT)	Number of known variants: 9
Other miscellaneous types of cannabinoids	Number of known variants: 11

Source: J. E. Joy et al., eds., *Marijuana and Medicine: Assessing the Science Base*, Institute of Medicine, 1999; and University of Washington, Alcohol and Drug Abuse Institute, "Cannabinoids," June 2013.

²⁸ More than 540 phytochemicals have been described in hemp (see J. Gould, "The Cannabis Crop," *Nature*, vol. 525, no. S2–S3 [September 24, 2015]). Other present compounds include certain terpenes and phenolic compounds, including flavonoids. See footnote 49.

²⁹ Clarke and Merlin, *Cannabis: Evolution and Ethnobotany*, p. 255.

³⁰ Isomers are molecules with the same chemical formula but distinct atomic structures.

³¹ Clarke and Merlin, *Cannabis: Evolution and Ethnobotany*. For example, cannabigerol, cannabichromene, and cannabidivarin are reported to be nonpsychotropic.

³² See, for example, E. A. Carlini, "The Good and the Bad Effects of (-) Trans-Delta-9-Tetrahydrocannabinol (Δ^9 -THC) on Humans," *Toxicon*, vol. 44 (July 2004), pp. 461–467. Other identified isomers of THC, such as delta-1 THC and delta-6 THC, may be related to delta-9 THC and delta-8 THC, respectively.

Differences in Genetic Composition

Scientific and genome research indicate that hemp and marijuana are neither genetically identical nor genetically similar. Although hemp and marijuana are from the same cannabis plant, available research supports the conclusion that selective breeding has resulted in two separate strains.

A 2015 study by Canadian researchers reports that “marijuana and hemp are significantly differentiated at a genome-wide level, demonstrating that the distinction between these populations is not limited to genes underlying THC production.”³³

A 2015 University of Minnesota study notes that marijuana and hemp “can be readily distinguished by the relative yield” of tetrahydrocannabinolic acid (THCA) in marijuana and cannabidiolic acid (CBDA) in hemp.³⁴ The study observed a “diversity of THCA and CBDA synthase sequences observed in the mapping population, the position of enzyme coding loci on the map, and patterns of expression suggest multiple linked loci.” The study also found that marijuana is distinguished from hemp by compounds that appear to have been “positively selected to enhance psychoactivity.”³⁵

The discovery of a single gene distinguishing two plant varieties suggests that the two plants are distinct. A 2011 Canadian study further concluded that “single nucleotide variant analysis uncovered a relatively high level of variation among four cannabis types, and supported a separation of marijuana and hemp.”³⁶ These studies find that available research and genome mapping suggest that hemp and marijuana are genetically separate and distinct plant varieties.

Genomic research in Canada supports the notion that over thousands of years of cultivation, cannabis farmers have “selectively bred *Cannabis sativa* into two distinct strains—one for fiber and seed, and one for medicine.”³⁷

Production Practices and Use

In general, hemp is grown and harvested differently from marijuana. Production practices among cannabis varieties vary with respect to cultivation, including plant height, density, and timing of their harvest. While marijuana is cultivated to promote the development of flowering tops and leaves of psychoactive cannabis plant varieties with elevated concentrations of THC, hemp is cultivated depending on its intended use across three different crops: fiber, seeds, and flower (Table 1).

³³ J. Sawler et al., “The Genetic Structure of Marijuana and Hemp,” August 2015, PLoS ONE, vol. 10, no. 8, <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0133292>.

³⁴ G. D. Weiblen et al., “Gene Duplication and Divergence Affecting Drug Content in Cannabis Sativa,” *New Phytologist*, July 17, 2015, <https://doi.org/10.1111/nph.13562>.

³⁵ Weiblen et al., “Gene Duplication and Divergence.”

³⁶ H. van Bakel et al., “The Draft Genome and Transcriptome of Cannabis Sativa,” *Genome Biology*, vol. 12, no. 10 (October 20, 2011), <https://doi.org/10.1186/gb-2011-12-10-r102>.

³⁷ *ScienceDaily*, “How Hemp Got High: Cannabis Genome Mapped,” October 24, 2011, citing vanBakel et al., “The Draft Genome and Transcriptome of *Cannabis Sativa*.”

Table 1. Primary Hemp Crops: Fiber, Seeds, and Flowers

	Fiber	Seed/Grains	Flower
Desired Plant Material	Stalks (bast fibers and hurd/core fibers)	Dried (high in oil and protein)	Dried and cut (flower bud and floral material)
Planting Density	Dense spacing to discourage branching and flowering (35-50 plants/ft ²)	Dense spacing to discourage branching and flowering (35-50 plants/ft ²)	Well spaced (typically planted 3-4 feet apart on a 3-5 foot center)
Physical Characteristics	Tall plants with small stalks and less leafy material	Plants with small stalks and less leafy material	Bushy plant with wide branching to promote flowers/buds (selecting female plants is ideal)
Harvest Height	10-15 feet	6-9 feet	4-8 feet
Harvesting Considerations	Typically using hay equipment (mow, field retting 2-3 weeks, then roll balling)	Must be harvested within a short window due to seed scatter issues	Harvesting is highly labor intensive, in part given possible degradation of plant material related to efforts to preserve the chemical properties of the plant's flowering heads; also requires drying down to 10% moisture
Yields	1.0-5.5 tons per acre of dry matter (whole dry stems)	Avg: 800-1,000 lbs./acre (up to 1,600 lbs./acres)	NA (varies widely); one plant yields about one pound of dried material
Price (2017)	\$70-\$135 per ton	\$0.65-\$0.75 per pound	\$25-\$200 per pound
Forward Contracting	About 8¢/lb. (\$160/ton).	NA	NA
Return per Acre	Up to \$700 per acre	Up to \$1,200 per acre	NA
Common Uses	Bast fibers used for paper, insulation, composites, and textiles; core fibers used for animal bedding, concrete, fiberboard, and oil absorbents	Foods and body products Shelled seed and fines Oil and seed cake	Extractions of plant resin (CBD, other cannabinoids) Nutraceuticals and wellness products
Postproduction Process	Decortication, removing the tough woody interior (hurd) from the softer, fibrous exterior of the stalk (separating the bast and the hurd/core fibers)	Dehulling and pressing of dried hemp seed/grains	Requires extraction using a variety of methods, including lipid or alcohol/ethanol infusions, CO ₂ extraction, or extraction using other types of chemical solvents (hexane, butane), as well as solvent-free extractions; extraction may or may not involve heat decarboxylation

Source: CRS from various sources, including K. Pularski, "Hemp Industry Overview," presentation at hemp conference hosted by the Greater Peoria Economic Development Council, Illinois, January 18, 2019.

Notes: Most figures are based on 2017 Kentucky crop data. Production data for other producing regions may vary. NA = Not available.

Cannabis is dioecious, meaning that there are separate male and female plants, each with distinctive growth characteristics. For drug production, the female flowers are more valuable, whereas male plants are used to produce hemp fibers. When cannabis is grown to produce marijuana, it is cultivated from varieties where the female flowers are specifically selected to prevent the return of separate male and female plants.³⁸ When cultivating marijuana, the female

³⁸ Van Bakel et al., "The Draft Genome and Transcriptome of *Cannabis Sativa*." In botany, *dioecious* describes plant varieties that possess male and female flowers or other reproductive organs on separate, individual plants.

flowers are short and tightly clustered. In marijuana cultivation, growers remove all the male plants to prevent pollination and seed set. Some growers will hand-pollinate a female plant to get seed. This is done in isolation from the rest of the female plants. Encouraging monoecism (female-only plants) in marijuana cultivation requires the skill of a competent plant breeder and rarely occurs under noncultivated conditions. By contrast, when cannabis is grown to produce hemp fiber and seeds (using only male plants), the plant is discouraged from flowering, forcing it to grow taller with less branching.

Cannabis seeds generally fall into one of three categories: regular, feminized, or autoflowering.³⁹ Regular seeds produce both male and female plants at about a 50/50 ratio, but often male plants may be identified to avoid the fertilization of the female plants. Feminized seeds are specially treated plants to produce only female plants, generally by stressing a female plant to produce viable, genetically identical seeds without being fertilized by a male plant, resulting in female offspring only. Autoflowering seeds are crossbred hybrids that generally result in all female plants that often contain less THC.⁴⁰ Some seeds are being genetically and/or selectively bred to produce strains that have zero THC.⁴¹

Preserving the genetic composition of each variety requires careful attention to the prevention of cross-pollination. Cross-pollination among the different varieties is a concern because cannabis plants are open (e.g., wind and/or insect pollinated), and thus cross-pollination is possible if the crops are grown in close proximity. Cross-pollination would result in unwanted characteristics in both industrial hemp and marijuana. For growers of marijuana, cross-pollination with hemp could significantly lower the THC content and thus degrade the value of the marijuana crop. Likewise, growers of hemp would seek to avoid cross-pollination with marijuana plants, especially given the illegal status of marijuana. If hemp varieties are grown in or around marijuana, the hemp would pollinate the female marijuana plant. Likewise, marijuana growers would not want to plant near hemp fields, because this could result in harvests that are seedy and lower in THC and thus degrade the value of their marijuana crops. Plants grown for oilseed are also marketed according to the purity of the oilseed, and the mixing of other genotypes would degrade the value of the crop.⁴²

Differences in the cultivation practices between marijuana and hemp generally result in different observable traits under field conditions.⁴³ Visual plant differences between hemp and marijuana generally include **plant height** (hemp is often encouraged to grow tall, whereas marijuana is selected to grow short and tightly clustered); **cultivation** (hemp is often grown as a single main stalk with few leaves and branches, whereas marijuana is encouraged to become bushy with many leaves and branches to promote flowers and buds); and **planting density** (hemp is often densely planted to discourage branching and flowering, whereas marijuana plants are well spaced).

³⁹ I. Zeiler and C. Bussink, “The Cannabis Seeds Business,” draft report by researchers at the United Nations Office on Drugs and Crime, 2012.

⁴⁰ Zeiler and Bussink, “The Cannabis Seeds Business.”

⁴¹ See, for example, *BusinessWire*, “GenCanna Announces First Patentable Non-GMO Hemp Genetics with 0.0% THC,” January 28, 2019.

⁴² An example of another plant whereby different crops are cultivated by selecting for different traits is sweet corn and field corn (or corn for grain). Corn may also naturally cross-pollinate and requires early selection and removal of plants before pollination based on certain plant traits. Intermixing plants of the two types of corn may result in cross-pollination and degradation of each crop.

⁴³ G. D. Weiblen, University of Minnesota, presentation at the 2013 Annual HIA Conference, Washington, DC, November 17, 2013.

In general, the period of seeding to harvest ranges from 70 to 140 days depending on its intended purpose, the cultivar or variety planted, and climatic conditions. Different cannabis varieties or cultivars may be harvested at different times depending on the growing area.

Recent advances in cannabis research and development, as well as plant breeding and the creation of new cultivars and hybrids, are resulting in plants that do not always precisely present these distinctive observable characteristics.⁴⁴ Specifically, some hemp plants are being grown to be short and bushy, encouraging larger flowers, often from high-CBD, low-THC hemp seed. Hemp plants grown for flower are planted less densely—about 3 to 5 feet apart—to encourage the plant to become bushy with many leaves with wide branching to promote flowers and buds. Similarly, marijuana’s high THC content is concentrated primarily in the flowers and to a lesser extent in the leaves.

The cannabis plant’s cannabinoids (e.g., CBD, THC) are generally concentrated not in the plant’s seeds but in the flowering head of the plant.⁴⁵ Specifically, the heads of the mature cannabis flowers and leaves contain the trichomes—a term that refers to the small resin-like hairs/glands of the flowering buds but may also cover the leaves, bracts, and stems of plants.⁴⁶ Trichomes—the plant hairs—are among the primary source of the plant’s cannabinoids. Cannabinoids may be present in other parts of the plant, including the seeds, but in lower quantities.⁴⁷ Cannabinoid concentration in hemp may also vary depending on the types of trichomes and secretory structures present.⁴⁸ Besides cannabinoids, cannabis trichomes produce other secondary metabolites, including terpenes and certain phenolic compounds, such as flavonoids.⁴⁹

In general, each cannabis plant yields approximately one pound of dried floral material available for extraction by chemical process (**Table 1**). However, the percentage of extract generated per pound of dried material, as well as the quality and level of cannabinoids extracted, varies widely. Still, the flowers of the hemp and marijuana plant differ. Drug-grade cannabis also contains high resin concentrations, whereas fiber-grade cannabis generally has low levels of resin.

Hemp plants grown for fiber or oilseed are planted more densely—about 35-50 plants per square foot to discourage branching and flowering—than hemp plants grown for flower. For fiber and oilseed, the plant’s stalk and seed are the harvested products.⁵⁰ Available 2017 production statistics for Kentucky indicate that 1 acre of hemp yields between 800 and 1,000 pounds of seed, or between 1 and more than 5 tons of dry matter (**Table 1**).⁵¹

⁴⁴ CRS communication with Duane Sinning, Colorado Department of Agriculture, February 2, 2016.

⁴⁵ J. E. Joy et al., eds., *Marijuana and Medicine: Assessing the Science Base*, Institute of Medicine, 1999.

⁴⁶ C. M. Andre et al., “*Cannabis sativa*: The Plant of the Thousand and One Molecules,” *Frontiers in Plant Science*, vol. 7, no. 19 (2016).

⁴⁷ See, for example, S. A. Ross et al., “GC-MS Analysis of the Total Delta9-THC Content of Both Drug- and Fiber-Type Cannabis Seeds,” *Journal of Analytical Toxicology*, vol. 24, no. 8 (November-December 2000), pp. 715-717.

⁴⁸ Hemp trichome types include unicellular nonglandular trichome, cystolythic trichomes, capitate sessile trichome, capitate-stalked trichome, simple bulbous trichome, and complex bulbous trichome.

⁴⁹ Ross et al., “GC-MS Analysis.” *Terpenes* refers to certain phytochemicals (or biologically active compounds) found in plants, generally associated with a plant’s aromatic organic compounds. *Phenolic compounds* refers to a large class of secondary metabolites found in most plants.

⁵⁰ The stalk provides two types of fibers: (1) the interior or core short woody fibers (or hurds) and (2) the outer portion of the stem, which contains the long bast fibers (referring to the cellulosic fibers that grow on the outside of the hemp plant’s stalk, which are used for animal bedding and oil absorbents, among other uses).

⁵¹ Previous estimates from Agriculture and Agri-Food Canada suggest that about 700 pounds of seed can be pressed into about 50 gallons of oil and 530 pounds of meal, whereas 5,300 pounds of hemp straw can be transformed into about 1,300 pounds of fiber.

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