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Primer, Part I

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# cannabis

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Optimizing Vapor Cartridge  
Hardware Selection for  
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## Note from the CEO

### New Year, New Horizons

**AS WE BEGIN A NEW YEAR**, we see new opportunities emerge in the cannabis space. The latest research, technology, science, cultivation methods, and expert commentary are constantly building up the community as well as guiding ongoing conversations into new territory. Stay tuned for up-to-date information on the industry through daily news, educational webinars, the Noid Knowledge podcast, monthly Stuck on Compliance blogs, and much more!

In our first Cannabis Analysis column of the year, Brian C. Smith, PhD, begins a new series that is a primer on mass spectroscopy. Mass spectroscopy is used in cannabis analysis to determine pesticides, mold toxins, and potency. Here, he explains the basics of how a mass spectrometer works and what the data it generates means. Lo Friesen, in her Extraction Science column, introduces a new two-part series on vapor cartridge hardware and how to pick the right hardware for the cannabis extract. You won't want to miss this guide to more efficient and safer vaporization experiences. In our Cultivation Classroom column, Zacariah L. Hildenbrand, Hannia Mendoza-Dickey, and Robert Manes discuss fundamental principles of photobiology—including Photosynthetically Active Radiation, photoreceptor-mediated responses, and the spectral influences on plant morphology and development. Read more on what's needed for advancing precision lighting methodologies.

Our first feature article, "A Consumer Trends Survey of Minor Cannabinoids" by Monica K. Pittiglio, Giovanni A. Ramirez, and Westley Cruces, examines results from their anonymous survey on the safety concerns and perceived benefits consumers indicated about minor cannabinoids and the need for more research.

Additionally, in this issue we bring you, "Around the World: A Look at International Cannabis Regulations," a section that includes regulatory snapshots for the United Kingdom and Poland, as well as a more in depth look at the German medical cannabis market with a feature from Niklas Kouparanis, that explores how the country's medical cannabis market is transforming, with potential opportunities to expand telemedicine, improve physician training, and enhancing accessibility in this rapidly growing industry.

Follow *Cannabis Science and Technology* on social media and sign up for email alerts to stay updated on this ever-growing industry. If you would like to submit a manuscript for consideration, please reach out to Editor Madeline Colli at [mcolli@mjhlifesciences.com](mailto:mcolli@mjhlifesciences.com).

We hope you enjoy our January/February 2025 issue!

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## Mass Spectroscopy Primer, Part I: Introduction

By **Brian C. Smith**

Mass spectroscopy is used in cannabis analysis to determine pesticides, mold toxins, and potency. Mass spectrometers are the most expensive and complex to operate instruments found in cannabis labs. In this first installment of a series on mass spectroscopy (MS), I will discuss the basics of how a mass spectrometer works and what the data it generates mean.

### Introduction to Mass Spectroscopy

Mass spectrometers take molecules, break them into ionized bits, sort them by their mass, count the number of ions of a given mass, and then present us the results in a plot of ion abundance versus mass (1).

My original field of expertise for over 30 years has been spectroscopy. I define spectroscopy as the study of the interaction of electromagnetic (EM) radiation, or light, with matter (2). EM radiation is composed of an electric wave and a magnetic wave undulating in mutually perpendicular directions. An important property that distinguishes different types of EM radiation from each other is their *wavelength*. Simply defined, wavelength is the distance between adjacent crests or adjacent troughs of a wave. There are different types of spectroscopies depending upon the wavelength or

light that is used to examine samples as shown in **Figure 1**.

So, given the name of the field we are about to study, you may be wondering what wavelengths are used in this application. The answer is none of the above! MS does not use light at all, and why it was ever given the moniker spectroscopy is beyond me.

A block diagram of how a mass spectrometer works is seen in **Figure 2**.

In MS, the sample must be in the gas phase before it is introduced into the instrument. The molecules are ionized using one of several ionization methods in what is called an ion source. Recall that an ion is an atom or molecule with a charge on it. It is imperative that the molecular fragments be ionized or else the spectrometer will not be able to analyze them. The mass analyzer sorts the ions generated by mass/charge ratio or  $m/z$ . The mass analyzer can be set to only allow ions of a specific  $m/z$  to pass through, which it does typically with magnetic or electric fields. The number of ions of a specific  $m/z$  that pass through the instrument are counted by a detector. Measuring a mass spectrum then is a matter of sweeping the instrument through different  $m/z$  values, counting the ions collected, and then making a plot of the two quantities. Certain scientists, myself included, chide

mass spectroscopists by saying that determining molecular structures by smashing molecules into pieces is like determining how an expensive watch works by hitting it with a hammer and looking at the pieces. There is some truth to this, but the amount of information we can obtain from a mass spectrum is remarkable. One can determine molecular structure, the functional groups present, molecular weight, and molecular formula. It is perhaps the most information-rich technique that we will discuss in this column series.

MS is very important in cannabis analysis. MS instruments are often interfaced with gas chromatographs giving us GC-MS, or liquid chromatographs (LC) giving us LC-MS. The beauty of GC-MS and LC-MS instruments, often called hyphenated techniques because of the hyphen in their names, is that they can take complex mixtures, purify them into their components, identify the molecules present, and then quantify them. GC-MS and LC-MS systems are widely used in cannabis labs to analyze for pesticides and toxins such as those present in mold. These instruments can also be used for potency analysis, but there are simpler and cheaper ways of doing this, such as by chromatography or infrared spectroscopy as I have discussed previously (3,4).

### How Do We Make Ions?

In MS, we must first generate a beam of molecules so they can enter the instrument. This can be done by injecting the sample with a syringe, but much more commonly we take as the source the effluent from a gas chromatograph or liquid chromatograph. We then need to turn the beam of molecules into a beam of ions so they can traverse the instrument, be separated by mass, and be detected. If the pressure inside the instrument is relatively high – let’s say 1 atmosphere – the molecular or ion beam will collide with the gas phase molecules present inside the instrument, the beam will be deflected in random directions, and the molecules will never be ionized, or the ions will never be detected. This is why the interior of mass spectrometers are evacuated to a pressure of  $1 \times 10^{-6}$  atmosphere or lower, so the molecular and ion beams have a free path from the sample introduction port and ion source to the detector. The pumps and seals needed to maintain this vacuum level add cost and complexity to the design and use of mass spectrometers.

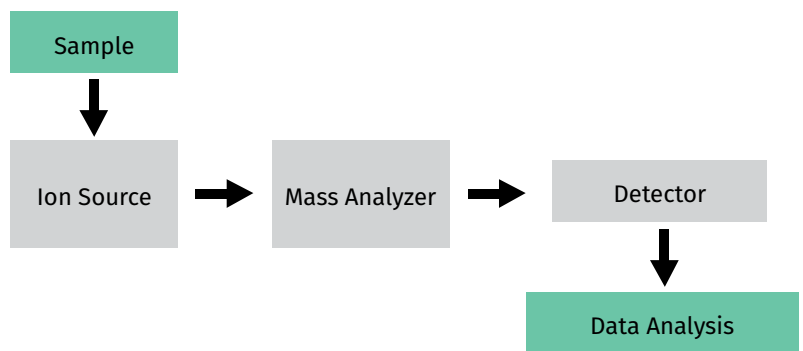
As the field of MS has developed, there have been many innovations in how to generate a beam of ions. However, one of the first ionization techniques developed and perhaps an easy one to understand is called electron impact ionization. An illustration of an electron impact ionization source is seen in **Figure 3**.

At the top of the figure is a filament, simply a hot wire, which gives off electrons when heated to a high enough temperature. Note there is a north pole of a magnet above the filament and a south pole at the bottom of the ion source. This sets up a magnetic field causing the electrons to move from top to bottom as seen in the figure. In Figure 3, the molecular beam is moving from behind you and through

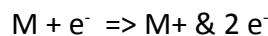
**Figure 1:** Different types of electromagnetic radiation.

> 14,000 $\text{cm}^{-1}$ Visible & UV	14,000 to 4,000 $\text{cm}^{-1}$ Near IR	4,000 to 400 $\text{cm}^{-1}$ Mid Infrared	400 to 4 $\text{cm}^{-1}$ Far Infrared	<4 $\text{cm}^{-1}$ Microwaves
Electronic Transactions	Molecular Vibrations	Molecular Vibrations	Molecular Vibrations	Molecular Rotations

**Figure 2:** A block diagram of a mass spectrometer.



the plane of the page as indicated by the grey circle. At the center of the source, the molecules and electrons collide generating ionized molecular fragments. You can think of the impact process like a chemical reaction illustrated below, where M = Molecule and e = Electron:

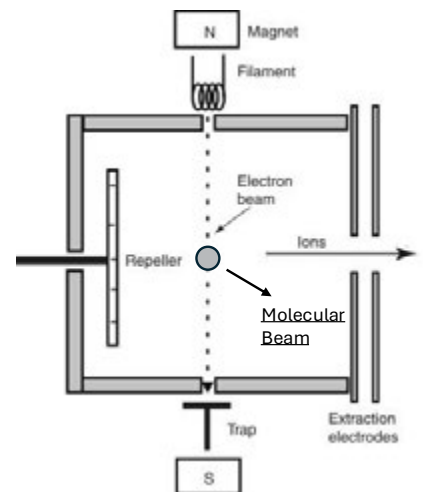


The repeller to the left of the source forces the ions to the right, while the extraction electrodes to the right pull the ions into the body of the instrument.

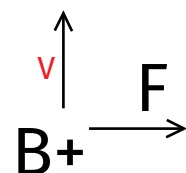
### Mass Analysis

Now that we have generated our beam of ions, how do we sort them by mass? For now we will discuss the tried-and-true method of using a magnetic field to sort ions of different mass, otherwise known as magnetic sector mass spectroscopy. There are

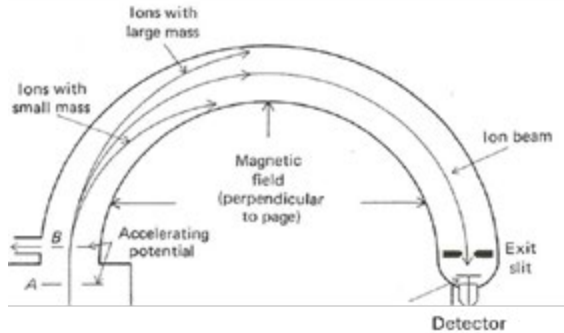
**Figure 3:** A schematic diagram of an electron impact ionization source.



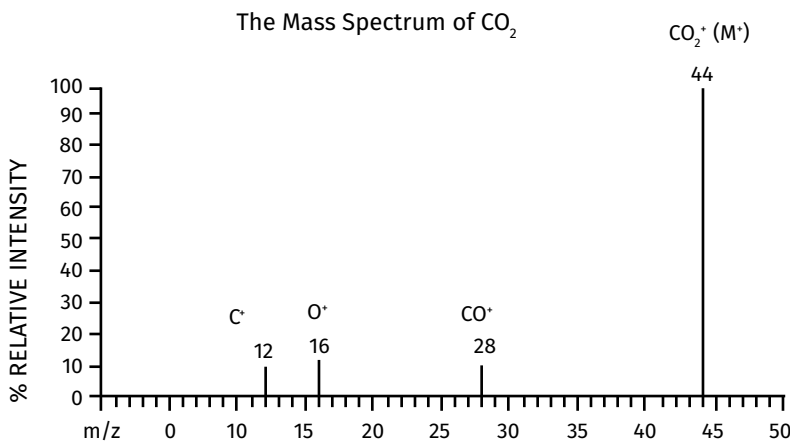
**Figure 4:** The forces present on an ion traversing a magnetic field.



**Figure 5:** A schematic diagram of how a magnetic sector mass spectrometer sorts ions by mass.



**Figure 6:** The mass spectrum of carbon dioxide (CO<sub>2</sub>).



other ways to sort ions by their m/z values I will discuss in future columns. To understand how a magnetic sector instrument works we need to understand how a charged particle such as an ion behaves in the presence of a magnetic field. This is illustrated in **Figure 4**.

The magnetic field, with strength B, is pointing into the plane of the page as represented by the + sign, which is an arrow tail. The ion is moving towards the top of the page with velocity (v), and we will assume this particle has charge (q). An ion moving through a magnetic field will experience a force (F) as illustrated

by the vector pointing to the right in **Figure 4**. The magnitude of this force is given by **Equation 1**, where F = force, q = charge, v = velocity, and B = magnetic field strength:

$$F = qvB \quad [1]$$

Thus, according to **Equation 1**, the force on an ion moving through a magnetic field depends upon the velocity of the ion, the charge on the ion, and the magnetic field strength.

An illustration of how a magnetic sector MS separates ions is seen in **Figure 5**.

In **Equation 1**, the velocity (v), depends upon the mass of the ion amongst other things. All other conditions being equal, a massive ion will move more slowly through a mass spectrometer than a light ion. Note the tube through which the ion beam passes is curved, and we will call this the ion tube. Note that for an ion to make it to the detector it must follow a path, or describe an arc, to be technical, where it follows the curvature of the ion tube. We would then say that the radius of curvature of the ion's path through the ion tube must equal that of the tube itself for the ion to be detected. For a given magnetic field strength (B), ions with a large mass will move slowly and be deflected weakly and collide with the outside wall of the ion tube. Ions with a small mass that are moving quickly will be deflected strongly and collide with the inside wall of the ion tube. Only ions of a specific mass will have the correct radius of curvature to make it to the detector and be counted. Measuring a mass spectrum then with a magnetic sector instrument is a matter of scanning through different values of the magnetic field strength (B) and counting the number of ions of a given m/z that make it to the detector. The resultant mass spectrum is then a plot of ion abundance on the y-axis versus m/z on the x-axis.

### A Mass Spectrum

An example of a simple mass spectrum, that of carbon dioxide, is seen in **Figure 6**.

Note that the x-axis is in "m/z" units, not simply mass and this is an important distinction. Technically, a mass spectrometer does not separate ions based on their mass but by their mass to charge ratio or m/z. It can happen, for example, that an ion with a mass of 100 and a charge of 1 and hence with an m/z of 100 will be detected at



# “What is interesting about **interpreting mass spectra** is that the peak positions **carry information**, as does how far away a peak is from the parent **ion peak.**”

the same time as an ion with a mass of 200, a charge of 2, and hence also have  $m/z = 100$ . Note that the  $y$ -axis here is “% Relative Intensity.” If we plotted the raw signal this scale would be labeled “ion abundance” which is a direct count of the number of ions detected at a specific  $m/z$ . It is convenient though to divide the intensity of each individual peak by that of the intensity of the largest peak, in this case  $m/z = 44$ , multiply by 100, then plot the  $y$ -axis in % Relative Intensity units as seen.

$\text{CO}_2$  has a molecular weight of 44. Note in Figure 6, that the peak with the highest  $m/z$ , and also the most intense peak, has  $m/z = 44$ . This is called the molecular ion peak (M+ peak), or parent ion peak, which in this case is from a  $\text{CO}_2$  molecule with a single positive charge on it. Molecular ion peaks are often seen in mass spectra and are very useful because they tell us the molecular weight of an analyte. Note that there are also peaks with  $m/z$  values of 12 and 18 in the spectrum. These are simply singly charged carbon and oxygen atoms, respectively. The peak at  $m/z = 28$  is more interesting. Its peak position tells us this molecular fragment has a mass of 28. However, if we subtract its mass from that of the molecular ion, we get  $44 - 28 = 16$ , and 16 is the

atomic mass of oxygen. What this tells us is that this ion was formed when the parent ion,  $\text{CO}_2^+$  lost an oxygen atom. So, what is interesting about interpreting mass spectra is that the peak positions carry information, as does how far away a peak is from the parent ion peak. The upshot here is that mass spectra give us functional group information as we will see in future articles.

## Conclusions

A mass spectrometer works by smashing molecules into ionized bits and then analyzes the resulting ions by mass/charge ratio. These instruments must be evacuated to low pressure to allow beams of molecules and ions to pass through them. A basic mass spectrometer consists of a sample injection port, an ion source, a mass analyzer, and detector. A common ionization method is electron impact

ionization, and a common mass analyzer is a magnetic sector. A simple mass spectrum was introduced and we defined what the molecular ion is and how to interpret mass spectra using  $m/z$  values of ions, and how far they fall from the molecular ion peak.

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# Optimizing Vapor Cartridge Hardware Selection for Different Cannabis Extracts: Key Considerations for Performance and Safety, Part I

By **Lo Friesen**

*The compatibility of vapor cartridge hardware with cannabis extract formulations plays a critical role in ensuring optimal performance, flavor retention, and consumer safety. Different extract types, such as distillates, live resins/rosins, and full-spectrum oils, exhibit varying viscosities, terpene profiles, and chemical compositions that influence the optimal configuration of vape hardware. This two-part series will outline the essential factors to consider when selecting vapor cartridge, disposable vape, and battery hardware. Additionally, we explore potential challenges such as clogging, degradation, leaching (introduction of harmful compounds), and more to guide manufacturers and consumers toward safer and more efficient vaporization experiences.*

## Introduction

Cannabis vaporization has continued to gain market share as a preferred method of consumption, achieving an estimated \$5.06 billion in 2024 and projected to reach \$10.05 billion in 2029(1). This consistent growth has driven an increased focus on the compatibility between cannabis extracts and vapor cartridge hardware. Proper hardware selection is crucial for optimizing vapor production, flavor preservation, and user safety. Different extract types, such as distillates, live resins/rosins, and full-spectrum oils have a number of variables that directly influence how they interact with cartridge components. Selecting the right hardware ensures an optimal vaping experience for the end consumer

on many levels. This article explores the key considerations in selecting vapor cartridge hardware tailored to specific cannabis extracts, ensuring an efficient, safe, and high-quality vaping experience.

## Understanding Cannabis Extract Variability

Cannabis extracts are diverse in their composition, directly dictated by the extraction method and post-processing techniques. The most common extract types used in vapor cartridges include:

- 1. Distillates:** These are highly refined, high-potency extracts with a thick viscosity and no naturally preserved terpene content. Using distillate in

vapes requires thinning agents or the reintroduction of botanical or cannabis/hemp-derived terpenes to introduce flavor and optimize vaporization. Because of their high viscosity, selecting the right cartridge with proper heating elements and wicking materials is essential for effective vaporization.

- 2. Live Resins:** Produced from fresh-frozen cannabis, these extracts preserve the terpene profile of the live plant. Live resins often include terpenes extracted from fresh-frozen cannabis combined with distillate or "liquid diamonds" (decarboxylated crystallized

THCA). This offers the opportunity for higher terpene content and lower viscosity. Live resins have a different flavor profile than cured cannabis terpenes. However, live resins are more heat-sensitive and prone to degradation, making it crucial to use hardware that maintains stable, lower temperatures.

**3. Full-Spectrum Oils:** These extracts are abundant in the full range of cannabinoids and terpenes from the original plant, maintaining its chemical complexity. Full-spectrum oils vary in viscosity depending on the input material and extraction method. However, they generally have a lower viscosity due to their high terpene concentration, making them more suitable for specific cartridge designs that prevent leaks while maintaining flavor integrity.

**4. Rosin-Based Extracts:** This solventless extraction method produces an extract often high in terpenes, requiring minimal refinement. Due to this physical separation extraction process, rosin-based extracts often have a thicker consistency while retaining delicate terpenes that are particularly susceptible to heat degradation. Cartridges designed for these extracts must be able to efficiently vaporize a thick extract without compromising the terpenes' integrity

Understanding these variations is fundamental when selecting vape hardware to ensure optimal performance and safety. Different extracts require specific hardware configurations to maximize efficiency and flavor

retention while preventing clogging, leakage, and degradation.

### Key Hardware Considerations for Extract Compatibility

There are a multitude of ways to customize hardware based on extract type, including but not limited to: coil type, atomizer resistance, and temperature/resistance settings.

#### 1. Coil Type and Heating Element

The heating element in vapor cartridges plays a crucial role in vaporization efficiency and the preservation of cannabinoids and terpenes. At one point in time there were metal coils and ceramic coils. However, given the risks of hot metals interacting with cannabis extracts, the industry has moved to ceramic cores with a lot of innovation happening with the ceramic material.

Ceramic heating elements function well for both high-viscosity extracts like distillates and low-viscosity/high terpene extracts due to their even heat distribution and resistance to overheating. Ceramic heating elements also reduce the risk of burning and offer better flavor retention, making them ideal for extracts rich in delicate terpenes, such as live resins and full-spectrum oils.

While most, if not all, vapes are using a ceramic core as a heating element, the atomizing wire position within the ceramic has offered unique advantages based on extract type (For examples of atomizer positions, see **Figures 1 and 2**) (2).

#### 2. Atomizer Resistance

The resistance of the atomizer is customizable to suit the vape experience that best suits the end consumer and the viscosity of the extract. A low resistance atomizer will allow more

**Figure 1:** Atomizer embedded in cylindrical ceramic core.



**Figure 2:** Surface mounted heating plate.



current to pass through the atomizer. This allows for faster heating time, more vapor, and higher temperatures. This is an advantage for high-viscosity oils and products that aim to satisfy the consumer that is seeking large vape hits. A high resistance atomizer permits less current to pass through, which produces more even heating, lower vapor temperature, more flavor, and less risk of burning the extract over

time. This functions very well with low-viscosity and terpene rich extracts. That said, there is much less vapor that can be produced, which is not ideal for some consumers.

### 3. Aperture size

Most cannabis vapes have a center post with a surrounding chamber to house the extract. The center post houses the heating element. There are apertures, or holes, within the center post to allow extract to flow into the heating element. These apertures can vary in size: the larger the hole, the easier it is for extract to flow into the heating element. Aperture size plays a big role based on extract type given the significant range of viscosities within the extract space. High viscosity extracts need larger apertures and low viscosity extracts need lower apertures. Despite vapes with center posts being the most popular option on the market today, postless vapes have surfaced and have introduced a new way for extracts to flow and heat within a cartridge.

### 4. Temperature Control

Each extract type has an optimal vaporization temperature range that preserves cannabinoids and terpenes while ensuring smooth vapor production:

- **Distillates:** Require higher temperatures (400–450°F) for effective vaporization due to their viscosity.
- **Live Resins:** Best vaporized at lower temperatures (300–380°F) to preserve terpene profiles and prevent degradation.

- **Full-Spectrum Oils:** Fall within an intermediate range (350–420°F), depending on their specific formulation. The higher the terpene concentration, the lower the ideal vaporization temperature.

Cartridges paired with variable voltage battery or temperature control options are ideal for accommodating different extract types, allowing users to fine-tune their experience based on the specific oil in use.

### Conclusion

Selecting the appropriate vapor cartridge hardware for different cannabis extracts is essential for maximizing performance, flavor retention, and user safety. Considerations such as heating element material, atomizer resistance, aperture size and temperature control all influence the vaping experience. By aligning hardware selection with extract properties, manufacturers and consumers can achieve a superior, safe, and efficient vaporization process. The right cartridge can enhance the longevity of the extract, preserve its natural chemical profile, and provide a consistent, enjoyable user experience. These customizations and hardware options can be overwhelming as

manufacturers try to focus on producing the best cannabis product for their consumer. It is challenging to be an expert in all things. Supply partnerships are vital to ensuring a product is using the best hardware for its specific makeup. The best next step for business is to align with a vendor that can be the factory supported supplier and expert resource for any of your hardware needs.

*A note from the author: Thank you to Rectitude Partners for offering key insights into the inner workings of vape cartridge hardware.*

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#### ABOUT THE COLUMNIST

**LO FRIESEN** is the founder, CEO, and Chief Extractor of Heylo. With a background in chemistry and clinical research, Lo was inspired to explore cannabis as a medicine and to enter the emerging industry. She joined Eden Labs, a leading CO<sub>2</sub> extraction equipment manufacturer to support and expand a Research and Development department. There she managed the development of their latest and greatest CO<sub>2</sub> extraction system. In 2017, after working with Eden Labs and another cannabis processor, Lo launched Heylo with a mission to help people get more out of life with cannabis.

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# A Call for More Representative Horticultural Lighting Metrics for Cannabis Cultivation

By **Zacariah L. Hildenbrand**, **Hannia Mendoza-Dickey**, and **Robert Manes**

*Optimizing horticultural lighting requires a comprehensive understanding of plant-light interactions, yet current metrics fail to capture the full complexity of photobiological responses. This article explores fundamental principles of photobiology, including Photosynthetically Active Radiation, photoreceptor-mediated responses, and the spectral influences on plant morphology and development. Conventional horticultural lighting metrics—such as Photosynthetic Photon Flux, Photosynthetic Photon Flux Density, and Daily Light Integral—provide useful benchmarks for light intensity but fail to account for spectral quality and plant-specific physiological responses. While the Design Lights Consortium Horticultural Lighting Program establishes industry standards for lighting efficacy, its metrics primarily emphasize energy efficiency rather than biological relevance. To bridge this gap, this article highlights the need for more biologically representative indicators of light efficacy. Physiological metrics such as photosynthetic rate, chlorophyll content, leaf area expansion, stem elongation, biomass accumulation, and gene expression offer deeper insights into plant-light interactions. By integrating these indicators into lighting assessments, researchers and cultivators can refine their strategies to enhance growth, optimize plant health, and maximize phytochemical production in controlled environment agriculture. A comprehensive approach that integrates plant physiology, photobiology, and spectral engineering is vital for advancing precision lighting methodologies, especially for high-value crops like cannabis.*

### **Introduction to Photobiology**

Light, a form of electromagnetic radiation, plays a pivotal role in plant growth and development. While the electromagnetic spectrum is vast, plants primarily utilize wavelengths within the visible spectrum (approximately 400-700 nm) for photosynthesis. However, it's important to note that plants respond differently to various wavelengths within this range, and even to some extent outside of it. For example, ultraviolet (UV) (280-400 nm) and far-red (700-750 nm) radiation are also important, as these wavelengths

can influence plant development and stress responses. Different spectral compositions can significantly affect plant growth, morphology, and even phytochemical content. The ideal spectrum often varies by crop and growth stage. Photosynthetically Active Radiation (PAR) is a critical concept in horticultural lighting. It encompasses the range of light wavelengths that drive photosynthesis, typically between 400-700 nm. PAR is quantified in  $\mu\text{mol}$  (micromoles) per square meter per second, representing the number of photons within the PAR range reaching a given area in a specific time frame.

Understanding PAR is essential for evaluating the efficacy of horticultural lighting systems, as it directly correlates with the light available for photosynthesis. However, it's crucial to remember that not all wavelengths within the PAR range are equally efficient for photosynthesis, which leads us to the importance of spectral quality.

Plants have evolved sophisticated systems to detect and respond to various aspects of light. These systems, known as photoreceptors, include chlorophyll, phytochromes, and cryptochromes. Chlorophyll is the primary pigment responsible for photosynthesis, absorbing light most

efficiently in the red and blue portions of the spectrum. This absorption pattern is a key factor in the design of many horticultural grow lights (1). Phytochromes are red and far-red light receptors that play crucial roles in various plant processes, including seed germination, stem elongation, and flowering. The ratio of red to far-red light can significantly influence plant morphology and development (2). Cryptochromes are sensitive to blue and UV-A light, cryptochromes are involved in regulating circadian rhythms and photomorphogenesis. They influence processes such as stem elongation, leaf expansion, and the transition to flowering (3).

Additionally, understanding plant responses to lighting is crucial for optimizing growth and development in controlled environment agriculture (CEA). These responses are complex and multifaceted, involving various physiological and morphological changes. Photomorphogenesis refers to light-mediated developmental changes in plant form, such as stem elongation, leaf expansion, and chlorophyll synthesis, which are influenced by the red to far-red ratio, spectral composition, and blue light intensity, respectively (4-6). Photoperiodism is the response of plants to the relative lengths of light and dark periods, which regulates various developmental processes, including flowering. Phototropism is the directional growth response of plants to light. While primarily studied in relation to blue light, recent research suggests that red light may also play a role. In indoor growing environments, phototropism can influence canopy structure and light interception efficiency (7). Shade avoidance responses are adaptive strategies plants use to compete for light. These responses are primarily mediated by changes in the red to



Courtesy of Bob Manes, OK Skunkworks, Skiatook, Oklahoma.

far-red ratio and overall light intensity. Typical shade avoidance responses include increased stem elongation, upward leaf movement, and reduced branching. In controlled environment agriculture, unintended triggering of shade avoidance responses can lead to undesirable plant morphology. Careful management of the light spectrum, particularly the red to far-red ratio, is essential to avoid these effects (8).

### Current Metrics

As of today, there are multiple horticultural lighting metrics that have been established to help guide growers in terms of photobiological efficacy. The metrics listed below are easy to understand and implement; however, are they the most representative of what one can expect to achieve in their cultivation environment? We explore the pros and cons of each and explore more physiologically-derived metric in the proceeding section.

Photosynthetic photon flux (PPF) quantifies the total amount of PAR produced by a lighting system per

second, measured in micromoles per second ( $\mu\text{mol/s}$ ). This metric provides insight into the overall light output of a fixture but does not account for the distribution of that light (9). Photosynthetic photon flux density (PPFD) represents the best lighting metric available to date. PPFD measures the amount of PAR that actually reaches the plant canopy, expressed in micromoles per square meter per second ( $\mu\text{mol/m}^2/\text{s}$ ). This metric is crucial as it indicates the usable light intensity at the plant level. PPFD can vary across the growing area, necessitating the use of PPFD maps to evaluate light distribution (10). It is essentially, 'the number of photons in the 400-700nm waveband incident per unit time on a unit surface'. Photosynthetic photon efficacy (PPE) is another pertinent horticultural lighting metric that is measured in  $\mu\text{mol/J}$  and determines how well your lighting system is converting electrical energy into photons. PPE is calculated by taking the PPF of the luminaire or system,



Courtesy of Bob Manes, OK Skunkworks, Skiatook, Oklahoma.

and dividing it by input electric power. PPE is represented as micromoles per second per electric watt ( $\mu\text{mol} \times \text{s}^{-1} \times \text{We}^{-1}$ ), or micromoles per joule ( $\mu\text{mol} \times \text{J}^{-1}$ ) and the theoretical maximum PPE for light emitting diodes (LEDs) is 4.6 to 5.1  $\mu\text{mol}/\text{J}^{-1}$ , depending on the composition of the LEDs used in an array. Unfortunately, none of these metrics account for a plant's spectral requirements, and all three metrics can be 'gamed' to present elevated metric values that are not representative of horticultural efficacy.

Daily Light Integral (DLI) is another available variable and is defined as the cumulative amount

of the total number of photons that land on a particular surface during the daily photoperiod and is measured in  $\text{mol}/\text{m}^2/\text{d}$ . It is 'the amount of PAR received each day as a function of light intensity and duration.' DLI plays a pivotal role in plant growth, yield and development, and it can be carefully managed and controlled in variable conditions to ensure that you get the best possible results. Different plant species have varying DLI requirements, making this metric valuable for tailoring lighting strategies to specific crops (11). DLI is a popular metric in the world of horticultural lighting,

particularly for greenhouse growers using supplemental lighting; however, as with the aforementioned PPF, PPFd, and PPE metrics, it's not the whole story. DLI measures the total amount of photosynthetically active radiation (PAR) over 24 hrs, but it's blind to the light spectrum. This is important because different plants require different lighting recipes and while plants might be getting enough light, the spectrum may not be optimized. DLI also ignores when light is delivered during the day, which can be problematic as some plants are early birds (For example, hibiscus) and others are night owls (Such as, evening primrose). Also, DLI provides the summation of total daily light exposure but does not calculate relative intensity at any given time throughout the day. Furthermore, pursuing an elevated DLI without considering intensity can lead to photoinhibition, where excess light actually reduces photosynthesis. Lastly, DLI oversimplifies the fact that plants are complex beings with constantly changing needs. Case in point, the variances in lighting intensity and spectra that are appropriate/optimal for seedlings compared to plants in vegetative growth, the stretch phase, and final flower. With all of that being said, DLI is still a useful starting point and should be coupled with careful considerations of spectral composition, light intensity at different growth stages, photoperiod, and any other plant-specific requirements.

### **What about DLC Metrics?**

The Design Lights Consortium (DLC) Horticultural Lighting Program has established a Qualified Products List (QPL) that uses these metrics to evaluate and list high-performance lighting fixtures for horticultural



applications. This list is becoming increasingly important for regulatory compliance and utility rebate programs. While the DLC metrics for horticultural lighting provide valuable standardization, there are some drawbacks to consider. As with the other aforementioned metrics, DLC metrics have a limited scope of measurement that is primarily focused on energy efficiency and light output; not lighting spectra or the nuances of different growth stages. This has the potential for misinterpretation as growers might overemphasize DLC ratings without considering other crucial factors, such as lighting distribution. And while an emphasis on PPE is certainly important in terms of electrical efficiency, it certainly doesn't tell the whole story with respect to plant-light interactions, which is the what we are all trying to optimize during cultivation. DLC metrics do provide a useful baseline, but they are not the be-all and end-all of horticultural lighting. Successful cultivation requires a holistic approach that considers your specific plants, environment, and goals. As we will discuss in the proceeding section, data-driven decision making is critical but only when the metrics that you are using to quantify success are representative of photobiology and the terminal goals that you are aspiring to achieve. It's important to 'listen' to your plants and observe their response to different lighting conditions.

### **Potentially More Relevant Physiological Indicators**

Physiological indicators of light efficacy in horticulture are crucial for understanding and optimizing plant growth and development, providing valuable insights into plant responses to different lighting conditions. By manipulating light quality, intensity, and duration using

advanced light technologies, such as full-spectrum LEDs, researchers and growers can optimize plant growth, development, and quality for various applications in controlled environment agriculture. Here are ten key physiological indicators, along with the resulting technical findings, and the corresponding analytical tools utilized in each investigation:

#### **Photosynthetic Rate: The Engine of Growth**

Photosynthesis is the cornerstone of plant growth, and LED lights are proving to be powerful tools for optimizing this process. Recent studies have shown that higher levels of green light increased photosynthetic rate at higher photon flux densities (PFDs) in lettuce (12). These findings underscore the importance of considering the entire spectrum, not just red and blue light, in horticultural lighting strategies. To measure photosynthetic rates accurately, researchers employ gas exchange systems. These sophisticated instruments measure CO<sub>2</sub> uptake and water vapor exchange, providing precise data on the plant's photosynthetic performance. It's worth noting that while PAR is crucial, it's merely a measure of photons delivered over a given area and time, expressed in micromoles per square meter per second ( $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ). PAR alone doesn't tell us how efficiently plants are using that light for photosynthesis.

#### **Chlorophyll Content: The Light-Harvesting Powerhouse**

Chlorophyll content plays a critical role in a plant's ability to absorb light for photosynthesis, directly influencing its photosynthetic efficiency. Light quality significantly affects chlorophyll biosynthesis and degradation, with species- and cultivar-specific responses. Research on various plant species, including

Coleus cultivars, has demonstrated that different light spectra can modulate chlorophyll accumulation, potentially impacting overall plant health, growth, and productivity (13). To quantify chlorophyll content, researchers use a variety of tools. Soil Plant Analysis Development (SPAD) meters provide a non-destructive way to estimate relative chlorophyll content in leaves. For more precise measurements, High-Performance Liquid Chromatography with Ultraviolet Detection (HPLC-UV) or UV-Vis spectrophotometry can be employed to measure chlorophyll a and b concentrations. These methods allow for a nuanced understanding of how different lighting conditions affect the plant's light-harvesting capabilities.

#### **Leaf Area and Expansion: Maximizing Light Capture**

Leaf area and expansion are critical factors in optimizing light capture for photosynthesis. Research indicates that far-red radiation enhances plant growth by stimulating leaf expansion and increasing whole-plant net assimilation (14). Precise quantification of leaf area and morphological traits is achieved using leaf area meters, such as the LI-COR LI-3100C, while image analysis software provides a non-destructive approach for tracking leaf growth over time by digitally assessing leaf area, shape, and color.

#### **Stem Extension: Reaching for the Light**

Stem extension rate reflects how plants respond to light quality and quantity. Research has shown that incorporating 6% green light into the lighting spectrum enhances stem elongation rate in microgreens compared to red and blue light alone (15). To accurately measure these responses, time-series image analysis software tracks stem growth dynamics under varying light conditions. Digital calipers and laser

displacement sensors offer precise manual and automated measurements, while automated phenotyping systems provide real-time monitoring in controlled environments, enabling high-throughput data collection for advanced growth analysis.

### *Biomass Accumulation: The Bottom Line of Growth*

Biomass accumulation serves as the fundamental measure of overall plant growth and productivity. Research indicates that lighting recipes containing green light significantly enhance biomass accumulation in lettuce (12). Gravimetric analysis (dry weight measurement) remains the standard for biomass quantification, providing a direct measure of plant growth. Additionally, HPLC-UV is particularly useful for separating and quantifying specific compounds, while Near-Infrared Spectroscopy (NIRS) provides rapid, non-destructive analysis of chemical composition, offering insights into the quality of the accumulated biomass.

### *Anthocyanin Content: Nature's Stress Indicator*

Anthocyanin content serves as a natural indicator of plant stress, contributing not only to pigmentation but also reflecting the plant's response to varying environmental conditions. In studies with Coleus, it was observed that different light intensities led to increased anthocyanin levels, resulting in noticeable changes in plant coloration (13). To accurately quantify anthocyanin content, researchers employ spectrophotometers (UV-Vis at approximately 530 nm) and HPLC, which offer precise measurements of these vital pigments. Although quantum sensors are used to measure PAR, they do not directly measure anthocyanins but are essential for correlating light intensity with anthocyanin production.

### *PPFD Response: Dialing in the Right Intensity*

Different plant species exhibit diverse growth responses to varying levels of light intensity, quantified as PPFD (16). This variability underscores the necessity for species-specific light recipes to optimize growth. Quantum sensors play a crucial role in directly measuring PAR and PPFD, providing vital data on light intensity at the plant level. Additionally, spectroradiometers offer detailed insights into the light spectrum and intensity, presenting a comprehensive view of the light environment.

### *Chlorophyll Fluorescence: A Window into Plant Health*

Chlorophyll fluorescence serves as a critical indicator of photosystem II (PSII) efficiency and overall plant health. In Coleus, fluorescence measurements revealed significant variations in response to different light qualities, highlighting the impact of spectral composition on photosynthetic performance (13). To assess these effects, chlorophyll fluorometers are employed as powerful analytical tools. These sophisticated, non-invasive instruments provide real-time measurements of PSII efficiency and plant stress responses, enabling precise monitoring of plant health under diverse lighting conditions.

### *NDVI: Remote Sensing of Plant Health*

The Normalized Difference Vegetation Index (NDVI) serves as a critical remote sensing metric for evaluating plant biomass and physiological status in a non-invasive manner. Variability in NDVI values observed in Coleus under different light spectra suggests significant modulation of plant health and biomass accumulation as a function of spectral composition (13). This assessment relies on advanced analytical instrumentation, including specialized

NDVI sensors and multispectral imaging systems, which facilitate high-throughput, non-destructive monitoring of vegetative health across extensive cultivation areas. The integration of NDVI in controlled environment agriculture enhances precision crop management by enabling real-time assessment of plant vigor and early detection of stress responses.

### *Gene Expression: The Molecular Response to Light*

Plants modulate gene expression in response to light conditions, influencing key physiological processes at the molecular level. Notably, exposure to green light was found to alter the expression of nitrate assimilation genes, including (NR and NiR), which are integral to protein biosynthesis and chlorophyll production (15). These molecular adaptations were quantified using real-time quantitative PCR (qPCR), a highly sensitive analytical technique that enables precise measurement of gene expression dynamics under varying light treatments. By elucidating the genetic mechanisms governing plant responses to spectral composition, qPCR facilitates deeper insights into optimizing lighting strategies for enhanced growth and metabolic efficiency.

For controlled experiments across all these indicators, environmental control chambers are crucial for maintaining consistent light, temperature, and humidity conditions. These chambers provide the precise control necessary for isolating the effects of light on plant physiology, ensuring the reliability and reproducibility of research findings.

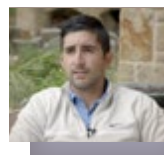
### **Conclusion**

The future of horticultural lighting depends on shifting from traditional efficiency metrics to biologically relevant, data-driven evaluations. Standard measures like PPF and DLI

fail to capture the complexity of plant-light interactions, limiting their effectiveness in optimizing cultivation strategies. To maximize growth and phytochemical production, lighting systems must be designed with plant physiology in mind rather than focusing solely on electrical efficiency. Advanced analytical tools are essential for this transition. By accurately measuring plant responses, cultivators can tailor lighting strategies to specific growth stages, refining spectral composition, intensity, and duration for improved productivity and sustainability. The next generation of horticultural lighting must be adaptive and data-driven, moving beyond static performance metrics. As research advances, the industry must embrace flexible lighting solutions as integral components of controlled environment agriculture. This shift is critical to unlocking the full potential of horticultural lighting, driving improvements in yield, quality, and sustainability.

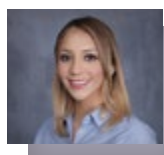
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## A Consumer Trends Survey of Minor Cannabinoids

MONICA K. PITTIGLIO, GIOVANNI A. RAMIREZ, AND WESTLEY CRUCES

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*The passage of the 2018 Farm Bill legalized the manufacture and sale of hemp-derived cannabinoids, leading to a surge in the availability and consumption of minor cannabinoids—phytocannabinoids present in low concentrations within the Cannabis plant and their semi- and fully-synthetic counterparts. Despite the growing market, scientific research on the pharmacology, toxicology, and long-term effects of these compounds remains limited. To assess consumer awareness, usage patterns, and safety concerns, we conducted an anonymous survey (n=105) across multiple online platforms. Results indicate that cannabidiol (CBD),  $\Delta 8$ -tetrahydrocannabinol ( $\Delta 8$ -THC), and cannabinol (CBN) are the most frequently used cannabinoids, with vapes and edibles being the preferred methods of consumption. Improved sleep, pain relief, and recreational use were the primary motivations for consumption. While 91.4% of respondents considered themselves at least "somewhat knowledgeable" about minor cannabinoids, concerns about product purity, long-term effects, and safety were widespread. Notably, 71.4% of participants reported seeking third-party testing results when purchasing these products. The findings highlight a disconnect between consumer confidence and the limited scientific understanding of minor cannabinoids, emphasizing the need for further toxicological and pharmacological research, as well as enhanced regulatory oversight to ensure product safety and efficacy.*

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### Introduction

Minor cannabinoids are traditionally defined as the cannabinoids found in minor relative quantities within the Cannabis plant. A more modern definition includes the phytocannabinoids as well their semi- and fully-synthetic counterparts. The passage of the 2018 Farm Bill legalized the manufacture and sale of cannabinoids extracted or derived from hemp, and as a result, products containing "minor" cannabinoids as a main component have exploded in both popularity and availability over the past several years, notably in states where the sale of Cannabis flower is banned. Many of these new cannabinoids are products of acid-catalysis (1), hydrogenation (2), or semi-synthesis (3). Functional group

interconversion or semi-synthesis using phytocannabinoids is rapid and cost-effective, ensuring a consistent flow of these products for years to come. Hemp-derived minor cannabinoid products are now available at an enormous range of retailers, from dispensaries to gas stations.

While behavioral, toxicological, and pharmacological studies have been performed for a select few of the roughly 100 identified minor cannabinoids, little is known about consumer trends or preferences. Because these compounds are regulated by a patchwork of state-by-state laws, there is no requirement to report or even collect consumer data. Our team used an anonymous survey (n=105) to collect information about consumer

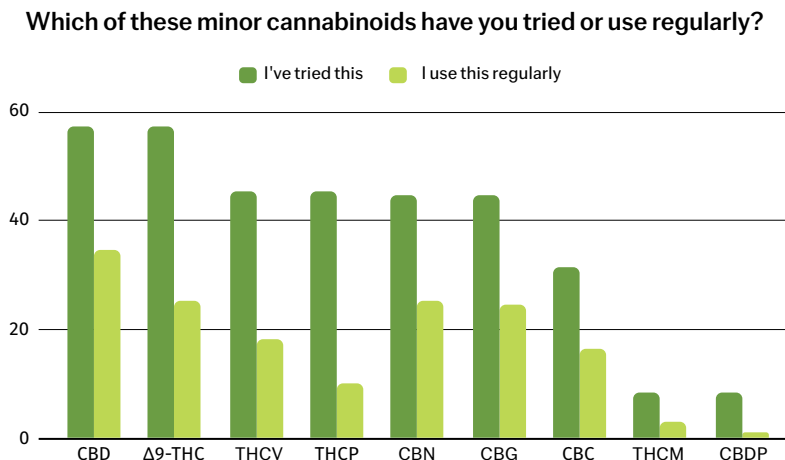
knowledge, usage and consumption preferences, awareness of impacts, and safety concerns.

### Methods

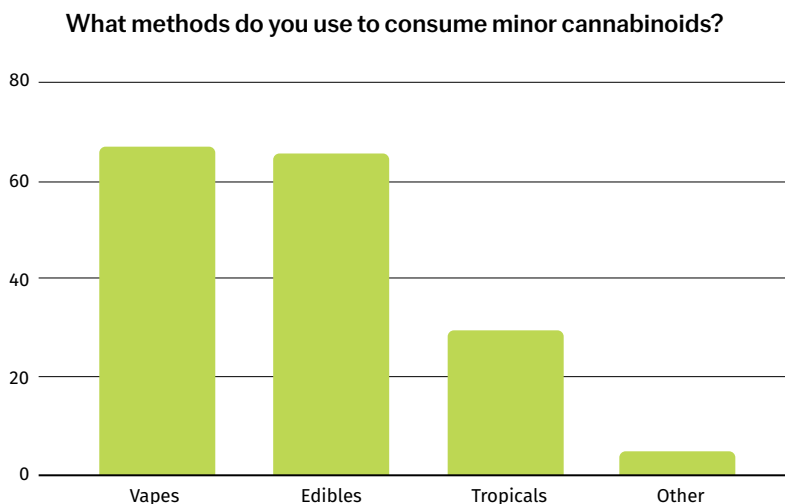
A set of 13 questions were generated to encompass a large set of unanswered thoughts within the hemp space. They focus primarily on safety, the purpose of using cannabinoids, methods of consumption, general knowledge about these products. The questions are as follows:

- What is your age range? (optional)
- What is your gender? (optional)
- What is your approximate annual income? (optional)
- Which of these minor cannabinoids have you heard of, tried, or use regularly? Followed on by: If you've heard of, tried, or regularly use any minor cannabinoids that are not in the question above, please list them here.
- What methods do you use to consume minor cannabinoids?
- For what purpose do you use minor cannabinoid products?
- Do you feel comfortable purchasing minor cannabinoid products from the following locations: Dispensary, smoke shop/head shop, gas station/convenience store, online retailer?
- How would you rate your overall knowledge of any potential health benefits or effects associated with minor cannabinoids in the human body?
- Do you have any concerns about the long-term effects of consuming minor cannabinoids?
- How important is product safety to you when choosing minor cannabinoid products?
- What specific safety concerns do you have regarding the use of minor cannabinoids?
- How concerned are you about

**Table I:** CBD and Δ8-THC were the most popular minor cannabinoids to try, but Δ8-THC tied or nearly tied with CBN and CBG for number of regular users. CBD was the most popular minor cannabinoid in both categories



**Table II:** Vapes and edibles were the favorite consumption methods amongst survey participants



the purity or quality of minor cannabinoids in the products that you use?

- Do you look for third-party testing lab results when purchasing minor cannabinoid products?

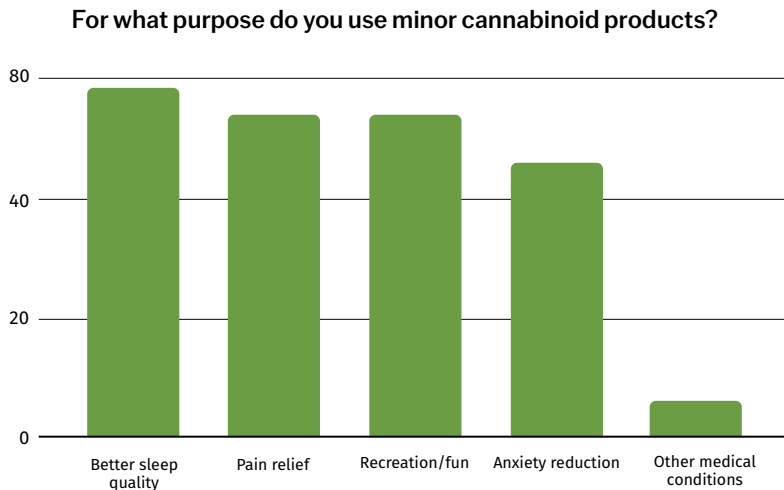
These questions were placed into Google Forms and the link was posted

onto several social media sites (LinkedIn, Reddit, Discord, Instagram). All data were exported into Microsoft Excel and analyzed.

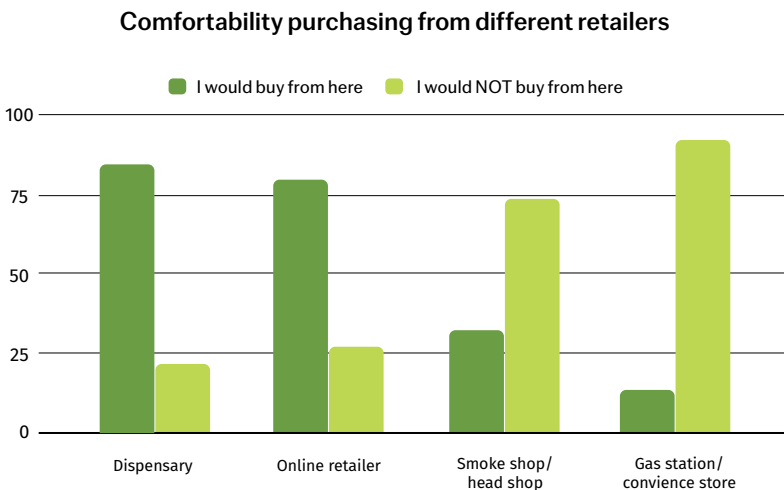
### Results and Discussion

Of the survey respondents who chose to disclose their age (n=103), 74.7% were between the ages of 20 to 50;

**Table III:** 33.3% of participants used minor cannabinoid products for three or more individual purposes



**Table IV:** Despite the media hype about these products' availability at gas stations and convenience stores, the majority of survey takers would prefer to buy their minor cannabinoid products at dispensaries and online retailers



9.7% were under 20 years of age; and 15.6% were over 50 years of age. Of survey respondents who chose to disclose their gender (n=99), 82.4% were male. Approximate annual income for those who chose to report it (n=88) was surprisingly evenly distributed. Of these respondents, 11.4% were unemployed. The two incomes with the

most respondents were <\$20,000 and \$20,000-\$40,000, both with 15.9% of the responses. The remaining categories, broken up in \$20,000 increments up to >\$140,000, shared between 4.5% and 14.8% of the remaining respondents. Participants with an approximate annual income of >\$140,000 made up 13.6% of the responses.

Survey participants were given a list of popular minor cannabinoids and were asked to declare which they had heard of, tried, and used regularly. Of the minor cannabinoids that were used regularly, cannabidiol (CBD) was the most popular (n=34), followed by Δ8-THC (n=25) and cannabinol (CBN) (n=25), cannabigerol (CBG) (n=24), tetrahydrocannabivarin (THCV) (n=18), and cannabichromene (CBC) (n=16). For the more popular cannabinoids, the ratio of those who had tried it to those who use it regularly was roughly 2:1; but for the more unpopular cannabinoids, that ratio was more pronounced, such as 4.5:1 for tetrahydrocannabinophorol (THCP), 8:1 for cannabidiophorol (CBDP) (see **Table I**). In a free response question, participants indicated that they also regularly used cannabidiolic acid (CBDA), cannabitrinol (CBT), cannabielsoin (CBE), cannabicyclol (CBL), cannabinodiol (CBND), cannabinol acetate-O (CBNO), hexahydrocannabinol (HHC), hexahydrocannabivarin (HHCV), hexahydrocannabiphorol Acetate (HHCPO), hexahydrocannabiphorol (HHCP), tetrahydrocannabihexol (THCH), hexahydrocannabidiol (H4 CBD), exo-tetrahydrocannabinol (exo-THC), and Δ10-THC.

Vapes and edibles were the two most popular consumption methods, at 63.8% and 61.9%, respectively. Topicals came in third with 27.6% (see **Table II**). Better sleep quality was the top reason for minor cannabinoid use at 55.2%, followed by a tie for recreation/fun and pain relief, both at 51.4% (see **Table III**). In a free response question, participants indicated that they also use minor cannabinoid products to help them cope with a myriad of mental health disorders, such as autism, attention-deficit/hyperactivity disorder, and obsessive-compulsive disorder. 80.0% of respondents expressed that they would be comfortable purchasing

their minor cannabinoids from dispensaries, and 75.2% were comfortable purchasing through online retailers. This is in stark contrast to the 69.5% who stated that they would not purchase their minor cannabinoids from a smoke shop/head shop, or the 87.6% who stated that they would not purchase from gas stations/convenience stores (see **Table IV**). This is interesting because there are several news articles (4,5) that bring up how the public has access to these products at gas stations.

A majority (91.43%) of respondents consider themselves either “somewhat knowledgeable” or “very knowledgeable” about the overall health benefits and effects on the body from minor cannabinoid use. This is interesting, because even scientists who specialize in cannabinoid research have extremely limited knowledge about how minor cannabinoids impact a biological system. A recent review by Docampo et al. (6) concerning saturated cannabinoid toxicological and safety profiling shows that there is not much literature on these topics outside of in vitro testing. With that said, only 39.1% of survey takers are “somewhat concerned” or “very concerned” about long-term effects of consuming minor cannabinoids, even though over 87.6% of respondents state that product safety is “very important” to them.

Product safety is reiterated when respondents were asked if there are any concerns about safety. Over 91% of respondents were concerned about purity, impact on long-term health, and side effects and 86.7% were “very concerned” or “somewhat concerned” about purity or quality of the minor cannabinoids in product that they are using or consuming. Of the survey takers, 71.4% “always” look for third party testing lab result when purchasing a minor cannabinoid product. Ingredients (79%),

potency (78.1%), and safety testing (76.2%) were most important to consumers when choosing a minor cannabinoid product.

### Conclusion

The surge in availability and use of minor cannabinoids following the 2018 Farm Bill has created a market where consumer interest far outpaces scientific understanding. Our survey results reveal a high degree of consumer confidence in the perceived benefits of these cannabinoids, though concerns about purity, quality, and long-term effects remain significant. While most users are drawn to these products for potential therapeutic benefits such as improved sleep, pain relief, and recreational purposes, many lack a clear understanding of the limited research available on safety and efficacy. The preference for purchasing from reputable sources and reliance on third-party testing further underscore a strong desire for product quality and safety. As industry continues to evolve, more educational efforts and rigorous research are essential to ensure that consumer knowledge and safety keep pace with market growth, empowering individuals to make informed choices about minor cannabinoids.

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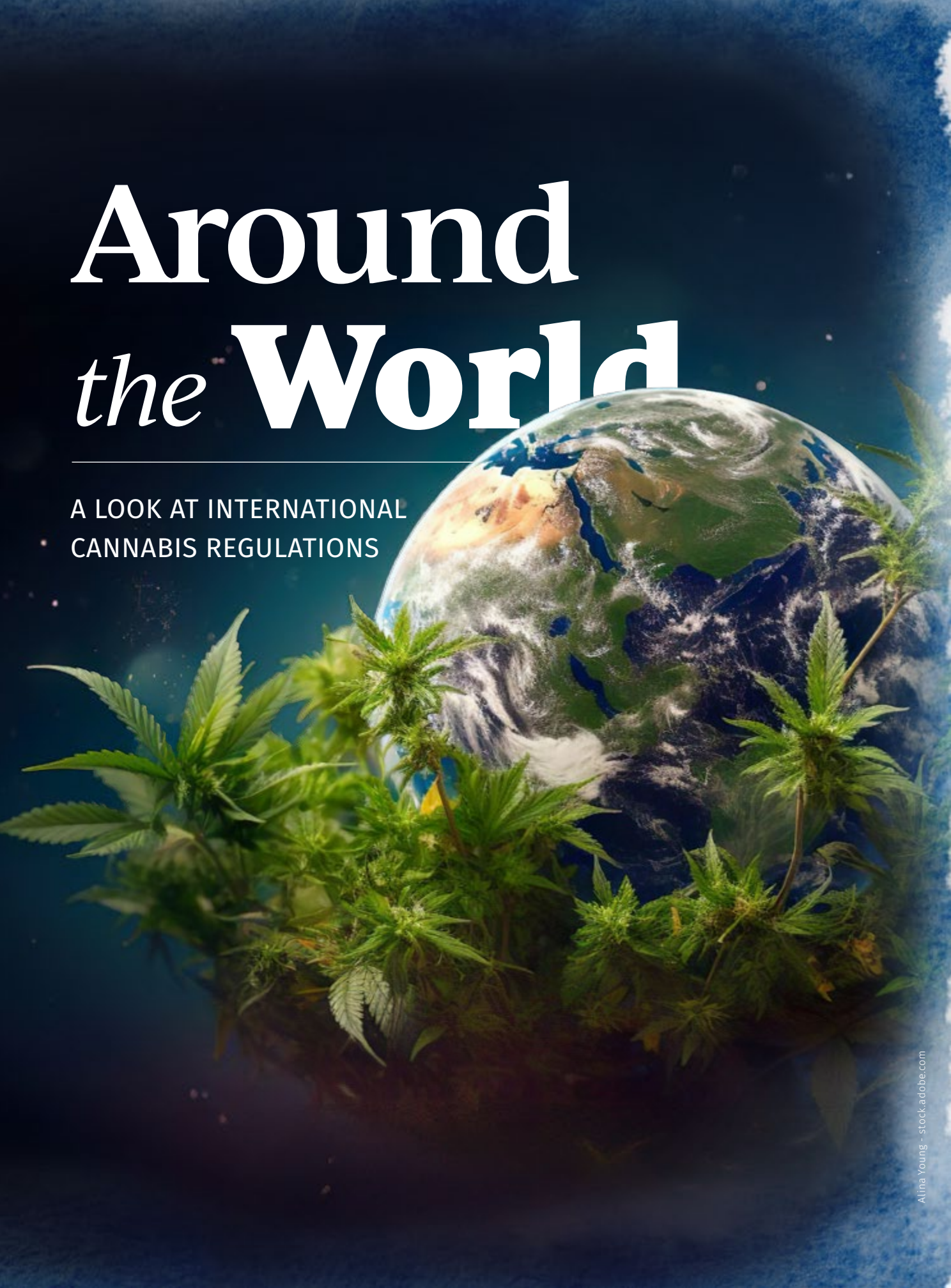
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# Around *the* **World**

A LOOK AT INTERNATIONAL  
CANNABIS REGULATIONS





*The information in these snapshots was compiled with the help of MM411, which has partners across the globe to create accessible education that is reflective of the regulatory framework within the global region that is specially curated for cannabis professionals. We would like to extend thanks to MM411's global partners Training 4 Health Care for insights on the UK cannabis framework, and to Cannabis Poland for their valuable contribution on the regulations in Poland.*

## UNITED KINGDOM

**IN THE UNITED KINGDOM (UK)**, cannabis is a controlled substance, classified as a Class B controlled drug under Part 2 of Schedule 2 to the Misuse of Drugs Act 1971 (MDA 1971).<sup>(1)</sup> It is also listed in Schedule 1 to the Misuse of Drugs Regulations 2001 (“MDR 2001”) and designated under the Misuse of Drugs (Designation) (England, Wales and Scotland) Order 2015 (2015 Order). While there are exceptions for the mature stock, the fiber produced from the stocks as well as the seeds, it is unlawful to “possess, supply, or offer to supply, produce, import, or export,” cannabis unless one has a license from the Home Office.

This license only allows farmers to use hemp for industrial purposes such as fiber, seeds, oil and food, whereas the flowers and leaves must be destroyed. Hemp in the UK is defined as cannabis with 0.2% THC or less. Like the plant itself, cannabinoids derived from cannabis are also controlled as Class B drugs under Part 2 of Schedule 2 to the MDA 1971. These include cannabidiol and its derivative such as tetrahydrocannabinol ( $\Delta^9$ -THC). Cannabidiol (CBD) is not controlled, but only in its isolated form. Full spectrum products that contain a low threshold of THC as well as other cannabinoids are not lawful.

CBD in foods and supplements are considered novel foods by the Food Standards Agency (FSA), and need to undergo authorization by FSA. There is a list of authorized products that includes those that have been on the market prior to February 13, 2020, and have submitted an authorization application by March 31, 2021. Subsequently, brands that want to sell CBD in the UK after these dates must undergo the novel food authorization process before it can reach retail shelves. CBD is permitted in topical products such as creams and balms but must comply with UK cosmetic safety regulations (UK Cosmetic Product Safety Report, CPSR) and be listed on the UK's Cosmetic Product Notification Portal (CPNP).

Cannabis for medicinal purposes is regulated separately and defined as “any preparation or product which is, or contains, cannabis, cannabis resin, cannabidiol and cannabidiol derivatives (not being dronabinol or its stereoisomers), which is produced for medicinal use in humans and is a medicinal product, or a substance or preparation for use as an ingredient of, or in the production of an ingredient of, a medicinal product.” Interestingly, cannabis products for medicinal purposes apart from approved drugs such as Sativex and Epidyolex are considered unlicensed medicines (special medicinal products). The smoking of cannabis products for medicinal purposes is still prohibited.<sup>(2)</sup>

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# regulatory snapshots



## POLAND:

**IN POLAND**, cannabis is classified in two ways: fibrous (e.g. hemp), with THC below 0.3% and non-fibrous, with THC above 0.3%. Non-fibrous cannabis is prohibited from being produced, imported, or sold for recreational purposes, but research institutions are allowed to grow non-fibrous cannabis for the preparation of prescription drugs. Medical cannabis may be prescribed by a doctor and distributed by a pharmacy.<sup>(1)</sup> Recent regulations set in November of 2024 prevent private clinics from offering remote consultations for cannabis prescriptions, meaning that only national health physicians can provide remote consultation and prescriptions to patients who have previously had an in-person consultation. This has caused prescriptions for medical cannabis to significantly decrease, from 68,000 in October of 2024 to 28,000 in December of 2024.<sup>(2)</sup>

Farmers can apply for a license to grow fibrous cannabis for research and development as well as commercial purposes such as textiles, food, or building material. Within the country, there are no specific regulations for the production and sale of non-intoxicating cannabinoids such as CBD; however, in the European Union (EU), to which Poland belongs, the cannabinoid is considered a novel food. A novel food is a food that has not been consumed significantly in the EU before 15 May 1997 and falls under one of the following categories:

1

Newly developed or innovative food such as plant-based meat alternatives, edible insects, or lab-grown meat.

2

Food produced using new processes such as nanotechnology or novel fermentation methods.

3

Food traditionally eaten outside the EU such as chia seeds, noni fruit, or baobab.

4

Engineered or synthetic food ingredients such as artificial nutrients or synthetic proteins.

Regulations require novel foods to be authorized prior to being marketed, evaluated for safety prior to approval, and listed on the EU List of Novel Foods upon approval. The European Food Safety Authority has not yet authorized any CBD products, but of course, that has not prevented their sale. Manufacturers must ensure their products contain less than 0.3% THC as to not be considered a controlled substance, but CBD in isolate form is often considered safer to sell from a legal perspective.

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# German Medical Cannabis Market Has Yet to Reach Its Full Potential

NIKLAS KOUPARANIS

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*Germany's Cannabis Act (CanG) is beginning to transform the country's medical cannabis market, with potential opportunities to expand telemedicine, improve physician training, and enhance accessibility in this rapidly growing industry.*

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**O**N APRIL 1, 2024, the Cannabis Act (CanG) passed in Germany and reclassified cannabis as a non-narcotic. These legislative actions eased administrative barriers for patients and prescribing doctors, sparking significant growth in the market. Since then, the medical cannabis industry has seen a substantial increase in both patient numbers and supply.

As of April 2024, there are an estimated 300,000 patients who use medical cannabis with 17 tons of supply. Yet the passage of CanG has only started to ignite momentum in the market. According to calculations based on findings in Bloomwell Group's recent report titled "*The Cannabis Barometer: Motives, Concerns and Preferences of Cannabis Consumers in Germany*," the German medical cannabis company found that the market has the potential to reach more than 20 million patients and a supply of 60,000 tons. With this in mind, Germany is poised to become one of the largest and most promising medical cannabis markets in the world, offering a bright future for investors, policy-makers, and healthcare professionals.<sup>(1)</sup>

## **Majority of German Consumers Cite Health Reasons for Cannabis Use**

Bloomwell Group's 2024 report revealed that 94% of respondents who consumed cannabis did so for at least

one medical or health reason. The most common reason cited by respondents for consuming cannabis was for stress relief (about 60%), followed by sleeping disorders (50.4%) and pain relief (35%).<sup>(1)</sup>

The report also revealed that while the majority of cannabis users in Germany use the plant for medical or health reasons, within the past year, only 10% of the survey participants obtained cannabis exclusively from licensed pharmacies. Almost 60% of consumers continue to obtain their cannabis illegally, often despite their concerns about poor quality and associated health damage. Over a quarter of respondents (26%) said they had already purchased contaminated cannabis, while around 31% had obtained poor quality on the illegal market in the past.<sup>(1)</sup>

## **Improving Patient Access Through Medical Training and Guidance from Experts**

One of the key barriers to consumers being able to access medical cannabis through a pharmacy is the lack of providers who are willing and experienced in prescribing cannabis as a medical treatment. Despite the improved legal framework, over 90% of those surveyed struggle to find a provider who is open to cannabis therapy and has the necessary expertise. This highlights the urgent need

for more providers to be trained and open to prescribing medical cannabis, a crucial step in improving patient access and care.

Physicians who specialize in medical cannabis should lead conversations, spread awareness, and help educate other providers in the field about cannabis as a medical treatment and its health potential. In addition, it's important for medical professionals to provide evidence-based factual information to the public that can help ease outdated stigmas and myths surrounding cannabis. They should also take a firm hand in helping to guide regulatory leaders and professionals within the scientific and medical communities as they seek to ease regulations surrounding the research of cannabis for patients.

### **Technology to Drive Patient Access and Ease of Use**

Within the last few years, telemedicine has increased worldwide, partly due to the travel and social distancing limitations imposed by the COVID-19 pandemic. According to McKinsey & Company, by the second quarter of 2022, 96% of outpatient practitioners in Germany were linked to the telematics infrastructure, up from 90% in 2020. As of the second quarter of 2022, 99% of pharmacies in Germany were connected to the telematics infrastructure, a significant increase from 75% in 2021, according to McKinsey & Company.(2)

Telemedicine allows patients to access medical care consultations without having to travel to a physician's

physical office. Using video chat, patients can speak with healthcare providers about their medical conditions, and providers can prescribe medical cannabis based on the patient's symptoms. Not only does this provide convenience and accessibility for patients, but it also helps reduce healthcare costs associated with in-person visits and cuts waiting times. This is especially useful to medical cannabis patients who are in remote parts of Germany and may not be in an area that has a provider who specializes in cannabis therapy. Such advancements also allow pharmacies to receive digital prescriptions from prescribing physicians and fulfill them on-site.

Cannabis patients have reported to prefer to receive prescribed cannabis products through a digital application and have them delivered directly to them from the pharmacy. According to the Bloomwell report, 92% of those surveyed would like cannabis treatment through an app with delivery from the pharmacy.(1)

### **Opportunities for Growth**

Stakeholders have opportunities to build upon the areas of the industry that are already fueling growth, like telemedicine, and also provide strategies to help transition German consumers from the illicit market to the legal medical market.

To do this, it is important for key players within the industry to help fuel conversations about medical cannabis therapy and the patient process. Providing clear and accurate information about the benefits and

regulations of the legalized medical cannabis market can help patients understand the benefits of securing cannabis through licensed pharmacies rather than risk contaminated products from the illicit market.

In addition, industry leaders and regulators alike should work together to ensure that legalized medical cannabis stays accessible and affordable for patients. The cost of medical cannabis must be competitive with that of the illicit market. To provide a steady supply, international imports of medical cannabis are needed and must continue to grow to meet consumer demand. Investors will need to continue fueling the German import market to ensure patients receive uninterrupted access to their prescribed treatment.

#### *about the author*

**NIKLAS KOUPARANIS** is the CEO and Co-Founder of Bloomwell Group

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