Field Testing Cannabis:

Executive Summary

Cannabis potency testing presents unique challenges. Cannabinoids' concentration variability between plants, between samples harvested off the same plant, and concentration of non-homogeneity even within a single sample hinders accurate product labeling.
A potency test of one cannabis flower will not adequately represent other flowers from the same crop or from the same plant.

Current testing practices struggle to overcome the challenge in a practical, affordable manner. Industry-standard HPLC (High-Pressure Liquid Chromatography) is qualified labor intense, slow, destructive, and leaves residuals to dispose of. Thus, may not serve as a decision support tool for cultivators, wholesalers, or processors.

To address cumbersome and destructive testing practices, some cannabis professionals are turning to spectroscopy which is far quicker and cheaper than HPLC.
Spectroscopy-based method mitigating sample non-homogeneity by analyzing the sample at multiple points and compensating for lesser than HPLC accuracy by averaging across multiple rapidly analyzed samples stands up to the challenge. Spectroscopy, backed by robust data science and intensive calibration against industry standard HPLC, may prove ideal for cannabis potency testing.

As the legal cannabis industry expands, active ingredient testing becomes increasingly important. Cannabis legitimacy as a medicine calls for pharmaceutical dosage consistency. Recreational consumption legalization requires labeling akin to alcohol and tobacco products.

The Challenge of Non-Homogeneity

Compared to pharmaceutical and food products, cannabis is hard to test. This attributes to high cannabinoid content variability [Potter].

- between strains and within strains [Royal Seeds]
- between crops of the same strain [Figure 1]
- between individual plants of the same crop [Potter]
- between the flowers from the same plant [Namdar]
- ...and even within the divided material of individual flowers [Wilks]

The cause of non-homogeneity is threefold. Through decades of cannabis horticultural, cultivators have bred plants to enhance desirable characteristics and diminish crop vulnerabilities. These manipulations have manifested in customized strains exhibiting higher or lower tetrahydrocannabinol (THC) and cannabidiol (CBD) compositions.

Secondly, within any species of animal or plant, genetic variability takes place, causing genotypic and phenotypic changes. Also, environmental conditions have considerable influence on the plant reaching its full genetic potential.

Even plants clonally propagated from the same “mother” plant will exhibit phenotypic traits based on their environmental histories. And within a selection of plants displaying similar phenotypic traits, different chemotypes (defined as THC, CBD, or CBG dominant, or a mixed ratio profile with varying THC and CBD concentrations) may occur independently of readily observable characteristics.
Microclimates in the grow room or outdoors, inconsistencies in the fertigation system, pests, or other factors can affect plant-to-plant potency.

Finally, the non-homogeneity in secondary metabolite content (with emphasis on cannabinoids) of cannabis flowers occurs naturally based on their location within the plant structure or even within a single flower. Cultivators commonly observe, and research has documented, more potent flowers at the top of the canopy as compared to those at the bottom. Proximity to the light source plays a causal role in determining the potency of individual flowers [Namdar] so intra-plant potency variance is unavoidable.

Testing Blind: The Challenge of Sampling

Industry stakeholders have come to acknowledge a critical problem, one that bypasses even world-class testing technology:

In a large crop of non-homogeneous cannabis, which individual flowers do you select for testing?

Some experts believe that poor sample selection practices and improperly “batched” crops can cause mislabeled potencies varying up to 75% from actual [T&T Magazine]. For health-compromised consumers who rely on cannabis as a medicine, such wild irregularities are clearly unacceptable.

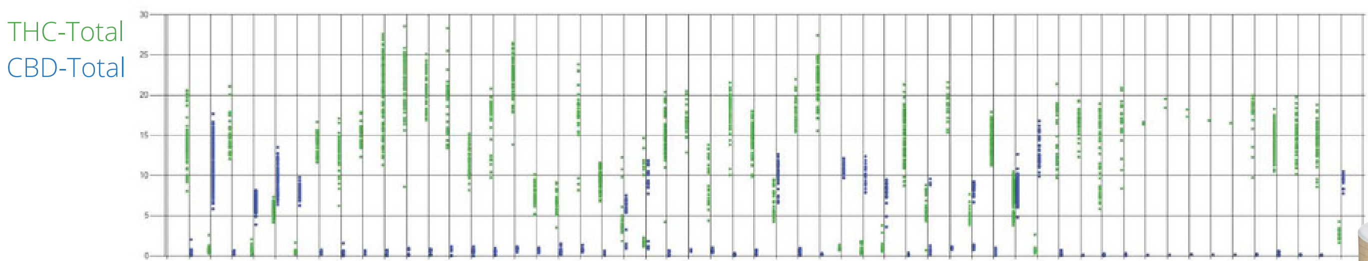


Figure 1: Potency variance of 54 strains as tested with HPLC by GemmaCert Ltd.

For solutions to the non-homogeneity challenge, field testing should look at how regulators and laboratories address the issue. Though their elaborate chromatography methods are not feasible for transactional testing, their approach to sampling sheds light on how to mitigate non-homogeneity in the field. Current testing methods estimate an averaged potency with extensive and random crop sampling. Some jurisdictions require random flower selections totaling 0.7% of the overall batch weight [CA regs].
Flowers are selected from the top, middle, and bottom of the batch to ensure a representative and random sample. Then, the sampled flowers are ground together, and the mixture is assumed homogenous. But, as sources note, [Sexton] [Rigdon] glandular trichomes, the most potent part of the plant, may fall through the grinding mechanism or settle at the bottom of the mixture. Hence cannabis testing presents challenges even to HPLC.

With HPLC, multiple flowers are ground together, and the mixture is presumed homogeneous.

HPLC is not feasible for field testing because

- Large, expensive equipment is required
- Highly-trained technicians must perform the work and interpret the results
- Hazardous solvents used in sample preparation require special disposal protocol
- A single test takes 30-45 minutes
- The sample is destroyed

HPLC isn't a feasible solution for field testing, but the method of combining multiple samples illuminates the solution to flower-to-flower non-homogeneity. Faced with the need to test non-homogenous crops, the food industry has turned to quick, spectroscopic testing methods for some applications. But for cannabis, the chemical variations within a single flower warrant a more refined approach.

Near-Infrared Spectrometry

Near-infrared spectrometry (NIRS) is a spectroscopic form of testing: it uses the light spectrum to assess the chemical contents of the test subject. By beaming calibrated light onto an object and detecting the wavelength intensities that bounce back, spectrometers measure light absorption and based on that estimate the chemical contents of a test specimen without altering it. For testing high-dollar crops, this non-destructive technique is valuable indeed!

NIRS is not as precise as chromatography. For any single test, HPLC is no doubt more accurate. Yet NIRS is appropriate for many applications and approved by the U.S. Food and Drug Administration for medical procedures, [Scheeren] pharmaceutical testing, [Morisseau], and food testing. [Osborne]

Non-homogeneous crop analysis has employed NIRS by averaging the results of multiple samples. And because NIRS testing takes a few, rather than 45, minutes, the "collate and average" approach has worked. For foraging materials like hay, sampling 20 test specimens have allowed farmers to overcome the crop's non-homogeneity to find an acceptably accurate active ingredient profile. [Putnam]

For NIRS to be viable for a given chemical's quantitation, spectroscopic engineers must carefully calibrate the equipment for that chemical of interest. Scientists repeatedly correlate the wavelength/intensity results of the spectrometer against gold-standard technologies like HPLC to ensure accurate results. The greater the number of correlations against HPLC, the more robust the NIRS results. [European Medical Agency]

Because cannabinoids are a new test subject for NIRS, the number of correlations and calibrations against HPLC results are scant. Some cannabis-specific NIRS units on the market now are not sufficiently correlated with HPLC and, without an extensive database of cannabinoid-specific algorithms, their accuracies suffer.

Near-infrared spectrometry benefits

- +/-5 minute test duration
- Non-destructive
- Minimal training needed
- No solvents or disposables
- More cost effective

- **Near-infrared spectrometry drawbacks**
- Less accurate than HPLC
- Intensive substance-specific reference correlation against HPLC
- Limited testing surface area
- Some implementations still require grinding

NIRS and Single-Flower Non-Homogeneity

Extensive research by GemmaCert Ltd. has documented the issue of single flower non-homogeneity. Coherent with other research into flower non-homogeneity [Wilks], the results show significant variations in potency within the material of a single cannabis flower.

To further our understanding of non-homogeneity and potential solutions, GemmaCert scientists partitioned twenty cannabis flowers into three to six parts, depending on size. Every flower partition was potency tested for THC and CBD using industry-standard HPLC techniques. Large variations were observed within the flower, with some differences amounting to +/-25% of the averaged potency. This research shows that, because NIRS units test only a small area of a sample, flower non-homogeneity may skew results significantly.

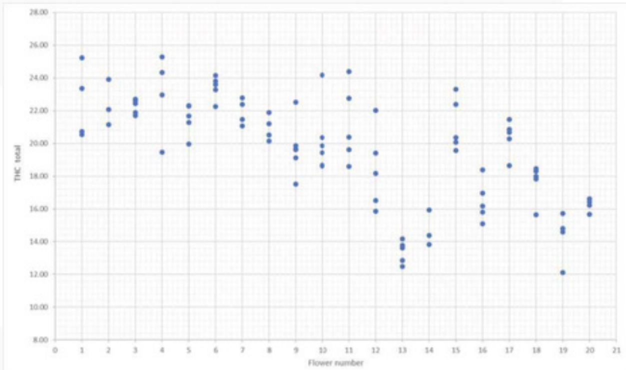


Figure 2: THC potency variance of 20 flowers as tested with HPLC by GemmaCert Ltd.

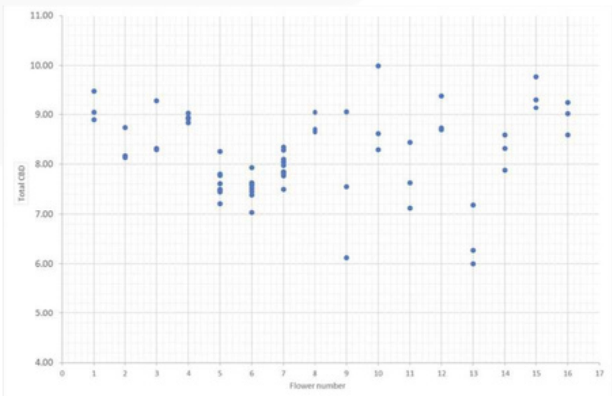


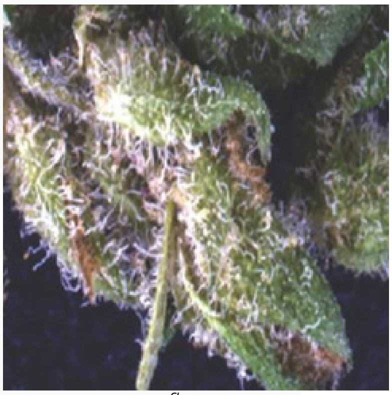
Figure 3: CBD potency variance of 17 flowers as tested with HPLC by GemmaCert Ltd.

Buyer's Guide Checklist for Cannabis Field-Testers

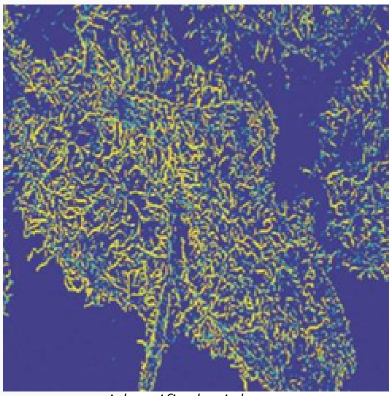
- Non-destructive testing that leaves specimens intact
- Proven accuracy for both THC and CBD
- Speed: minutes, not halves of hours
- Minimal preparation, no solvents to dispose
- Minimal operator training
- No ongoing costs for disposable supplies
- Easy integration with PCs and wireless devices

GemmaCert uses visual analysis

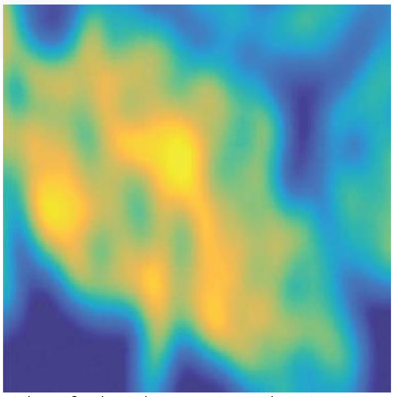
A simplistic examination of a cannabis flower, even without a microscope or magnifier, can reveal uneven trichrome distribution. Because an individual NIRS test accesses only a small surface area, understanding trichrome distribution and flower shape can improve results, even in the case of an advanced “collate and average” approach. Advanced digital image analysis helps ensure optimal calibration of the machine.



flower



identified trichomes



identified trichomes in a density map

GemmaCert uses data science and machine learning

NIRS technology is only as good as the quantity and quality of its correlations with HPLC. With over 15,000 flowers correlated with HPLC results in its database, the GemmaCert has far surpassed the data point libraries of other cannabis-specific NIRS testers. Consequently, each of the multiple measurements it performs during a single test has industry-leading accuracy.

GemmaCert employs machine learning. Machine learning techniques are employed to construct spectra correlations with HPLC, identify & reject outlier spectra, and estimate cannabinoid content in real-time. Cloud-based software conducts real-time analyses and conveys the results to the user's smartphone or PC.

By combining leading-edge NIRS methodology, visual image analysis, extensive data science, and machine learning, GemmaCert provides a testing solution that’s more than the sum of its parts.

For more information on GemmaCert and how GemmaCert technologies can benefit your business, visit www.gemmacert.com or email info@gemmacert.com