# A Detailed Research Plan for Compiling Cannabis Parameters and Characteristics

**1. Introduction**

The global landscape surrounding cannabis is undergoing a significant transformation, marked by increasing acceptance in various sectors, including medicine, industry, and recreation. This surge in interest has underscored the need for a comprehensive and scientifically rigorous understanding of the cannabis plant (*Cannabis sativa* L.) and its myriad properties. This research plan outlines a structured approach to compile an ultimate, detailed list of cannabis parameters and characteristics. This list aims to serve as a central, authoritative resource for industry professionals, researchers, policymakers, and the broader public seeking in-depth information on all relevant aspects of cannabis, from its fundamental botanical features to its complex chemical composition, cultivation requirements, effects on users, diverse applications, and the evolving legal considerations that govern its use and distribution.

**2. Defining Objectives and Scope**

* **2.1. Overall Objective:** The primary objective of this research plan is to establish a systematic framework for the creation of a comprehensive, scientifically accurate, and detailed list of cannabis parameters and characteristics. This list will integrate information from a wide array of sources to provide an in-depth understanding of the plant.
* **2.2. Specific Objectives:**
  + To meticulously identify and categorize all relevant botanical features of *Cannabis sativa* L. This will include a detailed examination of its morphology, encompassing plant height, stem and leaf structures, flower and fruit characteristics, and root systems. Taxonomic classification and the differentiation between species, subspecies, and varieties, including the historical context of these classifications, will be explored. Furthermore, the distinct growth stages of the cannabis plant, from germination to harvesting, along with their specific environmental requirements, will be documented. The research will also delve into the complex mechanisms of sex determination in cannabis, including its dioecious nature, the role of sex chromosomes, the occurrence of monoecious plants, and the potential for hermaphroditism. Finally, a detailed analysis of trichomes, their types, distribution on the plant, and their critical function in the biosynthesis of cannabinoids and terpenes, as well as their role in plant defense and maturity, will be undertaken.1
  + To compile a detailed chemical profile of *Cannabis sativa* L., encompassing the vast array of compounds it produces. This will involve a comprehensive listing of major cannabinoids such as THC and CBD, as well as a thorough investigation of minor cannabinoids like CBG, CBN, THCV, CBDV, and CBC, including their individual properties and effects. The research will also cover cannabinoid acids (THCA, CBDA) and the presence of synthetic cannabinoids. A significant focus will be placed on terpenes, detailing their diverse aromatic profiles and potential effects, and their interaction with cannabinoids in the entourage effect. Additionally, the plan includes an examination of flavonoids, including unique compounds like cannflavins, and other chemical constituents such as hydrocarbons, phenolic compounds, sugars, and volatile sulfur compounds, to provide a holistic understanding of the plant's chemical makeup.6
  + To meticulously document the critical cultivation conditions necessary for the optimal growth and yield of *Cannabis sativa* L. This will include a detailed analysis of environmental requirements such as soil type and pH, essential nutrient requirements (macro and microelements), optimal light conditions (photoperiod and intensity), precise temperature and humidity ranges across different growth stages, the importance of airflow and ventilation, and the specific requirements for water quality and irrigation practices. The plan will also address the specific parameters for hydroponic cultivation, including nutrient solution management, system types, and environmental control in soilless environments. Furthermore, the research will cover effective strategies for pest and disease management, encompassing common pests and diseases, integrated pest management approaches, the use of biological and chemical controls, and essential sanitation practices.19
  + To thoroughly detail the effects of cannabis use on users, encompassing both the psychoactive and physiological responses. This will involve examining the short-term and long-term effects of cannabis consumption, with a specific focus on how THC and CBD interact with the human body and mind. The research will also document the common responses to cannabinoids and the potential adverse health effects associated with cannabis use. Furthermore, the plan includes an exploration of evidence-based guidelines for lower-risk cannabis use, aimed at mitigating potential harms.17
  + To comprehensively outline the established and emerging medical applications of cannabis and its various components. This will include a review of the therapeutic uses of cannabis for conditions such as chronic pain, chemotherapy-induced nausea and vomiting, and multiple sclerosis spasticity, as well as an examination of FDA-approved cannabis-derived drugs. The research will also delve into the burgeoning field of minor cannabinoid research, exploring the potential applications of CBG, CBN, THCV, CBDV, and other compounds in treating a wide range of medical conditions.6
  + To provide a comprehensive summary of the legal landscape surrounding cannabis, with a particular focus on regulations in key US states. This will include a comparative analysis of medical and recreational legalization status, as well as detailed information on possession and cultivation limits. The research will also examine the specific cannabis regulations in California, Colorado, Florida, and Texas, covering aspects such as cultivation licensing and testing requirements. Furthermore, the plan includes an investigation of industry standards and quality control measures, including the roles of organizations like ASTM International, FOCUS, and USP in setting these standards.23
  + To thoroughly investigate existing cannabis ontologies, data standards, and quality control measures within the cannabis industry. This will involve an examination of ontologies such as the Drug Abuse Ontology (DAO) and CannabisO, as well as an analysis of conceptual issues related to cannabis terminology. The research will also cover the need for and development of cannabis data standards, including aspects of data privacy and laboratory quality systems. Furthermore, the plan includes a detailed review of standards and guidelines from organizations like ASTM International, FOCUS, and USP, focusing on their recommendations for testing, cultivation, and overall quality control in the cannabis sector.145
  + To consider guidelines for lower-risk cannabis use, drawing from evidence-based recommendations developed by health organizations and research institutions. This will involve summarizing key parameters such as age of initiation, THC and CBD content of products, frequency and intensity of use, preferred routes of administration, guidelines for driving after cannabis consumption, recommendations for use during pregnancy and breastfeeding, and the risks associated with combining cannabis with other substances.191
  + To identify authoritative sources and consensus within the scientific community regarding the parameters and characteristics of cannabis. This will involve examining publications from reputable organizations such as the United States Pharmacopeia (USP), as well as consensus statements and guidelines developed by expert panels and research initiatives. The goal is to establish a foundation of widely accepted information on cannabis from credible sources.24
* **2.3. Scope Limitations:** The primary focus of this research will be on *Cannabis sativa* L., recognized as the predominant species with significant global cultivation and research interest. While other species or subspecies within the *Cannabis* genus, such as *indica* and *ruderalis*, may be mentioned for comparative purposes or when they contribute uniquely to specific parameters (e.g., *ruderalis* in autoflowering traits), the detailed list will predominantly center on *sativa*. Furthermore, the research will primarily utilize publicly accessible information derived from scientific literature, government and regulatory documents, industry reports, and standards organizations. Primary laboratory research or the generation of original experimental data falls outside the scope of this plan.

**3. Identification of Key Parameters and Characteristics**

* **3.1. Botanical Features:**
  + **3.1.1. Morphology:** The morphology of *Cannabis sativa* L. is highly variable, influenced by both its genetic makeup and environmental conditions.1 Plant height can range dramatically from a compact 0.2 meters to over 12 meters in cultivated settings.1 Hemp varieties, selected for fiber production, tend to grow tall with minimal branching, while drug-type varieties exhibit a bushier structure to maximize flower production.1 The stem is typically erect, characterized by furrows, branching patterns, and a woody interior that can be hollow in the internodes.1 The leaves are compound, featuring an odd number (3 to 13) of leaflets that radiate from a central point at the end of the petiole.1 The shape of these leaflets can vary, described as lanceolate, ovoid, or oblanceolate, and their margins are typically serrated.1 A unique and diagnostic venation pattern in the leaves allows for easy identification of *Cannabis*.261 Leaf arrangement changes as the plant matures, transitioning from an opposite arrangement in the lower parts to an alternate arrangement on the main stem.11 The plant is predominantly dioecious, with male and female flowers occurring on separate plants.8 Male flowers are usually found on loose, branched structures called panicles, while female flowers are borne on racemes and have the potential to produce hundreds of seeds.8 The female flowers are characterized by ovaries sheathed in bracts, with stigmas protruding to catch pollen, which is primarily wind-dispersed.11 The fruit of the cannabis plant is an achene, typically small in size (less than 3.8mm in length), and often remains enclosed within the persistent perianth, giving it a mottled or marbled appearance.1 The root system of *Cannabis sativa* is adaptable, generally consisting of a laterally branched taproot that can extend up to 2.5 meters deep to access subsurface moisture, depending on soil characteristics and water availability.1 The significant morphological diversity within *Cannabis sativa*, influenced by both genetic factors and environmental conditions, underscores the importance of detailed and comprehensive descriptions that account for these variations. Furthermore, the legal distinction between hemp and marijuana, based on the concentration of THC (less than 0.3% for hemp and greater than 0.3% for marijuana), is a critical parameter that has both botanical and regulatory implications.9
  + **3.1.2. Taxonomy and Systematics:** *Cannabis sativa* L. belongs to the Cannabaceae family, which also includes the economically important hop plant (*Humulus lupulus* L.).1 Within the genus *Cannabis*, *sativa* is the primary species recognized by most botanical classifications.1 However, the taxonomic classification of *Cannabis* has been a subject of long-standing debate, with differing opinions on whether it should be divided into multiple species.1 The current prevailing view in the scientific community tends to recognize *Cannabis sativa* as a single, highly polymorphic species, which is then further divided into several subspecies or varieties based on a combination of morphological, chemical, and geographical characteristics.1 The most commonly recognized subspecies include *Cannabis sativa* subsp. *sativa*, which typically encompasses hemp varieties cultivated for fiber and seed oil, *Cannabis sativa* subsp. *indica*, often associated with drug-type cannabis originating from regions like India and Afghanistan, and *Cannabis sativa* subsp. *ruderalis*, a shorter, autoflowering variety adapted to harsher climates.1 The historical debates surrounding the taxonomy reflect the wide range of phenotypic and chemical expressions within the genus, driven by both natural adaptation and extensive human selection for diverse utilitarian purposes.1 The plan should therefore include the most widely accepted taxonomic framework while also acknowledging alternative classifications and the key distinguishing features used to differentiate between these subspecies and varieties.
  + **3.1.3. Growth Stages:** The life cycle of *Cannabis sativa* L. is annual, meaning it completes its entire cycle from seed germination to seed production within a single year, typically ranging from four to ten months.61 This cycle is broadly divided into several key stages. The process begins with **germination**, which usually takes between 1 to 10 days, depending on environmental conditions such as moisture, oxygen, and temperature.61 Once the seed sprouts, the plant enters the **seedling stage**, lasting approximately 2 to 3 weeks, during which the first iconic fan leaves develop.61 Following this is the **vegetative stage**, a period of rapid growth focused on developing leaves and branches, which can extend from 3 to 16 weeks depending on the cultivar and environmental factors.61 As the plant matures, it enters a **pre-flowering stage** lasting about 1 to 2 weeks, where it begins to show signs of sexual maturity.61 The crucial **flowering stage**, where the plant produces buds, typically lasts between 6 to 16 weeks, with *sativa* varieties generally taking longer to flower than *indica* varieties.61 The final stage is **harvesting**, which occurs when the buds reach full maturity. The environmental requirements for the cannabis plant, including temperature, humidity, and light, vary significantly across these different growth stages.62 For instance, seedlings thrive in high humidity (65-80%) and warm temperatures (22-27°C) with extended periods of light, while the flowering stage often necessitates lower humidity levels (40-50%) and a 12-hour light/12-hour dark cycle to induce bud formation.62 The varying durations and environmental needs of these stages underscore the importance of a flexible approach to defining these parameters in the comprehensive list.
  + **3.1.4. Sex Determination:** *Cannabis sativa* L. is predominantly a dioecious plant, meaning that individual plants are either male or female, a characteristic determined by an XY chromosome system.8 Female plants possess two X chromosomes (XX), while male plants have one X and one Y chromosome (XY).278 However, the species also exhibits a degree of sexual plasticity, with the occurrence of monoecious varieties, where a single plant bears both male and female flowers.1 Hermaphroditism, the presence of both staminate and pistillate structures within individual flowers, is less common in *Cannabis* but can occur.8 While sex determination is primarily under genetic control, environmental factors can also play a role in influencing sexual expression.279 For cultivation purposes, particularly when the goal is seedless flower production (sinsemilla) or seed propagation, the ability to identify the sex of a cannabis plant at an early stage is highly valuable. To this end, various genetic markers and PCR-based methods have been developed that allow for the identification of male and female plants even before the onset of flowering.281 The comprehensive list of cannabis parameters should detail the genetic basis of sex determination, the different sexual phenotypes observed in the species, and the methods available for early sex identification.
  + **3.1.5. Trichomes:** Trichomes are specialized epidermal appendages found on the surface of the *Cannabis sativa* L. plant, playing critical roles in its biology and chemical composition.285 These structures are broadly classified into two main categories: glandular and non-glandular trichomes.285 Glandular trichomes are of particular interest as they are the primary sites for the biosynthesis and storage of cannabinoids, terpenes, and flavonoids, the key compounds responsible for cannabis's effects and aromas.54 Several types of glandular trichomes have been identified, differing in their morphology and size, including bulbous, capitate-sessile, and capitate-stalked trichomes.11 Bulbous trichomes are the smallest and are found throughout the plant surface, potentially contributing to the production of cannabigerolic acid (CBGA).11 Capitate-sessile trichomes are larger and more abundant, characterized by a mushroom-like shape, and are found on leaves and stems, containing significant amounts of cannabinoids and terpenes.11 Capitate-stalked trichomes are the largest and most abundant on the female flowers and bracts, and are the most efficient producers of cannabinoids and terpenes, making them ideal for resin harvesting.11 Non-glandular trichomes, on the other hand, primarily serve as a defense mechanism for the plant, protecting it from UV radiation, deterring herbivores with their aroma and bitter taste, and helping to prevent fungal growth.285 The density of trichomes is highest on the female reproductive organs and their associated bracts.1 The color of the capitate-stalked trichomes changes as the plant matures, transitioning from clear to milky white and finally to an amber hue, which is often used as an indicator of optimal harvest time.285 The comprehensive list should provide detailed information on each type of trichome, their morphology, their specific roles in the production of key chemical compounds, and their function in the plant's defense and reproductive cycle.
* **3.2. Chemical Profiles:**
  + **3.2.1. Cannabinoids:** *Cannabis sativa* L. is renowned for its diverse array of chemical compounds, with over 140 cannabinoids identified to date.21 The most well-known and extensively studied are the major cannabinoids, delta-9-tetrahydrocannabinol (THC) and cannabidiol (CBD).6 THC is the primary psychoactive constituent, responsible for the euphoric and mind-altering effects of cannabis.17 CBD, on the other hand, is non-psychoactive and is recognized for its therapeutic potential, including anti-inflammatory, analgesic, and anxiolytic properties.6 Beyond THC and CBD, cannabis produces a variety of minor cannabinoids, each with its own unique set of properties and potential therapeutic applications. Cannabigerol (CBG) is being researched for its pain-relieving, anti-inflammatory, anti-anxiety, and potential antibacterial and bone growth effects.26 Cannabinol (CBN), often found in aged cannabis, is noted for its sedative properties and potential in pain relief and appetite stimulation.26 Tetrahydrocannabivarin (THCV) is gaining attention for its potential in appetite suppression, weight management, and its possible benefits for diabetes and neurological conditions.26 Cannabidivarin (CBDV) is being studied for its potential in treating epilepsy and other neurological disorders.26 Cannabichromene (CBC) exhibits anti-inflammatory, antiviral, and anti-tumor properties and may also support brain health.26 Cannabinoids are initially produced in the plant in their acidic forms, such as tetrahydrocannabinolic acid (THCA) and cannabidiolic acid (CBDA), which are precursors to THC and CBD, respectively, and also possess their own unique properties.6 Synthetic cannabinoids, created in laboratories, mimic the effects of natural cannabinoids and are used in some pharmaceutical products.17 These diverse cannabinoids exert their effects by interacting with the endocannabinoid system (ECS) in the human body, primarily through cannabinoid receptors type 1 (CB1) and type 2 (CB2), thereby influencing a wide range of physiological and psychological processes.20 The comprehensive list should detail each of these cannabinoids, including their chemical structures where available, their primary properties (psychoactive or non-psychoactive), their researched therapeutic effects, and their known mechanisms of action within the endocannabinoid system. Furthermore, the synergistic interactions between different cannabinoids, known as the entourage effect, should be highlighted as a significant parameter influencing the overall effects of cannabis.21
  + **3.2.2. Terpenes:** Beyond cannabinoids, *Cannabis sativa* L. synthesizes over 120 terpenes, which are aromatic compounds responsible for the plant's characteristic smells and flavors.8 These terpenes are produced in the same glands as cannabinoids (trichomes) and contribute significantly to the sensory experience of cannabis.38 Common terpenes found in cannabis include myrcene, which has an earthy, musky aroma and is known for its relaxing and sedative effects 33; limonene, characterized by its citrusy scent and uplifting properties 8; pinene, which imparts a pine-like aroma and may promote alertness and memory 8; linalool, with its floral, lavender scent and calming effects 8; and beta-caryophyllene, which has a peppery, spicy aroma and exhibits anti-inflammatory properties.8 Many other terpenes have been identified in cannabis, each contributing to the unique aromatic profile of different cultivars.33 Terpenes are not only responsible for the plant's smell and taste but also have potential effects on the body and mind, including relaxation, energy, pain relief, and anti-inflammation.33 Furthermore, terpenes are believed to interact synergistically with cannabinoids, a phenomenon known as the entourage effect, where they can enhance or modify the effects of cannabinoids.21 While certain terpene profiles are often associated with *sativa* and *indica* varieties, this classification is not always reliable.33 The comprehensive list should include a wide range of identified terpenes, their characteristic aromas, their researched physiological and psychological effects, and their role in the entourage effect with cannabinoids.
  + **3.2.3. Flavonoids:** *Cannabis sativa* L. produces over 30 flavonoids, a class of plant compounds known for their diverse biological activities.43 These include flavones such as apigenin and luteolin, and flavonols like kaempferol and quercetin.45 A unique group of flavonoids found in cannabis are the cannflavins (A, B, and C), which have demonstrated significant anti-inflammatory properties, potentially even more potent than aspirin.43 Other flavonoids present in cannabis, such as quercetin and kaempferol, are known for their antioxidant and anti-inflammatory effects, while luteolin and apigenin have shown promise for cognitive health and may possess neuroprotective properties.46 The concentration of flavonoids varies across different parts of the cannabis plant, with leaves generally containing higher amounts compared to the flowers.43 These compounds are believed to contribute to the overall therapeutic effects of cannabis, possibly through synergistic interactions with cannabinoids and terpenes in the entourage effect.45 The comprehensive list should include the major flavonoids identified in cannabis, their known properties and potential health benefits, and their distribution within the plant.
  + **3.2.4. Other Chemical Compounds:** Beyond the well-studied cannabinoids, terpenes, and flavonoids, *Cannabis sativa* L. contains a vast array of other chemical compounds, contributing to its complex profile.8 These include hydrocarbons, which are organic compounds composed solely of hydrogen and carbon atoms; phenolic and polyphenolic compounds, known for their antioxidant properties; various sugars, which serve as energy sources for the plant; ketones and aldehydes, which are organic compounds with carbonyl groups; organic acids, such as fatty acids and amino acids, essential for plant metabolism; esters and lactones, which contribute to aroma; phytosterols, which are plant-based sterols; alkaloids, a diverse group of nitrogen-containing compounds; vitamins, crucial for various biological functions; and biogenic amines, which play roles in plant signaling.21 Additionally, cannabis produces volatile sulfur compounds, which are responsible for its characteristic skunk-like aroma.8 In total, over 500 different chemical constituents have been reported in the cannabis plant, highlighting its remarkable biochemical complexity.8 While the roles of many of these compounds are still under investigation, they may contribute to the overall aroma, flavor, and effects of cannabis, potentially interacting with cannabinoids and terpenes to produce nuanced outcomes. The comprehensive list should acknowledge the presence of these diverse chemical classes, providing examples where their specific contributions to the plant's properties are known.
* **3.3. Cultivation Conditions:**
  + **3.3.1. Environmental Requirements:** For optimal growth, *Cannabis sativa* L. thrives in loose, well-aerated, and highly absorbent soil with a slightly acidic to neutral pH, ideally between 5.8 and 6.5.69 The plant requires a balanced supply of essential nutrients, including macronutrients like nitrogen (N), phosphorus (P), and potassium (K), as well as micronutrients.69 Sativa varieties generally have a higher demand for nitrogen, particularly during the vegetative stage.74 Adequate light is crucial for photosynthesis, with cannabis needing bright, direct light for at least 12 hours a day.71 Indoor cultivation often utilizes a photoperiod of 16-24 hours of light during the vegetative phase, which is then switched to a 12-hour light/12-hour dark cycle to induce flowering.61 The optimal temperature range for cannabis plants is generally between 24-30°C (75-86°F) during the day for vegetative growth, with slightly cooler temperatures (20-27°C or 68-80°F) preferred during the flowering stage.69 Nighttime temperatures should be a bit cooler, typically around 10°F lower than daytime temperatures.71 Humidity levels are also critical and vary depending on the growth stage: seedlings require high humidity (65-70%), vegetative plants prefer moderate humidity (40-70%), while the flowering stage necessitates lower humidity (40-50%) to prevent mold and mildew.62 Good air circulation and ventilation are essential for regulating carbon dioxide levels, humidity, and air temperature within the growing environment.19 Watering should be done as needed, allowing the soil to dry down adequately between waterings to prevent over-saturation, and the pH of the water should be maintained between 5.5 and 6.5.69 These environmental factors play a crucial role in maximizing plant growth, yield, and influencing the production of cannabinoids and terpenes.1
  + **3.3.2. Hydroponic Cultivation Parameters:** Hydroponic cultivation of *Cannabis sativa* L. involves growing plants without soil, using a nutrient-rich water solution as the primary medium.84 Various hydroponic systems are employed, including deep water culture (DWC), nutrient film technique (NFT), ebb and flow systems, and aeroponics.84 The nutrient solution in hydroponic systems requires careful management, with parameters such as electrical conductivity (EC), pH, and parts per million (PPM) of nutrients needing to be precisely controlled for optimal uptake by the plants.84 The ideal pH range for hydroponic cannabis is typically between 5.2 and 6.5.84 Nutrient concentration in the solution should generally increase as the plant matures, reaching its peak during the flowering stage before being reduced in the final weeks leading up to harvest.84 Maintaining the temperature of the nutrient solution within a specific range, typically 15.5-20°C (60-68°F), is also important for healthy root development and nutrient absorption.84 Similar to soil-based cultivation, controlling the ambient temperature and humidity within the hydroponic grow environment is crucial for preventing stress and promoting optimal growth.84 The lighting regimen for hydroponically grown cannabis follows the same principles as in soil cultivation, with longer light periods during the vegetative stage and a 12/12 cycle to induce flowering.84 Younger plants in hydroponic systems also benefit from higher humidity levels, which are gradually reduced as the plants mature and enter the blooming phase.84 Hydroponic cultivation offers the advantage of precise control over nutrient delivery and environmental conditions, potentially leading to accelerated growth rates and increased yields compared to traditional soil-based methods.90 Soilless propagation methods, such as using rockwool or horticultural foam, are also common in hydroponic setups.92
  + **3.3.3. Pest and Disease Management:** Effective pest and disease management is essential for successful cannabis cultivation, as these issues can significantly impact plant health, yield, and quality.293 Common pests that can affect cannabis plants include aphids, spider mites, caterpillars, leaf miners, whiteflies, fungus gnats, and thrips.296 These pests can cause damage by feeding on plant tissues, transmitting diseases, and hindering growth. Cannabis plants are also susceptible to various diseases, including damping-off, root and crown rot caused by fungi like Fusarium and Pythium, powdery mildew, bud rots, and viral pathogens such as Hop latent viroid.293 An integrated pest management (IPM) strategy is often recommended for cannabis cultivation, which involves a combination of preventive measures, regular monitoring for pests and diseases, and targeted interventions.294 Prevention includes practices such as maintaining a clean and sanitary growing environment and quarantining new plants to avoid introducing pests or pathogens.294 Monitoring involves regularly inspecting plants for signs of infestation or disease and using traps to detect pest populations.294 Intervention strategies can include cultural controls (adjusting watering and humidity), mechanical controls (manual removal of pests, sticky traps), biological controls (introducing beneficial insects or organisms that prey on pests), and chemical controls (using pesticides or fungicides as a last resort).294 Given that high humidity environments, often favored in cannabis cultivation, can promote the growth of fungal pathogens, maintaining proper environmental controls is also a key aspect of disease prevention.294 The comprehensive list should include detailed information on common cannabis pests and diseases, as well as effective strategies for their prevention and management, emphasizing integrated and sustainable approaches.
* **3.4. Effects on Users:**
  + **3.4.1. Psychoactive and Physiological Effects:** The effects of cannabis use are diverse and can vary significantly among individuals, influenced by factors such as the specific cannabinoids and terpenes present, the dose consumed, the route of administration (e.g., smoking, vaping, edibles), and the user's individual physiology and tolerance.17 Delta-9-tetrahydrocannabinol (THC) is the primary psychoactive compound in cannabis, acting on cannabinoid receptors in the brain to produce a range of mental and physical effects, including altered perception, enhanced sensory experiences, impaired memory and learning, and changes in mood and coordination.17 Short-term effects of marijuana use can include problems with memory and learning, distorted perception, difficulty in thinking and problem-solving, and loss of coordination.17 Common responses to cannabinoids, as reported in scientific literature, include initial dizziness, nausea, increased heart rate, and dry mouth, followed by effects such as merriment, relaxation, enhanced sensory perception, increased appetite, and short-term memory impairment.17 Long-term, regular use of cannabis can lead to physical dependence and psychological addiction.17 In contrast, cannabidiol (CBD) is non-psychoactive and can affect the body differently, known for its potential to reduce pain and inflammation without producing the "high" associated with THC.6 CBD may also modulate some of the psychoactive effects of THC.30 The physiological, psychological, and behavioral effects of marijuana can vary considerably from person to person.17
  + **3.4.2. Potential Health Harms:** While cannabis is being explored for its therapeutic potential, it is also associated with several potential health harms, particularly with long-term or heavy use.17 Short-term use can lead to anxiety, elevated heart rate and blood pressure, and at high doses of THC, there is a risk of psychosis.17 Long-term cannabis use may be linked to mental health issues, including an increased risk of certain psychiatric disorders, as well as chronic respiratory problems such as bronchitis and chronic obstructive pulmonary disease (COPD).17 Some studies also suggest a possible association between cannabis use and adverse cardiovascular events.93 Of particular concern is the potential impact of cannabis use on adolescent brain development and well-being, as early and frequent use has been associated with neuropsychological decline and an elevated risk for psychotic disorders in adulthood.93 Additionally, the increasing availability of cannabis edibles, which can resemble common food products, has led to a rise in unintentional cannabis exposures, especially among children, which can result in serious health issues like central nervous system depression, vomiting, and tachycardia.93 Regular and chronic use of high doses of marijuana can also lead to physical dependence and withdrawal symptoms upon discontinuation, including restlessness, irritability, sleep difficulties, and decreased appetite.17
  + **3.4.3. Lower-Risk Use Guidelines:** Recognizing the potential harms associated with cannabis use, several organizations and research bodies have developed evidence-based guidelines to help individuals reduce their risk if they choose to use cannabis.245 The most effective way to avoid any cannabis-related health risks is to abstain from use altogether.246 For those who choose to use, delaying initiation, particularly before the age of 16, is recommended to minimize potential long-term effects on brain development.244 Selecting cannabis products with low THC content and equal or higher amounts of CBD is advised to reduce psychoactive effects and potential risks.191 Starting with a low dose and proceeding slowly, especially with new products or edibles, is crucial.191 The use of synthetic cannabinoids, which carry a higher risk of severe adverse effects, should be avoided.244 To protect respiratory health, non-smoking methods of consumption, such as vaporizing or ingesting edibles, are preferable to smoking combusted cannabis.191 Practices like deep inhalation and breath-holding when smoking should be avoided to limit the intake of harmful substances.246 Limiting the frequency of cannabis use, ideally to once a week or less, can significantly reduce the risk of adverse outcomes.191 Driving or operating machinery while impaired by cannabis should be strictly avoided due to the risk of accidents.191 Pregnant and breastfeeding individuals should abstain from cannabis use due to potential harm to the developing fetus or infant.243 Individuals with a personal or family history of mental health issues, particularly psychosis or substance use disorders, should avoid cannabis use due to increased risk.243 Obtaining cannabis from legal, regulated sources ensures that products have undergone testing for potency and contaminants.191 It is also important to secure cannabis products out of reach of children 191 and to avoid mixing cannabis with other substances like alcohol or tobacco, as this can increase impairment and health risks.191
* **3.5. Medical Applications:**
  + **3.5.1. Established Therapeutic Uses:** Scientific evidence and clinical trials have established the therapeutic efficacy of cannabis and its cannabinoids for several medical conditions.21 There is strong evidence supporting the use of medical cannabis for the treatment of chronic pain in adults.17 Cannabinoids, particularly THC and CBD, have been shown to effectively alleviate pain, including neuropathic pain, through their interaction with the endocannabinoid system.257 Medical cannabis and certain cannabinoids are also established as effective antiemetics for the management of chemotherapy-induced nausea and vomiting (CINV).17 Furthermore, there is substantial evidence indicating that cannabis and oral cannabinoids can improve patient-reported spasticity symptoms associated with multiple sclerosis (MS).24 The U.S. Food and Drug Administration (FDA) has approved several drugs containing individual cannabinoids for specific medical uses. These include dronabinol and nabilone, which are synthetic forms of THC or THC analogs used to treat anorexia associated with AIDS and CINV 17, and cannabidiol oral solution (Epidiolex), which is approved for the treatment of seizures associated with severe forms of epilepsy such as Lennox-Gastaut syndrome, Dravet syndrome, and tuberous sclerosis.17 While these applications represent the most firmly established medical uses of cannabis, ongoing research continues to explore its potential in treating a wider range of conditions.
  + **3.5.2. Emerging Research and Potential Applications:** The scientific community is actively investigating the therapeutic potential of various cannabinoids beyond THC and CBD, revealing promising applications for several medical conditions.101 Cannabigerol (CBG) has shown potential in preclinical studies for treating neurological disorders like Huntington's disease, Parkinson's disease, and multiple sclerosis, as well as for its anti-inflammatory, antioxidant, and anti-anxiety effects. It is also being explored for its potential to reduce intraocular pressure in glaucoma and to stimulate appetite.26 Cannabinol (CBN), a metabolite of THC, is being studied for its potential as a sleep aid, as well as for its analgesic, anti-inflammatory, and appetite-stimulating properties.26 Tetrahydrocannabivarin (THCV), an analog of THC, has garnered interest for its unique properties, including appetite suppression and potential in weight management and the treatment of type 2 diabetes. It is also being researched for its neuroprotective effects and potential in managing anxiety, PTSD, seizures, and even symptoms of schizophrenia.26 Cannabidivarin (CBDV), a homolog of CBD, is showing promise in the treatment of epilepsy, particularly in pediatric populations with conditions like Dravet syndrome and Rett syndrome. It is also being investigated for its potential to ameliorate autism-like behaviors and its effects on gut health.26 Other minor cannabinoids are also under investigation for their diverse pharmacological activities, including anti-inflammatory, analgesic, antimicrobial, and anti-itch effects, suggesting potential therapeutic roles in various dermatological conditions.96 These emerging areas of research highlight the complex and multifaceted therapeutic potential of cannabis beyond the well-established uses of THC and CBD.
* **3.6. Legal Considerations:**
  + **3.6.1. US State Laws:** The legal status of cannabis in the United States is a complex and rapidly evolving landscape, with significant variations across different states.146 As of February 2025, 39 states, along with three territories and the District of Columbia, have legalized cannabis for medical use.146 Furthermore, 24 states, three territories, and the District of Columbia have legalized cannabis for non-medical, adult (recreational) use.146 In addition to full legalization for medical or recreational purposes, several other states have decriminalized the possession of small amounts of cannabis, meaning that it is treated as a minor offense similar to a traffic ticket rather than a criminal act.146 The specific regulations regarding possession limits, cultivation rights, and the availability of cannabis products vary considerably from state to state.70 For instance, some states permit registered medical cannabis patients to possess larger quantities and, in some cases, cultivate a limited number of plants for personal use, while recreational users may face different restrictions. Notably, a few states have adopted very limited medical cannabis programs, often only allowing the use of low-THC, high-CBD products for a specific set of medical conditions.147 This patchwork of laws across the United States reflects the ongoing debate and evolving societal views on cannabis.
  + **3.6.2. Regulations in Specific States:**
    - **California:** California has a well-established cannabis industry with comprehensive regulations. Commercial cannabis cultivation requires obtaining licenses from the Department of Cannabis Control (DCC), which involves submitting detailed cultivation plans, securing necessary permits (including environmental compliance), and often providing surety bonds.155 Personal cultivation for recreational use is limited to a maximum of six plants per household and must be conducted indoors in a primary residence or a detached, secure secondary structure.156 California mandates rigorous testing for all cannabis goods before they can be sold, covering a wide range of contaminants including residual solvents, pesticides, heavy metals, microbial impurities, and mycotoxins, as well as testing for cannabinoid and terpene content.154 Since January 1, 2024, licensed laboratories are required to use the DCC's standardized cannabinoid testing method for dried flower.154 Cannabis testing laboratories in California must maintain ISO/IEC 17025 accreditation to ensure the reliability and accuracy of their results.154
    - **Colorado:** Colorado, one of the first states to legalize recreational cannabis, has a mature regulatory framework overseen by the Marijuana Enforcement Division (MED).162 Both medical and retail marijuana businesses, including cultivators, manufacturers, and testing facilities, require state licenses.162 Personal use cultivation is permitted, with limits such as a maximum of six plants per person, with only three being mature at any one time.70 Colorado mandates testing for various contaminants, including microbials like Salmonella, E. coli, mold, and yeast, as well as residual solvents, heavy metals (arsenic, cadmium, lead, mercury), and the potency levels of key cannabinoids such as THC, CBD, and their precursors.162 Testing laboratories must establish their own guidelines for test batches and adhere to state-defined sampling procedures.162
    - **Florida:** Florida's medical marijuana program, established through voter initiative, is regulated by the Office of Medical Marijuana Use (OMMU).170 Only licensed Medical Marijuana Treatment Centers (MMTCs) are authorized to cultivate, process, and dispense medical cannabis; personal cultivation is prohibited.172 Florida requires all processed cannabis to undergo testing by certified marijuana testing laboratories before it can be dispensed to patients.170 This testing includes analysis for contaminants such as pesticides, heavy metals, mold, and mildew, as well as the determination of THC and CBD content to ensure products meet safety and labeling requirements.171 MMTCs are required to retain records of all testing for a specified period.171
    - **Texas:** Texas operates a limited medical cannabis program, known as the Compassionate Use Program, which allows the dispensing of low-THC cannabis to patients with specific medical conditions, such as epilepsy.171 The program licenses organizations to cultivate, process, and dispense low-THC cannabis.183 Regulations mandate testing of all processed products for the levels of THC and CBD, as well as for residual solvents, pesticides, fungicides, fertilizers, mold, and heavy metals, in accordance with the Texas Agriculture Code.181 Low-THC cannabis is defined as containing no more than 0.5% THC and at least 10% CBD.183 Notably, hemp, defined as cannabis with a delta-9 THC concentration of not more than 0.3% on a dry weight basis, is legal in Texas.178
  + **3.6.3. Industry Standards and Quality Control:** Several organizations are actively involved in developing and promoting standards and quality control measures for the cannabis industry. **ASTM International** has established Committee D37 on Cannabis, which brings together experts to develop voluntary consensus standards covering various aspects of the industry.218 To date, ASTM D37 has published over 50 standards, with many more under development. These standards address areas such as cultivation practices (including cleaning and disinfection, and water activity determination) 219, laboratory operations and testing procedures (including sampling and cannabinoid determination) 219, quality management systems (QMS) and good manufacturing practices (GMP) 213, packaging and labeling (including a standard international symbol for intoxicating cannabinoids) 219, security protocols, and personnel training guidelines.219 The **Foundation of Cannabis Unified Standards (FOCUS)** is another non-profit organization dedicated to protecting public health and consumer safety by developing cannabis-specific standards.205 FOCUS offers standards and certification programs encompassing cultivation 205, retail, extraction 205, infused products 205, laboratory operations 230, security measures, sustainability practices, and packaging and labeling requirements.205 FOCUS standards aim to provide a comprehensive framework for quality and safety across the cannabis industry.228 The **United States Pharmacopeia (USP)**, a science-based public health organization, has also developed considerations for quality attributes of cannabis inflorescence intended for medical purposes.190 These include recommendations for identification tests, assays for the quantification of cannabinoids and terpenes, and limits for various contaminants. The USP has proposed a cannabis monograph that sets acceptance criteria for plant chemotypes, cannabinoid content, microbial contamination, elemental impurities, pesticide residues, terpenes, and foreign organic matter.190 These efforts by standards organizations are crucial for promoting consistency, safety, and best practices within the rapidly growing cannabis industry.
* **3.7. Ontology and Data Standards:**
  + **3.7.1. Existing Cannabis Ontologies:** Several initiatives are underway to develop standardized vocabularies and knowledge models for the cannabis domain. The **Drug Abuse Ontology (DAO)** is a framework designed for analyzing web-based and social media data related to substance use. It includes a comprehensive hierarchy of marijuana types and associated slang terms, facilitating the extraction and categorization of information from diverse online sources.196 **CannabisO** is another ontology-based knowledge model specifically developed to provide reliable information about safe cannabis consumption to general users. It aims to address the lack of proper knowledge and the inconsistencies often found online regarding cannabis use, particularly concerning edibles, precautions, and side effects.196 Research has also focused on the conceptual issues surrounding cannabis and cannabinoid terminology, highlighting the weaknesses and inconsistencies in existing lexica and proposing updates to terms at various levels to improve clarity for patients, physicians, and regulators.194 The **SUMO (Suggested Upper Merged Ontology)** includes a representation for "Cannabis" within its broader knowledge graph, classifying it as an illicit drug and linking it to visual representations.202 The **Experimental Factor Ontology (EFO)** includes a term for "Cannabis use," defining it as the consumption of the recreational drug and noting its varying legal status across countries.197 These ontologies represent efforts to bring structure and clarity to the complex and often ambiguous terminology used in the cannabis field.
  + **3.7.2. Cannabis Data Standards:** The increasing prevalence and diversification of cannabis products have highlighted the growing need for standardized data collection, management, and exchange within the industry.204 The adoption of FAIR (Findable, Accessible, Interoperable, and Re-usable) data principles is becoming increasingly important to ensure that cannabis-related data can be effectively utilized by researchers, businesses, and regulators.211 Several initiatives are addressing this need. Ensuring **cannabis data privacy compliance** is a critical aspect, particularly for businesses handling sensitive patient or customer information. This involves implementing robust security measures and adhering to relevant data privacy laws and regulations.208 Efforts are also underway to standardize **cannabis potency data**, as evidenced by programs like the one at the National Institute on Drug Abuse (NIDA) that monitors THC and CBD levels in seized cannabis samples.209 Standardized **data collection practices for cannabis cultivation** are being explored to help growers optimize their operations and achieve Good Manufacturing Practices (GMP) certification.210 Organizations like the International Cannabis Genomics Research Consortium (ICGRC) are working on proposing and developing common standards for genetic, genomic, and trait data related to cannabis.211 Furthermore, regulatory bodies like the New York State Office of Cannabis Management have established **laboratory quality system standards** to ensure consistency and impartiality in cannabis testing.207 The National Institute of Standards and Technology (NIST) has also developed an integrated measurement services program for cannabis testing laboratories to improve the quality of routine analyses.206 These various efforts underscore the growing recognition of the importance of data standards in fostering a reliable and efficient cannabis industry.

**4. Outlining the Sources of Information**

* **4.1. Scientific Literature:** Peer-reviewed journals, research papers, and academic databases such as PubMed, Scopus, and Web of Science will serve as primary sources for scientific information on cannabis. These sources provide in-depth research findings on botanical characteristics, chemical profiles, effects on users, and medical applications.6
* **4.2. Government and Regulatory Documents:** Information on legal considerations, cultivation and testing regulations, and definitions will be sourced from legislation, regulations published by state and federal agencies such as the Drug Enforcement Administration (DEA), the Food and Drug Administration (FDA), and various state cannabis control boards.17
* **4.3. Industry Reports and Publications:** Market research reports, industry-specific journals, and publications from cannabis industry organizations will provide insights into current trends, cultivation practices, product standards, and market dynamics.21
* **4.4. Expert Interviews:** If necessary, interviews with botanists, chemists, medical researchers, legal experts, and industry professionals may be conducted to gather specialized knowledge and insights.
* **4.5. Cannabis Industry Standards Organizations:** Publications and standards from organizations such as ASTM International, FOCUS, and the United States Pharmacopeia (USP) will be crucial for understanding established and developing standards for cannabis quality, testing, and practices.190
* **4.6. Online Databases and Resources:** Online resources such as Wikipedia, government websites (e.g., DEA, Health Canada), and reputable cannabis information websites will be utilized for background information, definitions, and to identify further sources.5

**5. Establishing Methodologies for Data Collection and Validation**

* **5.1. Literature Review:** A systematic literature review will be conducted across the identified sources using keywords related to each category (e.g., "cannabis morphology," "cannabinoid profile," "cannabis cultivation," "medical cannabis uses," "cannabis regulations," "cannabis ontology"). The search will prioritize peer-reviewed scientific articles and official publications from government and standards organizations.
* **5.2. Data Extraction:** Relevant data points, parameters, and characteristics will be extracted from the selected sources. This will involve carefully reading and summarizing key information, ensuring accurate transcription and proper attribution to the original source through detailed citations.
* **5.3. Cross-Referencing and Triangulation:** Information obtained from different sources will be cross-referenced to identify consistent findings and any discrepancies. Contradictions will be resolved by prioritizing information from authoritative and peer-reviewed sources, as well as considering the context and date of publication.
* **5.4. Expert Consultation:** If necessary, consultation with experts in relevant fields (e.g., botany, chemistry, medicine, law, cannabis industry) will be sought to validate the collected information, clarify any ambiguities, and address potential gaps in the research material.
* **5.5. Database Compilation:** The extracted data will be compiled into a structured database. This could take the form of a spreadsheet for initial organization, with the potential for migration to a relational database if the volume and complexity of the data require it. The database will be organized according to the hierarchical structure defined in the outline.
* **5.6. Quality Assessment:** The quality and reliability of each source will be assessed based on factors such as the author's expertise, the reputation and rigor of the publication venue, the methodology employed in the research (if applicable), and any potential biases or conflicts of interest.

**6. Proposing Ways to Organize and Categorize the Compiled Information**

* **6.1. Hierarchical Structure:** The compiled information will be organized using a hierarchical structure to provide clarity and ease of navigation. The main categories will align with the user's query: Botanical Features, Chemical Profiles, Cultivation Conditions, Effects on Users, Medical Applications, Legal Considerations, and Ontology/Data Standards. Each main category will be further divided into relevant subcategories and specific parameters.
* **6.2. Parameter Tables:** Tables will be utilized to present detailed information for specific categories in a clear and organized manner.
  + **Chemical Profiles:** Separate tables will be created for cannabinoids, terpenes, and flavonoids. The cannabinoid table will include the name, abbreviation, primary properties (psychoactive/non-psychoactive), and key therapeutic effects for major and minor cannabinoids.22 The terpene table will list the name, characteristic aroma, and primary effects of common cannabis terpenes.8
  + **US State Cannabis Laws:** A table will be developed to compare the legal status of cannabis in key US states (California, Colorado, Florida, Texas), focusing on medical and recreational legality, possession limits for flower and concentrates, cultivation limits for personal use, and a summary of testing requirements for commercial products.146
* **6.3. Glossary of Terms:** A comprehensive glossary of cannabis-related terms will be included to define key concepts and terminology used throughout the list. This glossary will draw upon definitions from existing cannabis ontologies, industry standards, and authoritative sources to ensure accuracy and consistency.175
* **6.4. Cross-Referencing:** A system of cross-referencing will be implemented to link related parameters across different categories. For example, specific cannabinoids listed in the chemical profile section will be linked to their corresponding medical applications in the medical applications section. This will help to illustrate the interconnectedness of different aspects of cannabis.

**7. Setting Timelines and Milestones**

* **Phase 1 (Weeks 1-4):** Comprehensive literature review and initial data extraction for Botanical Features and Chemical Profiles.
* **Phase 2 (Weeks 5-8):** Detailed data extraction for Cultivation Conditions and Effects on Users.
* **Phase 3 (Weeks 9-12):** In-depth data extraction for Medical Applications and Legal Considerations.
* **Phase 4 (Weeks 13-15):** Focused investigation of Cannabis Ontology, Data Standards, and Quality Control measures.
* **Phase 5 (Weeks 16-18):** Rigorous data validation through cross-referencing and initial expert consultation (if feasible).
* **Phase 6 (Weeks 19-22):** Systematic compilation and organization of the database according to the defined hierarchical structure and creation of parameter tables.
* **Phase 7 (Weeks 23-26):** Final review of the compiled list for accuracy, completeness, and clarity, followed by the drafting of the glossary of terms and final expert consultation (if needed).

**8. Reasoning and Justification**

The outlined research plan is meticulously structured to ensure a comprehensive and accurate compilation of cannabis parameters and characteristics, directly addressing the user's request. The identification of key parameters is grounded in a thorough analysis of the provided research material, ensuring that all relevant aspects of cannabis, as specified in the user's query, are included. The diverse range of information sources, from peer-reviewed scientific literature to government and regulatory documents, industry reports, and standards organizations, has been selected to provide a multi-faceted and authoritative understanding of the subject matter. The methodologies for data collection and validation adhere to standard scientific practices, emphasizing systematic review, accurate extraction, cross-referencing, and expert input to maximize the reliability and validity of the compiled information. The proposed hierarchical structure and the use of parameter tables are designed to organize the complex information in a clear, logical, and accessible format, facilitating ease of use for the intended audience. Finally, the established timelines and milestones offer a realistic and manageable framework for the successful completion of this comprehensive research project.

**9. Conclusion**

This detailed research plan provides a structured and comprehensive approach for compiling an ultimate list of cannabis parameters and characteristics. By adhering to the outlined objectives, methodologies, and timelines, this research will result in a valuable resource for anyone seeking a deep and thorough understanding of the cannabis plant, its properties, and the complex landscape surrounding its use and regulation. The final list will integrate botanical, chemical, cultivation, effects, medical, and legal aspects, as well as considerations for ontology and data standards, providing a holistic view of this increasingly important plant.

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