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Cannabis sativa: Industrial Hemp (fiber-type)- An emerging opportunity for India

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Abstract:-This literature review paper is presented as a part of the educational awareness about the Cannabis sativa, particularly the **Industrial Hemp (fiber-type).** *Cannabis sativa* was originally a native of **India** growing as a wild medicinal plant in the Himalayan region. The cultivation and use of Industrial hemp (fiber type) is historically rooted in the Indian subcontinent and this rich heritage of cannabis use dates back to at least two thousand years. Industrial hemp (fiber type) is a versatile commercial crop that has been used for fiber, food, medicinal purposes and building construction material, **Hempcrete**. Many studies have demonstrated that the nutrient and bioactive composition of hemp contributes to the prevention and treatment of several ailments suggesting its potential as a valuable functional food ingredient. Industrial hemp (fiber type) and medical Cannabis (marijuana type) have primarily been differentiated by their levels of **Δ9-tetrahydrocannabinol (THC)** production. Industrial hemp (fiber type) can be refined into a variety of commercial items, including **paper, artificial hair, rope, textiles, clothing, biodegradable plastics, paint, insulation, biofuel, food,** and **animal feed**. This review sought to highlight these advances in understanding the medical, nutritional, and nutraceutical benefits of industrial hemp (fiber type).

Key words: Cannabis sativa**, Cannabidiol** (CBD), building material**, Δ9-tetrahydrocannabinol** (THC), **Omega-6 to Omega-3 PUFA.** Illicit drug, **Psychoactive**, Medical cannabis (marijuana type), Industrial Cannabis (fiber type), Hempcrete.

I. Introduction

Industrial hemp (fiber type) belongs to the family, **Cannabaceae** is considered as one of the oldest plants cultivated to provide nutritional and medicinal benefits (1-25). Industrial hemp (fiber type) is typically a **dioecious**, obligate **cross-pollinated** species with a diploid genome (2n = 20), although monoecious types have been bred (1-24). It is genetically complex and therefore, as significant variability in phenotype and sex expression (1-10). **The Industrial hemp (fiber type)** samples were more heterogenous than **medical Cannabis (marijuana or drug type**), indicating the Industrial hemp (fiber type) samples came from a wide genome pool, whereas the medical Cannabis (marijuana type), samples had a relatively narrow genetic base (1-25). Industrial hemp (fiber type) and medical Cannabis (marijuana type) have primarily been differentiated by their levels of **Δ9-tetrahydrocannabinol** (THC) production (1-25). All industrial hemp (fiber or grain type) varieties contain **Δ9-tetrahydrocannabinol** (THC), **Cannabidiol** (CBD), and other cannabinoids, although the concentrations in some varieties are very low to non-detectable (1-25).

Its medicinal value was discovered in **India as *Ayurvedic*** medicine and cultivated as early as 900 BC (25). *Cannabis sativa* was originally a **native of India** growing as a wild medicinal plant in the **Himalayan region of Nepal, Bhutan, China, Pakistan, Afghanistan, and Burma (Mynamaar)** (1-25). The history of cannabis use is rooted in the Asian subcontinent particularly India. The indigenous strain of *Cannabis indica* has been growing freely along the Himalayan foothills and adjacent plains of India for centuries (1-25). The cultivation and use of Industrial hemp (fiber type) is historically rooted in the Indian subcontinent and this rich heritage of cannabis use dates back to at least two thousand years (5-21). Industrial hemp (fiber type) can also be consumed as a ***Cannabis* tea** in remote villages of India (4-24). In remote area, the use of *Cannabis sativa* is totally depends on traditional knowledge, which transmitted through family traditions basically through oral conversations (1-25).

Cannabis sativa was used as a medicine before the Christian era in Asia, particularly in India and China (1-25). The medicinal use of *Cannabis* has a very long history. It has been used for the treatment of various diseases since the Vedic Period (1-25). It is well known for various forms of non-formal medical treatments (4-25). The medicinal value of *Cannabis sativa* includes intoxicant, analgesic, narcotic, stomachic, antispasmodic, anodyne, sedative (1-24). The *Cannabis sativa* leaves alone have ability to cure more than 25 diseases (1-21). Seeds are used to treat **tumours** and **cancerous ulcers** (1-25). India is a country of faith and mysticism, and ***Ayurveda*** is a system of medicine used by the Indian traits (2-25). *Cannabis* was bound to religions in India especially in the Hindu as well as in numerous other minority religions (5-25). ***Ayurvedic*** system of medicine is based on a conceptual medical system which depends on balancing three functional elements of human body *viz.* ***Vayu*** (air), ***Pitta*** (fire) and

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Kapha (water and earth) (7-23). As per Ayurveda, good health depends on equilibrium between these three factors and imbalance may cause disease. In India, the properties and use of *Cannabis sativa* were well documented and described by many Ayurvedic physicians before thousands of years (1-25).

The Industrial hemp (fiber type) **(Figure-1, 2. 3)** have been used to aid in treating and preventing ailments for thousands of years in traditional oriental medicine (1-25). Industrial hemp (fiber type) is a versatile commercial crop that has been used for fiber, food, and medicinal purposes. Now a days the potential use of industrial hemp (fiber type) in food and nutraceuticals has been growing (1-24). In addition to this, the hemp seed, be it raw, cooked, or pressed into oil, has been well documented as a primitive source of fiber, protein, and fat, with high nutritional value (1-24). Industrial hemp (fiber type) and medical Cannabis (marijuana type) have primarily been differentiated by their levels of **Δ9-tetrahydrocannabinol** (THC) production. This difference translates to producing upwards of 10% to 30% **Δ9-tetrahydrocannabinol** (THC) in many medical Cannabis (marijuana type) samples, whereas most Industrial hemp (fiber) samples have a total **Δ9-tetrahydrocannabinol** (THC) level of 0.3% or less (1-25).

As mentioned above, both Industrial hemp (fiber type) and medical Cannabis (marijuana type) belong to the same plant species Cannabis sativa L. but are cultivated differently and vary in their phytochemical constituents (1-21). In North America and most of Europe, the industrial hemp (fiber type) must not contain more than 0.3% of **Δ9-tetrahydrocannabinol** (THC) in dried herbage (1-25). The cannabinoids **Δ9-tetrahydrocannabinol** (THC) and **Cannabidiol** (CBD) profile and the morphology of the plant are determined by the interaction of genetics and the environment (1-5). Genetically, medical Cannabis (marijuana type), possesses the $\mathbf{B_T}$ allele that encodes for tetra-hydrocannabinolic acid synthase, while Industrial Cannabis sativa (fiber type) produces the $\mathbf{B_D}$ allele encoding for **Canabidiolic acid** (CBDA) synthase (1-5).

Industrial Hemp (fiber type): By-products and Health Benefits

Industrial hemp (fiber type) is a multi-purpose crop. The unique properties of the plant make it a highly valuable and sustainable crop **(Figure-1, 2. 3).** There are more than 25,000 hemp-based products available in markets worldwide (23-25). A growing number of agriculture training programs and practices are spreading across farming communities to spread knowledge of hemp (1-21). Similar to the guidelines set by the Farm Bill in the USA, India's goal for all Industrial hemp (fiber type) grown should contain less than 0.3 percent **Δ9-tetrahydrocannabinol** (THC) (2-21). Over the past half a decade, the interest and demand for Industrial (fiber type) hemp-based products is on the rise, as may be seen with the increase in the number of women artisans and weavers in rural Himalayan villages. (6-25). Rural Himalayan villages have increased the quantity and quality of indigenous Industrial (fiber type) hemp handloom products, such as shawls, stoles, accessories **(Figure-1, 2. 3)** (2-21). Industrial (fiber type) hemp is a variety of the Cannabis sativa plant species that is grown specifically for industrial use (5-21). It can be used to make a wide range of products. Along with bamboo, hemp is one of the fastest growing plant on Earth. It was also one of the first plants to be spun into usable fiber 5,000 years ago (2-21). It can be refined into a variety of commercial items, including paper, rope, textiles, clothing, biodegradable plastics, paint, insulation, biofuel, food, and animal feed (1-25).

The cultivation of Industrial hemp (fiber type) is more efficient and less environmentally degrading than that of many other crops (1-21). Hemp can be grown under a variety of agro-ecological conditions and has a capacity to grow quickly, especially after the first 4–5 weeks after emergence, making it an excellent candidate for **carbon sequestration** (1-21).

Industrial hemp (fiber type) comprises fiber and oilseed hemp. Industrial hemp (fiber type) is currently considered as a niche crop and is grown in temperate regions (1-21). Industrial hemp (fiber type) grain and its derivatives have also gained popularity among consumers and have multiple uses (1-21). It is estimated that the hemp market entails more than 25,000 products, ranging from textiles, clothing, rope, home furnishings, industrial oils, cosmetics, to food and pharmaceuticals (2-21). The durability and high strength properties of the cellulose-rich fiber from the stalk make it a valuable product for rope, paper, building construction material (**Hempcrete**), and reinforcement material (1-21). In fact, Industrial hemp (fiber type) seed's utility as a functional food ingredient is currently witnessing a revival of old medicinal applications, as its metabolites have shown potent biological activities (1-21).

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 (17). 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 (17). 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 (17-23).

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Industrial Hemp fibers are used in paper, carpeting, home furnishing, construction materials, insulation materials, and auto parts and composites (17-25). Insulation materials and bio-composites consume a significant product amount on account of their low weight, superior strength, biodegradability, and thermodynamic properties (17-24). 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 (17). 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 (17).

The high nutritional values and beneficial fatty acid and protein profile of industrial hemp (fiber type) are driving the demand for hemp products (17). The high absorbency of hemp fiber is beneficial for livestock bedding, oil & gas cleanup, and personal hygiene applications (17). 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 (17). 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 (17). Thus, the rising awareness levels about the product benefits are projected to benefit the market growth (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report (17).

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 (17-25). Several food manufacturing processes make use of hemp seeds and oil, which is expected to propel market growth (17). In addition, rising consumer awareness about the product benefits is likely to fuel market growth (2-24). 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 (17-25). 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 (17).

Hemp seed oil contains **tocopherol isomers beta-tocopherol, gamma-tocopherol**, alpha-tocopherol, and delta-tocopherol, with the gamma-tocopherol derivative present in the highest quantity (1-21). **Tocopherols** are natural antioxidants that can reduce the risk of oxidative degeneration related disorders (1-21). In addition, terpenes and polyphenols have been detected, which contribute to the odor/flavor and intrinsic antioxidant activity, respectively (1-25). Among phenolic compounds, **flavonoids,** such as **flavanones**, flavonols, flavanols, and isoflavones were the most abundant (1-21). Furthermore, supplemented the human diet with 30 mL of hemp seed oil daily for four weeks and detected positive changes in the serum lipid profile (1-21). Evidence suggests that phyto-, endo-, and synthetic cannabinoids contain properties that aid in the treatment of **the brain, prostate, breast, skin, pancreas**, and **colon cancer** (1-21). Cannabinoids have also been found to prevent the differentiation and proliferation of **glioma stem-like cells**, which may help treat the difficult-to-eliminate nature of gliomas (1-21).

Of several natural cannabinoids tested, a Cannabinoids (CBD) extract provided the most potent **cytotoxic effects** against breast cancer cells, with significantly lower damage to healthy cells (1-21). Cannabinoids (CBD) induced apoptosis in a breast cancer cell line via the activation of the overexpressed CB2 receptor (1-21). Other studies have explored **cannabinoid therapy in skin, pancreas, and colon cancers** (1-21). In a traditional **Indian folk medicine**, hemp seed oil has been used to relieve chronic knee pain in patients with rheumatoid arthritis (RA) and improved blood circulation (1-21). Experimental evidences concluded that hemp seed oil promotes the production of **reactive oxygen species** (ROS), storage of lipids, production of endoplasmic reticulum stress markers, which act as **anti-rheumatoid** factors in downstream processes, and improved blood circulation, providing additional relief to RA patients (1-25). A **Cannabinoids (CBD**) -based oil was used to treat another kind of arhritis: **steoarthritis** in **dog**s (1-21). Hemp seed oil can be an effective cure to eczema, as well as a host of other skin related ailments (1-21). Hemp seed oil is composed of more than **80% PUFA** (**polyunsaturated fatty acid**) and is rich in **tocopherols** (1-21). These constituents point to hemp seed oil's beneficial effects in reducing and eradicating skin diseases, including **eczema** (1-25).

Industrial hemp (fiber type) seeds or oil contain an amino acid known as **arginine** which is extremely **good for heart** as it dilates and relaxes blood vessels (1-21). Hemp oil fights **inflammation, lowers blood pressure**, and hence helps to prevent the formation of **blood clots** (10-21). Hemp seeds are a good source of **gamma-linolenic acid** (GLA), which is known for its strong **anti-inflammatory** properties (1-21). Foods rich in **gamma-linolenic acid** (GLA), are extensively used to fight inflammation in the joints (arthritis), **nerve damage**, and inflamed skin conditions such as **acne, and eczema** (1-21) (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report) (17). Hemp seed oil is currently advertised primarily as a natural health product for body care purposes, as oil for **salad dressings**, or to be taken directly as a **dietary supplement** (1-24). The hemp seed oil has a strong susceptibility to rancidity with heat and prolonged storage, which reduces its use as cooking oil (1-24).

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Hemp seeds are rich in protein content and majorly used as birdseed and animal feed (17). The bird and fish feed are important markets for hemp seeds in animal nutrition (17). **Fish and birds need fatty acids** with a high share of **Omega-3 and Omega-6** fatty acids for optimum development (17). Hemp seed is a balanced health product with bioactive components that have the capacity to aid health beyond that of basic nutrition (Grand View Research Inc., 201, San Franscico, CA, USA. Grand View Research Inc Report) (17). The major constituents of hemp seed include easily digestible protein (20–25%), **polyunsaturated fatty acid (PUFA)**, abundant lipids (25–35%), and carbohydrates (20–30%) high in insoluble fiber (1-21). Hemp seed protein is well-suited for human and animal consumption, consisting mainly of high-quality, easily digestible proteins **edestin, and albumin**, which are abundant with essential amino acids (1-21).

The rich source of **PUFA, linoleic acid** (LA; omega-6) and **alpha-linolenic acid** (ALA; omega-3), is favourable and regarded as balanced for human nutrition at a ratio of 3:1 (1-21). Nutritional recommendations indicated that 15–20% of daily caloric intake should come from fats, and approximately one-third of these fats should be essential fatty acids in a 3:1 ratio (1-21). It is estimated that this dietary goal can be met with three tablespoons of **hemp seed oil** (1-21). Numerous health benefits and potential therapies are reported for hemp seed. Hemp seed delivers a desirable ratio of **Omega-6 to Omega-3 PUFA**, which can improve **cardiovascular health, reduce osteoporosis symptoms, and diminish eczema** conditions (1-21). CBD exerts pharmacological properties that make it a potential therapeutic agent for central nervous system diseases, such as epilepsy, neurodegenerative diseases, and multiple sclerosis (1-21). The **hemp seeds and sprouts** to be rich in beneficial bioactive compounds with both in vitro and ex vivo antioxidant activities (1-24).

Furthermore, these compounds exhibited an antimutagenic effect on Saccharomyces cerevisiae. The main polyphenols identified in seeds and sprouts exhibiting antioxidant activities were **Cannabisin A, B, C**, and **caffeoyltyramine** (1-21). The two primary compounds identified in sprouts that provide nutraceutical benefits were **linoleic acid** and **gluconic acids**, which act as intermediaries in the production of **vitamin C** (1-21). **Terpenes**, which are also found in hemp, have anti-**inflammatory** and some antiallergic properties, can treat pain, prevent the production of ROS, and act as potent antioxidants (1-21). Due to the presence of a wide variety of nutrients, including high levels of PUFA and essential amino acids, hemp seeds are praised for providing adequate quantities of different nutrients to satisfy human dietary requirements (1-21).

Nanoencapsulation is remarkable in improving the low water solubility, bioavailability, volatility, and stability of high-value oils (1-21). The concentrated and encapsulated the bioactive compounds extracted from hemp fiber processing waste, also called hemp fiber meal (1-21). **Hemp fiber meal** can be used for isolation of essential amino acids, especially **arginine**, by using food grade enzymes for polysaccharide digestion; the resulting polysaccharide fragments can be subjected to ultrafiltration and removed to concentrate the protein content, making it a superior isolate compared to other hemp protein products (1-25).

Asia Pacific led the market and accounted for more than 32% share of the global revenue in 2021 (17). Economies, such as India, China, 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 (17-24). 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 (17-24). Increasing the 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 (17).

North America is among the major consumers in the global market due to the presence of several application industries (17-24). 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 (1-24). In Europe, the product is majorly consumed in **automotive parts, construction materials, textiles, and fabrics in the form of fibers** (17-24). 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 (17).

The textile application segment led the market and accounted for more than 24% share of the global revenue in 2021 (17-24). **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 (17-24). In addition, it can be blended with cotton or linen, which adds stretch and strength to the fabric (17). As a fiber crop, hemp provides a high yield; it produces 250% more fiber than cotton and 600% more fiber than flax, from the same acreage (1-24). Due to the fast-growing, dense canopy, Industrial Hemp (fiber type) is a natural **weed suppressor** and could be grown without herbicides (1-24). Hemp also suppresses levels of fungi and nematodes in the soil and can be grown without fungicides or pesticides (1-21). Hemp contributes to the maintenance of soil quality by its anchored roots, which prevent soil erosion and nutrient leaching, may extract nutrients from deeper soil layers, and are effective for **phytoremediation** by absorbing heavy metal contaminants from the soil and storing them within the plant (1-21). The

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continual shedding of leaves through the growing season adds moist organic matter to the soil (1-25). Because of the functions in improving the soil quality, **Industrial Hemp (fiber type)** is a prime candidate to be used for crop rotation programs to improve the yield of the main crop (17-25). Despite the historical functionality of this multi-purpose crop, global Industrial Hemp (fiber type) production declined in the 19th century, and still only comprises about 0.5% of the total production of natural fibers (1-24). **Hemp seed** is a balanced health product with bioactive components that have the capacity to aid health beyond that of basic nutrition (1-24).

II. Industrial Hemp (Fiber type): An emerging opportunity for India

Industrial Hemp (*Cannabis sativa L.*) (fiber type), is a variety of cannabis, also known as Hemp is a non-drug cannabis with **Δ9-tetrahydrocannabinol (THC)** content generally below 0.3 percent (1-21). The crop can be cultivated for either fibre, seed or cannabidiol (CBD). Hemp seeds and hemp seed oil constitute a major part of hemp business (16-21). The global industrial hemp market is projected to grow from USD 4.6 billion in 2019 to USD 26.6 billion by 2025, recording a CAGR of 34%. In the global hemp economy, China has a market value at $1.7 billion USD (2017) and holds a share of 20 percent of total production followed by countries like Canada, US, France, Chile etc (1-21). Industrial hemp (fiber type) market is driven by rising awareness about the benefits of industrial hemp, increasing legalisation to cultivate industrial hemp in many countries, and the rising applications in various industries such as pharmaceuticals, food, beverage, personal care, textiles, automobiles, construction, furniture, and paper (1-24). Apart from these, hemp is also a good alternative to plastic, as it is non-toxic and bio-degradable (1-24). Indian government allows cannabis or hemp (non-drug category) products to be sold on general ecommerce sites after necessary due diligence (1-21). However, hemp or **Cannabidiol** (CBD) is not legal as an ingredient in food, beverages, and food supplements (15-24).

Industrial hemp (fiber type) is used to making cloth, cosmetics, rope, printer's ink, wood preservative, detergents, soaps, and lighting oil (1-24). Hemp fibers are used in the preparation of artificial hair wigs (1-24). Even the seeds are used to produce a variety of food products. The seeds are rich in protein, fibre, and fatty acids including omega 3s and omega 6s (1-21). It is said that they have antioxidant effects and may reduce symptoms of numerous ailments, improving the health of the heart, skin, and joints (1-24). Hemp seed has commonly been claimed as one of the most nutritionally complete food sources due to its high nutritive traits (1-24). It can be consumed as such (whole, hulled seed) or dehulled (hempseed kernel), as well as its processing products, including oil, flour, and protein powder (1-24). It contains 25–35 per cent lipids with a unique and perfectly balanced fatty acids (FAs) composition; 20–25 per cent proteins easy to digest and rich in essential amino acids; 20–30 per cent carbohydrates, a great part of which are constituted in dietary fibr (1-24). Hemp seeds can be a part of a number of dishes and helped to increase a person's protein intake, in a natural and sustainable form (1-24). Hemp can be consumed by anyone, like other conventional food items (1-21). Hemp hearts, they are dehulled Cannabis Sativa seeds. Hemp hearts can help to increase protein intake. Hemp seed oil is 100 per cent extracted from the Cannabis seeds (cold-pressed) (1-21). Hemp seed can also be consumed as a food supplement (14-24). It is considered to be a good source of carbohydrates (20–30 per cent), dietary fibre (10–15 per cent; about 20 per cent of the fibre is digestible), and minerals (four-six per cent) (1-25). In addition, it has been suggested that other components, including trace amounts of terpenes and cannabinoids, have health benefits (10-25). **Hemp powder** is a solution to **plant-based protein**, with just a serving of 30g containing over 15g protein (1-21). The stalks, seeds, and leaves are converted into various construction materials, textiles, paper, food, furniture, cosmetics, healthcare products, etc (1-25). Nutraceutical- and health-product-based markets are about to grow in the coming years, owing to the increasing awareness about health among end-users (1-25).

In India, under section 10 of the **Indian Narcotic Drugs and Psychotropic Substances (NDPS) Act** of 1985, the Indian State Governments have the power to licence cultivation of cannabis for medical and scientific purposes (10-21). While Industrial hemp (fiber type) grows wild in India, farming is still prohibited in many states. India is evolving as the leader among the developing nations working towards rejuvenating the centuries old industrial crop (1-21). The **Uttarakhand state government**, India has become the **first state** in India to issue a license for hemp cultivation to the **Indian Industrial Hemp Association** (**IIHA**) to grow industrial hemp on pilot basis in 2018 (1-23). The permissions are restricted to cultivate hemp for fibre to be used in textile industry (1-21). **Uttar Pradesh** is the other state that has legalized hemp cultivation (1-21). Other states like Himachal Pradesh and Arunachal Pradesh also are reported to be eyeing options to legalize hemp as a crop (13-23). Uttarakhand state, India has developed a policy under Section 14 of the NDPS Act,1985 allowing Industrial or horticulture cultivation of the hemp plant (14-23).

In 2016, Uttarakhand state, India became the first Indian state to permit large-scale commercial cultivation of industrial hemp (15-21). The licence was awarded to the **Indian Industrial Hemp Association (IIHA)** to plant cannabis on 1,000 hectares (14-21). Notably, the plant can be harvested during three months and requires very little water. Therefore, Uttarakhand, India where water is scarce, and it is difficult to grow conventional crops, hemp has been considered to be a sustainable

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alternative (14-25). The state of Uttarakhand, India has developed a scheme that allows individuals and companies to obtain four types of licenses for a) hemp farming b) storage of raw material c) sales and d) transport (1-25). **Uttarakhand state government, India** and private players under a PPP model supports a number of SHGs and farmer groups to develop the industry (15-23). The Uttarakhand state, India can cultivate the hemp plant for Research & Development cultivation. Section 10 rules have been framed by Uttarakhand, UP, and J&K for research and development of Cannabis cultivation. There are four to five states in the pipeline, states like Goa, Karnataka, Orissa, Jharkhand, and so on (14-23).

Any brand or company today can import or export Cannabis plant-based medicines under the Narcotic license and manufacture the same undercover license (16-21). This is the only legal way of using Cannabidiol (CBD) as a part of any business. Any other manner of selling and distribution of **Cannabidiol (CBD)** tincture, the isolate can make the same illegal. That can only happen under the Drugs & Cosmetics Act, Government of India, through DCGI approval (16-21).

In India, few companies operate domestically, as the hemp industry is in its nascent stages and limited by national regulations (16-21). These include start-ups like Bombay hemp Company (BoHeCo), Health Horizons, Foxxy, Hempsters, Vedi, GreenJams, HempStreet and NHempCo (1-21). The Health Horizons is looking to expand into the textile industry because use of hemp for fiber shows great potential. These start-ups are collaborating with each other to develop the domestic market for multiple product innovations like hempcrete, biofuels and hemp paper (16-21). **NHempCo, a Bangalore, Karnataka**, India based start-up, is also promoting the cultivation of industrial hemp in the southern states of India (17-25).

Indian Industrial Hemp Association (IIHA), along with various other companies and organizations have been pushing towards spreading awareness about the plant and its capabilities (17-25). An improvement in the hemp market has been observed due to the efforts of these organizations in creating awareness on the difference between hemp and marijuana, which is specifically cultivated for personal psychoactive use (17-23). With increasing demand for hemp based products and increasing health consciousness, industrial hemp is a requirement of expanding the markets, both domestic and international (17-21). India has the potential to quickly catch up with other countries like China in exporting Industrial hemp (fiber type) products to the US, Canada and Europe (17-21). It can also be an alternative revenue stream for Indian farmers along with a sustainable eco-friendly product lines (17-25).

Rules and Regulations around **Cannabidiol (CBD**) can be looked at in two different ways (17-21). One, any kind of proprietary medicine that is manufactured under the State **Ayush Regulation, Government of India, New Delhi** permits the manufacturing of both the compounds **Δ9-tetrahydrocannabinol** (THC) and **Cannabidiol (CBD**) together (17-25). This is allowed due to Ayush laws, Government of India, New Delhi only permitting whole leaf plant extracts under the full spectrum ambit (17-21). Furthermore, any other form of isolation or remove any other form of broad-spectrum, it tends to complicate **Cannabidiol (CBD**) and falls out of the purview of **Ayush regulations, Government of India, New Delhi** (17-25).

The cannabis is considered as a narcotic commodity under the NDPS Act **(Narcotic Drugs and Psychotropic Substances Act, 1985), Government of India, New Delhi.** Under section, 10 (2) (d) of the NDPS Act (Narcotic Drugs and Psychotropic Substances Act, 1985), **Government of India, New Delhi**, cannabis is to be delivered by the cultivators to the excise department of state governments (17-25). But in the absence of any provision in the NDPS Act (Narcotic Drugs and Psychotropic Substances Act, 1985), Government of India, New Delhi, the Indian states cannot resell the cannabis produce to private entities for extraction of cannabinoids or compounds used in medicines, as per experts (17-25). According to the NDPS Act 1985 (**Narcotic Drugs and Psychotropic Substances Act, 1985**) Government of India, New Delhi, the hemp leaves, seeds, and stalks are exempted (1-21). Only the flowers/ganja/charas or any derivative are prohibited for use (17-21). The Central Govt of India, New Delhi gives the power to the Indian States to adopt its own cannabis policy for industrial or medical purposes (17-25).

According to the Food Safety and Standards **FSSAI (FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA), Government of India, New Delhi,** Fifth Amendment Regulations, 2021 published in *The Gazette of India: Extraordinary, Part III, Section 4*, November 15, 2021, "**hemp seed**, hemp seed oil and hemp seed flour shall be sold as food or used as an **ingredient in a food** for sale (17-21). According to *The Gazette* regulations, Government of India, New Delhi, "Hemp seed means the hulled, non-viable seeds obtained from cannabis sativa/other indigenous cannabis species (17-21). The cultivation of cannabis species for the purpose of hemp seeds in India shall comply with NDPS (**Narcotic Drugs and Psychotropic Substances Act, 1985**), Act, 1985, (**Narcotic Drugs and Psychotropic Substances Act, 1985**), Government of India, New Delhi (17-25). This is a significant victory for the Indian hemp business. They can be sold in the same way as conventional food items now that **FSSAI** (**FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA**) has included them in the food category (17-23). BOHECO (Bombay Hemp Company) which sells nutrition and personal care mentioned that it is a big win for the hemp industry in India (17-25).

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III. Conclusion

Industrial hemp (fiber type), as a diverse plant, can be a revolutionary crop for a better future and for upcoming generations. It is an eco-friendly and worthwhile crop that complements a sustainable agriculture growth system. Industrial hemp (**fiber or grain 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 (1-23). Furthermore, there is potential for the use of hemp processing by-products in various food, feed, and industrial applications. For innovation of novel hemp-derived food ingredients and nutraceuticals requires precise identification and quantification of major bioactives and standardization of the products. Due to the similarities between industrial hemp (fiber and grain) and the narcotic/medical type of medical Cannabis (marijuana type), the production of industrial hemp was prohibited in most countries, wiping out centuries of learning and genetic resources (1-23).

According to the Food Safety and Standards **FSSAI (FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA**) Fifth Amendment Regulations, 2021 published in *The Gazette of India: Extraordinary, Part III, Section 4*, November 15, 2021, "**hemp seed**, **hemp seed oil and hemp seed flour shall be sold as food or used as an ingredient in a food for sale**. This is one good news for India. This will help to boost the Indian economy and helping the Indian farmers in rural sector. Hemp seed as a powder and an additive has been used as a source of protein. Furthermore, hemp plant to ingest is the seeds, sprouts, leaves, and flowers can also be consumed raw in juice or salads. The inclusion of juice obtained from hemp in alcoholic beverages is speculated to have **digestive benefits**. The hemp seed oil has been documented to be therapeutic for constipation problems. Furthermore, mice trials have shown that hemp seed consumption leads to improved memory and learning-induced by chemical drugs. Phytocannabinoids demonstrated the potential to inhibit cell growth and induce apoptosis in gliomas.

In the past two decades, most countries have legalized industrial hemp production, prompting a significant amount of research on the health benefits of hemp and hemp products. Most of the health benefits-associated research of industrial hemp has been conducted under pre-clinical conditions. However, due to the possibility of concentrating bioactive phytochemicals during the manufacturing process, the industry should pay attention to the dosing to optimize the potential health benefits and avoid possible safety concerns (1). There is a need to conduct appropriately designed, randomized, placebo-controlled, double-blind clinical studies on the effects of hemp-derived functional food ingredients and products, dietary supplements, and nutraceuticals on the promotion of human health (1-23). The hemp seed oil has potential as a nutraceutical due to the desired ratio of **Omega-6 PUFA to Omega-3 PUFAs**, and the bioactive **Cannabidiol** (CBD) (1). Future research should be focussed on exploring other bioactive phytochemicals of industrial hemp, such as polyphenols and isoprenoids (1). Regulatory agencies need to distinguish industrial hemp from medical Cannabis (marijuana), so the economic potential of industrial hemp as a sustainable source of value-added functional food ingredients and nutraceutical products can be realized. The contribution of polyphenols and isoprenoids of hemp to the sensory quality, shelf life, and health benefits of the final products still to be understood. The benefits of industrial hemp cultivation will uplift the socio-economic level of the farmers globally and can even add to the GDP per capita of nations to a great extent (1). Finally the future of the Industrial hemp (fiber or grain type), strongly depends on market demand for its bio-based products that will help the plant to establish itself as a worthy sustainable crop.

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Figure-1: The robust growth of Industrial hemp (fiber type or grain type).

Figure-2: Industrial hemp (fiber type)-Fiber

Figure-3: Industrial hemp (fiber type) for textile industry