How is Hemp Processed: An Overview of Extraction Methods

Introduction

In theory and practice, cannabinoid extraction methods are similar to those employed within the botanical, food, and pharmaceutical industries. There are, however, only a few solvent-based technologies that can be used for industrial-scale hemp extract production: hydrocarbon, carbon dioxide (CO_2), and alcohol extraction. Regardless of the extraction method, the objective of extraction is to separate the target active compounds (cannabinoids and terpenes) from the hemp plant (biomass) without adulterating or degrading those compounds, thereby preserving their form and function for subsequent use in consumable products.

Preparing Biomass for Extraction

Biomass can be refrigerated, flash frozen, or dried after harvest; each of these methods aim to conserve the target compounds within the biomass while in storage prior to extraction. Infrastructure and energy requirements to cool biomass can oftentimes be cost prohibitive. While cold storing and flash freezing can slow down oxidative and degradative mechanisms, these storage methods retain moisture in the biomass, which can reduce solvent efficacy and extraction capacity down the line. Alternatively, drying the biomass is a more economical process that reduces the biomass moisture content, preserving the plant for long-term storage in a form that is ideal for solvent-based extraction, although this method moderately impacts cannabinoid and terpene content.

The Basics of Solvent-Based Extraction

Solvent-based extraction relies on the general rule of solubility, "like dissolves like," a criterion used in chemistry that at a basic level explains that polar solutes will dissolve in polar solvents, nonpolar solutes will dissolve in nonpolar solvents, and therefore nonpolar solutes will not dissolve in polar solvents and polar solutes will not dissolve in nonpolar solvents. In addition to solute/solvent polarity (conditionally dependent on temperature and pressure), particle size of the biomass, solvent-to-solid ratio, and extraction duration are all factors that can impact the effectiveness of the extraction method.[i]

Step-by-Step Extraction Principles

The "target compounds" are separated from hemp biomass through the following stages:

1) The solvent is passed through the biomass matrix (flowers, leaves, stems, seeds).

2) The solutes (cannabinoids, terpenes, plant fats, and waxes) dissolve in the solvent.

3) The solutes are separated from the biomass matrix.

4) The extracted solutes are collected, filtered, and concentrated.

Hydrocarbon Extraction

Hydrocarbons, such as butane and propane, are nonpolar compounds with low boiling points and high affinity for cannabinoids and terpenes, making hydrocarbons effective solvents for extraction, although their utility is limited by their hazard profile.

Hydrocarbon's Safety and Hazard Considerations

Hydrocarbons are flammable, so safe working conditions depend on costly equipment that can withstand high pressure levels and ensure the concerns around flammability are addressed and properly prevented. It is important that hydrocarbon vapors are contained; regulations require that hydrocarbon extraction operations take place in specially certified facilities. Components such as closed-loop systems have been engineered to make this process relatively safe. The safety concerns and associated engineering requirements make hydrocarbon extraction costly and difficult to scale.

Supercritical Carbon Dioxide Extraction

Also known as **supercritical fluid extraction (SFE)**, supercritical carbon dioxide (CO_2) extraction relies on CO_2 as a solvent, where it is neither in its gaseous form nor in its solid, "dry-ice" form. Instead, CO_2 is converted to its supercritical form through a combination of extremely high pressure and heat. This process results in a liquid-like state that allows CO_2 to move and be manipulated in much the same way that solvents such as hydrocarbons and alcohols can be. The necessity to compress the gas to its liquid state makes this extraction method dangerous and expensive. With pressure levels sometimes approaching 5,000 PSI, the engineering requirements to ensure the safety of the equipment and the extraction protocols are much more rigorous compared with other solvent-based extraction methods.

Longer Processing Times

The conversion to supercritical form changes the polarity of the carbon dioxide such that it binds cannabinoids and terpenes; however, supercritical CO_2 is only a moderately effective solvent and requires several "passes" in order to achieve yields comparable with other solvent-based methods. This increases the overall duration of the extraction, which limits throughput scalability and ultimately extracts more than just cannabinoids and terpenes—and necessitates additional refinement of the extract.

SFE is nonflammable and relatively safe, with removal of solvent being quite simple: Decreasing the pressure and temperature of the solvent converts CO_2 to its gaseous state, leaving the extracted compounds behind as an oil (i.e., liquid state).

Alcohol Extraction

Pure (200 proof) ethanol, also known as ethyl alcohol, is a food-safe polar solvent often used in culinary extracts and essential oils. Ethanol is highly flammable, but alcohol extraction can be performed safely in much the same way as hydrocarbon extraction: using professionally engineered equipment and facilities and following fire safety protocols.

Decreased Temperatures Yield Better Results

To more selectively extract cannabinoids and terpenes from biomass, the polarity of ethanol can be modulated by chilling (-40° C or below) the solvent used during extraction, thus minimizing the extraction of other co-soluble polar plant compounds from hemp such as chlorophyll and lipids. Regardless, filtration steps during and after the extraction process are required to remove the compounds that are not wanted from the extract. Colder extraction decreases the overall yield, but ultimately the lower extraction temperatures make undesirable plant components less soluble, resulting in a higher-quality extract.

The Bottom Line

While the qualities of the harvested plant are the blueprint of what can be expected from a final extraction, the potency of that final product depends on much more than just the plant material itself. The effectiveness of each step of the extraction plays a huge role in determining the overall quality of the products that will eventually go into consumers' hands, whether they're edibles, tinctures, or topicals. A successful extraction avoids changing or degrading those compounds at every step so that product formulations are as pure a reflection of the plant's original cannabinoid and terpenoid profiles as possible, preserving its therapeutic, beneficial, and aromatic offerings from start to finish.

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[i] Li, P., Xu, G., Li, S. P., Wang, Y. T., Fan, T. P., Zhao, Q. S., & Zhang, Q. W. (2008). Optimizing ultraperformance liquid chromatographic analysis of 10 diterpenoid compounds in Salvia miltiorrhiza using central composite design. *Journal of agricultural and food chemistry*, *56*(4), 1164–1171. https://doi.org/10.1021/jf073020u