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ETHOS X INFOPACK

TERPENE EXTRACTION



Thank you for your interest in Milestone's ETHOS X Solvent-Free Terpene Extraction Solution. This Infopack will help you learn how the ETHOS X can enhance your production of high quality terpenes from Cannabis.

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MAXIMIZE YOUR **CANNABIS** TERPENE PROFILE



ETHOS X: Microwave Terpene Extraction



THE GREATEST EFFICIENCY WITH THE HIGHEST QUALITY

Multiple US states, along with other countries, permit the use of cannabis for medicinal and recreational use, greatly increasing the market for cannabis-related products. THC, CBD and terpenes are the major target compounds in the cannabis plant. Although there are several technologies available to extract THC and CBD, they are not designed to selectively extract terpenes, and thus often lead to loss, damage or only partial extraction of these molecules. Terpenes from cannabis plants are extremely valuable as they are responsible for the strain-specific variation in smell, taste, and effects of cannabis. Due to their unique flavor, they are widely used as ingredients for multiple end-products, such as vape pens and edibles, just to mention a few. Terpenes are also used in the medicinal field as they can enhance the therapeutic effects of THC, CBD, and other cannabinoids.

HIGHEST QUALITY TERPENES
FOR A FULL FLAVOR PROFILE

EXTRACT FROM FRESH
OR DRIED MATERIAL

SHORTER RUN-TIMES
FOR FASTER PROCESSING

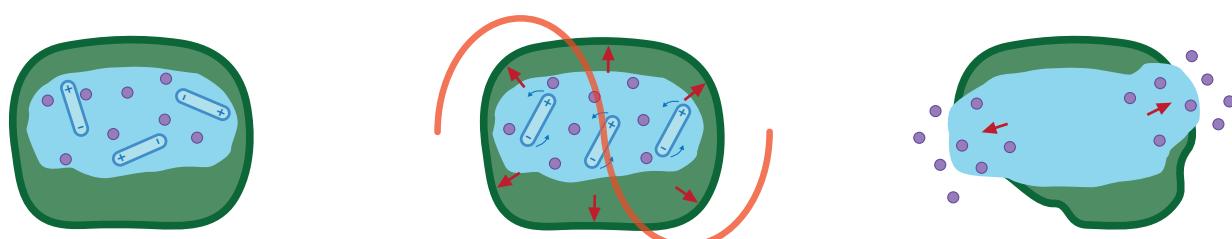
FLEXIBLE CONFIGURATIONS
TO MEET THROUGHPUT NEEDS



MILESTONE ETHOS X

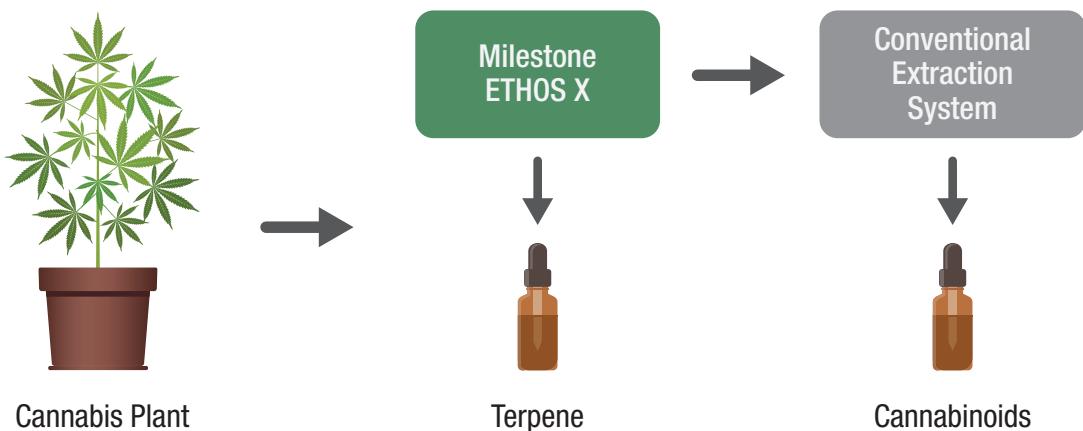
To address the limitations of conventional extraction techniques Milestone has developed and patented (European patents EP 1 439 218, EP 1 618 798 and EP 1 629 725) the ETHOS X for Microwave Green Extraction of Natural Products. The ETHOS X takes advantage of a unique microwave selective heating mechanism. The internal heating of water within the sample distends its cells and leads to rupturing of the glands and oleiferous receptacles. This process frees the oils which are then evaporated with the in-situ water of the plant material.

PERFECTLY FIT FOR CANNABIS EXTRACTION



Effect of the microwave selective heating on the plant cells

The most common extraction techniques used in the cannabis field are: hydrocarbon, ethanol and CO₂ extraction. The ETHOS X is a perfect complement to any extraction technique as it selectively extracts the terpenes without compromising the subsequent cannabinoid extraction step. Most conventional extraction systems work on dry plant material, causing loss of some of the characteristic terpenes, while the ETHOS X works on fresh material providing the most complete and representative terpene profile and maintaining the natural flavor and aroma. The ETHOS X completes the extraction process in only a few minutes without the use of solvent, providing high efficiency, reducing the process costs and ensuring the strain-specific profile of the plant.



Scheme of typical terpene and cannabinoid extraction processes using ETHOS X

THE EXTRACTION PROCESS

Fresh, frozen or even dry cannabis are placed into the ETHOS X vessel; instrument setup takes only a few minutes and the extraction process starts. The microwave heating allows a quick evaporation of the target compounds along with the water content of the plant material; the oils and water re-condense into a dedicated stainless-steel water-cooled apparatus, and are then separated in two phases based on the different densities. The oils (terpenes) are easily separated and collected into a dedicated flask. As the ETHOS X doesn't compromise the THC and CBD, the terpenes-free cannabis can then be processed by any conventional extraction technique to obtain these compounds.

Cannabis material	Fresh, frozen or dry
Sample amount	Up to 3 Kg
Typical extraction time	Less than 60-90 minutes

HIGH-QUALITY TERPENES AT LOW COST

The ETHOS X microwave technology allows for quick heating of the cannabis material. The extraction process takes only a few minutes and prevents any thermal degradation often noticed during use of conventional extraction methods. The fresh and characteristic taste of strain-specific cannabis is maintained, and high-quality terpenes are assured. In addition to providing this full profile terpene extraction, its simple setup and shorter run-times allow the ETHOS X to provide significant return on investment.

SCALABLE PRODUCTIVITY THROUGH FLEXIBLE CONFIGURATION

The Milestone ETHOS X microwave cavity has a volume of 70 liters, allowing use of glass reactors from 2 to 12 litres of volume. All the reactors are interchangeable, meeting day-to-day needs with maximum flexibility.



2, 5 and 12-liter glass reactors

EASY EXTRACTION APPROACH TO A FULL TERPENE PROFILE

MILESTONE HELPING CHEMISTS

Established in 1988, Milestone is headquartered in Italy and has offices in Germany, Switzerland, the United States, China, Japan and Korea. We operate worldwide through a network of over 100 exclusive distributors, all providing our customers premium application and service support. Milestone's mission is to help chemists by offering them the most advanced instrumentation for sample preparation and direct mercury analysis in the world. Our industry-leading technology, in combination with fast, responsive service and applications support, allows Milestone to support our goal of providing you the highest return on investment possible.

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I ETHOS X VIDEO



Learn how the Milestone ETHOS X enables cannabis processing labs to run fast extractions on fresh or dry material, allowing them to achieve a complete terpene profile with a pure smell and taste.

→ **see the ETHOS X Video**



IMPROVING THE QUALITY AND EFFICIENCY OF TERPENE EXTRACTION FROM CANNABIS PLANT

Highly efficient microwave processing of terpenes with the Milestone ETHOS X

| INTRODUCTION

As the cannabis industry matures, it creates additional opportunities for cannabis processors and growers for both medicinal and recreational use. Originally cannabis processors focused on designing efficient extraction processes to maximize the THC and CBD extraction, while other key molecules were not considered, such as the strain-specific terpenes in the plant. Along the multitude of different technologies available the most common techniques used in the cannabis market are light hydrocarbon, ethanol, or supercritical fluid extraction. Many cannabis extract producers understand that during their extraction procedures terpenes are lost or

degraded, losing a pivotal component of the plant. Terpenes and terpenoids are small molecules synthetized by the cannabis plant, well known for their characteristic taste and smell. These molecules are predominantly used for flavoring in edible and recreational products. Terpenes are volatile molecules and they might be lost in the drying step, fundamental for most ethanol and supercritical fluid extractions. To address the limitations of the conventional extraction techniques, Milestone has developed and patented (European patents EP 1 439 218, EP 1 618 798 and EP 1 629 725) the ETHOS X for the Microwave Green Extraction of Natural Products. The ETHOS X takes advantage of

APPLICATION REPORT ETHOS X | TERPENES



the unique microwave selective heating mechanism. The internal heating of the water within the sample distends its cells and leads to rupturing of the glands and oleiferous receptacles. This process is extremely fast and terpenes are completely evaporated by the in-situ water of the plant material without any previous sample preparation typically required for other extraction approaches. The ETHOS X process leads to the efficient and fast production of terpenes, providing a complete terpene profile with superior quality over all the other extraction

techniques. Cannabis extract producers can integrate Milestone's ETHOS X into their process, maximizing the extraction capabilities, and therefore profitability, of their entire process as represented in the Figure 1.

This technical note describes how the cannabis plant can be processed using Milestone's ETHOS X to produce high quality flavoring terpenes, while preserving the quality of the cannabis plant material for the further processing for THC and CBDs extraction with conventional techniques.

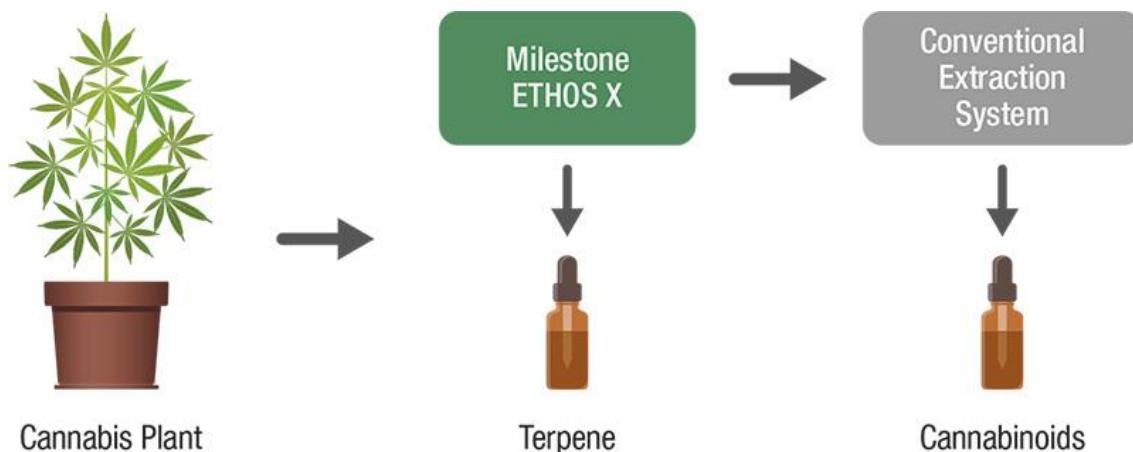


Figure 1 - Cannabis processing diagram with Milestone ETHOS X

| EXPERIMENTAL INSTRUMENT

The ETHOS X meets the requirements of the growing demand for production of high-quality terpenes expressing the complete terpene profile of the cannabis plant, thanks to its unique benefits, such as:

- Solvent-Free Extraction for Highest Quality
- Shorter Run-Times Combined with User-Friendly Platform
- Flexible Configuration for the Widest Range of Lab Needs
- Market-Leading Innovation, Safety, and Technology

APPLICATION REPORT ETHOS X | TERPENES



Developed and patented by Milestone, the ETHOS X is the unique benchtop microwave extraction system able to provide production scale capability in the shortest processing time. It has been specifically designed for production, with the stainless-steel distillation module for and easy use and handling.



The ETHOS X, with its high sample capacity, up to 12 L, is simply the most productive, fastest, easiest and most efficient extraction system for terpene extraction ever made!

SAMPLE AND REAGENTS

- Cannabis sample: OGKB 2.0 strain
- Distilled water.

TYPICAL PROCEDURE

1. Cannabis sample weight vary based on the ETHOS X reactor volume, see the table below for detailed information:
 - a. Fresh material, weight it directly in the 5 L ETHOS X glass extraction reactor

- b. Fresh frozen material, weight it directly in the 5 L ETHOS X glass extraction reactor, wait 30 min to thaw before proceeding with the extraction
- c. Dry material, the plant material has to be moistened prior to start the microwave extraction
2. Close the reactor with its glass cover, place it inside the ETHOS X, assemble the stainless-steel distillation module and connect to the water chiller.
3. Run the microwave program as shown in table 1.
4. Pure terpene products are collected into the stainless-steel distillation module.

REACTOR SIZE	SAMPLE AMOUNT	MICROWAVE POWER
Small (2 L)	up to 400 g	400 W
Medium (4 L)	up to 1500 g	1500 W
Large (12 L)	Up to 3000 g	1800 W

Table 1 - ETHOS X suggested working conditions

RESULTS AND DISCUSSION

The aim of the study was to prove that the ETHOS X will efficiently extract the complete terpene profile of cannabis without degradation of the cannabis material, allowing for further processing to obtain the cannabinoids (including THC and CBD) by conventional extraction techniques.

In this specific work, terpene extraction was performed on fresh frozen OGKB 2.0 strain working on 1 kg of cannabis with the 5 L ETHOS X reactor. The sample was microwave-treated at constant power for 40 min. After 10 min, the terpene fraction started to be collected in the distillation

APPLICATION REPORT ETHOS X | TERPENES



module, above the water layer. The extraction was completed after 40 min when the terpenes were completely extracted. At the end of the extraction, the terpene fraction was collected from the glass distillation module, frozen for 30 min to remove extra water and then stored in a fridge at 4°C.

The ETHOS X provided a superior terpene fraction with characteristic fragrance and flavor profile of the original fresh cannabis plant. This was possible thanks to the ability of the ETHOS X to quickly process fresh material, protecting the valuable molecules from the oxidation processes.

The terpene fraction was analyzed via GC-MS providing the fingerprint of the extract.

ETHOS X EXTRACT - Total Yield* 1.59%

D-Limonene

β-Myrcene

Linalool

α-Humulene

α-Pinene

trans-Nerolidol

β-Pinene

cis-Nerolidol

Camphene

*by weight

Table 2 - List of the main terpenes in the ETHOS X extract
(from OGKB 2.0 strain)

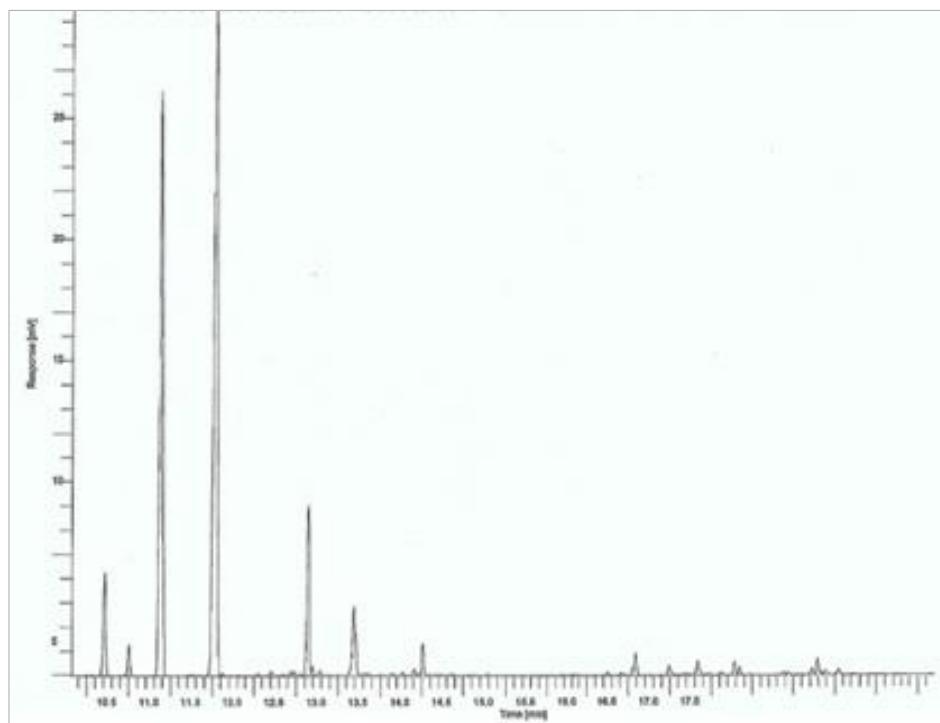


Figure 2 - GC-MS profile of the ETHOS X extract

APPLICATION REPORT ETHOS X | TERPENES



To conclude the evaluation, the cannabis material has been extracted before and after the ETHOS X treatment with closed-loop hydrocarbon extraction to collect the cannabinoids.

	Plant Raw Material ^b	ETHOS X extract	ETHOS X processed plant material ^d
Terpenes ^a	1.4	1.6	0.1
Total Cannabinoids ^a	78	- ^c	77

Table 3 - Recovery data of terpene and total cannabinoids from the described processing step in Figure 1

^a Data are calculated in yield by weight

^b Extracted with close-loop hydrocarbon extraction system

^c Not detected (<LOQ)

^d Cannabis plant material extracted with close-loop hydrocarbon extraction system after Ethos X process.

The potency analysis (Table 3) shows that the ETHOS X did not affect the yield or quality of the cannabinoids (78% in the raw material vs 77% in the processed material). Moreover, the ETHOS X extract is free of cannabinoids, avoiding the need for a purification step. The very low content of terpenes in the ETHOS X processed plant material confirms the ability of the ETHOS X to efficiently extract the terpene molecules in 40 min process.

This provides a better solution for cannabis processors to extract their cannabis derived terpenes and then continue the extraction for cannabinoids with any of the traditional methods.

CONCLUSIONS

The data shown in this work, demonstrates that the ETHOS X maximizes the extraction of terpenes from cannabis material, without compromising the quality of the THC and other cannabinoids extracted in the following process. Its ability to work with fresh material produces a superior terpene profile that is unmatched by conventional extraction techniques. Moreover, the fast processing times ensures the integrity of all cannabinoids, enhancing the overall efficiency in the cannabis processing industry and ensuring fast return on investment.

Milestone's ETHOS X is proven to be a unique and beneficial tool for cannabis processors, allowing them to obtain terpenes with unmatched quality and completeness, ready to use for flavoring for flavoring in edible and recreational products without effecting the cannabinoid quality and extraction process.



| CUSTOMER

Medizin is a premier cultivator, producer and dispensary of cannabis related products based in Las Vegas, NV. Their mission is to provide compassionate, dignified, and affordable access to medical and recreational cannabis for approved patients. They are committed to providing a wide range of the highest quality products suited to meeting the unique needs of each patient.

| CHALLENGE

Rapidly expanding departments for their finished products had been putting pressure on their production department, who was experiencing difficulties keeping up with demand.

| SOLUTION

"The ETHOS X is the only instrument on the market that can perform this technique. After seeing the unit in operation I was convinced that this instrument would improve our process and final product."

| BACKGROUND

Medizin is in the process of scaling up production to support aggressive corporate growth goals, with a focus on developing new products and optimizing manufacturing processes for maximum efficiency. Rapidly expanding departments for their finished products had been putting pressure on their production department, who was experiencing difficulties keeping up with demand.

| IMPLEMENTATION

A second challenge was sourcing terpenes for their new vape pen product line. Purchasing directly from third party vendors was either too expensive or yielded inferior products, thus they decided to research doing their own extractions in-house. What they found is the traditional technique of steam distillation is a longer extraction process than desired and is difficult to scale. Supercritical CO₂ extraction is expensive to implement and has limitations in the types of materials that can be used within the system.

"I think that Solvent-Free Microwave Extractors like the ETHOS X will become the industry standard for terpene isolation from cannabis" said Stephen Markle, Director of Infused Products.

LAB PROFILE MICROWAVE EXTRACTION | CANNABIS



| SOLUTION

The team elected to purchase an ETHOS X Microwave Extraction System from Milestone after a demonstration showcased its state-of-the-art technology completing a terpene extraction in less than an hour. Since the ETHOS X performs solvent-free microwave extraction requiring no preliminary clean-up or solvent exchange steps, a more complete terpene profile, and thus a higher quality product is produced.

"The ETHOS X is the only instrument on the market that can perform this technique. After seeing the unit in operation I was convinced that this instrument would improve our process and final product." - said Stephen Markle

| CONCLUSION

Medizin employs a team of full time chemists and lab technicians not only to develop new products, but also to optimize their extract manufacturing process for maximum efficiency.

"Since the ETHOS X has been installed, the isolation of terpenes now possible allows us to create a lot of different products that other manufacturers using CO₂ or butane extraction cannot." - stated Stephen Markle



"The speed, ease of use, and low level of maintenance has been a real bonus for our team of chemists carrying out the high workload of extractions."

– Stephen Markle, Director of Infused Products, Medizin

| FUTURE PLANS

Medizin is driven to produce the highest quality and most diverse range of cannabis concentrates in the entire state of Nevada, which they firmly believe is a result of the purity of extraction assisted by the ETHOS X. Such is the demand for their products that they will be scaling up production and opening the largest cannabis entertainment complex in the world in November 2018. It is their continuing wise investment in people and technology like the ETHOS X, which provides the scalable platform for this rapid growth.

| SOLVENT-FREE MICROWAVE EXTRACTION

The analytical procedure for essential oils and aromas from plant or spices comprises two steps: extraction by steam distillation, and analysis by GC or GC-MS. While the analysis step requires just a few minutes, extraction takes at least several hours. Even today the standard procedure is based on the Clevenger method, which dates back to 1928! To address the limitations of this 90-year-old technology, Milestone developed the new ETHOS X for the Microwave Green Extraction of Natural Products.

The ETHOS X performs solvent-free microwave extraction at atmospheric pressures of fragrances, such as terpenes and essential oils in plant material. These methods involve placing the sample in the microwave reactor. A cooling system outside the microwave continuously condenses the vapors which are collected in dedicated glassware, and the excess of water is refluxed back into the extraction vessel to restore the in-situ water of the sample. Once the essential oils have been extracted, they can be analyzed directly by GC-MS without any preliminary clean-up or solvent exchange steps.

Learn more at www.milestonesrl.com or request an on-site demonstration at marketing@milestonesrl.com

| ABOUT MILESTONE

With over 50 patents and more than 20,000 instruments installed in laboratories around the world, Milestone has been widely recognized as the global leader in metals prep technology for the past 30 years. Committed to providing safe, reliable and flexible platforms to enhance your lab's productivity, customers worldwide look to Milestone for their metals digestion, organic extractions, mercury analysis and clean chemistry processing needs.