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# The Science of *Exotic*

## PART I: THE DAWN OF FLAVORANTS

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## FOREWORD:

The aroma of cannabis is evolving, becoming increasingly diverse and complex due to the work of breeders across the world, who have sought the newest, most unique aromatic notes possible. While they have done so with great success, the chemical understanding for why many of these varieties smell the way they do has historically not been well understood.

The terpene concentrations of two cultivars can be **very similar** and yet have **widely different** aromas. There are cracks in our current understanding of cannabis knowledge.

Our recent publication has transformed this understanding by introducing entirely new classes of compounds that distinctly influence the aromas of specific varieties.[1] We initiated research in collaboration with top breeders in the industry along with 710 Labs, a leading cultivation and extract company, and analytical instrument experts, SepSolve Analytical and Markes International. Our goal was to address the most pressing questions about cannabis's unique aromatic properties.

**This work unveiled many compounds never reported before in cannabis literature.**

To help explain the most important aspects of this research, we present a series of white papers focused on key aspects of the work conducted.

MARKES international  710LABS  SepSolve Analytical

This introductory paper places the newfound compounds within the broader framework of cannabis aroma comprehension. We explore terpenes and reexamine their significance in scent generation from both chemical and sensory angles. Additionally, we highlight that terpene profiles might not be the most effective method for discerning aromas. Let's dive in.

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# INTRODUCTION

Cannabis produces a bouquet of aromas unlike any other plant. Depending on which variety of cannabis you may have, this bouquet may smell completely different from another, leading one to ponder why exactly this happens.

## What makes GMO smell so intensely savory?

## What makes Cake Crasher so incredibly sweet?

## Or Sour Tangie so very citrusy?

These questions now have answers, thanks to new research published by Abstrax Tech in collaboration with 710 Labs and Markes International.[1] But before we get into this, we will first discuss what the current science says about the aroma of cannabis.

The cannabis plant is truly unique in the plant kingdom. It has a propensity to produce a wide array of compounds that are completely unique to itself, as shown in **Figure 1.** These range from cannabinoids – compounds such as tetrahydrocannabinol (THC) and cannabidiol (CBD) – to terpenes, cannflavins, and more. Why this plant produces many of these compounds is still up for debate, but one thing for certain is that ***cannabis is a powerhouse*** in producing unique chemical compounds that can have profound psychoactive effects on humans when consumed.

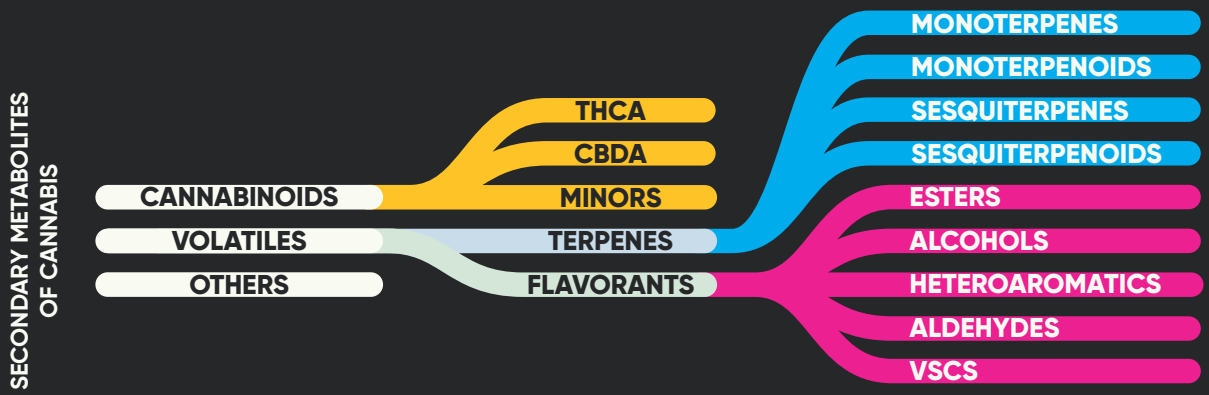



**Figure 1.** Sankey diagram showing the phytochemical makeup of cannabis.

While THC is the primary psychoactive constituent in cannabis, there is increasing evidence to suggest that the other hundreds of compounds present in a given variety may influence or modulate these effects. This phenomenon is referred to as the Entourage Effect and is being actively investigated to understand why certain compounds beyond THC may modify the effects brought on by consuming a specific strain. Further, these other compounds are responsible for the aroma of cannabis.

# THE RISE OF TERPENES

To this end, much focus has turned to terpenes, which are some of the compounds responsible for the unique aromatic characteristics of cannabis. In the cannabis industry, the word "terpenes" has been colloquially used to refer to all of the volatile aromatic compounds that give cannabis its scent. However, in the scientific cannabis community, this term specifically refers to monoterpenes, monoterpenoids, sesquiterpenes, and sesquiterpenoids, as shown in **Figure 1.**

Several decades ago, both scientists and cannabis enthusiasts noticed a connection between distinct cannabis aromas and their associated effects. This is where much of the “indica,” “sativa,” and “hybrid” nomenclature was born. While these terms technically refer to phenotypic traits, such as the growth pattern or physical appearance of the plant, people slowly started to also categorize aromas and psychoactive effects based on this nomenclature. While this broad classification system may have had some sort of value and accuracy in the past, the complexities of cannabis have since outgrown this simplistic three-category system.

**This is where terpenes have come in.**

Scientists started looking into the chemistry of these different classes to understand if there are differences that may explain the various aromas and effects. They found that in some cases, there were some clear-cut differences between certain varieties.

For example, varieties that would be considered classic, energetic sativas – Jack Herer or Hazes, typically have high Terpinolene (a monoterpene with a citrus, woody scent) levels compared to classic indicas or hybrids. An example of classic indicas would be either OG Kush or Chemdawg. Both have earthy, sometimes chemical, and often intense, gassy aromas different from the aforementioned sativas, as well as having more sedating effects. However, as time has gone by, cannabis breeding has muddied the differences between these two, making it more and more difficult to say for certain how a variety may smell or the effects they produce.

## If terpenes aren't the sole contributors to the aroma of cannabis, what else might be responsible?

# THE EXPERIMENT BEGINS

This study started by first asking the question, **"What are the chemical origins for the exotic aromas that cannabis produces?"** To do this, it was necessary to procure a wide variety of products to measure their chemical profiles. We at Abstrax, being located in Southern California, had access to some of the premiere and most popular varieties on the marketplace. Additionally, **710 Labs** provided samples and procurement suggestions. Thirty-one different varieties in total were collected for evaluation.

One aspect of the study involved deciding what sample matrix would be ideal. There are many form factors of cannabis products, ranging from cured flower to live resin. **We found that ice-hash rosin was an ideal matrix for measuring the low concentration analytes using our instrumentation.**

710LABS

710 Labs provided choice selections of the finest rosin in the marketplace.

## ICE-HASH ROSIN WAS CHOSEN FOR THREE PRIMARY REASONS:

**1**

Ice-hash rosin is a concentrated form of cannabis, thus raising the overall levels of compounds in the sample and making it easier to detect them.

**2**

It is manufactured without exogenous solvents such as butane, thus reducing any sort of contamination or change in aroma profile due to the removal of solvents.

**3**

Many high-quality, cutting edge varieties with unique aromas are produced by ice hash rosin experts who selectively prioritize the extraction of flavor & aroma.

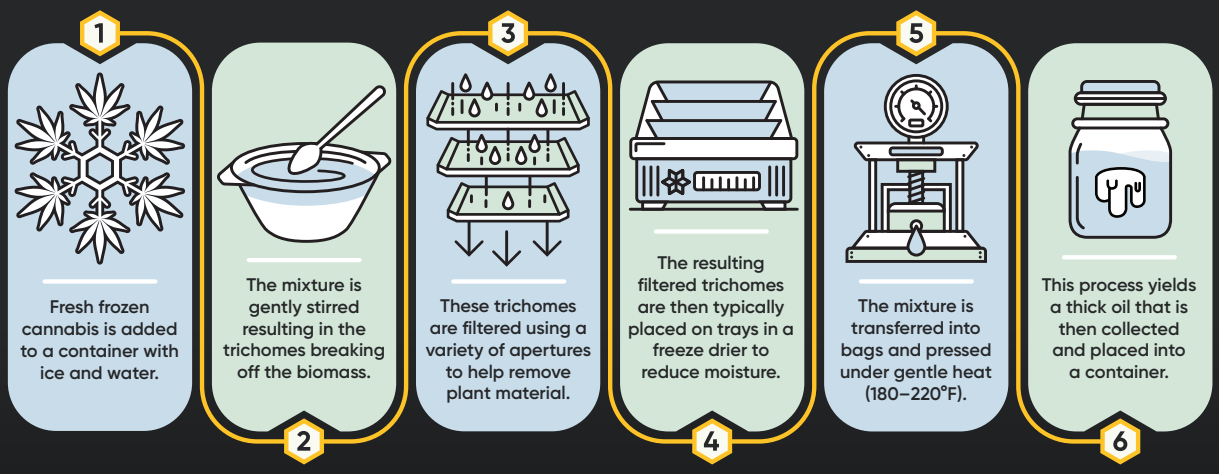



**Figure 2.** A general explanation of the ice-hash rosin making process.

Cannabis is both an art and a science. The human nose is incredibly adept at recognizing and evaluating aromas, but in order to analyze these samples thoroughly, we needed to perform both a qualitative and quantitative assessment in the form of a sensory analysis and a chemical analysis.

# SENSORY ANALYSIS

## EMPLOYING OUR OLFACTORY SENSES AS AROMA DETECTORS

In the preliminary sensory examination of the samples, **the spectrum of scents produced by cannabis was so vast and varied that it necessitated a reevaluation of what we define as "exotic."** The term "exotic cannabis" might conjure thoughts of "sweet or fruity" for many consumers, but our sensory panelists discovered varieties that were equally "savory and chemical," expanding the definition of exotic.

Consequently, we devised a novel scheme to spotlight these diverse aromatic characteristics, including those found in more typical strains, like Hazes or OGs. This scheme, termed the "Abstrax Exotic Cannabis Aroma Spectrum," is depicted in **Figure 3.** Beneath the spectrum, density plots illustrate the frequency with which the sensory panel allocated specific aromatic descriptors to the top and bottom four ranked varieties. It's observable that the top four varieties have higher density (peaks) on the sweet end of the spectrum, while the bottom four have a denser presence on the savory end. But, how exactly were these varieties ranked?

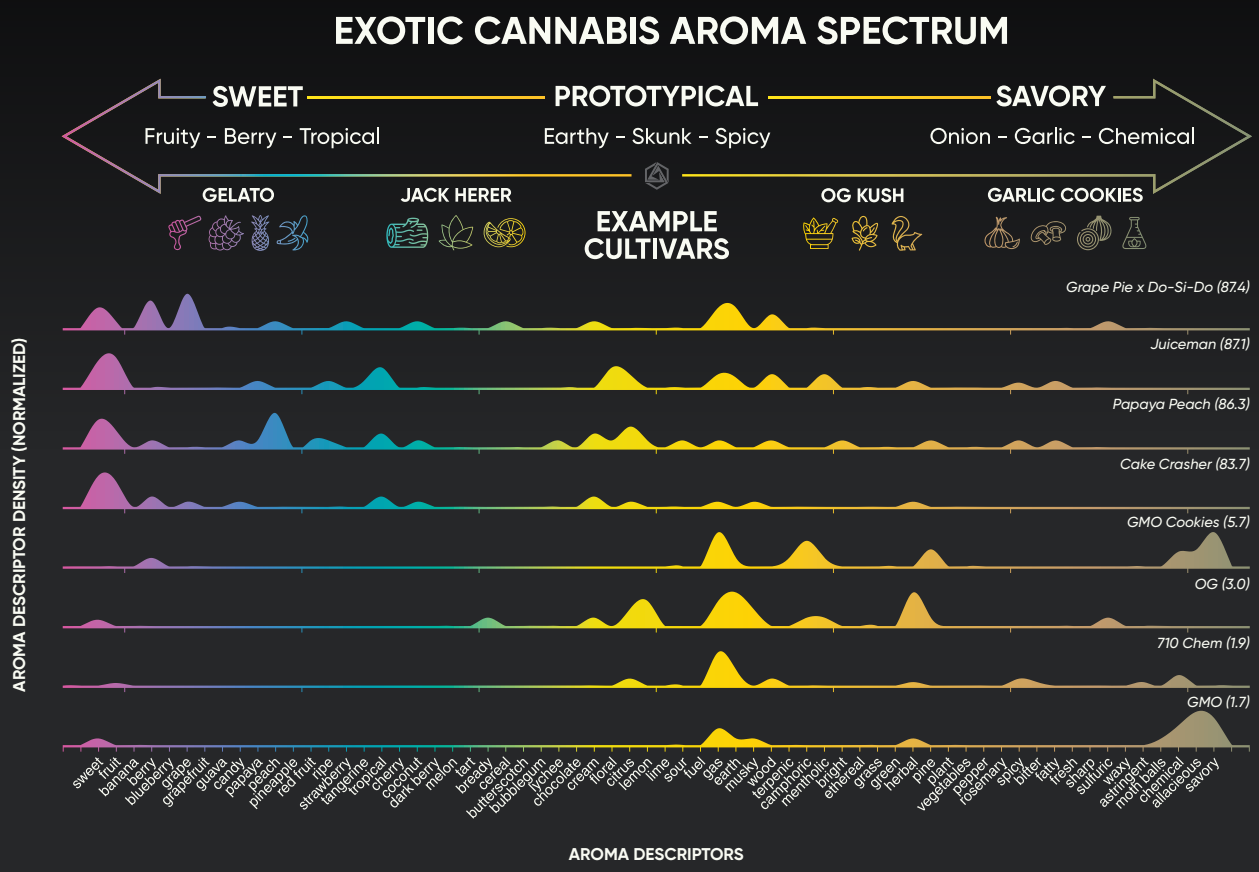



**Figure 3.** Schematic illustrating the wide spectrum of cannabis aromas reported from a sensory panel for multiple cultivars. The numbers in parenthesis are each variety's Exotic Score (explained below) that indicates how exotic the cultivar is. Higher numbers indicate the variety was ranked to be sweet or fruity, while lower numbers indicate the varieties were ranked as not sweet or fruity. The numbers do not correspond to quality - meaning a higher number is not *better* than a lower number, rather just aromatically *different*.

## QUANTIFYING EXOTIC:

To quantitate how the sensory panelists perceived each variety relative to one another, we instructed them to not only identify the various aromas but also to assign an "Exotic Score" to each one.

The "Exotic Score" was defined as a number from 0 to 100, where 0 represents "not sweet or fruity at all" and 100 was "extremely sweet or fruity." This allowed us to assign numerical values and rank each sample against one another, as can be seen in **Figure 4.**

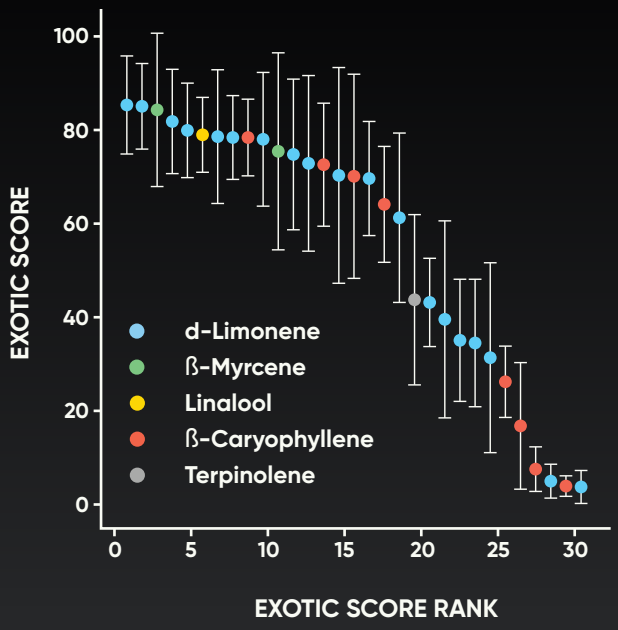



**Figure 4.** This graph represents the Exotic Score in relation to the rank for all samples analyzed. A superior Exotic Score is indicative of predominately sweet or fruity aromas, whereas inferior scores are suggestive of more savory aromas. The dominant terpene of each variety is also depicted, clearly demonstrating its minimal influence on the overall aroma profile.

Once we plotted this data, we noticed something interesting.

**There was no clear trend correlating the dominant terpene present in the samples to their exotic score rank.**

For instance, Grape Pie x Do-Si-Dos, the highest-ranked variety noted for its sweet and fruity essence, shared the same dominant terpene with GMO, the lowest-ranked variety known for its intense, garlic, and savory aroma.

This was the first indication that terpene profiles do not necessarily tell the full story about the aroma of cannabis, hinting at the existence of alternative contributors to its scent.

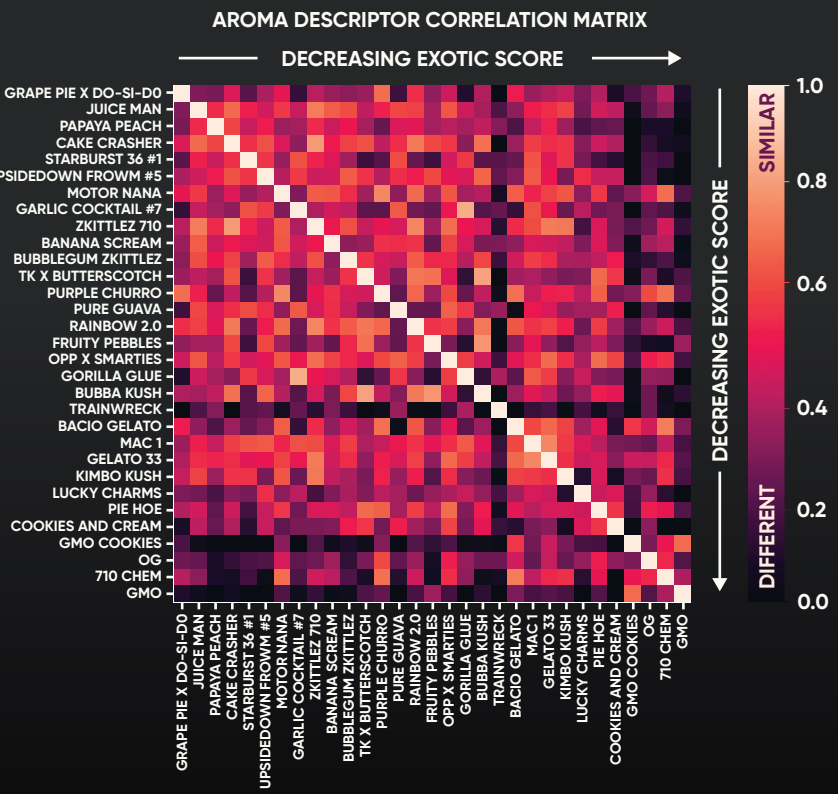
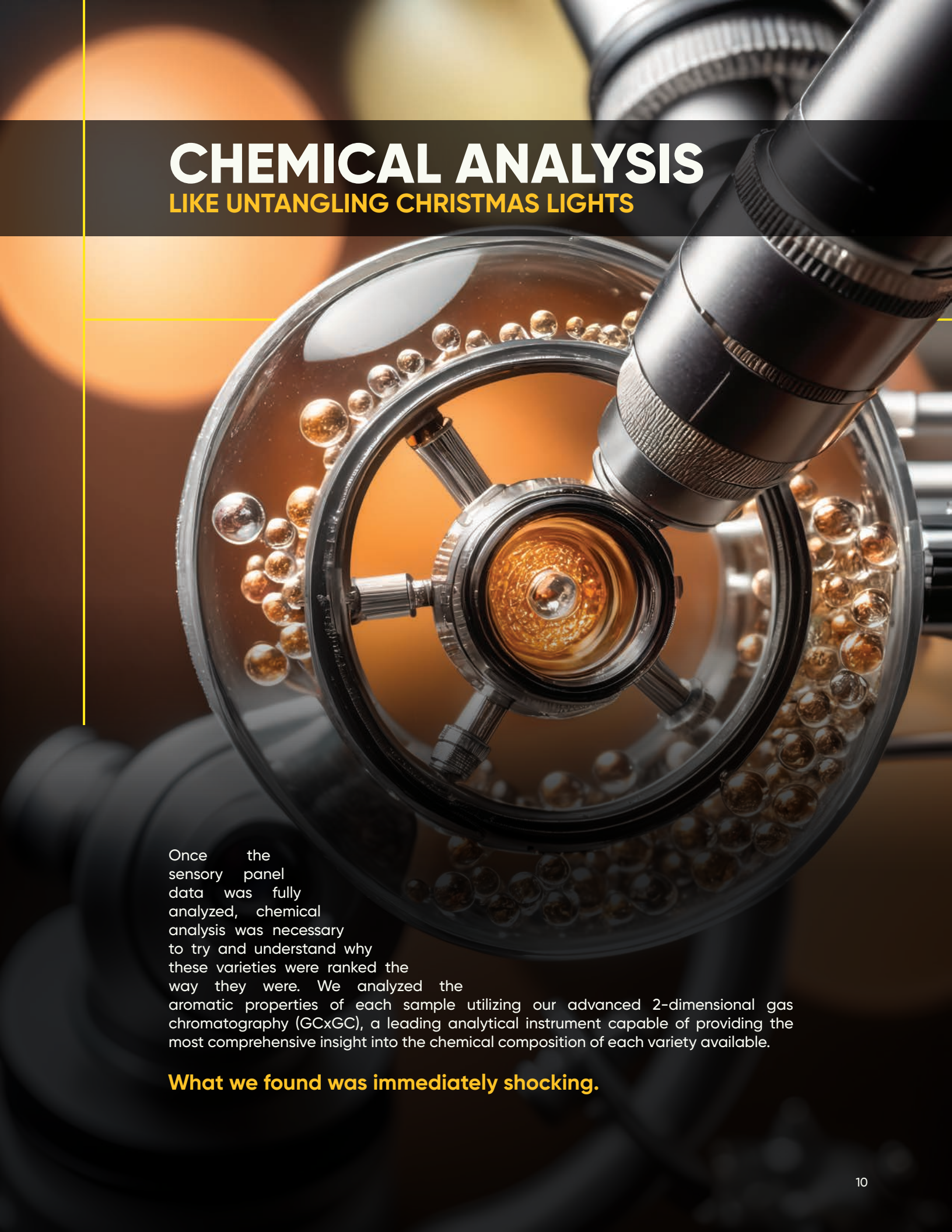



**Figure 5.** This correlation table illustrates the similarities and differences in the aromatic properties of each variety studied. Lighter colors indicate a higher degree of aromatic similarity between varieties, while darker colors indicate a less similar aroma.

# CHEMICAL ANALYSIS

## LIKE UNTANGLING CHRISTMAS LIGHTS



Once the sensory panel data was fully analyzed, chemical analysis was necessary to try and understand why these varieties were ranked the way they were. We analyzed the aromatic properties of each sample utilizing our advanced 2-dimensional gas chromatography (GCxGC), a leading analytical instrument capable of providing the most comprehensive insight into the chemical composition of each variety available.

**What we found was immediately shocking.**

When we compared the aromatic chemical fingerprint of each cultivar, we found that there are no clear chemical distinctions between cultivars that possess extremely different aromas, as illustrated in **Figure 6.** Meaning that even though two varieties can have nearly identical compounds, their aromas are vastly different. Why?

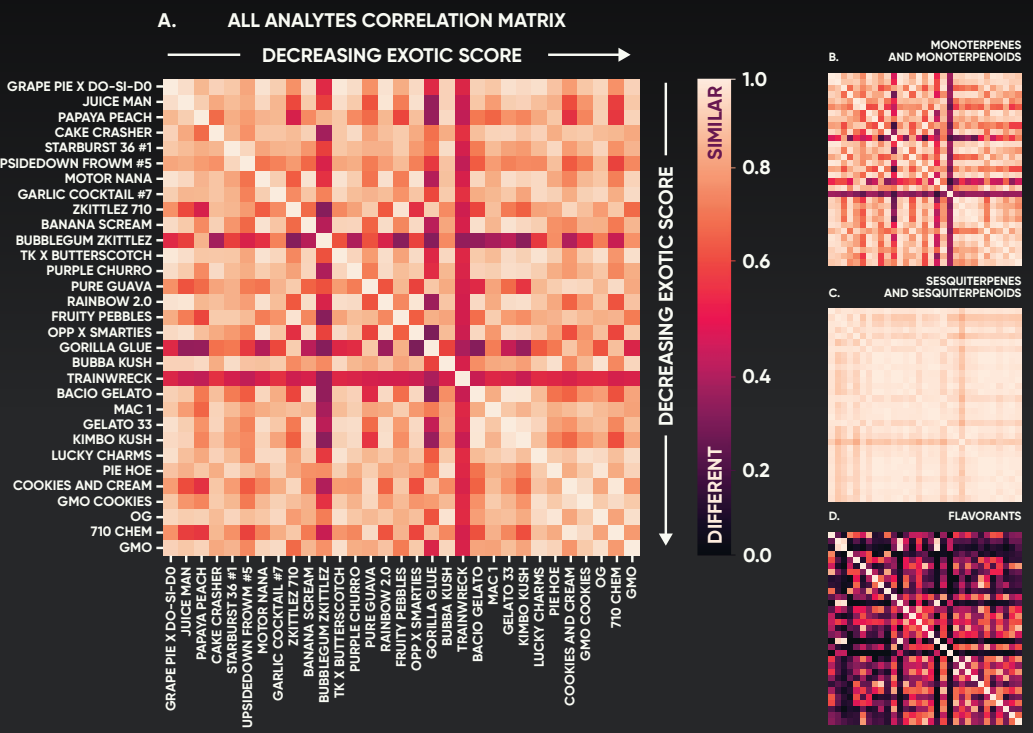



**Figure 6.** Correlation tables of different chemical classes. **A.** Table taking all analytes into account showing high correlation for most varieties. **B.** Correlation table showing high correlation for most varieties when considering only monoterpene and monoterpenoids. **C.** Correlation table showing very high correlation for all varieties when considering only sesquiterpene and sesquiterpenoids. **D.** Correlation table showing divergence in similarities between samples when analyzing flavorants exclusively. This data indicates that while terpenes remain similar between many samples, low concentration non-terpene compounds (flavorants) change drastically, indicating their importance in producing unique aromas in cannabis.

This graphic contains four different correlation tables. These tables allow us to compare how similar the chemistry is between each variety in a single graphic. **Lighter colors indicate more similar** chemical profiles between varieties, **while darker colors indicate more differences.** Generally speaking, an r-value greater than 0.4 is considered to be at least *modestly* correlated.

What becomes immediately apparent is the exceptionally high correlation amongst nearly all varieties when **all analytes** are considered. While some, like Trainwreck, Gorilla Glue, and Bubblegum Zkittlez, exhibit a relatively lower correlation (indicated by the darker colors), the majority showcase high correlation, indicating substantial chemical similarity. This raises intriguing questions, especially when these varieties have been ranked based on their Exotic Score from sensory analysis.

**If the sensory panel ranks these to have divergent aromas, why do they all look so similar chemically?**

Further, when considering monoterpenes or monoterpenoids here in **Figure 7**, the results remain very similar (as indicated by the lighter colors). There are even more similarities between the sesquiterpene and sesquiterpenoids compounds.

This data strongly suggests that terpenes have minimal influence on the exotic, or unique aromatic notes of cannabis.

**It must be other compounds that drive the aroma differences seen in the sensory data.**

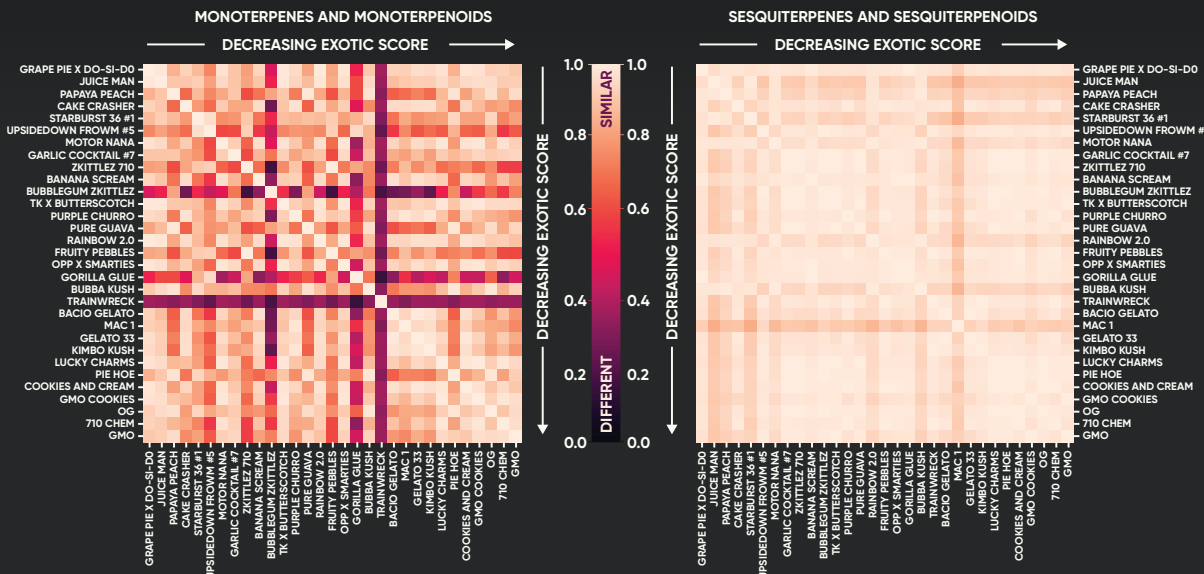



**Figure 7.** The lighter colors indicate that the chemical composition among the cultivars is similar for monoterpenes/monoterpenoids, and nearly identical for sesquiterpenes/sesquiterpenoids. However, despite this similarity, each variety still produces unique and distinct aromas. Therefore, terpenes cannot be considered the key differentiators when it comes to exotic aroma.

By isolating our examination to non-terpene compounds, such as esters, volatile sulfur compounds, alcohols, etc, we find that there are **clear differences** between varieties. Notice the consistently dark colors in **Figure 8**, indicating a low correlation between cultivars. This implies that it's these compounds - not terpenes - that are the true origin of the diverse aromas in these exotic cannabis samples.

## WE REFER TO THIS CLASS OF NON-TERPENE COMPOUNDS AS FLAVORANTS, AS THEY ARE RESPONSIBLE FOR PRODUCING MANY OF THE UNIQUE AND DIVERSE FLAVORS WITHIN CANNABIS.

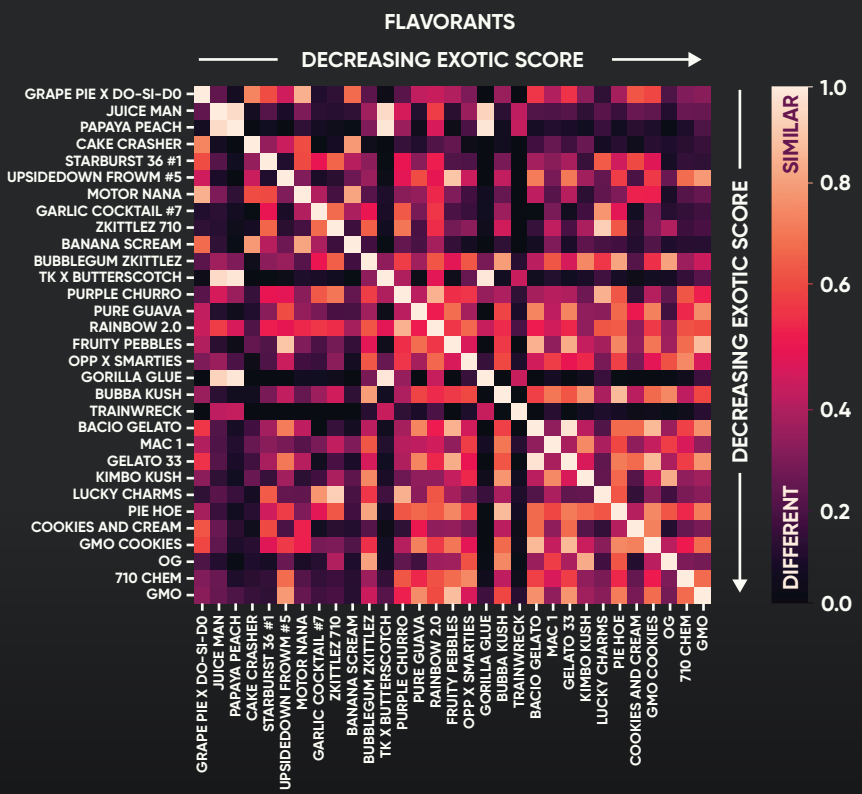



**Figure 8.** Here we observe a breakthrough. In contrast to the comparison of terpenes in **Figure 7**, we notice significant variations in chemical characteristics among these low concentration compounds. This suggests that they are the primary factors responsible for the distinctive aromas observed between different cultivars. We refer to them as *Flavorants*.

# INTRODUCING FLAVORANTS

Upon discovering the importance of this missing piece, we immediately performed a detailed analysis on each of the 31 cultivars, revealing over **60 unique flavorant compounds**.

Once these flavorant compounds were identified and quantified, it became time to determine how exactly they fit into the puzzle that is the aroma of cannabis. It is great that we now have many more compounds to work with, but understanding how they all fit together is a completely different question.

# THE ABSTRAX PERIODIC TABLE OF FLAVORANTS

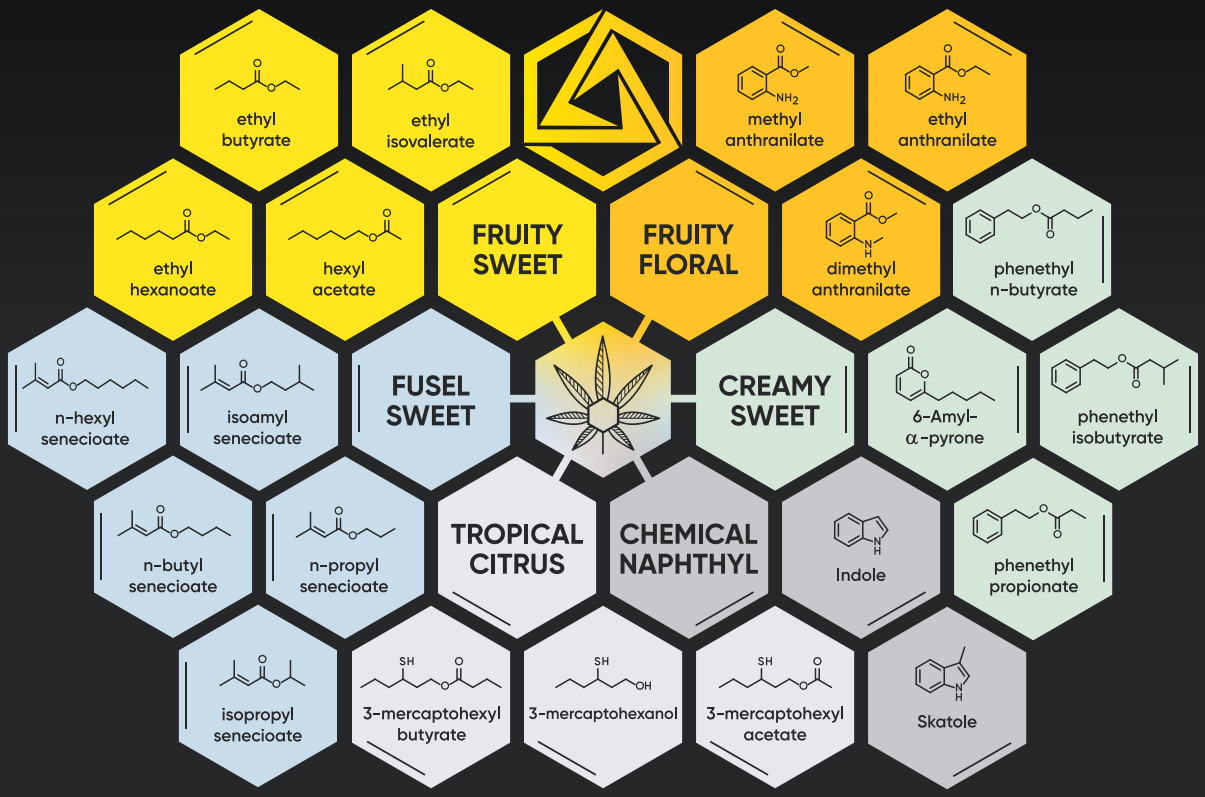



**Figure 9.** The Abstrax Periodic Table of Flavorants. This graphic shows many of the most important compounds identified in cannabis that drive many of the unique and exotic aroma notes found in different cultivars.

We began to do statistical analysis between the 31 cannabis samples to identify which flavorants were most important, or which may contribute most to specific scents. Before proceeding, we aimed to determine whether the sensory panelists assigned rankings to the cultivars based on the total aroma percentage, meaning the portion of a product's weight constituted by volatile compounds responsible for its aroma.

***To read about each of these chemical classes in detail, please see the epilogue describing where to find them.***

# TERPENES, FLAVORANTS, AND A NEW MYSTERY

The total aroma percentage, often equated with "terpene concentration" since most testing labs focus predominantly on terpenes, is a pivotal metric highlighted on packaging and is scrutinized by many consumers. Hence, establishing whether a product with a higher Exotic Score correlates to a higher aroma percentage is crucial; it would suggest that a higher aroma percentage is synonymous with more exotic aromas. However, our findings contradicted this hypothesis.

**We discovered that the total aroma percentage bore no relation, exhibiting virtually no correlation, to the perceived exoticness of the cannabis aroma, as illustrated in Figure 10. In fact, some varieties with the highest Exotic Scores recorded the lowest total aroma weight percentages.**

The implications of this data are significant. Given that terpenes constitute the most concentrated compounds in the aroma of cannabis, the aroma percentage is largely determined by the quantity of terpenes present. The absence of a correlation between the total aroma weight percentage and the predominance of terpenes in this measurement reinforces the notion that, while terpenes *do contribute* to many characteristic scents of cannabis, they are not the defining elements of the exotic aromas that set one cultivar apart from another.

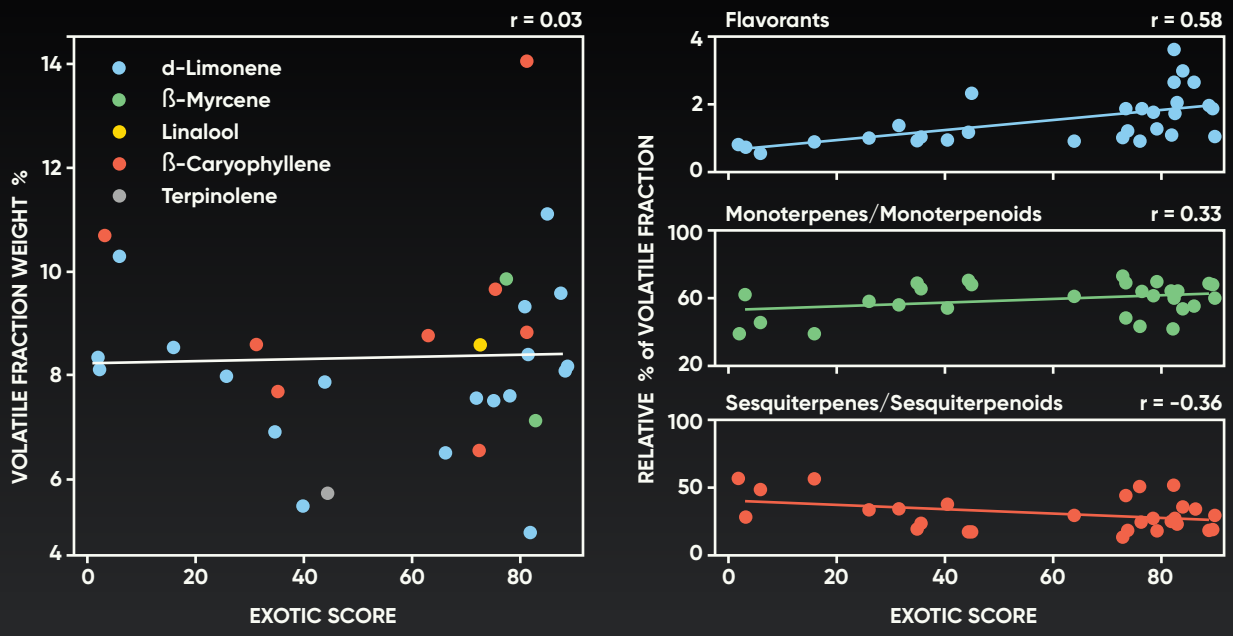



**Figure 10.** The percentage of volatile fraction weight in the measured samples exhibits minimal correlation to the exotic nature of cannabis. Flavorants display a positive correlation with the Exotic Score, underscoring their significant role in contributing to these distinct aromas. In contrast, monoterpenes/monoterpenoids and sesquiterpenes/sesquiterpenoids show negligible positive and negative correlations, respectively, indicating their relatively inconsequential contribution to the unique aromas of the varieties studied.

Despite observing no correlation between aroma percentage and Exotic Score, we pondered whether specific chemical classes might show some relationship. To explore this, we calculated the relative percentages of all flavorants, monoterpenes/monoterpenoids, and sesquiterpenes/sesquiterpenoids to one another.

**The results were remarkable:** flavorants constituted only approximately 1–4% of the total volatile compounds, yet there was a distinct positive correlation between this small percentage and their Exotic Scores. This strongly indicates that, although these compounds are present in minor quantities by weight, their influence on odor is disproportionately significant.

In contrast, we observe only a moderately positive correlation between monoterpenes/monoterpenoids and the Exotic Score, and similarly, only a slight negative correlation with sesquiterpenes/sesquiterpenoids. These findings collectively reinforce the notion that flavorants, despite their minor concentrations, play a significant role in shaping the exotic aromas of cannabis.

## FLAVORANTS, NOT TERPENES, DRIVE THE UNIQUE AROMAS IN CANNABIS.

# WHAT ABOUT KEY DOMINANT TERPENES? DO THEY HAVE ANY CORRELATION WITH EXOTIC CANNABIS?

Lastly, we were interested in determining if any of the key major terpenes had any correlation to the exotic nature of cannabis. As many consumers focus on just a few key terpenes (for good reason – the complexity of the plant makes it impossible to know each compound present), this would provide evidence that certain compounds do indeed correlate with the aromatic character of certain varieties.

**Once again, our results show that some of the most discussed and heralded terpenes show essentially zero correlation with the exotic aroma discussed here.**

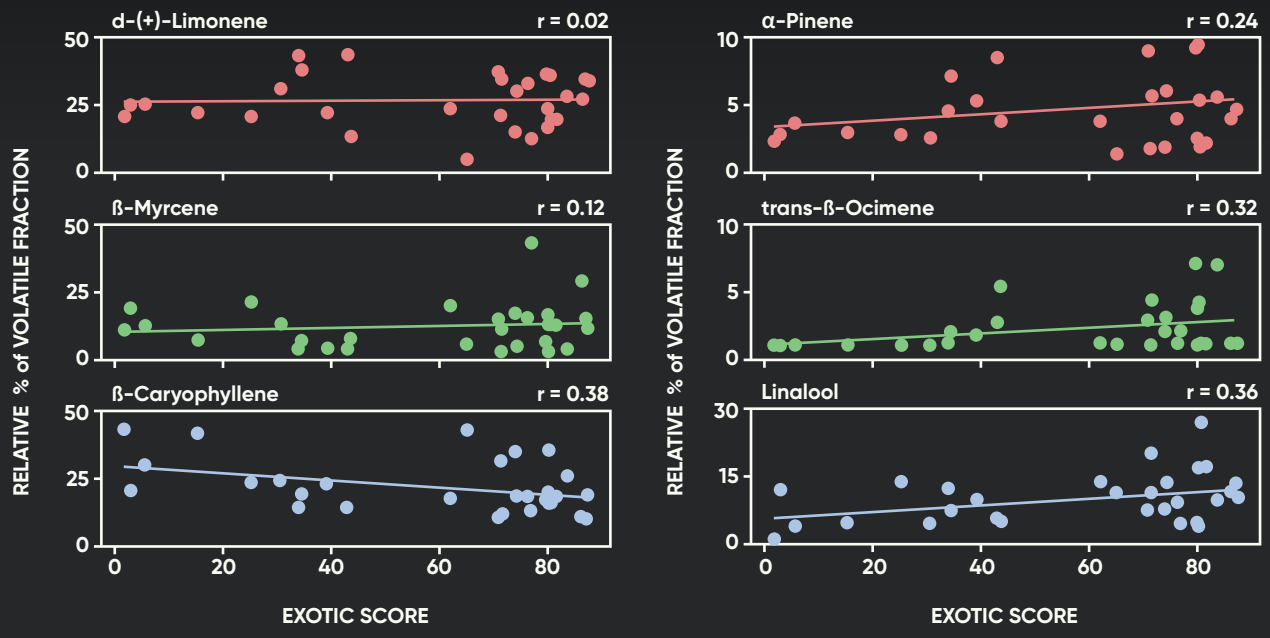



**Figure 11.** Correlations of relative weight percentages of key terpenes in cannabis as a function of exotic score. Minimal correlation is observed in many of these compounds, suggesting their minimal contribution to the exotic aromas of cannabis.

What does this mean? It means that if you want to consume cannabis based on some sort of chemical indicator of a certain flavor attribute, terpenes are not the answer. In particular, ß-Myrcene and d-Limonene – two of the most often discussed terpenes in cannabis – demonstrate virtually no correlation with the Exotic Score **(Figure 11)**. ß-Caryophyllene exhibits a moderate negative correlation with the Exotic Score, while α-Pinene, trans-ß-Ocimene, and Linalool show a moderately positive correlation. This suggests that among the predominant terpenes, only a few have even negligible influence on the exotic aromas in cannabis.

With that said, cannabis continues to spin mysteries out of mysteries. There is one apparent outlier in all of our research - **Trainwreck**. Out of all 31 cultivars, this was the single variety that saw lower sensory similarities that also correlated with lower chemical similarities, indicating that terpenes **did** help to differentiate this variety.

Why would a classic sativa like Trainwreck break the mold? And is it possible that other sativas might offer more insights? We will do a deep dive into Terpinolene-dominant varieties in the future to expand on this interesting observation.


## OUR DATA PROVIDES PROFOUND INSIGHTS INTO HOW THE CHEMISTRY OF CANNABIS CHANGES ACROSS DIFFERENT VARIETIES.

A few key takeaways include the following:

**TERPENES,** while heralded as the key aroma compounds in cannabis, are not nearly as important in dictating the unique aromatic qualities of different varieties as originally thought. They provide the canvas that is the characteristic aroma of cannabis, but do not drive many of the unique aromas in most cases.

**FLAVORANTS,** non-terpenoid compounds found in low concentrations, are the true drivers in many of the unique exotic aromas in cannabis.

**TOTAL AROMA PERCENTAGE** has limited impact on the perceived aromatic properties of different strains, suggesting that this commonly used quality metric may not be a reliable guide for consumers seeking specific aroma profiles.

# EPILOGUE

## DO YOU WANT TO LEARN MORE ABOUT THE CHEMISTRY OF EXOTIC CANNABIS? BE SURE TO READ THE OTHER WHITE PAPERS IN OUR ANTHOLOGY OF EXOTIC CANNABIS.


• **The Science of Exotic II: Chem** – Learn about what makes some of the most savory, or chemical-like varieties smell and taste the way they do.


• **The Science of Exotic III: Tangie** – Learn why certain cannabis varieties have intense, pungent citrus notes that seem to linger. Spoiler: it's not Limonene!


• **The Science of Exotic IV: Sweet** – Learn about all of the new chemistry in many of your favorite sweet, fruity, or dessert-like varieties.

## LEARN HOW ABSTRAX IS USING THIS DISCOVERY TO MAKE THE WORLD'S MOST ACCURATE TERPENE PROFILES.

## REFERENCES

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