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Research Article

CANNABIS SATIVA: MEDICINAL PLANT WITH 1000 MOLECULES of Pharmaceutical Interest

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ABSTRACT

This literature review paper highlights the importance of **female inflorescence** of Cannabis sativa (medical cannabis**; marijuana type or drug type**). The inflorescence was used, traditionally, for acute pain, insomnia, coughing, and wounds. **Cannabidiol** (CBD) could be used as an **anti-viral agent** or anti-inflammatory tool, or to inhibit **pulmonary fibrosis in COVID-19 patients**. The female inflorescence is the main product of medical cannabis (marijuana type). The Cannabis inflorescence can be defined as a highly branched compound racemose. **Δ9-tetrahydrocannabinol** (THC) is the major **psychoactive** component and the toxicity of this metabolite of Cannabis is the most studied. Sales and cultivation of **Medical Cannabis (marijuana type)** is banned in **India** as **an illicit drug** and are **illegal** in **India.** One plant, Cannabis sativa with two names; **Medical cannabis sativa (marijuana type)**, and second one is **Industrial Cannabis sativa (fiber type).** Furthermore, pollination is a process by which plants increase the genetic diversity within the species. The most common stressors impacting cannabinoid production are light, nutrition, predation, temperature, and water deficit. **Industrial Hemp (fiber-type**) is both an agricultural and industrial commodity and stem supplies both cellulosic and woody fibers. **Hempcrete** is a building construction material made from **hemp fibres, lime and water**. This composite, hempcrete breathes, as well as having good thermal and acoustic-insulation properties. However, **hempcrete** does have several key drawbacks that make it **less than ideal as** a building material. In addition to **poor mechanical performance**, hempcrete also has a high **capacity to absorb and retain water**. Therefore, future in detail study is warranted for the commercialization of hempcrete as a building material.

Keywords: Cannabis sativa, building material, Δ9-tetrahydrocannabinol (THC), Illicit drug, Psychoactive, Medical cannabis (marijuana type), Industrial Cannabis sativa (fiber type), hempcrete.

INTRODUCTION

The term "**Cannabis**" is used to define the products (drugs and essential oils) that are prepared or obtained from the annual herb Cannabis sativa and its variants, which are of the family Cannabaceae (1-35, 40-48). **Cannabis sativa** is a well known herbal medicine, and is a complex mixture of compounds, including, cannabinoid phenols, non-cannabinoid phenols (stilbenoids, lignans, spiro-indans, and dihydrophenanthrenes), flavonoids, terpenoids, alcohols, aldehydes, n-alkanes, wax esters, steroids, and alkaloids (1-48). The plant produces a unique class of terpenophenolic compounds, called **cannabinoids**, as well as non-cannabinoid compounds (1-48). The utilization of this multipurpose Cannabis sativa (medical cannabis; marijuana type), has been restrained for a long time because of the **psychoactive effects** of a specific Cannabinoid **Δ9-tetrahydrocannabinol** (THC) $C_{12}H_{30}O_2$) (1-48). Despite various reports of its economic and therapeutic values, it is legal in a handful of jurisdictions (Uruguay, Canada, some US states, and parts of Africa). Presently, Cannabis (medical cannabis; marijuana type), remains illegal in several countries including **India** (1-48).

Over **565** chemical compounds have been isolated from the cannabis plant and have been reported (1-48). The several classes of secondary metabolites are present in different parts of the plant with a wide range of applications (**nutraceuticals, cosmetics, aromatherapy, and pharmacotherapy)** that are beneficial for humans (1-39, 40-48). Further, Cannabinoids are a class of terpenophenolic compounds obtained by the alkylation of an alkyl-resorcinol with a monoterpene unit (10-48). Cannabis sativa is known among many cultures for its medicinal potential (20-48). Its complexity contributes to the historical application of various parts of the plant in ethno-medicines and pharmacotherapy (1-48). **Cannabis sativa** has been used for the treatment of rheumatism, epilepsy, asthma, skin burns, pain, the management of sexually transmitted diseases, difficulties during child labor, postpartum hemorrhage, and gastrointestinal activity (1-48). However, the use of Cannabis sativa is still limited, and it is illegal in most countries including **India** (1-48). Studies on the clinical relevance and applications of cannabinoids and non-cannabinoid phenols in the prevention and treatment of life-threatening diseases is indeed significant(1-48). Furthermore, **psychoactive cannabinoids**, when chemically standardized and administered under medical supervision, can be the legal answer to the use of Cannabis sativa (1-45).

Non-psychoactive compounds found in **Cannabis sativa (Industrial hemp; Fiber type)** are associated with fewer side effects and can be used for several industrial applications. The Industrial hemp (Fiber type) stem supplies both cellulosic and woody fibers (1-48). The woody fibers are used for animal beddings, while the cellulosic fibers (bast fibers) are used as a substitute for fiberglass, and to produce bioplastics (1-48). Its use as an anti-bacterial finishing agent and in functionalized textiles have also been reported (1-36). The inflorescence was used, traditionally, for acute pain, insomnia, coughing, and wounds. The leaves were used for malaria, panting, roundworm, scorpion stings, hair loss, and the greying of hair. The stem bark was used for physical injury and strangury (1-40). **Vaginal discharge, difficult births, strangury, the retention of the placenta, and physical injuries were treated using the roots** (1-48). In addition, Cannabis sativa contains essential oils of a high value, which can also improve the effectiveness of cannabinoids in pharmaceutical formulations (1-47).

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Δ9-tetrahydrocannabinol (THC) is the major psychoactive component and the toxicity of this metabolite of Cannabis is the most studied (1-45). Its psychoactive component decreases in the order of inflorescence (the flower), leaves, stem, roots, and seeds, respectively. The psychoactive cannabinoids reported include **Δ9-tetrahydrocannabinol (THC)**, cannabinol (CBN), and cannabinodiol (CBND), while cannabidiol (CBD) and other cannabinoids are non-psychoactive (1-46). The **Cannabis root** has been recommended for **treating fever, inflammation, gout, arthritis, and joint pain, as well as skin burns, hard tumors, postpartum hemorrhage, difficult child labor, sexually transmitted diseases, gastrointestinal activity, and infections** (1-48). Cannabis has also been used to treat **asthma, epilepsy, fatigue, glaucoma, insomnia, nausea, pain, and rheumatism, as well as being used as appetite stimulant and a digestive aid** (20-48).

Cannabis inflorescence and leaf material may contain sufficient cannabinoids, mono- and sesquiterpenoids, and flavonoids for therapeutic applications (10-40). Cannabis terpenoids and flavonoids, mainly myrcene, limonene, pinene, -caryophyllene, and cannflavin A, act in synergy with cannabinoids to induce pharmacological effects (1-48). It was proven that these compounds, which are synthesized in the aerial parts of the plant, enhance CBD's anti-inflammatory effects and antagonize **Δ9-tetrahydrocannabinol** (THC) dysphoric action (20-48). Cannabidiol (CBD) and Cannabidavarin (CBDV) (neutral cannabinoids) have been reported to have the therapeutic potential for the treatment of epilepsy (focal seizures), as well as treating nausea and vomiting (2-48).

Cannabis female flowering tops can be simply administered through commercially available **vaporizers** (e.g., Micro Vape, G Pen Herbal Vaporizer, and Volcano), buccal sprays (e.g., Sativex), oral capsules (e.g., Cannador), decoctions, or oils (10-48). Only cannabis use through oral or inhalatory administration is allowed (1-40). Smoking reduces the bioavailability of cannabis ingredients by 40%, and its complete combustion can cause lung diseases and airway obstructions (2-48). They have hypothesized that **Cannabidiol (CBD)** could be used as an anti-viral agent or antiinflammatory tool, or to **inhibit pulmonary fibrosis in COVID-19 patients** (2-48). In addition, Cannabis-based pharmaceutical products must undergo long purification processes to eliminate the unwanted components such as chlorophyll and residual organic solvents (2-48).

In the following section, the pharmaceutical importance of **female inflourescence** of medical cannabis (marijuana type), misconception of cross-pollination, industrial cannabis (Fiber type) and finally Hempcrete has been discussed.

CANNABIS SATIVA: THE FEMALE INFLORESCENCE

The **female inflorescence** is the main product of medical cannabis (marijuana type) (17). The Cannabis inflorescence can be defined as a highly branched compound racemose (17-22). Cannabis contains hundreds of secondary metabolites such as, cannabinoids, terpenes, and flavonoids, which are produced and accumulated in the **glandular trichomes** that are highly abundant mainly on **female inflorescences** (17-22). Therefore, appearance of these solitary flowers represents the transition from adult vegetative stage to reproductive stage (17). The induction of solitary flowers is age-dependent and controlled by internal signals, but not by photoperiod (17-22). Short photoperiod induces intense branching, which results in the development of a compound raceme (17-22). Cannabis cultivars used for medical purposes are considered to have a short photoperiod requirement for flowering (17-22). When cannabis plants were moved to a short photoperiod, compressed inflorescences developed at the top of the main stem (17-22). Therefore, the effect of short photoperiod on cannabis florogenesis is not flower induction, but rather a dramatic change in shoot apex architecture to form a compound racemose inflorescence structure (17-22).

The most common taxonomy of this plant is that the genus Cannabis comprises one species, *C. sativa* L., with highly polymorphic subspecies *sativa*, *indica*, and *ruderalis* (17-22). These subspecies differ in their phenotypic characteristics and chemical profiles (17). The uniform taxonomy of the *Cannabis sativa* L. has been proven rather challenging and often confusing, due to the huge variability within the same genus (17-23). Cannabis interbreeding has contributed to the enormous phenotypic and chemical diversity of Cannabis cultivars that are in use today (17-22).

CANNABIS SATIVA: MISCONCEPTION OF CROSS POLLINATION

The two main phenotypes according to **Δ9-tetrahydrocannabinol** (THC) content are most frequently taken into consideration. The first one is **drug-type medical cannabis (marijuana type)** with high **THC** amount (30%) issued for medical and recreational purposes. The second one **is fiber-type (industrial) hemp** with THC less than 0.2%. (1-22). The misconception is that if industrial hemp is cross-pollinated by high **Δ9-tetrahydrocannabinol (THC)** medical cannabis (marijuana type), the industrial hemp (fiber-type) will become "hot" (high in THC) thereby rendering the crop illegal under the 2018 Farm Bill (1-7). But how do these crops result in excess **Δ9-tetrahydrocannabinol** (THC) production when feminized and certified seeds are used?. A main misconception within the cannabis industry is that it is caused by cross-pollination or how the crop was cultivated (1). The passage of the 2018 Farm Bill in USA renewed interest in *Cannabis* spp. as a commercial crop (1). Currently, in the **United States, 24 states** have approved hemp production plans with two plans under review and an additional 20 operating under the 2014 pilot program, three being USDA industrial hemp producers (1-7).

Cannabis sativa L. is naturally **dioecious**, with the staminate plants that are usually slender, taller, and that come to flower earlier that the pistillate ones (23). Hemp is wind pollinated, and the male plants die after producing millions of pollen grains (23). A small percentage of monoecious plants can naturally occur, particularly in short-day conditions (1-23). Monoecious varieties have been selected in modern times to reduce the agronomic problems related to the sexual vegetative dimorphism present in dioecious varieties (1-23). Usually seeds in monoecious varieties are smaller than in dioecious ones (23).

Cannabis spp. being an annual **dioecious flowering** plants that produce **male and female flowers** are borne on separate plants (1-16). Flowering is induced when day and night lengths become equal (1-16). However, monoecious- or **hermaphrodite plants** are readily observed when cannabis is under stress (1-23). The proximity of pollen donors around female flowers is not ideal for cannabinoid production because of high probability of self-pollination which induces the energy relocation toward seed formation, resulted in lower cannabinoid yields (1-16).

Male cannabis plants flower for a period of two to four weeks, and a **single male flower** can produce **3,50,000 pollen grains** (1-16). Pollen is carried to female plants on the wind and can travel great distances when conditions are favourable (1-9). **Bees** will collect **cannabis pollen** but are generally **not attracted to the female flowers to contribute to pollination** (1-16). The anther of the male flower is responsible for the pollen in question (1). In theory, only one pollen grain is required to fertilize the pistil of a female plant flower, as such more than one grain significantly increases the likelihood of fertilization (1-16). On average, the male plant produces **3,50,000 pale yellow** pollen grains, thereby dramatically increasing the chances of fertilization (1-16). Adding to the generation of copious

amounts of pollen is that the plants are exclusively wind pollinated (1). Therefore, the pollen has evolved for maximum dispersal on the wind (1-16).

As such, the risk of **pollination** is significant and several studies have sought to establish "safe" buffer zones between hemp crops (1-16). The wind dynamics is necessary for establishing buffer zones (1). Holding to the notion of one pollen grain is being needed to fertilize a flower, the buffer zone would preclude more than a few cultivations globally to prevent cross-pollination (1-16). Many governments have adopted a 5 km buffer zone between hemp and marijuana cultivations (1). An example is a recent litigation in Oregon where a hemp farm had to destroy its crop of female plants because of high **Δ9-tetrahydrocannabinol** (THC) levels due to cross-pollination from a neighbouring marijuana cultivation containing male plants (McGuire, 2020) (1, 2).

Furthermore, **pollination** is a process by which plants increase the genetic diversity within the species (1-16). To avoid the potential of seeds with questionable genetics, many farmers have turned to clones (1). The clones all carry the desired traits of the originally selected "mother" plant and are genetically identical in morphological and chemical characteristics (1). However, other factors such as abiotic and biotic stressors are the most likely cause of these high **Δ9-tetrahydrocannabinol** (THC) instances (1-16).

The most common stressors impacting cannabinoid production are light**, nutrition, predation, temperature, and water** deficit (1-16). The increased levels of **Δ9-tetrahydrocannabinol** (THC) following irradiation are thought to account for the physiological and morphological tolerances to UV-B radiation in drug-type plants (1-16). A recent study by Caplan *et al.,* (2019) (3) demonstrated that subjecting cannabis to drought for 11 days during flowering resulted in an **increase** in **Δ9-tetrahydrocannabinol** (THC) and Cannabidiol (CBD) levels by 50 and 67%, respectively (1-16). The impact of environmental conditions, specifically nitrogen nutrition, water stress, and salinity, was examined in a review by Landi *et al.,* (2019) (4) where it is reported that multiple genes are up regulated and down regulated by these abiotic stressors thereby allowing for altered secondary metabolite production (Landi *et al.,* 2019) (1-16). Therefore, on the basis of these studies it is clearly demonstrated a link between **environmental factors** and increased cannabinoid production, with increased **Δ9-tetrahydrocannabinol** (THC) being the main concern (1). Further, they also demonstrated the **Δ9-tetrahydrocannabinol** (THC) production is rooted in the genetics of the plant (1-16).

The **abiotic and biotic stressors** are merely the triggers for up- and down regulation of the plants genes (1-16). However, the Cannabidiol (CBD) yields from field grown hemp plants turned out to be different than the yields claimed in the sale's catalog because of the genetic heterozygosity of the seeds (1-16). The heterozygosity is a major issue for industrial hemp growers (1). Most commercially available hemp seeds are heterozygous (1-16). The **Δ9-tetrahydrocannabinol** (THC) levels concentrations can readily go above 0.3% upon receiving external and internal cues, even though an initial test certifies the variety produces less than **0.3% Δ9-tetrahydrocannabinol (THC)** (1-16). This is the most frequently observed case for growers who purchased the **seeds from uncertified brokers** (1-9).

Most importantly, the males produced pollen in that field, which introduced unwanted cross-pollination with a plant carrying an undesirable and illegal trait, THCA production (1-16). One of the misconceptions is that "cross-pollination" of marijuana pollens on industrial hemp females spikes the **Δ9-tetrahydrocannabinol** (THC) concentration in hemp fields (1-16). The reasons including (1) various environmental stressors (e.g., light spectrums and water deficit), (2) using highly heterozygous seeds containing high **Δ9-tetrahydrocannabinol** (THC) allele(s), and (3) using seeds resulted from industrial hemp that is cross-pollinated with medical cannabis (marijuana type) (1). Lastly, if possible, setting up a buffer zone, even further distant than suggested, can be definitely helpful to lower the chance of cross-pollination between industrial hemp and medical cannabis (marijuana type) (1-23).

CANNABIS SATIVA: INDUSTRIAL HEMP (FIBER TYPE)

Figure-1: Industrial Cannabis sativa (fiber type): Hemp

Figure-2: Industrial Cannabis sativa (fiber type): Hemp

In general **Industrial hemp** (**Fiber type**) contains minimal amounts of psychoactive component **Δ9-tetrahydrocannabinol (THC) (0.3% or less THC)** and moderate to high amounts of Cannabidiol (CBD), when, in fact, medical cannabis (marijuana type) can contain up to 30% **Δ9-tetrahydrocannabinol** (THC) (1-23). **Industrial hemp (Fiber type),** as a diverse plant, can be a revolutionary crop for a better future and for upcoming generations (27). It is an eco-friendly and worthwhile crop that complements a sustainable growth system (27). **Industrial hemp (Fiber type) farming** has the potential to dramatically minimize the amount of carbon impact on the environment and can be cultivated with little or no usage of chemical pesticides or fertilizers (27). The stalks, seeds, and leaves are converted into various construction materials, textiles, paper, food, furniture, cosmetics, healthcare products, and soon. Bioplastics, biofuels, and biopesticides are some of the innovative applications of the plant (27).

Industrial hemp (Fiber type) **(Figure-1, 2)** is recognized as a crop that could be cultivated in different surroundings, exploiting marginal land (23-26). Generally, it can be grown without pesticides and with a low input technique (23). Hence Industrial hemp (Fiber type) is considered as alternative viable crop for sustainable agriculture (23). As a multifunctional crop, it can have different end use: traditional ones as fiber but also innovative ones as the use of seeds and inflorescences as sources of interesting bioactive

secondary metabolites for nutraceutical (23-26), medicinal and cosmetic purposes or for producing essential oils as natural flavour and fragrance additives (23-26). **Industrial hemp (fiber type)** has been traditionally cultivated as a source of fibers but increasing concern in the nutritional properties of the seeds has promoted its further development, especially for the fatty acid and protein portions (23). **Industrial hemp (Fiber type)** is a plant adaptable to various growing and ecological conditions (23-26). Furthermore, there is a growing interest about the valorization of a hemp inflorescence that could display potential pharmacological effects (23). In this regard, hemp essential oil is reported to have an intriguing antimicrobial activity, whereas the whole decocted plant is used against migraine, or as pain-relieving substance (23**). Industrial hemp (Fiber type)** plants produce and accumulate a terpene-rich resin in glandular trichomes, which are abundant on the surface of the female inflorescence (23-26).

As per the **Grand View Research Inc, USA** report, the global **industrial hemp (fiber type**) market size was estimated at **USD 4.13 billion** in 2021 and is expected to grow at a compound annual growth rate (CAGR) of 16.8% from 2022 to 2030 (50). The market is driven by the growing demand for industrial hemp (fiber type) from application industries, such as the food & beverage, personal care, and animal care industries, across the globe (50). Growing awareness regarding the dietary advantages of hempseed and hempseed oil, along with rising demand from the cosmetics and personal care industries will augment the market growth (50). Increasing production of soaps, shampoos, bath gels, hand and body lotions, UV skin protectors, massage oils, and a range of other hemp-based products is expected to have a positive impact on the market growth (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (50)

Industrial Hemp fibers are used in paper, carpeting, home furnishing, construction materials, insulation materials, and auto parts and composites (50). Insulation materials and bio-composites consume a significant product amount on account of their low weight, superior strength, biodegradability, and thermodynamic properties (50). Hemp shivs cost half the value of fibers and have several applications in different industries, which is expected to drive the segment growth over the forecast period (50). These are majorly used in animal bedding materials on account of their high absorbance ability, which is around four times their own dry weight (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (50)

The most important secondary metabolites are phytocannabinoids that have biomedical relevance (23-26). Acidic forms of cannabinoids are exclusively biosynthesized in the trichromes: inflorescences of industrial hemp varieties are particularly rich in cannabidiolic acid (CBDA) that is susceptible to the spontaneous decarboxylation to cannabidiol (CBD) under favourable environmental/conservational conditions, such as heat and light (23-26). Cannabidiol (CBD) is responsible for a variety of pharmacological actions that could have some remarkable applications, but unlike **Δ9-tetrahydrocannabinol** (THC), Cannabidiol (CBD) does not possess any psychoactive effects (23) Therefore, Cannabidiol (CBD) dietary supplements obtained from different industrial cannabis chemotypes have become particularly widespread (23-26).

The **phytochemical characterization** of cannabis highlights the presence of various non-cannabinoids constituents including flavonoids, spiroindans, dihyrostilbenes, dihydrophenanthrenes, lignanamides, steroids, and alkaloids (23-26). Furthermore, other phytocannabinoids detected in plant samples include principal oxidation products of THC(A) and CBD(A): Cannabinol (CBN) and Cannabinolic acid (CBNA) obtained from THC(A) and Cannabielsoin (CBE) and Cannabielsoinic acid that derive from CBD(A) (1-26).

The high nutritional values and beneficial fatty acid and protein profile of industrial hemp (fiber type) are driving the demand for hemp products (50). The high absorbency of hemp fiber is beneficial for livestock bedding, oil & gas cleanup, and personal hygiene applications (50). In addition, increasing product demand from the textile, paper, and building materials markets, owing to favourable acoustic and aesthetic properties, will support the market growth (50). The products manufactured from hemp are eco-friendly, renewable, and associated with less harmful methods of preparation (50). Paper produced from hemp fiber requires fewer chemicals for processing as compared to paper produced from wood pulps (50). Thus, the rising awareness levels about the product benefits are projected to benefit the market growth (2-45, 50) (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (50).

The seeds product segment is estimated to register the fastest CAGR of more than 20% from 2022 to 2030 (50). The hemp seeds are gaining popularity in the food and **nutraceutical** markets (50). The rising product usage in lotions, shampoos, soaps, bath gels, and cosmetics further benefits the segment growth (50). Hemp seeds are also used in the production of oil, which is consumed in the personal care, food & beverages, and animal feed industries (50). In addition, the oil is used in nutritional supplements and medicinal & therapeutic products, such as pharmaceuticals (50). The fibers segment led the global market in 2021 and is estimated to expand further maintaining its dominant position throughout the forecast period (50) (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (50).

The **textile application segment** led the market and accounted for more than 24% share of the global revenue in 2021 (50). Industrial Hemp (fiber type) fabric is strong, hypo-allergic, and naturally resistant to UV light, mold, and mildew, which represents an added advantage over other fabrics (50). In addition, it can be blended with cotton or linen, which adds stretch and strength to the fabric (50). Hemp seeds are rich in protein content and majorly used as birdseed and animal feed (50). The bird and fish feed are important markets for hemp seeds in animal nutrition (50). Fish and birds need fatty acids with a high share of **Omega-3 and Omega-6** fatty acids for optimum development (50). The growing product demand in the animal care industry is likely to fuel the industry growth (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (50).

Hemp oil is widely used in the manufacturing of food & beverages on account of its high nutritional content, including fatty acids, proteins, and several other ingredients (50). Several food manufacturing processes make use of hemp seeds and oil, which is expected to propel market growth (50). In addition, rising consumer awareness about the product benefits is likely to fuel market growth. The product is widely used in insulation and construction materials, such as fiberboard, cement blocks, putty, stucco and mortar, coatings, and other products as a fiberglass substitute (50). Construction materials using industrial hemp also include roofing underlay, acoustic materials, pipe wraps, house wrap, and shingles (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (50).

Asia Pacific led the market and accounted for more than 32% share of the global revenue in 2021 (50**). Economies, such as China, India, Japan, Korea, Australia, New Zealand, and Thailand,** are actively involved in the production and consumption of industrial hemp (fiber type) and its products, such as fiber, seed, hurds, and oil (50). Increasing global product demand along with advancing technologies and innovation are making harvesting easier for cultivators, thereby changing the face of hemp production in the region (50). Increasing consumption of hemp-based food products and supplements in developing economies with a growing population

is expected to drive the regional market over the forecast period (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (50).

North America is among the major consumers in the global market due to the presence of several application industries (50) Moreover, high consumer disposable income levels, a growing population, and rising concerns related to skin diseases and UV protection are expected to drive the demand for hemp oil in the personal care industry in the region (50). **In Europe**, the product is majorly consumed in automotive parts, construction materials, textiles, and fabrics in the form of fibers (50). However, the growing demand for hemp oil in the food & supplements, cosmetics, and personal care markets is expected to drive the market for hemp seeds over the forecast period (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (50).

Some of the industries involved in the Industrial hemp (fiber type) products marketing are, Parkland Industrial Hemp Growers Cooperative Ltd.; CBD Biotechnology Co.; Botanical Genetics, LLC; Marijuana Company of America Inc.; HempMedsBrasil; Terra Tech Corp.; American Cannabis Company, Inc.; HempFlax B.V.; Industrial Hemp Manufacturing, LLC; American Hemp; Hemp, Inc.; Boring Hemp Company; Plains Industrial Hemp Processing Ltd.; Ecofiber; Industries Operations; Valley Bio Ltd (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (50).

INDUSTRIAL CANNABIS SATIVA (FIBER TYPE): HEMPCRETE

Industrial Hemp (fiber-type) is both an agricultural and industrial commodity, highlighted by its usefulness as a sustainable resource for an estimated twenty-five thousand different products (Johnson, 2015) (34, 35, 36**). In addition to its ability to absorb carbon dioxide while it is being grown** (28-35, 36). The pressure for improved construction methods also leads to the search for new materials. One possible material with suitable technical properties based on renewable resources is hemp fibre concrete – hempcrete (28-36). **Hempcrete** is a construction material made from hemp fibres, lime and water (35-36). This composite breathes, as well as having good thermal and **acoustic-insulation properties** (28-36). A life cycle analysis of hempcrete will be used to examine its ecological footprint, especially in **reducing carbon dioxide emissions** (35,36). The preliminary results suggest that hempcrete offers both environmental and construction opportunities which can help to deliver sustainable housing solutions (35, 36). **The hemp and lime product** proved to be a natural alternative to cement based concrete (28-36). **Hempcrete is bio-composite mixture of hemp shive, lime binder and water** (28-36). A lightweight material, it is about one eighth the weight of concrete (28-36). **Hempcrete** can be used to construct walls, floors and roofs; or moulded (monolithic), sprayed or precast (e.g. hemp bricks or panels) (28-36).

However, as it more specifically relates to the field of **civil engineering, hemp can be mixed with lime to form a bio-aggregate concrete, known as "hempcrete** (28-35). **Hempcrete** is a sustainable building material that is made with a low environmental impact that removes waste production, decreases both energy use and the consumption of natural resources. **Hempcrete locks CO_2 within its fibres, has low thermal conductivity, and exceptional acoustic performance and vapour permeability, which regulates the temperature inside structures** (35, 36).

Hempcrete is a lightweight concrete, made from industrial hemp pulp (or shiv), and hydraulic or aerated lime (28-34). It is typically used for timber frame infill, roofing tiles, insulation, renders, and floor slabs (28-35). Although hempcrete cannot provide enough structural integrity to be used as a load-bearing material, it can, however, make up for its mechanical drawbacks through functionality and environmental benefits (28-35). For instance, **hempcrete** exhibits a low thermal conductivity that regulates the temperature and humidity levels within a dwelling, a high acoustic performance when compared to traditional concretes, and an exceptional resistance to fire without the need for fire-preventative measures (Arizzi *et al.,* 2015) (28-35). In the construction phase, hempcrete is most commonly used for a timber frame infill, which is built using a removable formwork mold, such as a plastic casing (28-35). The hempcrete is poured between the two formwork plates into a dismountable mold (28-35). Each layer is carefully leveled when placed in the mold, around 20 cm in thickness for each addition (28-35, 36).

Hempcrete is a highly breathable material, which allows for the regulation of indoor temperature and humidity (28-35, 36). This is mainly caused by the porosity of hempcrete, which allows the transfer of water vapor with the surrounding air (28-35). This phenomenon occurs at times of high humidity, allowing the vapor to condense back into the liquid state and coming to rest on the surface of the pores (28-35, 36). This process can be reversed in times of low humidity, essentially acting as a natural humidifier(28-35). Consequently, this has an interesting effect on the **thermal conductivity of hempcrete** (28-35). This works to regulate the indoor temperature, reducing the need for heating and cooling systems, in addition to lending the material greater insulation capacity, while maintaining the quality of the air. (Arnaud, *et al.,* 2013) (28-35).

MAJOR DRAWBACKS OF HEMPCRETE

Despite its many benefits, **hempcrete** does have several **key drawbacks that make it less than ideal as a building material** (28-35). For instance, the porous structure of the hempcrete **decreases its mechanical performance**, and **increases its ability to retain wate**r (Arizzi *et al.,* 2015) (28-35). Though these issues are not so befouling as to prevent the use of hempcrete within the construction sector altogether, they do, however, provide strong limitations regarding what it can be used for (28-35). The most significant **setback of hempcrete is its poor mechanical performance**, which prevents hemp from being used as a load-bearing material (28-35). This is due primarily to the fact that hempcrete is highly porous, causing a poor adhesion to the lime binder that results in an elastic-like behavior (Arnaud *et al.,* 2013) (28-35). Theoretically, this can be a useful trait in some situations, such as earthquakes, in which the material can bend without compromising its structure or cracking (28-35). On the other hand, it does cause **hempcrete** to deform a significant amount under stress (28-35). However, recent experimentation has indicated that this can be avoided (28-36). **In addition to poor mechanical performance, hempcrete also has a high capacity to absorb and retain water** (28-35, 36). Although this can be of benefit to the agricultural process, in that it decreases the irrigation requirements of the hemp crop, it can be a significant detriment to its use as a construction material (28-35, 36). For instance, the hemp shiv is able to absorb up to 300-400 times its weight in water (Arizzi *et al.,* 2015) (28-35, 36).

CONCLUSION

The use of the **female cannabis** (Cannabis sativa L.; Cannabaceae) **inflorescence** for medical purposes has increased greatly in the past decade (49). The constituents of Cannabis sativa well recognized for its pharmacological effects are known as cannabinoids. Mono- and sesquiterpenes are the other major components of cannabis. Cannabinoids are terpenophenolic compounds, and the most abundant and well-known

phytocannabinoids are **Δ9-tetrahydrocannabinol (THC)** and cannabidiol (CBD) (49). These are produced by cannabis in their carboxylic acid forms, Δ9- tetrahydrocannabinolic acid (THCA) and cannabidiolic acid (CBDA) respectively, which are decarboxylated by heating (e.g., smoking or baking), by light, or by natural degradation. Δ9-THC, the decarboxylated form of THCA, is the cannabinoid predominantly responsible for the **psychoactive properties** of cannabis (49). Furthermore, this literature review paper highlights about the pharmaceutical importance of **female inflourescence of medical cannabis (marijuana type**), misconception of cross-pollination, industrial cannabis (Fiber type) and finally hempcrete has been discussed.

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