What's in Your Weed?

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Policy, Education, and Regulation

Introduction

AS THE POPULARITY OF CANNABIS continues to grow, it is increasingly important for consumers and patients to be informed about the cannabinoid-containing products they choose to use. Currently, at least some form of cannabinoid-containing products is legally available in every state across the country; access to recreational and/or medical cannabis products is allowed in the majority of states, and hemp-derived products are sold legally online or in retail stores across the nation. However, the absence of federal legalization has created an often confusing and difficult-to-navigate landscape. In this paper, we will clarify the lexicon, outline important questions for both policymakers and consumers to consider, and explain how to interpret information about cannabis- and hemp-derived products, underscoring why "what's in your weed" matters.

Cannabis 101: Clarifying the Lexicon

CANNABIS VS. HEMP

The terms "cannabis" and "marijuana" are often used to describe anything from the plant *Cannabis sativa L.* which has been classified as a controlled substance and federally illegal since 1970. Cannabis is comprised of hundreds of compounds, including more than 100 cannabinoids; the most abundant of these are delta-9-tetrahydrocannabinol (delta-9-THC, more commonly known as "THC") and cannabidiol (CBD). Delta-9-THC is considered the primary intoxicating constituent of the plant, often associated with the typical "high" that many expect from cannabis, while CBD is non-intoxicating and often touted for its therapeutic potential.

"Hemp" refers specifically to varieties of cannabis that contain 0.3% or less THC by weight. In 2018, the Agricultural Improvement Act (commonly referred to as "The 2018 Farm Bill") legalized the production of hemp and differentiated it from other cannabis plants, effectively removing it from the Drug Enforcement Administration (DEA) list of controlled substances. The US Department of Agriculture (USDA) issued regulations regarding the ≤0.3% THC threshold for hemp, stating the "total concentration level shall be determined and reported on a dry weight basis" where "dry weight basis" refers to "the percentage of THC, by weight, in a cannabis item (plant, extract, or other derivative), after excluding moisture from the item."[1a] For more on testing practices for THC concentration in hemp, visit https://www.ams.usda.gov/rules-regulations/hemp/information-laboratories/lab-testing-guidelines. It is important to note the 2018 Farm Bill provided USDA authority over the cultivation of hemp at the farm level, but explicitly preserved the FDA's authority to regulate food, drug, and cosmetic products, including those derived from legally-grown hemp[b].

MINOR CANNABINOIDS

Cannabis chemovars (chemical varieties, commonly referred to as "strains") also contain "minor," or less common cannabinoids, such as cannabichromene (CBC), cannabigerol (CBG), cannabinol

[a] https://www.ecfr.gov/current/title-7/subtitle-B/chapter-IX/part-990/subpart-A/section-990.1

[b] https://www.congress.gov/115/plaws/publ334/PLAW-115publ334.pdf

(CBN), tetrahydrocannabivarin (THCV), and dozens of others. Minor cannabinoids have been shown to have therapeutic and neuroprotective effects, which may mitigate some of the negative effects commonly associated with THC[2-5]. As a result, many of these cannabinoids are becoming more prevalent. In fact, a small, but growing selection of products now feature minor cannabinoids as the primary focus.

NEUTRAL VS. ACID FORMS

Notably, cannabinoids can be found in both neutral forms and acid forms. The well-known neutral forms of cannabinoids (THC, CBD, CBC, etc.) result from the decarboxylation of the acid form of the compound. In simpler terms, the acid form of a molecule converts to the neutral form when heated; tetrahydrocannabinolic acid (THCA) converts to THC when it is smoked, vaped, or heated by other means. Similarly, CBDA converts to CBD, CBCA converts to CBC, and the list goes on. For consumers, this is particularly important information when using any product that is heated, as the total content of individual cannabinoids must consider both the acid and neutral forms. For example, a significant percentage of THCA converts to THC when heated, increasing the potency and potential for intoxication. For more on this, see "Certificates of Analysis (COAs)". This has implications for policymakers as well. Regulations aimed at addressing intoxicating compounds will need to consider that some compounds only become intoxicating once converted by heat (e.g., products that are designed for inhalation). For example, if regulations exclusively address THC, products containing high levels of THCA could reach the marketplace without regulation. Separately, emerging research focused on the acid forms of cannabinoids suggests these compounds also have unique therapeutic properties and are now featured in a growing number of products (e.g., THCA concentrates, CBDA solutions).

NOVEL, INTOXICATING CANNABINOIDS: "DELTA-8" AND OTHER SEMI-SYNTHETIC DERIVATIVES

A growing number of potentially intoxicating minor cannabinoids, generally found in only trace amounts within the plant, are now being synthesized to create products containing high levels of these compounds, like delta-8-tetrahydrocannabinol ("delta-8"), delta-10-tetrayhydrocannabinol ("delta-10"), delta-9-tetrahydrocannabiphorol (THCP), and hexahydrocannabinol (HHC), among others. These products are often used for their intoxicating effects and, for some, to potentially avoid testing positive for THC. For more on issues related to novel cannabinoids and drug testing, see CPEAR's recent report on workplace cannabis testing.[c]

[c] http://www.cpear.org/wp-content/uploads/2023/01/A-Science-and-Equity-Centered-Framework-to-Reimagine-Workplace-Cannabis-Testing_.pdf

“One common concern with using products containing these semisynthetic derivatives is related to the processes required to manufacture them, as harsh chemicals or solvents are often used in the extraction process.

Interestingly, although delta-8 and delta-10 are examples of compounds synthesized or created in a lab, they are not considered wholly synthetic as they exist naturally in the plant in trace amounts, and accordingly fall into a bit of a legal loophole. Essentially, these compounds can be created by converting hemp-based CBD (which is unregulated at the federal level) into delta-8 or delta-10. At present, these semi-synthetic derivates (also sometimes referred to as “biosynthetic cannabinoids”) are federally unregulated, although there has been discussion of revising the Farm Bill to also address semi-syntheticderivates like delta-8 and delta-10 as well as those yet to be discovered. Cannabinoids that are created synthetically and do not occur naturally in the cannabis plant (e.g., delta-8-THC acetate ester [THCO]) remain illegal, controlled substances under federal law.

One common concern with using products containing semi-synthetic derivatives is related to the processes required to manufacture them, as harsh chemicals or solvents are often used in the extraction process. Removal of these chemicals is rarely complete, and exposure to even trace amounts is potentially harmful. Further, a report by the FDA[d] revealed that delta-8 products are often associated with adverse events (e.g., hallucinations, vomiting, tremor, anxiety, dizziness, confusion, and loss of consciousness) as well as a significant number of calls to poison control centers. Although an increasing number of states have either blocked sales of delta-8 products or require purchase at a dispensary, these products continue to be widely available and raise the risk of adverse effects.

TERPENES AND FLAVONOIDS

Terpenes are compounds found in plants that are responsible, in part, for their characteristic scent and flavor profile and have their own therapeutic effects[6]; examples of terpenes include linalool, limonene, pinene, myrcene, and caryophyllene. **Flavonoids** are another class of molecules found in plants that have demonstrable therapeutic benefits, including anticancer, antioxidant, anti-inflammatory, and antiviral effects.[7] More than 20 different flavonoids have been identified in cannabis, some of which are exclusively found in cannabis plants (aka “cannflavins”).[8]

[d] https://www.fda.gov/consumers/consumer-updates/5-things-know-about-delta-8-tetrahydrocannabinol-delta-8-thc

Cannabinoids may interact synergistically with both terpenes and flavonoids, resulting in a phenomenon known as the **entourage effect.** Offering support to this theory, some evidence suggests that products can be effective at lower doses when multiple cannabinoids, terpenes, and flavonoids are present.[9,10]

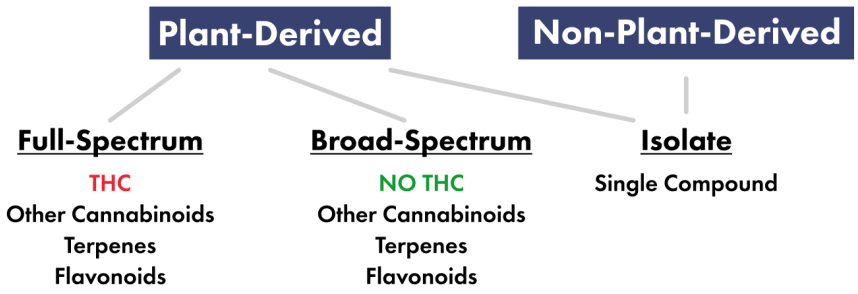
CLASSIFYING PRODUCT TYPES

Cannabinoid-containing products can be classified in several ways, based on whether they are derived from cannabis plants (**plant-derived**) or produced synthetically in a laboratory (**non-plant-derived**), and based on the compounds they contain. Virtually all products for sale in the retail market are plant derived. Plant-derived products can be either full-spectrum, broad-spectrum, or isolates. Non-plant-derived products are typically FDA-approved pharmaceutical products available by prescription only, such as wholly synthetic (man-made) forms of THC like nabilone and dronabinol, or other cannabinoid molecules synthesized in a lab to be used specifically in controlled research investigations.

Full-spectrum products contain an array of cannabinoids, terpenes and other naturally occurring compounds. **Broad-spectrum** products also contain an array of compounds from the plant; however, the difference between full- and broad-spectrum products is that *broad-spectrum products contain no quantifiable THC*. Broad spectrum products are often chosen by those who wish to actively avoid potential intoxication.

Isolates are products that contain only a single compound. For example, Epidiolex (an FDA-approved medication for intractable seizure disorders) contains a purified form of CBD. Other isolate products are also available for retail purchase online or in stores/dispensaries. Importantly, however, labels may be confusing or misleading, and it is currently up to the consumer to do their due diligence to determine which compounds are present in the products they choose.

FIGURE 1. CLASSIFYING CANNABINOID PRODUCTS BASED ON SOURCE AND COMPOUNDS PRESENT



Contaminants

In addition to the cannabinoid components consumers seek out, cannabis- and hemp-derived products are susceptible to contamination by various types of pathogens or other elements which may adversely affect consumers[11]. These contaminants may be introduced at any stage of the growth or production process, and include things such as mold, *E. coli*, pesticides and mycotoxins, among others. As is the case with other food products, this is a concern because certain contaminants, when present in sufficient quantities, can pose a significant risk to consumers.

Pathogens and other contaminants that may be present in cannabis-derived products include:

- **Mycotoxins** - Mycotoxins are produced by fungal microorganisms and are toxic to humans when consumed; some of these are actually considered carcinogenic[12]. Two of the most common mycotoxins, Aflatoxin and Ochratoxin, are regulated by the FDA and the World Health Organization (WHO) and have established maximum limits for several food products[e,f]. Currently, however, only some state regulations require testing for mycotoxins in cannabis.

- **Heavy Metals (Elemental Impurities)** - Heavy metals are toxic to humans when consumed in certain doses or as the result of long-term exposure. These contaminants are found naturally in the environment at varying concentrations and appear in cannabis products through plant bioaccumulation or cross-contamination during production[11]. These elements include lead, cadmium, arsenic, mercury (considered "the big four" heavy metals) and may include a smaller subset of elements such as cobalt, vanadium, nickel, lithium, antimony, barium, molybdenum, copper, tin, and chromium. Setting appropriate thresholds for heavy metals is complicated, as they are generally present at different levels in different geographical regions (e.g. different states), making standardization challenging.

- **Pesticides** - In the United States, pesticides are regulated by the Environmental Protection Agency (EPA) and are divided into three categories: conventional pesticides, antimicrobial pesticides, and biopesticides[g]. Two of these, conventional pesticides and biopesticides are used in crop production for their ability to mitigate pests on a crop. When the EPA approves a new

[e] https://www.fda.gov/food/natural-toxins-food/mycotoxins

[f] https://www.who.int/news-room/fact-sheets/detail/mycotoxins

[g] Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and Federal Facilities, U.S. EPA (Mar. 28, 2022), https://www.epa.gov/enforcement/federal-insecticide-fungicide-and-rodenticide-act-fifra-and-federal-facilities#:~:text=The%20Federal%20Insecticide%2C%20Fungicide%2C%20and,pesticides%20in%20the%20United%20States.

pesticide, the approval is specific to a particular crop under specified conditions (i.e., time of year). There is currently no EPA-approved pesticide for use on cannabis. Many states, however, do allow for limited pesticide use on cannabis plants[h]. As cannabis is a relatively new market, there is significant state-to-state variability in testing requirements for pesticide residues[13].

- **Residual Solvents** - Residual solvents are chemicals used to extract or pull cannabinoids or other cannabis compounds from flower to be used in oils, vape cartridges, edibles, etc. Recent studies indicate that more than 80% of cannabis concentrates contain at least some residual solvent from the extraction process[14]. Common solvents such as ethanol, isopropanol, acetone, and hexane, as well as more toxic solvents like propane, butane, and other hydrocarbons, are all used in industry due to their low cost and easy implementation. Testing regulations often reference United States Pharmacopeia (USP) guidance for minimum acceptable amounts of residual solvents.

BACTERIAL AND FUNGAL MICROORGANISMS

A majority of states require testing for one to three types of pathogenic microorganisms: *Aspergillus, Salmonella*, and *E. coli*. *Salmonella* and *E. coli* are human pathogens known to cause contamination through irrigation water. While many species of *Aspergillus* are ubiquitous in the environment, certain species are explicitly regulated due to their ability to cause human illness.

For certain microorganisms, such as yeast and mold, states may use quality indicator testing to determine whether the cultivation or production process was conducted under sanitary conditions. Maximum threshold levels are subsequently established and products exceeding these levels are generally prohibited from entering the marketplace.

Adequate testing can help mitigate the risk posed by harmful microorganisms. However, testing requirements vary between states and even within a state depending on the product type (flower, concentrate, edible). It should be noted that testing for contaminants is separate and distinct from potency testing (e.g., THC content), which is now more widespread and standardized following the passage of the 2018 Farm Bill.

[h] Oregon Cannabis: Cannabis and Pesticides, Oregon Department of Agriculture (Apr. 2018), https://www.oregon.gov/oda/shared/Documents/Publications/PesticidesPARC/CannabisPesticides.pdf

Interpreting Product Labels

In general, a product label should provide clear and comprehensive information about the product's composition, ingredients, and potential risks and benefits of use.[15] Currently, there are no universal guidelines or mandate for labeling cannabis products, and requirements vary widely by state. Unfortunately, a lack of a consistency increases potential risks associated with cannabis use, as consumers may not understand exactly what they are taking, how to take it, or how much to take.

A recent paper examining label requirements for cannabis-containing products in states with legal medical cannabis programs[16] found that less than half of states include amount of THC or CBD per serving, usage instructions, or storage recommendations. Across states, the required label content varies widely, although all states require cannabis products to list overall delta-9-THC content. Notably, in the US, hemp-derived products are not required to state delta-9-THC content. In theory, these products should contain relatively small amounts of THC (up to 0.3% by weight). This limit is akin to the FDA allowing "fat free" products to contain 0.5g/serving of fat, or non-alcoholic beer to contain up to 0.5% alcohol by volume. For some, however, this is still a considerable amount of THC and may yield undesirable effects. Importantly, studies testing the delta-9-THC content of hemp-derived CBD oils have found that some products test well above the legal limit, and almost a quarter of hemp products labeled "THC-free" had detectable levels of delta-9-THC.[22,27]

ISSUES RELATED TO PRODUCT LABELS AND PURCHASING PRODUCTS

Overall, there are some common characteristics on most labels – more than 80% of states with medical cannabis programs require batch number, health risks, production tracking, a cannabis symbol, cannabinoid content, child safety disclaimer, and an impairment disclaimer. However, there is no federal regulation in place for the content that must appear on labels or the format it should be in. Labels can therefore be confusing. Here are some important tips for interpreting product labels:

- **Labels are often inaccurate:** Without overarching regulation in place to ensure consistency and accuracy of labels, it is not surprising that a growing number of studies have documented discrepancies between labels and a product's actual cannabinoid content[17-25]. Inaccuracies include products that are over-labeled (label says it contains more than it does), under-labeled (label says it contains less than it does), or omit information from the label (e.g., product contains THC or other cannabinoids that are not noted on the label).

- **"CBD" is not always *just* CBD** - Products containing CBD very often contain other cannabinoids or compounds. Look for more information about the other compounds and see how the product is labeled – does it include terms like full-spectrum or broad-spectrum, which indicates it contains other compounds? (See Figure 1). The exception to this would be products marketed as CBD isolate, which should only contain CBD.

- **Hemp products can – and often do – contain THC:** By law, hemp products can contain up to 0.3% THC by dry weight, and labels are not currently required to disclose THC content in hemp-derived products. Why is this a concern? Roughly translated, the legal limit of ≤0.3% by weight could, in the example of a CBD oil product, result in up to almost 3 mg/ml of THC. While it may seem unlikely that these products could cause intoxication or impairment, for some, this is a considerable amount of THC which may yield undesirable effects. In addition, small amounts of delta-9-THC can build up in the body over time, potentially resulting in a positive drug test. In one recent study, 50% of patients enrolled in a clinical trial of a high-CBD product tested positive for metabolites of delta-9-THC after 4 weeks of use, even though the product contained one-tenth the amount of delta-9-THC legally allowed in hemp products[26]. For consumers looking to avoid THC, look for products labeled "THC-free," "broad-spectrum," or products that contain isolates of non-intoxicating cannabinoids.

- **Cannabis 'strains' or chemovars are not standardized:** There are no requirements or set conventions for naming different cultivars of cannabis. Moreover, products with the same name can actually vary widely in terms of their chemical composition. In other words, OG Kush purchased at Dispensary A may contain much more THC than OG Kush purchased at Dispensary B. Or ACDC flower, generally considered a high CBD chemovar, purchased in October might have far less CBD than in April. A Certificate of Analyses (COA) will provide

more definitive information about which compounds are present and in what amounts in specific batches (see next section on COAs).

- **Serving size is not always clear:** It is important to understand that a package may contain multiple servings. For example, a package containing a single cookie may state that it has 25mg THC per serving, but without reading the label, the consumer may not realize the whole cookie is actually considered four servings. As a result, they could unintentionally ingest 100 mg THC if they eat the entire cookie. It is important to check the packaging to determine how many serving sizes are in one package, and how much of each cannabinoid is in each serving. Consumers should be aware that well-defined serving sizes for products containing multiple servings are unfortunately not always indicated on the label.[27]

Given these issues associated with accuracy and clarity of product labels, some have suggested it is safest to request a certificate of analysis (COA) for each product. A COA which has been conducted by an accredited, independent laboratory (and not the product manufacturer), is considered an informative and more reliable analysis of what a product contains.

Certificates of Analysis (COAs)

A COA is a lab report that provides specific information on what is and is not contained within a product. Due to a lack of federal regulation, requirements for testing and COAs are determined by each state; while most states require laboratory testing for cannabis products, mandatory testing and associated thresholds or limits vary from state to state. Importantly, hemp-based products are not subject to the same testing requirements. Very often, however, reputable cannabis and hemp-based companies utilize outside laboratories for COAs to ensure their products contain what they expect (and what is noted on the label), and that their products do not contain anything potentially harmful.

Consumers can ask for a COA at a dispensary, search for it on a company's website, or request it from the manufacturer. First and foremost, a **COA from an independent laboratory should provide valid information on the amount of individual cannabinoids contained in a product.** In some cases, a COA will also include information about terpenes. Finally, a COA should also provide information regarding the presence or absence (and in some cases the quantifiable amounts) of heavy metals, pesticides, residual solvents, microbial contamination (e.g., yeast, mold, and other bacteria), and mycotoxins.

WHY CONSUMERS SHOULD REQUEST A COA

A COA can verify the potency, or cannabinoid content, and determine if the label is accurate. While there is always some "wiggle room" when dealing with botanical or plant-derived products, in general, a label is considered accurate if the actual quantified amount of a constituent is within 10% of the stated amount on the label. Products labeled "full-spectrum" or "broad-spectrum" might only list cannabinoid information for THC and/or CBD on the label, but a COA may offer quantification of additional cannabinoids. Finally, for a product marketed as an "isolate", a COA can confirm that only the single cannabinoid is present. Knowing the exact amount of cannabinoids contained within a product is important to help achieve the desired effects. For example, some CBD products tested by third party labs are over-labeled, and contain less than the label states, (with some containing so little CBD that they would have little to no effect – in other words, "snake oil"), while other products have been found to be under-labeled and contain more than the label states. Under-labeling can increase risk of unwanted side effects such as intoxication or unexpected drug-drug interactions (see "What's in Your Weed: Implications").

For hemp-derived products, a COA can clarify if the product contains any THC. As previously noted, a product labeled as "hemp-derived" may also contain THC (≤0.3% by weight), but there are no laws stipulating that the presence or amount of THC in hemp products be disclosed on the label. Accordingly, a COA can inform a consumer about whether they may be putting themselves at risk for testing positive on a drug test for cannabis (which assess for metabolites associated with THC), or whether they could potentially experience intoxication.

Note: If a COA is not available for a product or cannot be obtained, consumers should be reminded that they are reliant on only the label information, which could be inaccurate.

HOW TO OBTAIN A COA

For those purchasing products at a dispensary, most states require that COAs are available to consumers, so consumers can simply ask the dispensary staff. For products purchased online, it should be fairly easy to obtain a COA from reputable sellers. Many companies have COAs readily available on their websites. If not, it is recommended to call, email, or chat with the company online to request a COA for the specific product being considered for purchase.

HOW TO READ A COA

If the relevant testing is done, a COA can ensure that the product passes testing regulations indicating the absence of or safe levels of contaminants. COAs are structured to specify the types of contaminants evaluated, the methodology used, and the results of the analysis. Results will indicate a pass or failure result, indicating if the analysis meets state testing regulations. For tests with qualitative results, absence or non-detection of the contaminant is required. For quantitative analysis, consumers can review the results and determine if purchasing a passing product is in their best interest (e.g., a consumer may decide not to purchase a specific product with a COA indicating 19 ppb for Total Aflatoxin which passes the state requirement of 20 ppb).

TIPS FOR USING COAs

Ensure that testing was completed by an independent or third-party laboratory. In other words, the COA should not be issued by the company itself, as there is no way to guarantee that results are accurate and free of bias if the company performs their own testing.

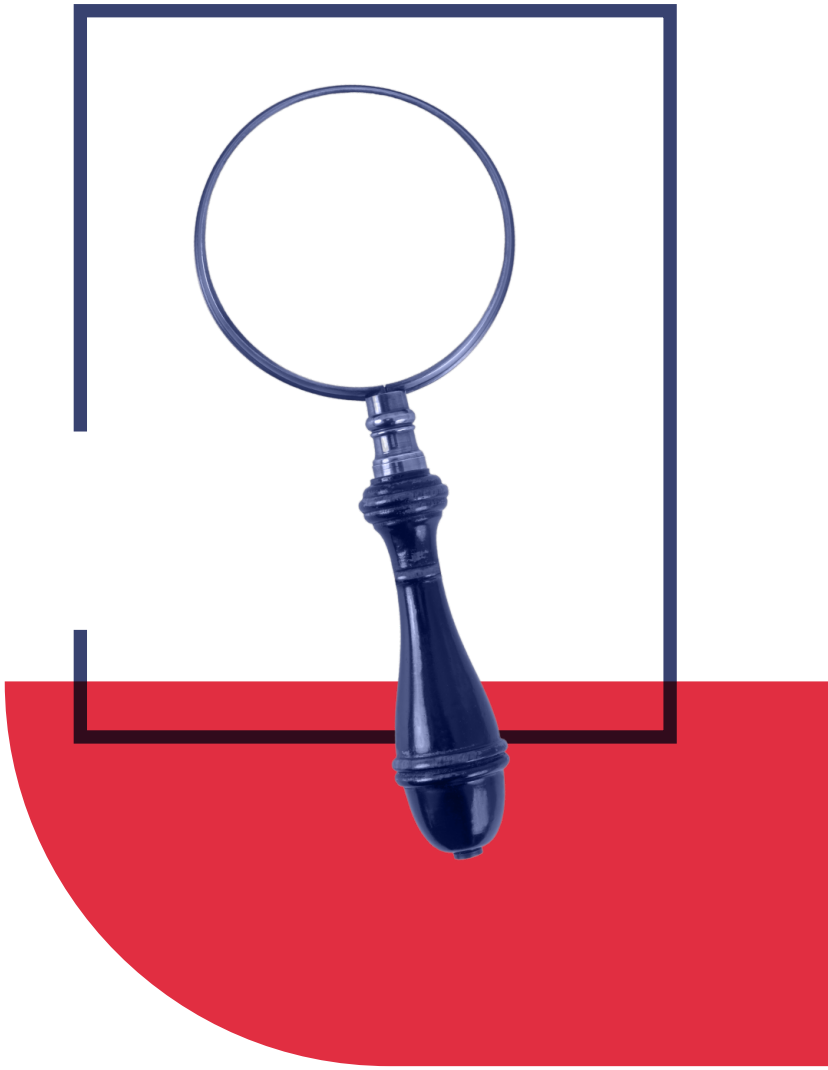
'Match the batch'. Botanical products, like those made with cannabinoids, have some degree of variability when a new batch is made. As a result, to ensure that the COA reflects the product a consumer is using, the batch number on the product should match the COA. Further, consumers should check the date to ensure that testing has been done recently.

Testing Standards

It is important to note that critical differences exist between testing practices and protocols in the cannabis space relative to those in other food or drug production processes. While most cannabis regulations sit at the state level, most food safety regulations exist at the federal level, creating gaps in both regulations and industry accepted practices. For instance, state cannabis regulations often neglect "Good Cultivation" or "Good Manufacturing Practices" (GMP) as part of their guidance. These practices, instituted in food safety for over 20 years, apply risk assessments to monitor environments and establish controls for potential pathogens. Similar environmental monitoring programs for facilities producing edible cannabis products are needed to control for organisms with a known risk in the cannabis space. This includes organisms such as Listeria monocytogenes, which have a high mortality rate, especially among those who are immunocompromised[i]. Monitoring product contact surfaces, water intake and air flow are all measures that can mitigate the spread and contamination of products by microbial contaminants.

[i] https://www.cdc.gov/listeria/technical.html#:~:text=Nearly%20everyone%20with%20listeriosis%20is,or%20death%20of%20the%20newborn.

What's in Your Weed: Implications



Knowing "what's in your weed" is important for several reasons:

CANNABINOID EXPOSURE

First, confirming if a product contains THC, and how much, is critical for individuals actively looking to avoid exposure to THC. Avoiding THC exposure is prudent for those who are sensitive to THC, at risk for adverse reactions (due to medical/family history of psychiatric conditions, previous experience, genetic predisposition), or want to avoid potentially testing positive on a drug test. It is also imperative that individuals understand that there are different levels of risk associated with different types of products. In general, products containing high levels of THC may increase risks to both recreational consumers and medical patients given the potential for adverse effects.

DRUG-DRUG INTERACTIONS

While hemp-derived or high-CBD products are generally considered safe, they are not totally benign. Individuals taking conventional medications should be aware of the potential for individual cannabinoids, specifically CBD, to interact with the hepatic cytochrome P450 (CYP450) system which is also involved in the metabolism of commonly prescribed drugs.[28] Accordingly, use of cannabinoids can alter blood levels or the effects of conventional medications. This is generally a concern when using orally ingested products (edibles, sublingual/oral solutions or oils), as cannabinoids are introduced through the gastrointestinal tract where they are processed, absorbed into the bloodstream, and travel to the liver where they undergo first-pass metabolism, resulting in a delayed onset of action and raising significant concern regarding drug-drug interactions (DDIs). Medications raising the greatest concern include anticoagulant, anticonvulsant/antiepileptic, antidepressant and hormone-based medications. Given the increasing numbers of older adults using cannabis, and since the majority of older adults take medications involving the CYP450 system, this group is particularly important to monitor for DDIs when initiating cannabis use.

CANNABINOID SYNERGY (THE ENTOURAGE EFFECT)

Importantly, it has been theorized that when multiple cannabinoids, terpenes, flavonoids and other compounds native to the plant are present in a product, these compounds work synergistically, potentially enhancing effects - a phenomenon dubbed "the entourage effect." While additional research is needed, some evidence suggests that full- or broad-spectrum products are effective at lower doses than products containing only a single, isolated compound (e.g., pure THC or CBD). This is an important consideration for product selection, as consumers should not expect the same effects from 10mg of an isolate as compared to 10mg of a full- or broad-spectrum product.

HEALTH IMPLICATIONS OF CONTAMINANTS

Contaminants in cannabis can present a range of potential health hazards to consumers, underscoring the need for appropriate regulation, testing and oversight. For example, while the immune response of a healthy adult may defend against bacterial or fungal illness, those with preexisting conditions or other factors affecting immune response may be susceptible to infection, illness, or even death in extreme circumstances. This is increasingly concerning in the cannabis space as cannabis and its derivatives are often sought out by consumers for perceived medical benefits, leading to increased use by those with pre-existing medical conditions and by the elderly[29]. Pesticides, when not applied and handled as directed, are also potentially toxic to humans and may have both acute and chronic effects, depending on the level and type of exposure. While the EPA sets allowable pesticide maximum residue limits (MRL) for food products, no such federal

MRLs exist for cannabis as it is not considered a food product from a federal regulatory standpoint, although some state programs do set limits.[30] Further, even low concentrations of heavy metals have been shown to be toxic to humans.[31] Additionally, heavy metals differ with regard to their biological impact depending on route of administration (e.g., inhalation versus ingestion of cannabis products).[32] Many residual solvents are also hazardous when inhaled or ingested and pose potentially serious health risks, underscoring the importance of testing products thoroughly prior to them entering the marketplace.

Working Towards Solutions: Policy Recommendations

CENTRALIZED OVERSIGHT

Currently, states vary widely with regard to requirements for testing and labeling of cannabis-containing products, while hemp products are effectively unregulated in the United States. This leads to both inconsistency in the regulations (different states adopt different regulations) as well as gaps in regulation (certain regulations, such as food safety, sit primarily at the federal level). This lack of centralized oversight and regulation regarding testing and labeling of products negatively impacts public health, as consumers are more likely to receive inaccurate information about their products and are more likely to use products with unknown cannabinoid constituent profiles. Lack of regulation also puts individuals at a higher risk of encountering products that contain harmful contaminants. Moreover, research has shown that consistency in labeling (requiring the same information in the same layout across products) promotes better understanding of labels. Regulation is particularly important for medical cannabis patients, as having consistent doses and safe products is critical. *Accordingly, Federal oversight and regulation which introduces clear, consistent requirements for testing and labeling of both cannabis and hemp-derived products would improve public health as well as consumer and patient experiences.*

STANDARDIZATION AND ADDITIONAL RESEARCH

States have historically relied on other industries (food, dietary supplement) and standards groups (AOAC International, ASTM International) to determine the appropriateness of certain methods and instruments for use in testing cannabis and cannabis-derived products. While several consensus-based standards to evaluate technologies, cannabinoid concentration, and contaminants have been developed, further work is still needed. Many standards provide method performance-based acceptance criteria and while this is a first step, once implemented by industry, there are clear gaps that show these standards need further support. Federal recognition of established laboratory and testing standards is needed to reduce the instances of what is known as "lab shopping" in the

industry, a practice in which companies seek out labs that are more likely to provide favorable results. *Increasing the availability of data through funded research can strengthen future regulations and allow for the adoption of industry-wide testing standards.*

EDUCATION FOR SELLERS AND BUYERS

Given the complexities of cannabinoid-based products, education for both vendors and consumers is critical. There is a growing need for accredited, evidence-based courses for patient care advocates or "budtenders" that teach important principles such as risks associated with vulnerable populations, drug-drug-interactions and impact of products via different routes of administration or modes of use, among other topics. Further, consumers and patients often turn to the web with questions about using cannabis but are frequently faced with incorrect or biased information. Offering centralized, verified resources where individuals can receive accurate information about cannabis and cannabinoids will allow consumers and patients to make better, more informed decisions about their cannabis use.

Conclusions

As cannabis use continues to expand across the nation, it is increasingly important for consumers and patients to be informed about the cannabinoid-containing products they choose to use. In the absence of federal oversight, the discord between state and federal policy has resulted in a complex, often confusing landscape for consumers, patients, policy makers, researchers, industry stakeholders, and health care providers alike. Ongoing efforts to develop overarching guidelines for standardization of testing and analyses, label information, and education are currently underway by several organizations including ASTM International. For example, ASTM International has proposed a universal symbol created by a consensus process, which defines a symbol for identifying intoxicating cannabinoids in consumer products. This committee has also developed guidelines for labelling products containing cannabinoids including label content as well as standard format for style, location and prominence of elements that are important parts of a product label. It is also imperative to create and implement standards and guidance for knowledge and skill requirements for the education, training, assessment and credentialing of personnel involved across multiple facets of the cannabis industry. *Taken together, the creation and implementation of universal, comprehensive standards will help address the important question "what's in your weed?", a critical issue for those accessing cannabis and cannabinoid-containing products.*

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