Carbon isotopes – the chemist's tool to trace marijuana cultivation environment

The lawful usage of marijuana is a complex legal minefield and point of conflict between states and the federal government. With the US Drug Enforcement Administration recently reaffirming marijuana as a Schedule I Drug, the cultivation, possession, and sale of marijuana remains illegal under the Controlled Substance Act. However, 25 states and the District of Columbia now allow for medical marijuana, with five of these jurisdictions additionally legalizing non-medical usage of marijuana. And, more states are considering medical and non-medical marijuana legislation. In response to state-level initiatives, the US Department of Justice released a statement requiring jurisdictions legalizing marijuana with "*implementing effective measures to prevent diversion of marijuana outside of the regulated system and to other states*".

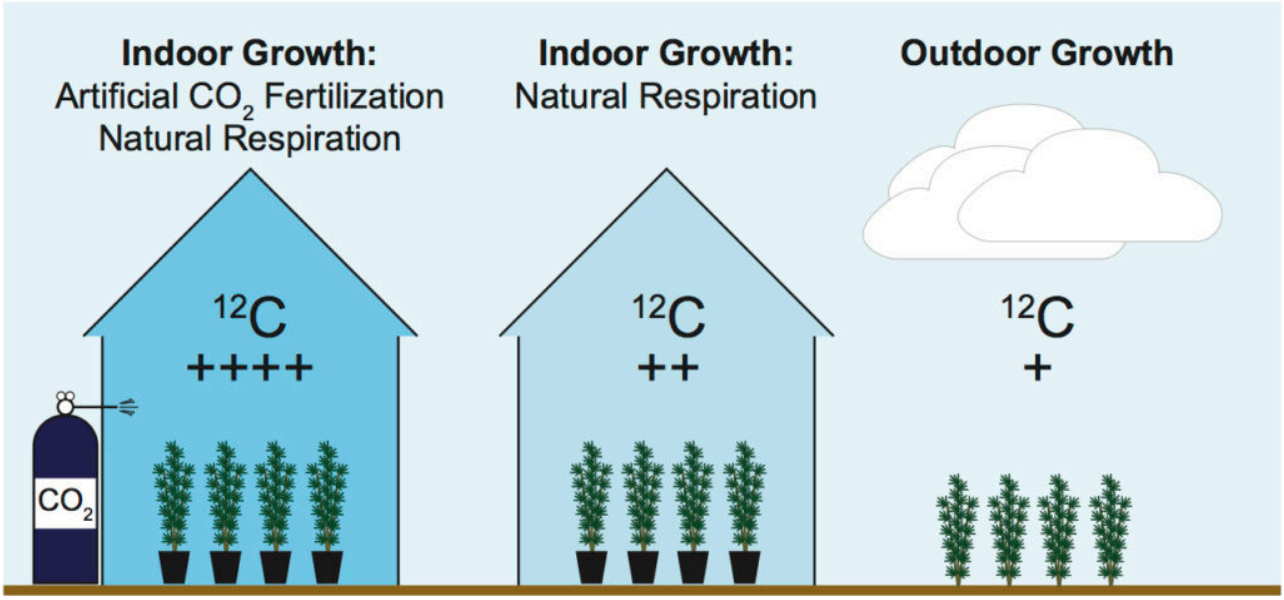

Fig. 1. This illustration shows three common environments where marijuana is grown (i.e., indoor with and without CO_2 fertilization and outdoors) with the relative abundance of carbon-12 (^{12}C) in the marijuana plants from each environment. The darkness of the blue color represents the relative concentration of CO_2 in that environment, with the darker shades of blue indicating greater concentration of CO_2.

Currently, nearly 60% of the states allowing medical marijuana require that the marijuana plants only be grown indoors, such as in a secure greenhouse or converted warehouse. This specific regulation offers product traceability, as well as protects the safety of consumers and general public. Yet how can this regulation be reliably verified without costly physical oversight? Regulators are in need of an analytical tool to distinguish how a particular marijuana plant or product was

cultivated. Today many states rely only on easily falsified tracking methods, such as labels and barcodes. Unfortunately, once a marijuana plant is harvested and removed from its cultivation environment, marijuana or marijuana-based products from plants grown indoors are indistinguishable from those grown outdoors. This lack of quantifiable validation of the cultivation environment creates a ready-made avenue for illicit marijuana to enter a state's product stream or for legal marijuana to exit it, particularly when marijuana has been extracted and processed for oils, tinctures, or food products.

To solve this challenge, we have developed a novel analytical method to reliably distinguish between marijuana's cultivation environments. Our method applies nature's recorder of plant growth environment — stable carbon isotopes — in specific molecules from marijuana to differentiate between plants grown indoors and outdoors. Specifically, by measuring the natural abundances of the two stable carbon isotopes (i.e., carbon-13 [^{13}C] and carbon-12 [^{12}C]), we are able to reliably and effectively distinguish marijuana plants that were cultivated indoors from ones that were cultivated outdoors. Figure 1 illustrates that ^{12}C is elevated in marijuana cultivated indoors compared to plants grown outdoors due to the processes of carbon dioxide fertilization and/or plant respiration within enclosed cultivation environments. This independent and natural "barcode" of cultivation environment remains encrypted within the molecules of the marijuana and cannot be adulterated or forged.

The need for reliable analytical tools to ensure safe cultivation of medical marijuana will continue to grow as many states are in the process of implementing medical marijuana initiatives and still others will consider bills in upcoming legislative sessions. Regardless of politics, medical marijuana patients must have access to a product that was grown safely, securely, and as regulated by law. Requiring marijuana to be grown in a secure indoor environment allows states a way to ensure quality and safety. Our findings provide an analytical method to certify or verify that medical marijuana was grown according to this regulatory requirement; both helping law enforcement uphold state statutes, as well as providing increased consumer confidence in this emerging medicine.

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Publication

The influences of cultivation setting on inflorescence lipid distributions, concentrations, and carbon isotope ratios of Cannabis sp.
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