WHITE PAPER

HOW DRYING CANNABIS WITH LYOPHILIZATION INCREASES CANNABINOIDS, PRESERVES TERPENES, AND REDUCES TIME TO MARKET

Exclusive white paper presented by:
Industry Processing Solutions , The Original Resinator, & Cuddon Freeze Dry

Sections

Executive Summary

This white paper examines the significance of employing proper lyophilization techniques for drying cannabis and hemp, which is commonly known as “live dried”. By utilizing advanced freeze drying and curing methods, licensed operators can consistently enhance the quality, potency, and shelf life of their dried smokeable flower while bringing it to dispensary shelves in a fraction of the time traditional drying and curing methods typically require (one to two days instead of weeks or months). This not only has the opportunity to increase consumer satisfaction but also enables cultivators to command increased prices in competitive markets. Well lyophilized cannabis and hemp also can be beneficial for producing manufactured or extracted cannabinoid products as well given the enhanced porosity within the inflorescences as a result of freeze drying.

Moreover, efficient freeze drying techniques minimize the loss of valuable cannabinoids and terpenes during the drying process, resulting in increased overall profit potential. By implementing these new methods, operators can better position themselves as industry leaders, capture larger market shares, and establish a reputation for delivering superior products. While industry adoption has been limited up until this point, due mainly due to a lack of adequate processes prior to 2022, the corollary of the rise of solventless which began around 2015 to the incoming live dried boon is now clear. While this paper primarily focuses on THC-cultivated smokeable flower, hemp is also considered.

Opportunity

The greater market for dried, smokable cannabis flower in the United States has experienced significant growth in recent years, solidifying its position as a substantial and expanding industry segment that doesn't show any signs of slowing down overall. With total recreational and medical flower sales eclipsing $30 billion in 2022 alongside a projected 10% increase to over $33.6 billion in 2023, sales of dried flower have emerged as a majority of overall sales among legally available THC products[1]. US hemp-based CBD product sales added up to $4.1 billion in 2022 as well, with additional increases forecasted over the coming years[2]. The demand for flower virtually guaranteed to continue, driven by shifting attitudes towards cannabis legalization, increasing consumer acceptance, and the growing recognition of its benefits for both pleasurable and therapeutic purposes. Additionally, the potential for expansion of legalized cannabis markets across several additional major states, such as Minnesota and perhaps even sunny Florida, has opened up new avenues for entrepreneurs, cultivators, and investors to capitalize on previously untapped potential.

Traditionally Dried

The industry's success can be attributed to several factors. First, the decriminalization and legalization efforts across the nation have dismantled barriers that previously hindered market expansion. As more states legalize recreational and medicinal cannabis use, a larger customer base is emerging, creating a conducive environment for increased sales and revenue. Second, the growing body of scientific research supporting the therapeutic properties of cannabis has boosted consumer confidence, attracting new users and widening the market's appeal. Furthermore, the advent of innovative cultivation practices, post harvest processing, improved genetics, and now the introduction of cutting edge lyophilization drying methods have elevated the overall quality and potency of dried flower, enhancing its desirability. As the legal cannabis markets continue to evolve and regulatory frameworks become more accommodating, the smokeable flower sector is poised to experience sustained and even exponential worldwide growth in the coming years.

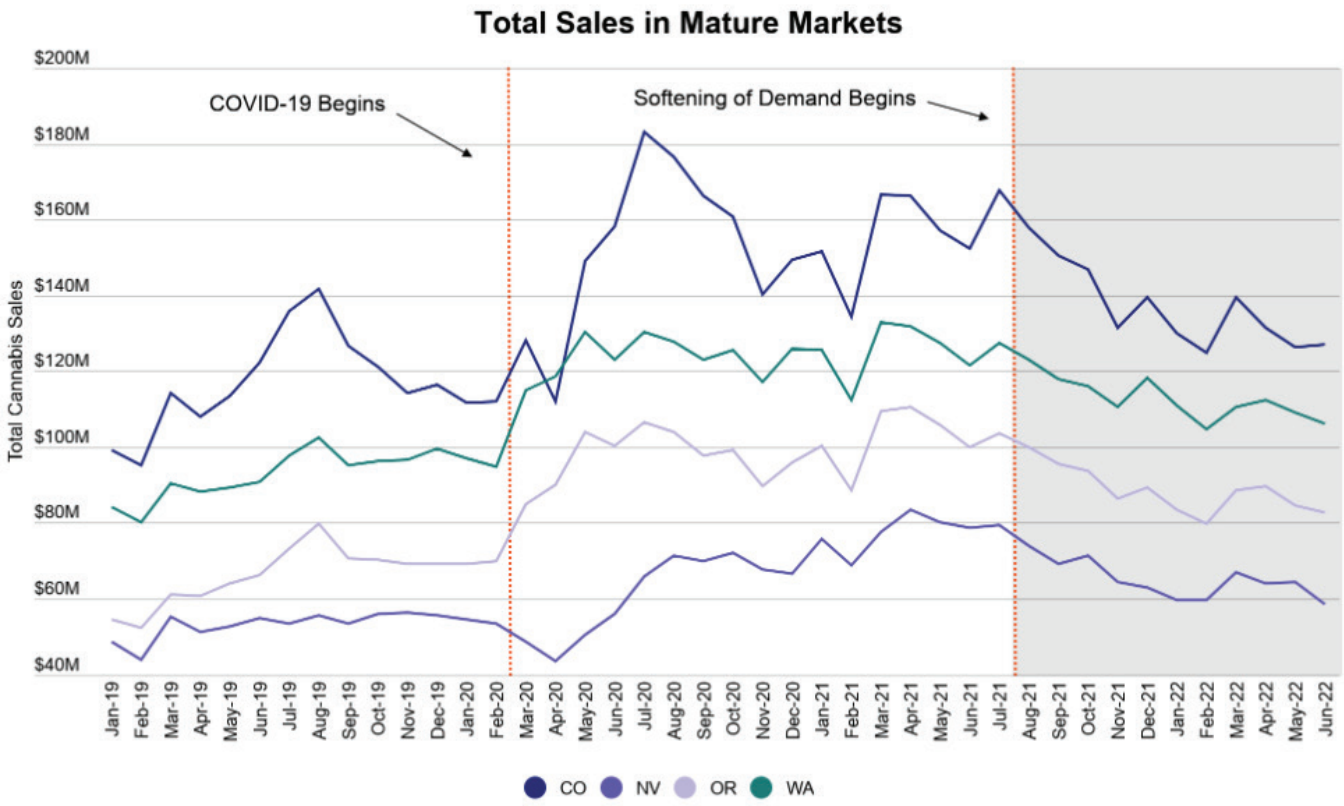
With all of the hype and interest that has been building for roughly a decade surrounding recreational cannabis, an inevitable market correction has demonstrably

occurred in many states, beginning towards the end of 2021. According to data from BDSA, many long standing mature markets have seen average retail prices falling by roughly 13% and in some cases as much as 20%[3]. Another telling data set published by Headset has shown recent softening demand in many of the same locations, but notes that virtually all states, despite seeing recent sales declines from COVID-related highs, have still grown significantly compared to three years ago when taking the entire picture in[4].

Against this backdrop of an overall growing market with rapidly developing

Live Dried

competition, cultivators have had to get creative when it comes to the strains they grow, process, and market them to stay competitive. Among the most popular methods to combat this are choosing exotic sounding strains, but they can be difficult to grow or aren't always excellent yielders. Even though it's anecdotally repeated ad nauseum that THC percentage doesn't matter either, that isn't what dispensaries will tell you – it matters a lot to consumers, because they feel like they're getting more bang for their buck with a higher potency selection. That's the primary reason why every grower wants to maximize potential cannabinoid and terpene production with every strain they take the trouble to produce. This is hard enough with traditional drying and curing methods when those techniques end up causing losses in the end product that have been seen as the cost of doing business, until recently.



Graph Source: Headset[4]

Challenges of Traditional Drying & Curing Methods

Traditional cannabis drying and curing methods present unique difficulties that licensed operators must navigate every harvest to ensure the production of high-quality end results. Achieving the optimal drying conditions is not an easy feat and typically needs a considerable amount of non-cultivating space, which is extremely valuable real estate per square foot in any licensed facility. Even in outdoor and greenhouse grow situations, ample sealed indoor space must be constructed for their crop. Cannabis requires a precise balance of temperature, humidity, water activity, and airflow during the drying process, with each strain being different depending on the density of its bud structure.

Pictured: cannabis plants hung up to dry

If the drying environment is too humid, it can lead to pest, mold, and mildew growth, which can compromise the quality, viability and economic potential of a harvested crop. On the other hand, if the room is too dry, it can result in quickly over drying, affecting the appearance, aroma, flavor, and overall market value negatively. Cannabis is exquisitely heat sensitive as well, as the delicate terpenes that give each plant its

unique aromas and flavors are easily degraded, not to mention the cannabinoids themselves are similarly affected. What this amounts to is additional costly HVAC solutions and environmental controllers. Maintaining consistent drying conditions across large-scale operations can be particularly demanding, requiring careful monitoring and management to avoid these pitfalls. It also translates to higher labor costs to manage the entire process. Standard drying procedures usually take anywhere from 5 to 7 days alone, and that's before curing begins.

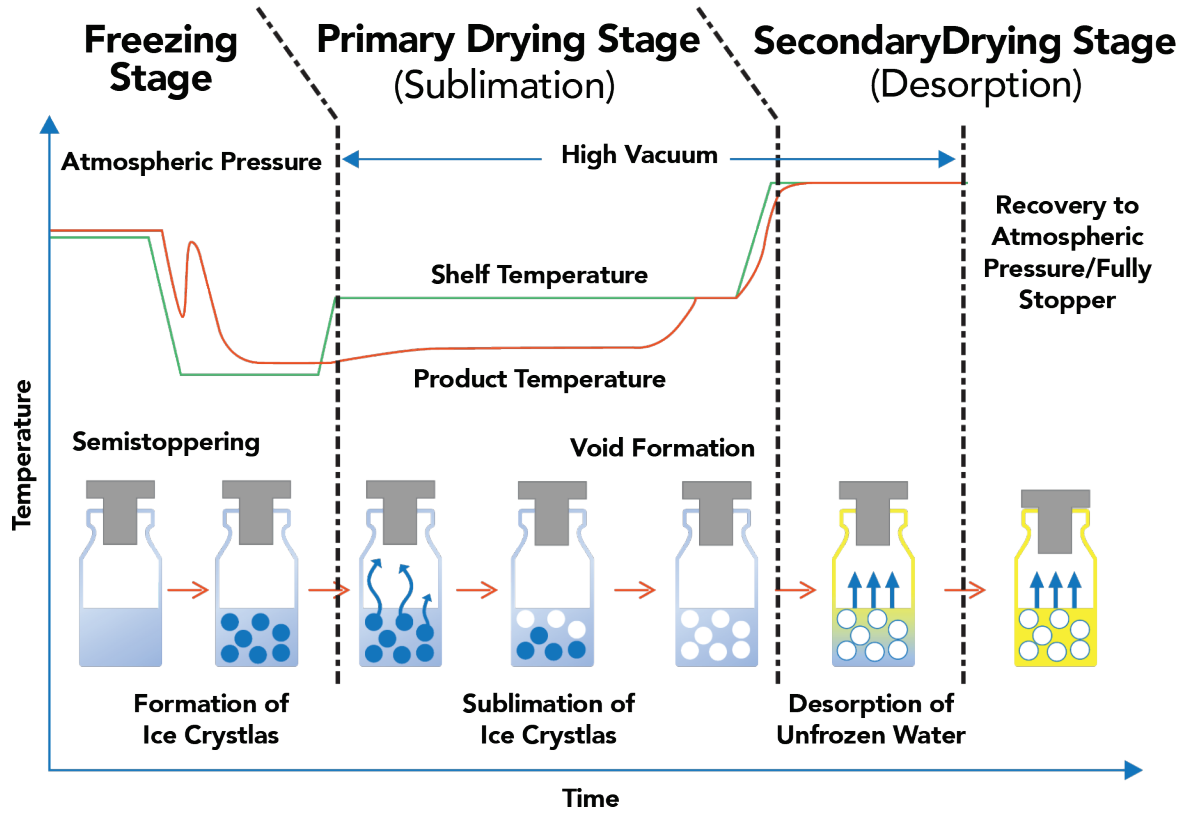
The curing process adds another layer of complexity. Properly curing cannabis involves storing the dried flower in additional tightly controlled environments to allow for the breakdown of chlorophyll and the development of desirable terpenes. However, this process requires patience and attention to detail, as the timing and conditions must be carefully calibrated too. Rushing or neglecting the curing phase can result in harsh or grassy-tasting buds that fail to meet consumer expectations. What is more, curing large quantities of cannabis is logistically burdensome as every seasoned operator knows. It requires adequate storage space, careful monitoring of humidity levels, and precise handling to prevent damage or contamination.

The challenging standard drying and curing process, especially at scale, is viewed by today's cultivators as a necessary evil in order to deliver a competitive finished product. As we'll show, this historically one lane-only path from garden to shelf is no longer the sole option, and for a multitude of reasons, is one many growers will elect to move on from to newer, better techniques such as lyophilization.

Pictured: traditional scissor trimming of dried material

The Science Behind Lyophilizing Cannabis

Lyophilization, more commonly known as freeze drying, is a specialized drying technique first discovered in in 1906 that preserves the integrity and quality of sensitive materials, including cannabis and hemp[5]. While freeze dryers are now routinely used in cannabis to dry premium ice water hash, they are otherwise scarcely leveraged but find extensive applications in various businesses, primarily pharmaceuticals, food, and biotechnology. In the pharmaceutical industry, freeze drying preserves the integrity and efficacy of delicate drugs, vaccines, and biological materials, ensuring their long-term stability and extending their shelf life. In the food industry, freeze drying enables the preservation of flavors, nutrients, and textures in food products, which also allows for extended storage without the need for preservatives[6]. Lyophilization is depended upon by some of the largest industries in the world because it can be very finely tuned to the specific desiccation needs of each individual product and affords a much greater degree of



How lyophilization works[7]

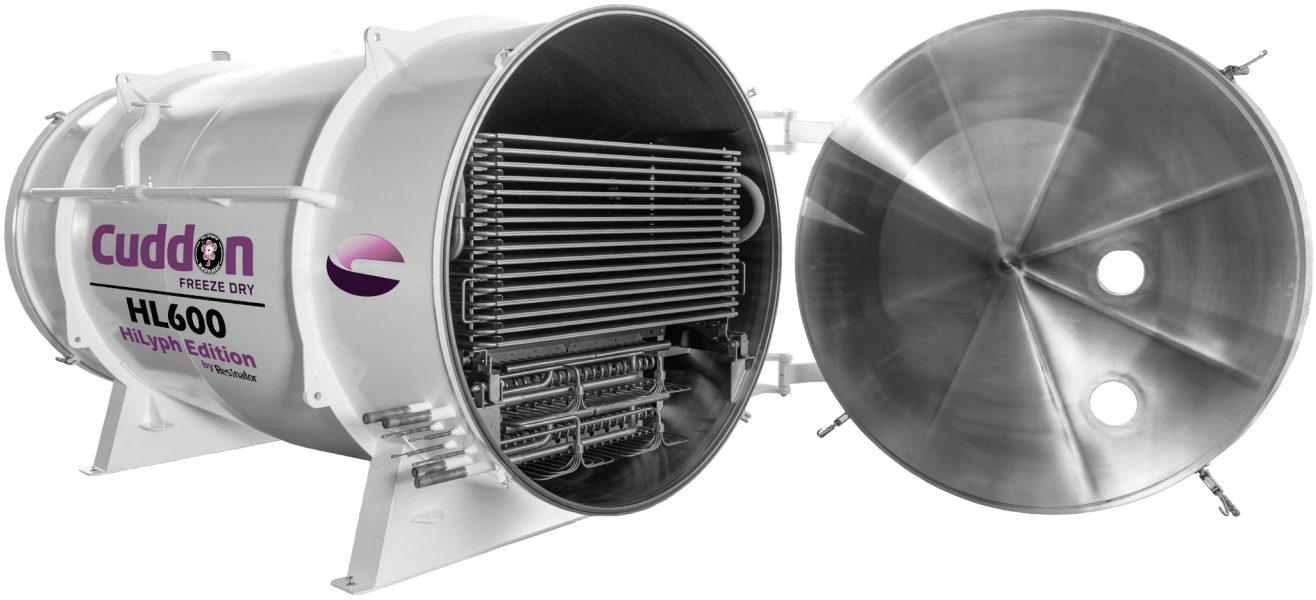
consistency than any air drying equivalent. When it comes to cannabis and hemp, the requirements for drying freshly harvested or frozen inflorescences is virtually identical to these other massive global industries. Freeze drying mitigates the guesswork and artistry out of the procedure, which gives operators more dependable results in less time.

Freeze drying involves freezing the product and then subjecting it to a vacuum, causing the frozen water content to sublimate directly from solid to vapor without passing through the liquid phase. By removing moisture through sublimation, lyophilization prevents the formation of ice crystals, which can damage the cellular structure and compromise the quality of the cannabis. The resulting dried product retains its original shape, size, color, flavor, and increases economically valuable compounds such as cannabinoids as well as terpenes, as we'll validate in the next section. Freeze drying cannabis or hemp also ensures enhanced potency, shelf life, as well as rehydration properties. Lyophilization has begun to emerge as a preferable method for drying cannabis due to its ability to preserve the plant's subtle live essence, which commands a sharp premium in the world of concentrates, and maximize overall quality significantly faster compared to standard drying and curing techniques.

It would be natural for any reader up to this point to be experiencing some level of skepticism. If lyophilization of cannabis has so much utility, then why isn't it common practice already? The answer is that until just recently, performing satisfactory lyophilization of cannabis and hemp simply hadn't been figured out yet, let alone scaled for commercial operations. At the outset, you need to be able to gently trim material while it's still fresh or ideally frozen, which in of itself requires special technique and care including precise cold storage practices. Then you have to carefully construct freeze drying cycles with the exact right amount of vacuum pressure at the right temperature and over the optimized timed stages, accompanied with precision monitoring of product conditions to ensure the buds are dried just enough.

Precise vacuum pressure is crucial for freeze drying cannabis to preserve terpenes effectively. It's the trichomes that contain most of these valuable organic compounds, which are protected by a waxy membrane. If the vacuum pressure is set too low, creating a significant pressure difference, the membrane may rupture, leading to the release and evaporation of the most volatile terpenes. Striking a balance with vacuum pressure, along with temperature and drying time control, is vital to maintain the integrity of the entire trichome for a more potent, flavorful dried flower.

Growers have been working at this for many years, mostly unsuccessfully. Home and



Pictured: Cuddon Hi-Lyph edition freeze dryer, which is capable of producing 75 dried lbs (from 300 wet lbs) of cannabis or hemp every 24 hours.

hobbyist-oriented freeze dryers simply don't offer enough cycle control or capacity, whereas commercially available equipment typically needed a highly experienced science-minded staff member to use correctly. Early attempts at freeze drying whole flowers usually resulted in an overdried, crispy styrofoam-esque end product bud. When all utility and labor factors are weighed, most cultivators will be pleasantly surprised at how modest the costs tend to be when running even larger freeze dryers, to say nothing of smaller units.

After five years of research and development, Industry Processing Solutions in tandem with The Original Resinator have created and patented their proprietary and award winning Crop-to-Cure® method that has perfected the process of Cryo-Trimming® and freeze drying cannabis and hemp flowers. While freeze drying cannabis does require capital investments to begin, ROI is often achieved in 1-2 years on commercial models and contract-based tolling arrangements are also becoming more common. Options exist today to produce anywhere from 1 to 300 or more dried pounds of flower per day in a single freeze dryer unit. This method can now be performed at both boutique and industrial scale so that cultivators of all sizes and requirements can gain a competitive advantage.

The Benefits of Lyophilizing Cannabis and Hemp

In today's hyper competitive cannabis market, any edge cultivators can achieve in terms of efficiency, elimination of waste, bud retention, space recapture, potency, and most importantly consumer product appeal are key difference makers when it comes to profits and losses. In many cases, simply offering a genuinely new product that no one else has is more than enough to dramatically boost sales and brand recognition. That's where live dried comes in, whose moniker is denoted in correlation to live bubble hash, live rosin, or hydrocarbon-made live resin, being that a product can only be called "live" if it was processed from live or fresh frozen plant material. The Crop-to-Cure® protocol is the most effective process by which cultivators can trim and dry their cannabis or hemp, and offers many benefits for operators that traditional drying methods cannot.

Increased Potency

Extensive lab testing has proven that properly lyophilized cannabis can retain significantly more cannabinoids and terpenes compared to traditional drying and curing techniques, sometimes as much as 10-15% more. For example, identical strains that test at 24% total cannabinoids under standard drying procedures can test at as much as 27% or more when employing Crop-to-Cure® methodology instead of traditional dry and cure procedures. Over time, these gains in potency can translate to greater buyer interest, extract yields, and sales potential.

Strain:
Lemon Cherry Gelato

Traditional Dried Test Results:

Total Cannabinoids:
24.03%

Total THC:
21.18%

Scan to view full results

Live Dried Test Results:

Total Cannabinoids:
27.46%

Total THC:
23.17%

Scan to view full results

14.27% more potent!

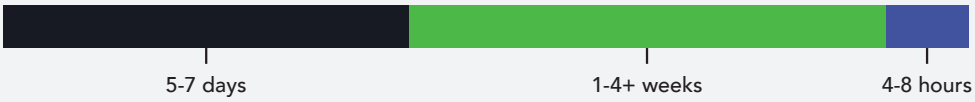
Reduced Time to Market

Lyophilization techniques enable cultivators to take their crop from the garden to testing and package ready in a day or two, instead of multiple weeks or over a month. This also allows growers to trim and freeze their crop for future processing on demand, so that they can always offer a fresher, live dried flower instead of being forced to dry their entire harvest all at once, which degrades quickly. According to a peer reviewed article on cannabis storage protocols, freezing cannabis is by far the best way to preserve cannabinoids and fresh frozen buds in airtight bags can last for years with minimal degradation[8].

Traditional Dry vs. Crop-to-Cure® Timeline Comparison

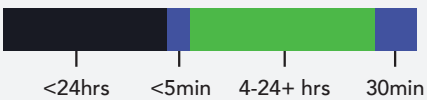
Drying Curing Trimming *Based off of 1lb processed*

Traditional Dry Timeline



Total Time = 3+ weeks

Crop-to-Cure® Timeline



Total Time = < 2.5 days

Enhanced Consumer Appeal

Cannabis and hemp flowers that have been freeze dried correctly don't experience any loss of volume while maintaining their original color, shape, and "live" aroma. How a product looks and smells on the shelf are key signaling mechanisms to prospective purchasers, and exacting lyophilization drying improves these sensorial cues. Live dried is instantly recognizable as a high quality product that can command a top shelf price point.

Creates a Truly Differentiated Product

Live dried cannabis is currently uncommon or non-existent on most dispensary shelves, which gives brands the rare opportunity akin to being an early solventless pioneer the chance to sell a high quality offering that their competitors aren't. The value of bringing a legitimately new category of product is extremely high in today's markets.

Eliminates Mold, Mildew, & Pests During Drying

When plants are exposed to open environments during the drying and curing process, if humidity controls aren't perfect, the chance for microbial growth or pest infestation becomes much higher. Lyophilized drying eliminates that possibility by bringing cannabis or hemp flowers down to below -34°F or -36°C during freeze cycles, which stop any present microbials in its tracks.

Requires Less Space

Even some of the largest Cuddon Hi-Lyph edition freeze dryers used in the Crop-to-Cure® process only take up a small portion of the space typically required for standard drying and curing techniques. Given the true cost of each square foot at modern licensed facilities when permitting, licensing, and maintenance is factored in, every inch of an operator's floor space must be used to its full potential.

Potential for Increased Extraction Yields

Freeze dried cannabis and hemp flowers can be extracted in all the same ways that traditionally dried and cured ones can, but offer the unique benefit of increased cellular porosity while maintaining a live terpene profile. This means that in a variety of cases from hydrocarbon to solventless ice water extraction, increased yields and potency are possible with certain strains. For hemp cultivators specifically, even marginal final increases in total CBD, CBG, and other commodity cannabinoids can lead to meaningful additional revenue.

Conclusion

Although it has been a very long time coming, cultivators of cannabis and hemp finally have a premium alternative method to traditional drying and curing techniques that demands serious consideration. Due to its ability to preserve more cannabinoids and terpenes, bring flower to market faster, and many other important profit-driving perks, lyophilizing as a drying method is in the process of quickly rising to prominence with growers and consumers alike. The technique allows cultivators to maintain the integrity of the plant, resulting in a premium product that commands a higher retail price point and reduction in labor cost resulting in greater potential for increased revenue. With its numerous benefits, freeze drying presents a compelling solution for commercial cultivators looking to maximize the value and marketability of their cannabis.

Ready to talk to an expert about how Crop-to-Cure® can revolutionize your cultivation efforts?

Service:

1-833-444-0420

info@industryprocessingsolutions.com

www.industryprocessingsolutions.com

Equipment:

1-877-RESINATOR (737-4628)

info@theoriginalresinator.com

www.resinator.com

References

1 https://mjbizdaily.com/us-cannabis-sales-estimates/

2 https://www.statista.com/statistics/1067467/cbd-product-dollar-sales-us/

3 https://bdsa.com/content/pricing-compression-in-an-evolving-cannabis-market-2/

4 https://www.headset.io/industry-reports/an-analysis-of-declining-growth-in-recent-us-cannabis-sales

5 https://www.ift.org/news-and-publications/food-technology-magazine/issues/2018/february/columns/processing-freeze-drying-foods#:~:text=Freeze%2Ddrying%20was%20invented%20by,of%20heat%2Dsensitive%20biological%20materials.

6 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7603155/

7 https://www.researchgate.net/figure/a-Schematic-illustration-of-lyophilization-process-Green-and-red-curves-represent-the_fig1_332893430

8 https://www.sciencedirect.com/science/article/abs/pii/S0379073818308818

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