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Top Tips for Success: Potency and Pesticides Testing

Part One of a Three-Part Series

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LAKE SUPERIOR STATE UNIVERSITY

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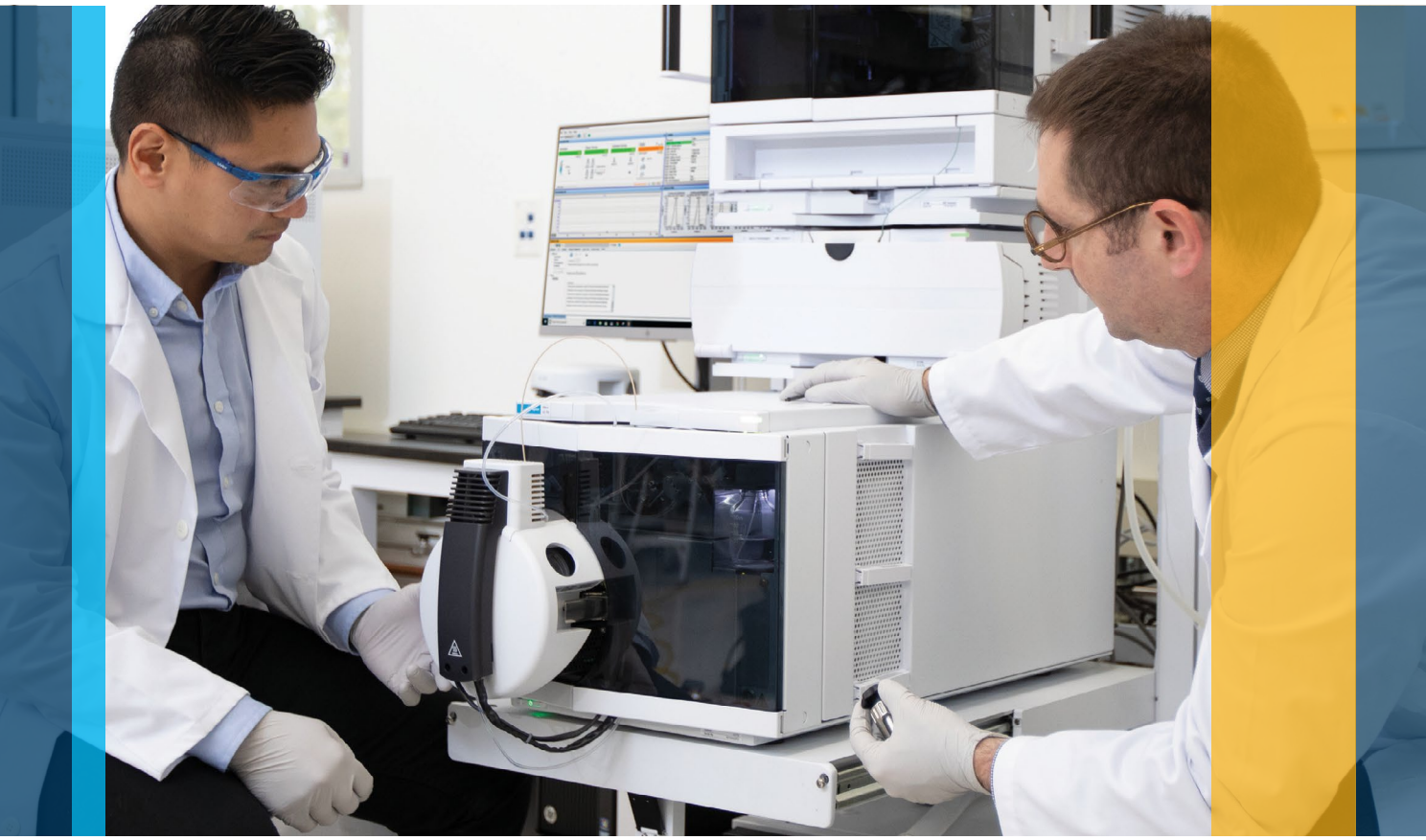

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INTRODUCTION

The increased legalization of cannabis products (both medicinal and recreational) has spurred enormous growth in the cannabis market, underscoring the need for robust, reliable, and accurate analytical testing to ensure safety.

Top Tips for Success is a three-part guide (sponsored by Agilent) that covers best practices for laboratories involved in various types of cannabis testing, including:

- Potency and Pesticide Testing, Part 1
- Heavy Metals and Microbial Testing, Part 2
- Residual Solvents and Terpenes Testing, Part 3

Each workflow offers tips about samples preparation techniques, methods, quality control, reporting and analysis, instrument maintenance, and more.

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Agilent products and solutions are intended to be used for cannabis quality control and safety testing in laboratories where such use is permitted under state/country law.

INTRODUCTION TO POTENCY TESTING

How much tetrahydrocannabinol (THC) and cannabidiol (CBD) is *really* in my cannabis gummy? Can I trust the levels listed on the label?

The accuracy of potency in the cannabis market is a top-of-mind concern for every consumer, producer, and analytical laboratory in the industry. That's because potency values not only reflect the quality of a product; they also indicate the cannabinoid content that users can expect—and, in turn, the potential outcomes they can receive. Thus, accurate values are crucial for consumer

safety and regulatory compliance, as well as the reputations of producers and laboratories.

As the cannabis industry evolves, the number of products introduced for both recreational and medicinal uses have grown. Flowers, buds, stems, oils, edibles, tinctures, shatters, waxes, baked goods, gummies, and butters are just a few of the forms on the market today. They all require accurate potency measurements and each matrix presents different analytical challenges. Moreover, changing regulatory requirements can complicate cannabis potency analysis.

For reliable results, every aspect of the analytical process must be carefully considered when setting up a cannabis analysis workflow. Sample collection, storage, and preparation are vital concerns, along with the analytical methodology employed. Laboratories must consider quality control, reporting, and instrument maintenance as well. As every lab is different, there are no universal plug-and-play system that can address all the complexities of the various matrices. There are, however, common issues that laboratories can recognize and manage to ensure high-quality results.

SAMPLE PREPARATION FOR POTENCY TESTING

Sample preparation may seem like such a basic step in the analytical workflow that it's easy to forget how important it is for achieving reliable, reproducible results. The reality is that it's critical for cannabis analysis; even tiny variations in the process can have dramatic effects on potency and other measurements, in the short- or long-term.

SAMPLE TYPE VARIABILITY

Laboratory analyses are complicated by the ever-growing array of new sample matrices. For reliable data, understanding the sample type is essential.

Think about the analysis of cannabis flower for a hemp product, for instance. Ground-up samples containing stems and stalks together with flower material can yield low potency values if the data are not adjusted to account for the sample's non-floral constituents. Accuracy at this point in a product's lifecycle will certainly have downstream effects. What may have started as a bud will become an extract, and maybe move into an edible product. Thus, it's critical to have accurate analytical results from the get-go, which is contingent upon appropriate sample prep.

Since there are so many matrices and, thereby, special analytical workflow considerations, some laboratories choose to focus on one product style while others opt for the flexibility to handle any matrix that is submitted. If it's the latter, the lab should be prepared to modify the sample prep depending on the matrix; a brownie will have a different fat content than a gummy, and the preparation must be modified accordingly. The choice of whether to specialize in a handful or a full range of cannabis product analyses should be based on a cost-benefit analysis, as a broader scope comes with additional investments of time and money.

Another consideration to keep in mind is that each state has testing requirements for both recreational and medicinal markets, which are often not aligned. As such, each sample preparation methodology must be validated for the proper market, in addition to each matrix. Thus, considerable time may be spent developing appropriate standard operating procedures (SOPs) in labs that accept a variety of cannabis matrices.

SAMPLE STORAGE

Sample collection and storage are critical aspects of sample preparation. Storage prior to submittal, as well as in the analytical lab, can significantly affect potency measurements. Storage must be carefully managed to avoid consequences on the reported values caused by incorrect practices. For instance, samples stored in a vehicle's trunk may see highly elevated temperatures that could affect the final potency values.

Once in the lab, storage procedures should be well defined and consistent for each sample type, as inconsistent or improper storage leads to inconsistent measurements. Laboratories with well-defined storage SOPs will generate more reliable results.

PERCENT WATER VARIABILITY

Understanding the percent water of cannabis samples is requisite for potency measurements of flower material or trim. This area has several challenges, too. Not only do different states have different regulations, but they also are not uniform across the medical, recreational, or hemp-based markets.

In addition, regulations do not typically define what "dry" means—a huge gap. Thus, different laboratories are drying their products to different moisture levels, which can bias the potency values based on the initial product masses. This issue offers laboratories an opportunity to be upfront with their clients about their SOPs and demonstrate consistency, which will highlight their authenticity.

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METHODS FOR POTENCY TESTING

Where can I find a reliable source for my standards? What instruments are best suited for my lab and my analysis? Cannabis potency presents some interesting challenges for method development and execution.

STANDARDS

Standardization of potency analysis is the key to success. The source of a lab's analytical standards plays an important role, as several recent studies have revealed variability in commercially available standard concentrations and identities. Analysts must be confident that the standards are accurate and that a steady supply is available. Certified reference materials are the most reliable and should be used if you can get your hands on them. Unfortunately, as new cannabinoids that are relatively minor components are added to the analyses, it can be very difficult to find reliable standards that are of high quality and dependably available.

Standards may be labeled with quantitative variation for a cannabinoid concentration, such as +/- 5%. That error can be propagated, so labs should consider how the reported values could change accordingly. Applying Beer's

Law to standard concentrations is valuable for verifying the concentrations of the standards. Using HPLC with UV detection allows analysts to calculate the standard concentration based on molar absorptivity (also known as the molar extinction coefficient) and measured absorbance. This secondary quantification check gives laboratories added certainty in the values. Once a reliable source of standards is established, laboratories should stock enough materials to weather instabilities in the supply.

VARIABILITY

As much as we strive for consistent analyses, there's a degree of inherent variability in cannabinoid separations because the plant-derived matrices have cultivars that are continually adjusted, thereby altering the cannabinoid profiles of different plants. This complicates the analysis, especially for HPLC/UV. Although there are no state regulations regarding this issue yet, some laboratories are considering methodologies to avoid having unknown cannabinoids go undetected. One way to deal with it is by frequently spiking known standards into the different sample varieties, then checking for a full recovery, and accounting for any variations that are present in the matrix.

For optimal productivity, analysts acquiring data using a particular SOP should monitor key method parameters (backpressure, retention times, peak resolution, etc.) throughout the process to catch problematic issues as they arise. This is much easier and more efficient than trying to troubleshoot crises down the line.

INSTRUMENT SELECTION

Once procedures for managing the standards and analyte variability are in place, the analytical instrumentation must be chosen. Typically, labs use cost as the primary determining factor in the selection of instruments, but other factors should be considered as well. Liquid chromatography or gas chromatography separations are commonly used for cannabis analysis, and laboratories usually employ the technology that is most familiar to them. In general, most states allow for both LC and GC methods.

After the analytes are separated, they must be detected, which can be accomplished by several different techniques. In the case of potency, a diode array detector (DAD) is frequently utilized for UV-Vis measurements. Alternative detectors include a mass spectrometer and a tandem mass spectrometer. The choice depends on the ultimate goal for the outcome of the experiment. For routine potency measurements, LC-DAD is the most applicable and cost-effective option. However, labs engaging in more advanced analyses, for example, with pesticides or mycotoxins, would benefit from working with LC-MS/MS. The differences in instrument selection come down to cost and specificity. While UV-Vis instruments are fully functional, they are limited in the information they can provide, particularly when working with matrices that

are not well-defined. In contrast, tandem mass spectrometers can be highly specific, but they come at a cost premium. Laboratories need to decide if the benefits of MS/MS capabilities are something their clients need or desire.

SOLVENT PURITY

Solvent purity is another essential parameter for cannabis laboratories to evaluate. Each of the listed detection strategies can be affected by impurities, which can lead to erroneous data. Thus, appropriate purity solvent is recommended, as it will eliminate unnecessary, time-consuming problems with the measurements. Becoming versed in the different solvent grades is advisable.

IN-SITU DECARBOXYLATION WITH MS

In-situ decarboxylation is a concern during analysis, especially for plant materials that undergo a heated drying step. Inside an instrument, the acidic form of the cannabinoids can be converted into the corresponding neutral analogue. If the instrument consistently uses the same parameters for the same analytes with the same matrix, then online processes that are part of the instrumental analysis could be considered acceptable. Nonetheless, laboratories need to understand *in-situ* decarboxylation for their systems and methods.

IN-SITU ESTERIFICATION

Esterification, another analysis-based issue, is commonly caused by using methanol as a solvent. Methanol can interact with different cannabinoids, based on the chemical characteristics of the separation matrix with the mobile phase. In certain situations, the product may begin to esterify, such that the retention time and absorption spectra will be modified in UV-Vis experiments. With mass spectrometry detection, the mass will change, thereby skewing the expected results as well. Regardless of the detection mode, the lab has altered the product so that it is no longer detected correctly. Therefore, the data will be biased while labs may not even realize this is happening. Consistent and rigorous quality assurance programs can help with that, but those only work well as long as robust validations are carried out reliably with each new type of sample matrix.

REPORTING FOR POTENCY TESTING

There are many new cannabis laboratory startups, as indicated by the booming sales across the instrumentation market. From a reporting standpoint, numerous inconsistencies can be introduced by the various analytical techniques and different understandings of terminology. States are just starting to change their rules to more clearly define the reporting of sample characteristics such as Total THC and Total CBD. A few years ago, reporting focused solely on CBD and Δ-9-THC; now that more cannabinoids are being included, there is irregularity in reporting.

There are at least 12–15 common variations of commercially available THC standards, yet there is broad unpredictability on their availability. Laboratories must choose a well-understood standard from a dependable source and define Total THC if it is not specified by the state. It is important to determine if the client wants Total THC to represent Δ-9-THC + THCA or if they expect a dozen THC variants to be included. From a consumer confidence perspective, the variants do not all affect humans the same way, so unclear reporting affects the anticipated dosing. To address this, laboratories should adopt state standards, where available, and clearly communicate with clients in the absence of state guidance.

Laboratories can stand out by offering consistent, information-rich reporting. Although water content is not required for most applications, it is nonetheless an influential piece of the potency measurement. Ensuring that the water is effectively taken into account and understanding its full impact on potency measurements is significant. Including this topic in the report will add credibility to both the lab and client.

Additionally, Certificates of Analysis (CoAs) vary widely from lab to lab, potentially causing confusion for consumers. For example, most end users do not understand limits of quantification. This situation may translate directly into the individual not buying the product. If LOQs are being reported, laboratories should provide an educational component to ensure that people fully understand what those values mean. This can enhance public relations and enable the consumer to make a more informed decision. For scientists, setting limits of quantification is relatively straightforward. A lab's quality assurance manual includes how it is calculated. However, the LOQ will vary according to the sample matrix and extraction efficiency. It is therefore essential for laboratories to devise a consistent strategy for setting and reporting these limits.

QUALITY CONTROL FOR POTENCY TESTING

A solid quality control program is vital for product safety, as well as data reproducibility and litigative defense.

The use of dependable standards with valid, robust methods is a key component of quality control. As it grows, the cannabis industry is working toward producing different forms of reference materials to allow labs to develop efficient extractions and analytical methods. Reference materials are widely used to judge both the method and the analyst to ascertain that different technicians are working

efficiently and providing high quality data. The current lack of broadly available standards at a national level relates directly to the fact that there are still federal prohibitions on the transport of cannabis products across state lines. The National Institute of Standards and Technology (NIST) is working to develop these materials, but their ability to transport those materials across state lines when they are ready is still a gray area.

Another aspect of quality control, limits of quantification (LOQs) for disparate sample types should be validated. Labs need to build strong relationships with their clients regarding the variations in LOQs caused by different sample matrices. As diverse products come in, laboratories must understand what they are capable of reporting to meet both product safety requirements and expectations of clients. Being forthright about LOQs with clients will help retain their business.

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MAINTENANCE FOR POTENCY TESTING

Analytical laboratories are involved in two types of instrument maintenance: those that relate to daily operations, and those pertaining to equipment repair. The importance of these daily tasks cannot be understated. These include clearing away old samples, verifying proper temperatures of system components, checking for leaks, filling solvent containers, and emptying used reagent containers. Skipping any of these jobs, or performing them incorrectly, can have deleterious effects on data quality and sample throughput. As such, all laboratories should have a firm understanding of these everyday responsibilities.

As consumable items, chromatography columns must be changed periodically. If analysts are unable to recognize when a column begins to degrade, then column replacement should be undertaken on a regular schedule. Although this approach may seem expensive, it prevents failed analysis runs that can be costly in both time and money. A guard column placed ahead of the analytical column is an effective tool that acts as an inexpensive sacrificial component to protect and extend the life of the chromatography column. Maintenance items should be part of a laboratory's quality assurance program and ongoing defined maintenance schedules.

Even the most reliable instrumentation will eventually need parts replaced or malfunctioning components repaired. If laboratories prefer to use in-house expertise, they must ascertain that their staff has had the appropriate training. Alternatively, labs could engage in service contracts. All major industry manufacturers offer extended service agreements through which they will interact with the lab for customer support opportunities and repairs. These can be advantageous, especially for laboratories relying on a single instrument. With no backup when an instrument goes down, it is critical to get up and running as soon as possible. Service contracts ensure that downtime is minimized, and repairs are performed correctly, using the correct parts.

Last, pick a single vendor to supply the technology, software, consumables, and support, which will help streamline the analytical process.

SUMMARY – AGILENT CANNABIS POTENCY TESTING SOLUTIONS

The complexity of cannabis analysis is escalating as the industry evolves. From the proliferation of matrices to the addition of numerous cannabinoid analytes, analytical laboratories face a plethora of challenges. Every aspect of potency analysis must be carefully considered and managed, including proper sample collection and storage, acquisition of standards, solvent selection, sample preparation, analytical equipment and methods, definition of terms, and reporting. Consistency throughout the process is the key to generating reliable results, and well-planned quality programs help labs stay on track. In addition, daily maintenance tasks and timely equipment repairs ensure efficient sample throughput.

Potency testing with the Agilent LC/MSD iQ can precisely determine total THC and total CBD content, as well as profile and quantify many other cannabinoids. Straightforward testing for eleven common cannabinoids in flower, hemp, and oils is rapidly achieved using the Agilent 1220 Infinity II LC with UV detector. Potency testing also can be performed on the Agilent 1260 Infinity II LC with UV or the MSD iQ detectors with Agilent OpenLab CDS software. Agilent's Cannabis and Hemp Potency Kits are designed for use with their instrumentation and eMethods. The consumables kits include

sample preparation, analytical columns, and associated supplies needed to analyze 400 cannabis flower samples for potency.

Choosing a single vendor to supply the technology, software, consumables, and support helps streamline the analytical process and provide stability. Through every step of the analytical process, Agilent offers extensive support for cannabis laboratories. Reference materials, chromatography columns, and robust instrumentation are complimented by sample preparation tips, streamlined workflows, optimized methods, and reporting templates. Their knowledgeable applications chemists engage with analysts to help maximize throughput and data integrity, while service contracts are offered to safeguard productivity. Agilent's comprehensive cannabis solutions help laboratories get set up quickly and continue running smoothly.

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Resources for Potency Testing for Cannabis & Hemp

INTRODUCTION TO PESTICIDE TESTING

Insecticides, herbicides and fungicides, are widely used throughout the agricultural industry to protect crops from pests, weeds, and diseases. While pesticides have an important role to play in the food supply chain, these chemicals can be also be harmful if consumed. That's why regulators have stringent rules and standards in place for the maximum levels of residual pesticides allowed to be detected on crops intended for consumption.

Unfortunately for compliance labs, residual pesticide analysis is one of the most complicated tests in the cannabis industry. Why? The cannabis plant, with its trichomes structure on the buds and many of the leaves, is particularly good at absorbing pesticides and moving them into storage areas of the plant. Additionally, successfully extracting and detecting a multitude of pesticide analytes from an enormous variety of sample types is a daunting task. While all the different matrices—plants, gummies, brownies, concentrates, and more—present their own unique challenges, the sheer number of pesticides adds another layer of complexity. Analysts must evaluate the solubility, extractability, and instrument sensitivity for each compound in order to meet state requirements and authenticate consumer safety. Even more disconcerting is the fact that the requirements vary widely across different

jurisdictions. And that's not all. The number of pesticides used in the United States is far from stagnant, with new chemicals being assessed and approved each year.

In some jurisdictions, pesticide analysis involves a combination of liquid chromatography and gas chromatography tandem mass spectrometry systems to achieve accurate, sensitive measurements. It is critical for laboratories and producers to understand the state requirements, develop reliable processes, and provide assurance to their clients. Although the analytical process can be challenging, a lab can use several tips and trick to address challenges and achieve high-quality, reliable results.

SAMPLE PREPARATION FOR PESTICIDE TESTING

In the cannabis market, there is an enormous variety of sample matrices emerging from the plant, including both the hemp- and cannabis-based products. The various forms, including edibles, extracts, and resins, introduce further complexity for their analysis, as each typically requires a different sample preparation strategy. After all, the makeup of a concentrate is vastly different from that of a cookie.

Moreover, the collection of a representative sample is challenging but important so that the dataset will reflect the true pesticide profile. In general, most state regulations provide limited guidance on this topic.

The manner in which the pesticide is applied to the plant has an impact on sampling. As a result, sampling of the outer exposed leaves compared with the inner portions of the plants may influence the pesticide measurements. Laboratories must decide where to perform the sampling and how to provide consistency in the sample. The latter will involve the planning of a homogenization process to be included in the method validation.

Representative sampling of edibles is definitely another area that labs must carefully considered. For example, labs may question if it is necessary to homogenize an entire piece of cake. Pesticide analysis in cakes is not required in all states; rather the plant material is tested before it goes into the cake. However, there are instances in which the plant material tested negative, but pesticide residues were still found in the edibles. In evaluating and selecting the sampling method, laboratories must ensure they are compliant with their state requirements.

Once a representative sample has been acquired, the next step is to extract the pesticides from the matrix for quantification. The characteristics of the analytes of interest play a role in their solubility and effective extraction, as different types of pesticides can require different extraction methods. Analytical laboratories can purchase predefined extraction kits, follow a published extraction method, or develop an extraction method of their own. That decision will be tied to the types of samples the facility will be encountering. It must be established that the method used for extraction works for the chosen compounds while not destroying the remainder of the sample. Some labs choose to accept only one type of sample, such as edibles, which helps focus the analytical process. Regardless of the lab's scope, they nonetheless must find or develop appropriate methodology to extract, detect, and quantify a complex mixture of analytes.

METHODS FOR PESTICIDE TESTING

The methods for analysis of pesticide extracts are of critical importance, and laboratories are burdened by the varying sets of regulated compounds across the United States and internationally. As different regions ban and allow different pesticides, the components of the analysis change. Analytical facilities must assess whether to only search for banned pesticides in their jurisdiction, or to include other pesticides as well. Once established, the method should be well-defined, and labs should be up front with their clients regarding their scope of analysis. What's more, if the U.S. moves toward federal legalization status, or if samples are allowed to move across state lines, laboratories must be prepared to analyze another states' pesticide suite. How this is dealt with internally from regulatory and quality control standpoints will be important.

To meet some states' current requirements, labs need both LC/MS/MS and GC/MS/MS instrumentation. The vast majority of pesticides can be analyzed with LC/MS/MS, but the technology is limited by solubility, matrix issues, insufficient ionization efficiency, or sensitivity for a few of the compounds. Thus, those analytes must be measured using GC/MS/MS. Although acquiring

both instruments is a costly investment, certain states Like California, Nevada, and Florida have a pesticide suite that dictates these two technologies be available.

A vast number of compounds must be detected and quantified with a validated method, which can seem especially daunting for new laboratories. As the cannabis industry evolves, some instrument vendors are rolling out technology in a packaged format to streamline the analyses. Remember, too, that acquiring the instrument/method package is only the beginning; it will still take months for experienced analysts to validate a full pesticide method. Laboratory managers should understand that it is easy to generate bad data; as such, engaging knowledgeable, qualified staff is vital. For instance, Agilent offers well-established eMethods to accelerate cannabis laboratory start up that is supplemented with technical expertise to guide analysts through the process. This offering is particularly beneficial for new laboratories.

Solvent purity is also a critical piece of pesticide analysis. Mass spectrometry is sensitive to impurities, thus having high-quality solvents of defined, consistent purity becomes very important. Using low-grade solvents can cause serious issues that may invalidate entire datasets. Therefore, it is worth paying the additional costs to acquire solvents of high purity.

REPORTING FOR PESTICIDE TESTING

Reporting for pesticide analysis varies widely in both format and content. Consumers like to see that a product passed the testing, yet there is considerable variation in the appearance of the Certificates of Analysis, as well as the data that is reported. This can confuse potential buyers of the product. Some certificates report the data for all state-listed pesticides on every report, even if they are not detected, which is advisable. However, many labs adopt different strategies in which they only report the detected analytes and state that others are below some threshold level. In any circumstance, the limit of quantification (LOQ) is a fundamental value that should be reported for every analyte. This is especially relevant for pesticide analysis. Without reported LOQs, laboratories have no idea where they stand in relation to other labs, and consumers cannot make informed decisions. One side effect of reporting the values is that it invites comparisons to other laboratories' capabilities. This could end up being either good or bad for public relations, depending on competitors' LOQ values.

As for reporting recovery, labs must define what is acceptable for each compound. In general, cannabis methods in most states require tight ranges,

such as +/-10%, although some specify even narrower ranges. In this manner, they are beginning to look more like the limits used for pharmaceutical compounds. That may be a harbinger of the industry's direction as it moves to more standardization across different components.

The majority of states have reporting thresholds for pesticides, but they vary widely across the United States. Currently, there are organizations working on different methodologies to try to standardize some of the inconsistencies. Early on, states simply stated that nothing could be present, with no clear definition on what "nothing" meant. That caused confusion, as nothing in one lab is likely different from that of another lab, due to varying detection limits. Clear definitions and consistent reporting are essential.

Another facet of reporting is that most states have a centralized reporting platform, especially for the regulated markets. Laboratories are often required to report into an electronic state database. Thus, analytical facilities must ensure that they have a system designed to handle reporting for both consumers and the state. To simplify analysis and reporting, all manufacturers have software packages that are available for their instrumentation. When combining datasets from LC and GC for pesticide analysis, the software for both techniques would ideally be the same. This provides consistency for the analysis as well as the reporting, as automated processes remove human interaction and eliminate variability. The most important thing from a lab managing standpoint, especially with a multitude of pesticide analytes, is a constant reporting format and procedure. Most software packages also feature quality control parameters such as user controls and audit trails to assist with compliance.

QUALITY CONTROL FOR PESTICIDE TESTING

For regulatory compliance, data validity and method robustness are greatly influenced by analyte recoveries. Recovery describes how effectively the pesticides for analysis are removed from the samples for analysis. Laboratories must consider what surrogate materials to use in addition to evaluating the effectiveness of matrix-spiked solutions to ensure equivalence in the quality of the recoveries. These issues should be included in the quality assurance program for each analyte. As the pesticide industry is well established, plenty of sources are available for pesticide mixtures, surrogate compounds, and isotopically labeled components. Ideally, there

would also be external reference material related to pesticides in cannabis but as this is not the case, surrogate materials are required. NIST has peach leaves and tomato leaves available that can be utilized for some of the components. In general, the most critical aspect of quality control is consistency once the method is developed and validated.

Software plays a critical role in ensuring quality control through proper technical control and password protection. For instance, having a proper audit trail is essential in regulated markets, so software packages should have the ability to allow user control at various levels to ensure only certain users have access to the sequence programming, the order of operations programming, method-based parameter, and data analysis parameters. In most cases, those parameters should not be changed without broad consent and acknowledgment because they could have dramatic impacts on the method. If changes are not accounted for and then revalidated, you can have entire lab data sets invalidated. If that happens repeatedly, it can be detrimental to the lab's reputation. Making sure these quality control areas are built into the software you choose is important.

MAINTENANCE FOR PESTICIDE TESTING

Operating concurrent LC/MS/MS and GC/MS/MS technologies for pesticide analysis demands a significant amount of maintenance. Routine maintenance includes basic tasks, such as filling solvent bottles, checking carrier gas flows, and drying gas traps. Yet there are other components that introduce additional maintenance issues. Vacuum pumps are employed at several levels, and there may be on-site gas generation that requires operational checks. Moreover, carrier and collision gases must be high purity and delivered at steady rates in order to avoid dramatic degradation of data quality. In addition to sample preparation and method validation, test sites must ensure that appropriate supporting services for instrumentation are available and provided in a timely manner.

A manufacturer's service agreement is particularly advantageous for more complex instrument maintenance issues and repairs, especially for the two tandem mass spectrometers. Considering the magnitude of the investment for these instruments, laboratories are less likely to acquire redundant instrumentation for pesticide analysis. Without backup systems, the uptime for these two techniques becomes even more crucial. Additional training

opportunities for users are typically included in the contracts as well. Long-term service and technical support are invaluable as instrument issues arise.

Choosing a single vendor to supply the technology, software, consumables, and support helps streamline the analytical process and provide stability. A single-source vendor enables control for the entire chain of the analytical process, offering confidence for laboratories regarding the quality of materials as well as a continual supply.

When choosing instruments for a pesticide workflow, laboratories should evaluate the robustness and long-term considerations. Over time, instruments should continue to deliver reliable performance with reasonable operational costs. It is advisable for labs to consult peer-reviewed research trade journals for information regarding this matter. Additionally, most vendors have locations that customers can visit and get hands-on experience with their instruments. That gives analysts the opportunity to assess whether the instrumentation will be suitable for their applications. Labs should also consider whether the vendor will be available in the long run for dependable support when it is needed. Overall, the choice of vendor and equipment becomes a balance of cost and performance.

SUMMARY - AGILENT CANNABIS PESTICIDE TESTING SOLUTIONS

Pesticide residue analysis for cannabis plants and products is not for the faint of heart. The complications of numerous matrices are exacerbated by the plethora of analytes and differing regional regulations. Skilled analysts are needed to understand the complexities of LC/MS/MS and GC/MS/MS operations and pitfalls. Every step of the analytical process must be carefully developed and documented for a well-defined quality program. Consistency is critical for sample preparation, analysis, and reporting.

Maintenance of the tandem mass spectrometry instrumentation also plays a key role in successful pesticide analyses. While operators are typically trained in daily tasks, the more involved services, such as troubleshooting and repairs, usually require the more extensive skills of a manufacturer's engineer. Agilent offers service contracts to help laboratories operate efficiently and produce high-quality results.

Unlike an LC/MS/MS-only approach for pesticide analysis, in jurisdictions where the target pesticide list includes compounds that have been proven to be challenging for LC/MS/MS, a dual-platform approach of employing

both GC/MS/MS and LC/MS/MS allows the detection of each analyte with the most suitable detection technique. Agilent's superior analytical workflow for this analysis includes an efficient single-stream sample preparation, which cleans up the complex matrix associated with cannabis and is amenable to both LC/MS/MS and GC/MS/MS analyses. Using both platforms assures that data quality is not sacrificed, and maximum productivity is reached. In addition, Quant-My-Way tools, specifically designed for cannabis laboratories, provides effortless data review and report presentation.

For LC/MS/MS measurements, the ideal platform comprises the Agilent 1260 Infinity II Binary Pump with the 1260 Infinity II Multisampler, coupled to the Agilent 6470 or Ultivo triple quadrupole LC/MS. This hardware configuration, which uses the Agilent MassHunter software, has been demonstrated to meet the most demanding limits of quantitation on large target lists such as those found in California and Canada. GC/MS/MS testing with the Agilent 8890 or Intuvo 9000 GC system equipped with the 7693 Automatic Liquid Sampler (ALS) and the Agilent 7010 triple quadrupole mass spectrometer can not only test for many of the target analytes in the various regional pesticide lists, but they also specifically target those compounds that are not amenable to electrospray ionization (ESI). Using only a LC/MS/MS approach, analytes not detected by ESI would require a second analysis using atmospheric pressure chemical ionization (APCI). A multi-platform approach better fits the needs of this complex testing in high-throughput laboratories.

Agilent's Cannabis Pesticide and Mycotoxin Kits are designed to go hand in hand with their LC/MS/MS and GC/MS/MS instrumentation and eMethods. The consumables kits include sample preparation, analytical columns, and associated supplies needed to analyze 400 cannabis flower samples for pesticide residues and mycotoxins. The kits can accommodate different instrument configurations used for the analysis and provides step-by-step instructions on how to perform the expert-developed single stream sample preparation procedure.

The available suite of instrumentation, software, consumables, methods, supplies, and technical advice from Agilent cover the entire analytical process. Accordingly, using Agilent as a single-source vendor can ensure reliability in materials supply as well as confidence in the pesticide laboratory's end product.

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Resources for Pesticides & Mycotoxin Testing for Cannabis & Hemp

Agilent products and solutions are intended to be used for cannabis quality control and safety testing in laboratories where such use is permitted under state/country law.

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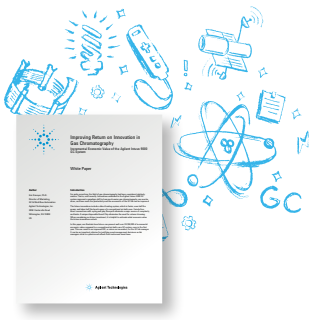

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