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Technical Report

Increasing Return on Investment (ROI) for Pesticide Analysis in Cannabis

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After analysis of cannabinoid concentrations, also called potency analysis, pesticide testing is the most in-demand application in the cannabis lab according to SDi report, "Pot of Gold…" Report 18-025. Potency accounts for 44% of the test, pesticides 15%, microbial 14%, heavy metals 12%, terpenes 9%, and residual solvents 6%. Since all labs in the cannabis industry have a HPLC cannabis analyzer for potency, this article will focus on the return on investment (ROI) for pesticide analysis by mass spectrometry, an analysis that brings in the most revenue per sample.

The first question is what type of mass spectrometer and should it be a single quadrupole or triple quadrupole system? For pesticides in cannabis, the recommendation is a triple quadrupole mass spectrometer in order to obtain superior sensitivity and selectivity. The next question is which technique is required: LC-MS/MS, GC-MS/MS, or both. In general, it depends on a number of factors, including the molecular weights of the compounds, polarity, volatility, thermal stability, and ionization efficiency. Also, as this industry continues to evolve, the list of pesticides continues to grow with more and more compounds added.

For example, Colorado started with 15 pesticides. Oregon quadrupled the number of pesticides to 59. California used the previous states plus additional pesticides to increase the number to 66. Canada used certain states in USA plus additional pesticides to increase the number to 95. Finally, AOAC International is developing a method using every state in the USA with requirements and Canada's list for a total of 104 pesticides. In addition, this method specifies maximum residual limits (MRLs) that are half of what's currently listed, making analysis more difficult.

The Venn Diagram in Figure 1 shows select pesticides that are easiest to analyze by LC-MS/MS and by GC-MS/MS, and an overlapping area where either technique will suffice. The darker the blue circles on the Venn Diagram, the easier the analysis is by LC-MS/MS; conversely, the darker red circles indicate analysis that is easier by GC-MS/MS. It can be seen that Imidacloprid would have high sensitivity by LC-MS/MS and Endosulfan would have high sensitivity by GC-MS/MS. For example, Cyfluthrin could be measured by either instrumental technique.

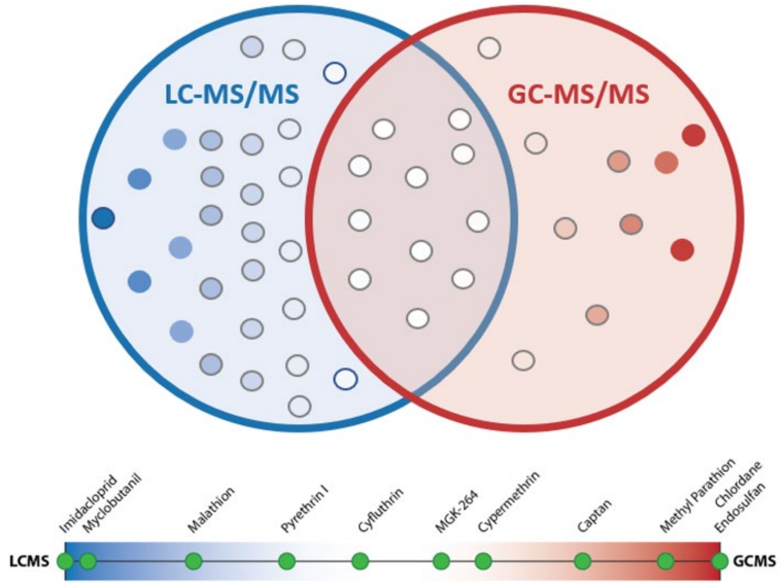

Figure 1: Venn Diagram of pesticides analysis by LC-MS/MS & GC-MS/MS

High-throughput contract laboratories are in the business to make money and hopefully to protect consumers, especially immunocompromised patients, from contaminants such as pesticides. Some laboratories want to analyze the entire California pesticide list by LC-MS/MS only, often to minimize initial capital equipment costs, but is that the most efficient way with the highest return on investment (ROI)?

To attempt such an analysis on an LC-MS/MS requires an optional dual ionization source platform with electrospray ionization (ESI) typically used for "LC-MS/MS pesticides". An atmospheric pressure chemical ionization (APCI) source, which costs additional money, may be able to be used for pesticides that are historically analyzed by GC-MS/MS. The measurements by dual ionization sources are analyzed sequentially; in other words, the ESI measurement run time may be 19 minutes followed by APCI measurement time of 6 minutes for a total analysis time of 25 minutes. Thus, the bottleneck is the sequential analysis.

The other approach uses both LC-MS/MS and GC-MS/MS for a simultaneous analysis. The LC-MS/MS is a 15-minute analysis, while the GC-MS/MS analysis is only 6 minutes since only a handful of pesticides are analyzed. Thus, all the results are completed in 15 minutes utilizing both instruments compared to 25 minutes using only LC-MS/MS.

Shown in Table 1 are the ROI calculations utilizing both approaches. The revenue per day for the LC-MS/MS is $12,825, compared to $21,600 by LC-MS/MS and GC-MS/MS, for an advantage of $8,775 for the two-instrument approach. The capital cost shown in Table 1 is more expensive with the two-instrument approach, but payoff days for the LC-MS/MS only approach is 31 days compared to 23 days for the two-instrument approach. So, the return on investment is 8 days less for the two-instrument approach. After the instruments are paid off, the two instruments will continue to earn an additional $8,775/day. Over a one-year period, that amounts to an extra $3,202,875 in revenue compared to the single instrument, dual ionization source LC-MS/MS.

Table 1: Return on Investment (ROI) for Pesticide Analysis utilizing two approaches

	Pesticides Analysis	
Method	**LC-MS/MS (ESI) + GC-MS/MS**	**LC-MS/MS (ESI + APCI)**
Instruments Cost	$500,000	$400,000
Price Difference	$100,000	($100,000)
ESI Time (min)	15	19
APCI (min)	X	6
GC-MS/MS (min)	6	X
Time (max)	15	25
Revenue/sample	$225	$225
Min/Day	1440	1440
Samples/Day	96	57
Revenue/Day	$21,600	$12,825
Additional Revenue	**$8,775**	($8,775)
Break Even (Days)	23	31
Profit Per Year (365 Days)	$7,884,000	$4,681,125
Profit Difference/Year	$3,202,875	($3,202,875)

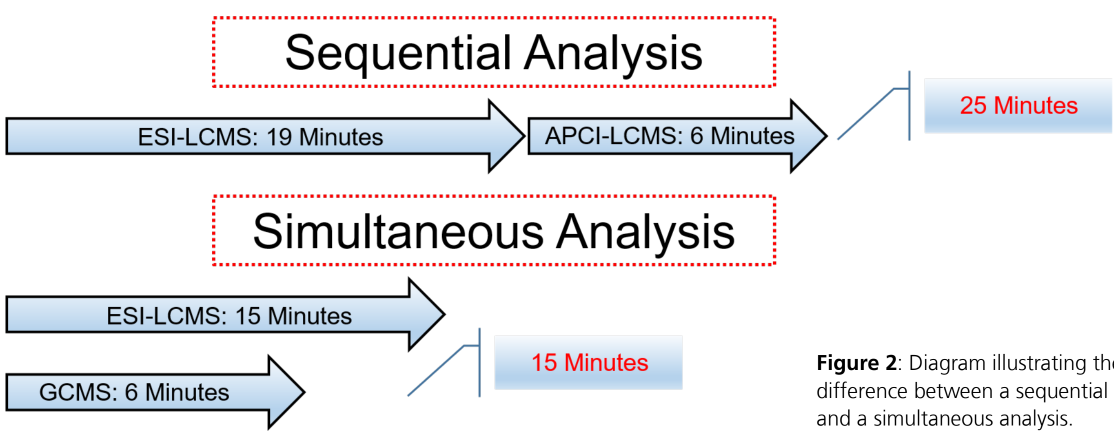

Figure 2: Diagram illustrating the time difference between a sequential analysis and a simultaneous analysis.

The additional revenue provided by the two-instrument approach is not limited to the total shown above because GC-MS/MS can also be used to analyze terpenes or residual solvents since the analysis time is 9 minutes faster than the LC-MS/MS method. As mentioned above, terpenes account for 9% of the cannabis analysis while residual solvents account for 6% of the analysis. While the power of GC-MS/MS is not required for residual solvent analysis, the instrument can be operated in the single quadrupole GCMS mode or the GC/FID mode if equipped. Shown in Table 2 is an example of the ROI for residual solvent analysis using the free time on the GC-MS/MS. This will result in an additional revenue of $1,244,842/year for residual solvent analysis. The combined extra revenue for the two-instrument approach for pesticides and residual solvents would be $4,447,717/year.

Table 2: Additional Revenue earned by using the free time on the GC-MS/MS for residual solvents

Additional Revenue Method	GC-MS/MS (Residual Solvents)
Minutes/Day	1440
Required GC-MS/MS Pesticides/Day	96
GC-MS/MS Pesticide Analysis Time (min)	6
Total Pesticide Time by GC-MS/MS (min)	576
Open Time on GC-MS/MS (min)	864
Analysis Class of Compounds	Residual Solvent
Number of Compounds (CA)	21
Analysis Time (min)	19
Analysis/Day	45
Revenue/sample	$75
Revenue/Day	**$3,411**
Profit Per Year (365 Days) - Solvents	$1,244,842
Profit Per Year -Pesticides & Solvents	**$4,447,717**

Interesting to note is that the cannabis class of compounds are not analyzed in equal numbers in some facilities. For example, if 96 pesticides are analyzed/day (Table 1), which equals 15% of a total cannabis analysis, and residual solvents require 6% of the time, then 38 residual solvents would have to be analyzed per day to keep the ratios even because 96 x (6/15) =38. Table 2 shows 45 residual solvents per day are possible, which is more than the 38 required. Also showing the combination of LC-MS/MS and GC-MS/MS provides a better ROI.

■ Conclusion

On the surface, using a single LC-MS/MS instrument for analysis of a single class of compounds (i.e. pesticides) appears to provide the best ROI. In reality, though, the use of a combination of both LC-MS/MS and GC-MS/MS for a single class of compounds provides the greatest ROI because this dual approach enables simultaneous analysis, resulting in a potential of up to $3 million more in revenue per year. In addition, up to $1 million in extra revenue per year could be earned for additional compound classes such as residual solvents with the open time on the GC-MS/MS. The two-instrument simultaneous approach could provide up to an additional $4 million in revenue over the single instrument sequential method. LC-MS/MS is the most expensive instrument in a cannabis lab and has the highest revenue per sample so it is important to have the highest throughput to analyze the most samples per day and obtain the best ROI. It should also be noted aflatoxins B1, B2, G1, G2 and the mycotoxin ochratoxin A are analyzed during the LC-MS/MS pesticide analysis with the two-instruments approach.

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