

Safe Processing, Production, and Testing of Cannabis- and Hemp- Derived Products for Consumer Use

**MCAFDO-2020
Rogers, Arkansas –
February 25, 2020**

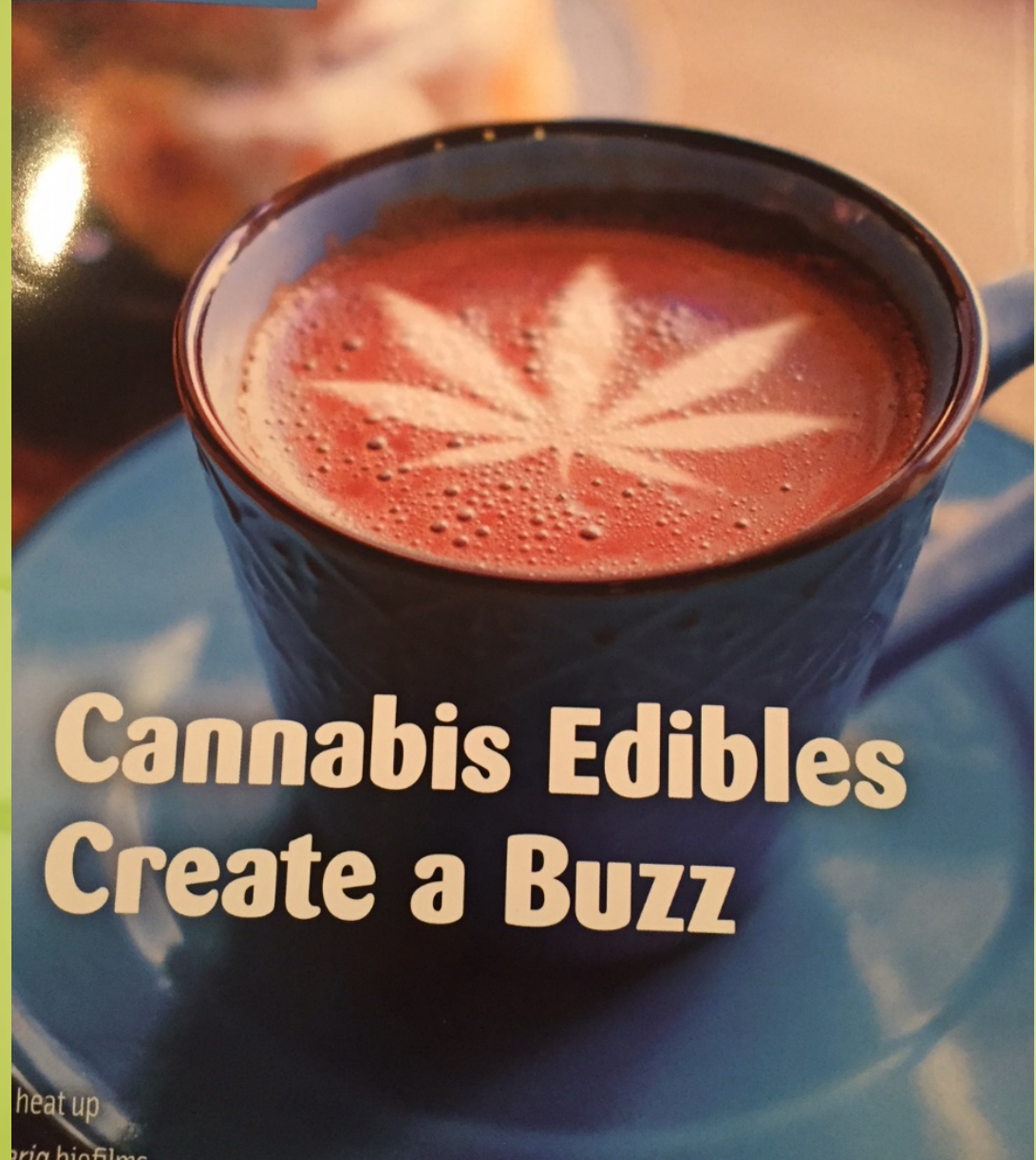
**Jerry W. King, CFS
Fayetteville, AR, USA**



CANNABIS - DEVIL OR ANGEL?

Presentation Content and Topics

- **Context of cannabis/hemp processing with respect to extracts and the post-processing of extracts and their use in food matrices**
- **The criticality in choosing the extraction method and solvent with respect to end use in foods**
- **Appropriate analytical methods for cannabis and hemp**
- **Processing optimization – importance of physicochemical data and its use in processing and product formulation methodology**
- **Examples of formulating food products employing cannabis extracts – important considerations**



Cannabis Edibles Create a Buzz

heat up
eria biofilms

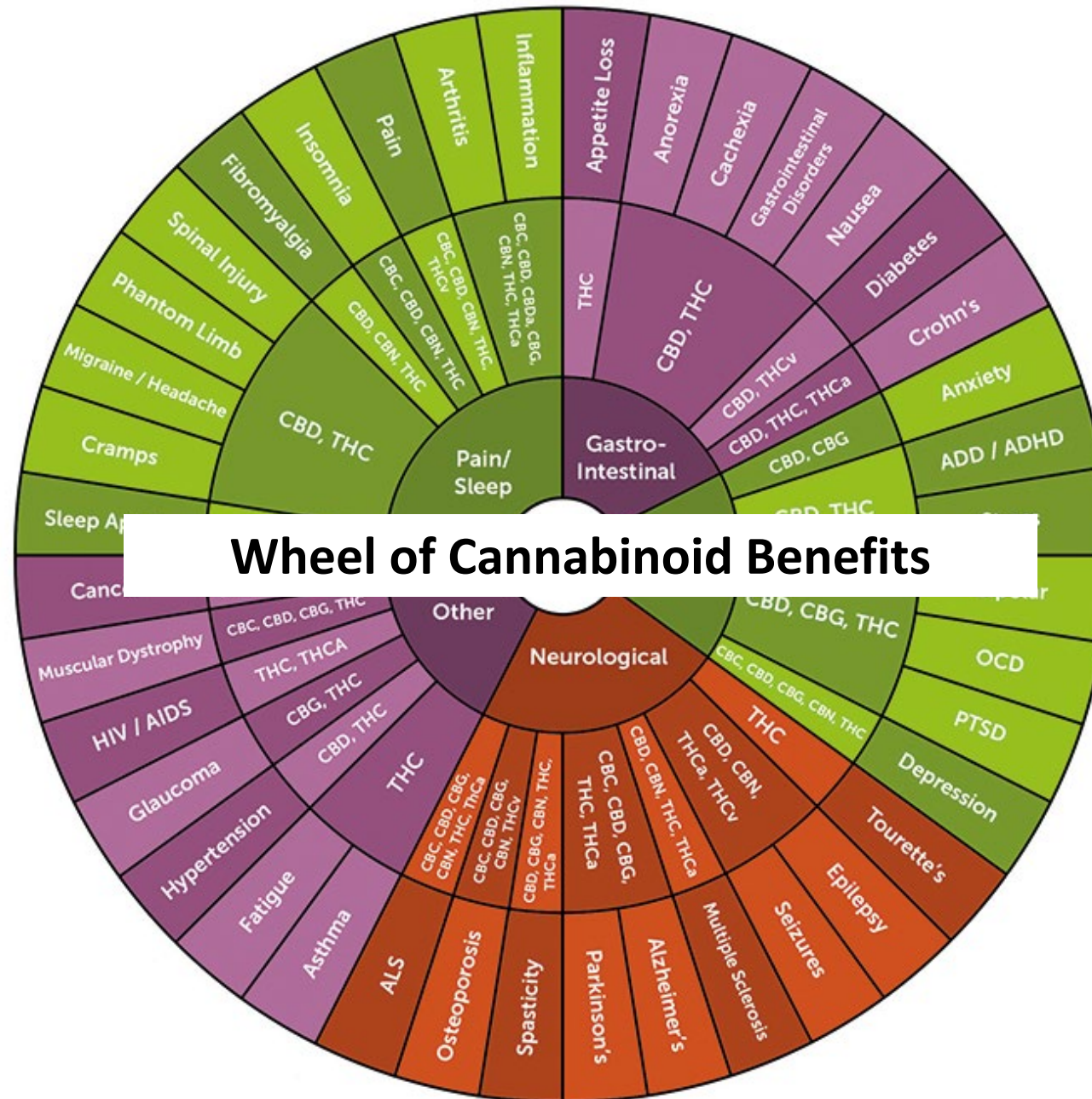
cannabis products

The Industry Resource for Developing Legal Cannabis Edibles & Beverages

DEVELOPING BEVERAGES AND GUMMIES

Plus supply-chain insights on
terpenes, safe packaging, filling
equipment and more

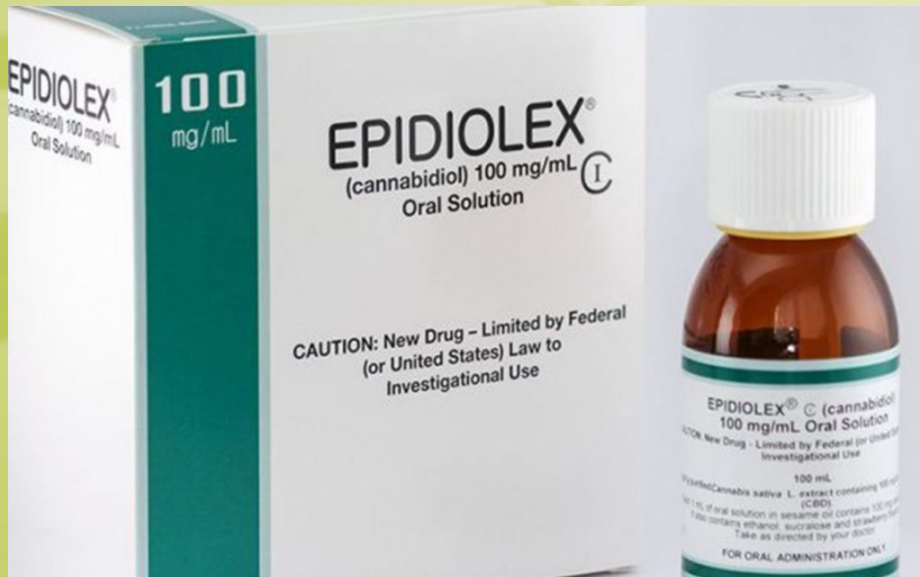




GW PHARMA FDA-APPROVED CANNABINOID-BASED DRUGS

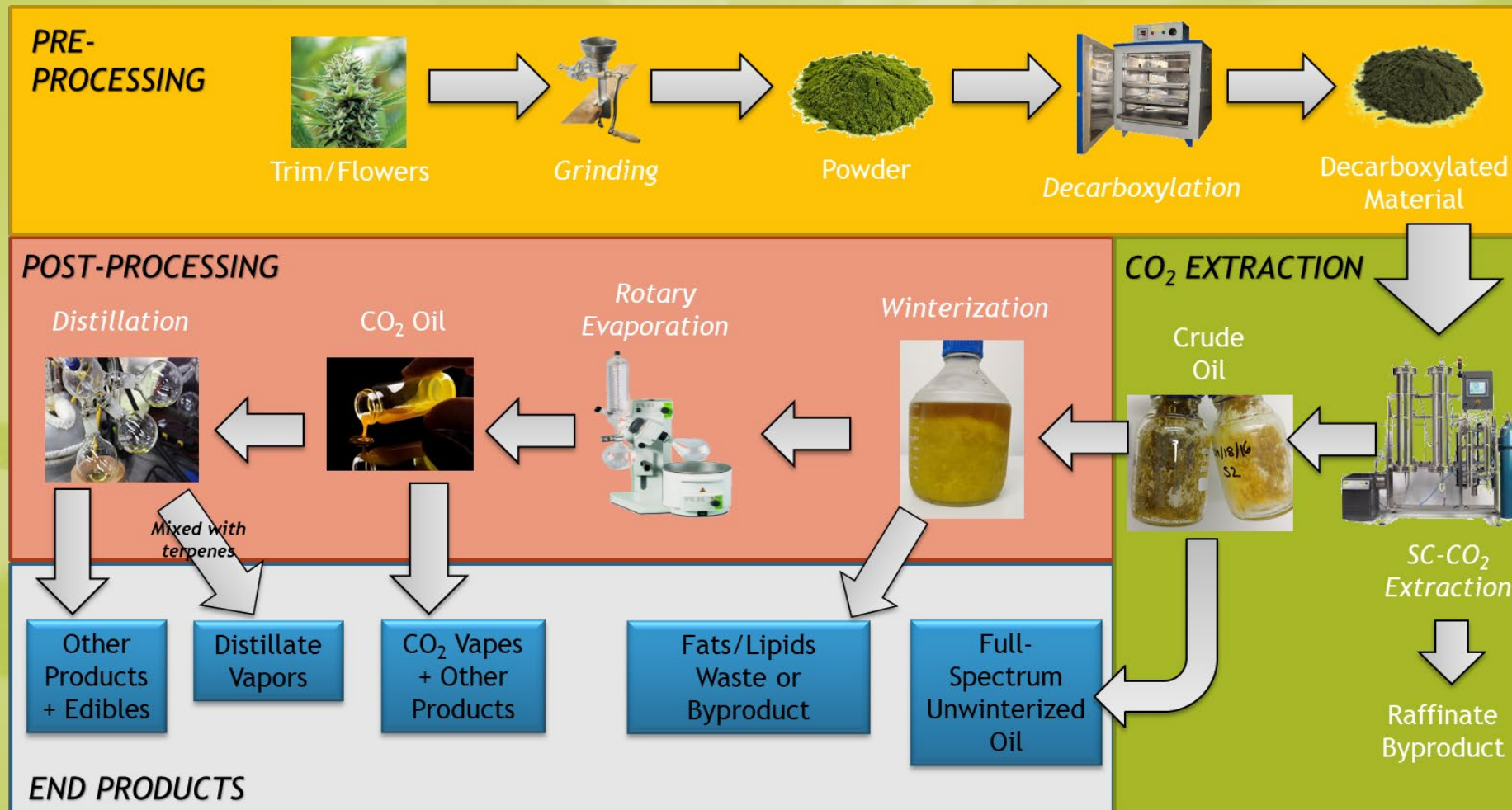


Sativex (by GW Pharma)
Approved in 2010 for
treatment of multiple
sclerosis
THC:CBD ~1:1



Epidiolex (by GW Pharma)
Approved by FDA in 2018 for
treatment of paediatric
epilepsy
98% CBD

Cannabis or Hemp Processing and Resultant End-Products





AURORA, COLORADO INDOOR CANNABIS GROW

GNgāti Kahungunu ki Wairarapa Morai-Tribal Hemp Plantation Tane nui a Rangi Operating Group – North Island-NZ



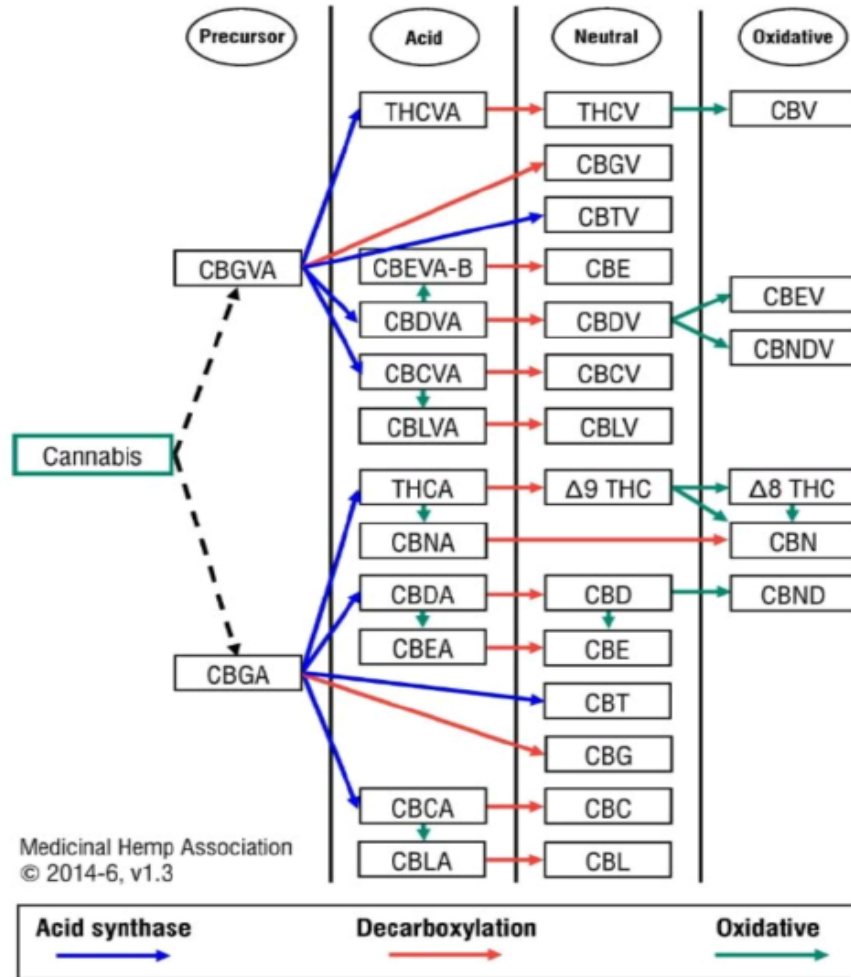
ARKANSAS HEMP GENETICS – FAYETTEVILLE, AR, USA



Components in Cannabis or Hemp

- Over 480 hundred compounds have been identified in cannabis
- Physiologically-active cannabinoids are responsible for imparting cannabis' medicinal and recreational benefits (10 major chemical sub-classes)
- Terpenoid-type compounds are responsible for characteristic flavor/odor of cannabis and they often occur at low levels in the extracted oil
- Other prominent classes are the carbohydrates, hydrocarbons, flavonoids, alkaloids, lignanamides, glycosides, and lipids, i.e. fatty acids

Cannabinoid Pathway



“MINOR” CANNABINOIDS

CBG = CANNABIGEROL
CBC = CANNABICHROMENE
CBL = CANNABICYLOL
CBV = CANNABIVARIN
THCV = TETRAHYDROCANNABIVARIN
CBDV = CANNABIDIVARIN
CBCV = CANNABICHROMEVARIN
CBGV = CANNABIGEROVARIN
CBGM = CANNABIGEROL MONOMETHYL ETHER



Terpenes – “Entourage Effect”

EXTRACTION AND PROCESSING FLUIDS UTILIZED FOR CANNABIS

- **Propane or n-Butane**
- **70% N-Butane/30% Propane**
- **L-CO₂ or Supercritical CO₂**
- **Ethanol**
- **Ethanol – Hydrocarbon Azeotropes**
- **Chlorofluorohydrocarbons**
- **Dimethyl Ether**
- **Water**

***Additional Non-Solvent Methods are also Used by Artisan Extractors such as Mechanical Pressing and Comminution to make Useful “Extracts”**

BUTANE EXPLOSION – NEW MEXICO





Hemp Roll-On - 7500 mg



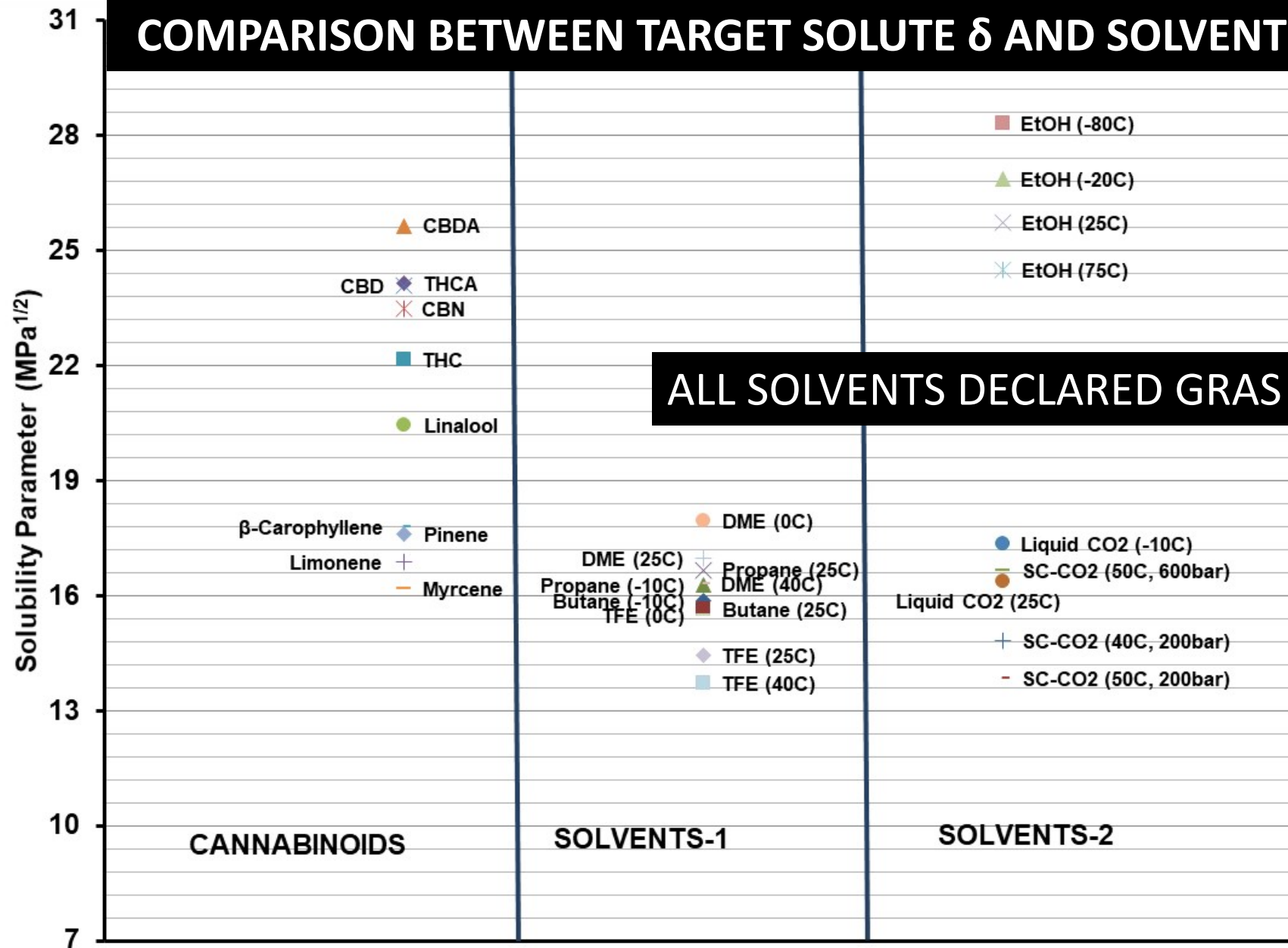
CO₂ EXTRACT

ETHANOL EXTRACT

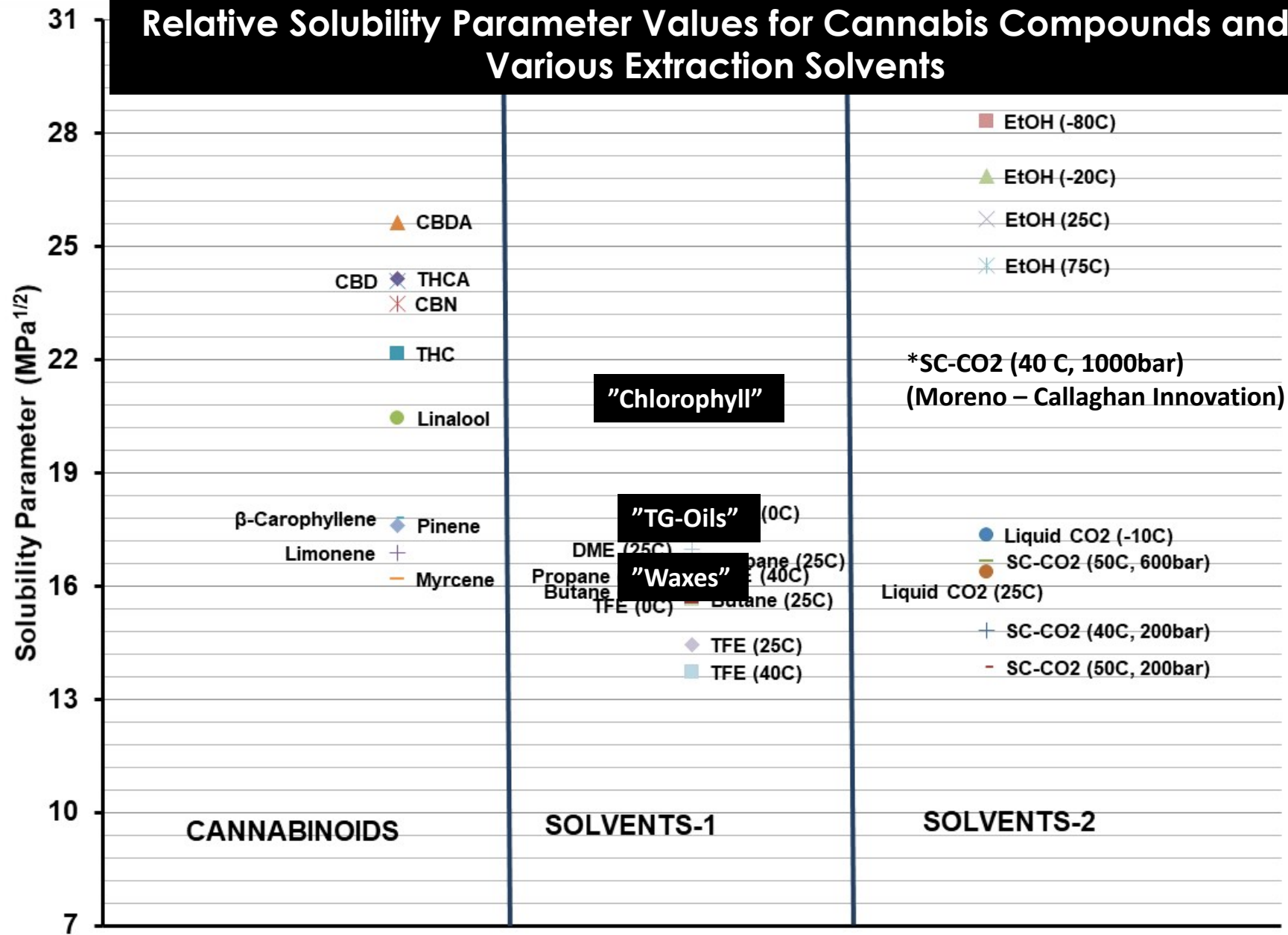


Concentrate After Wiped Thin Film Distillation

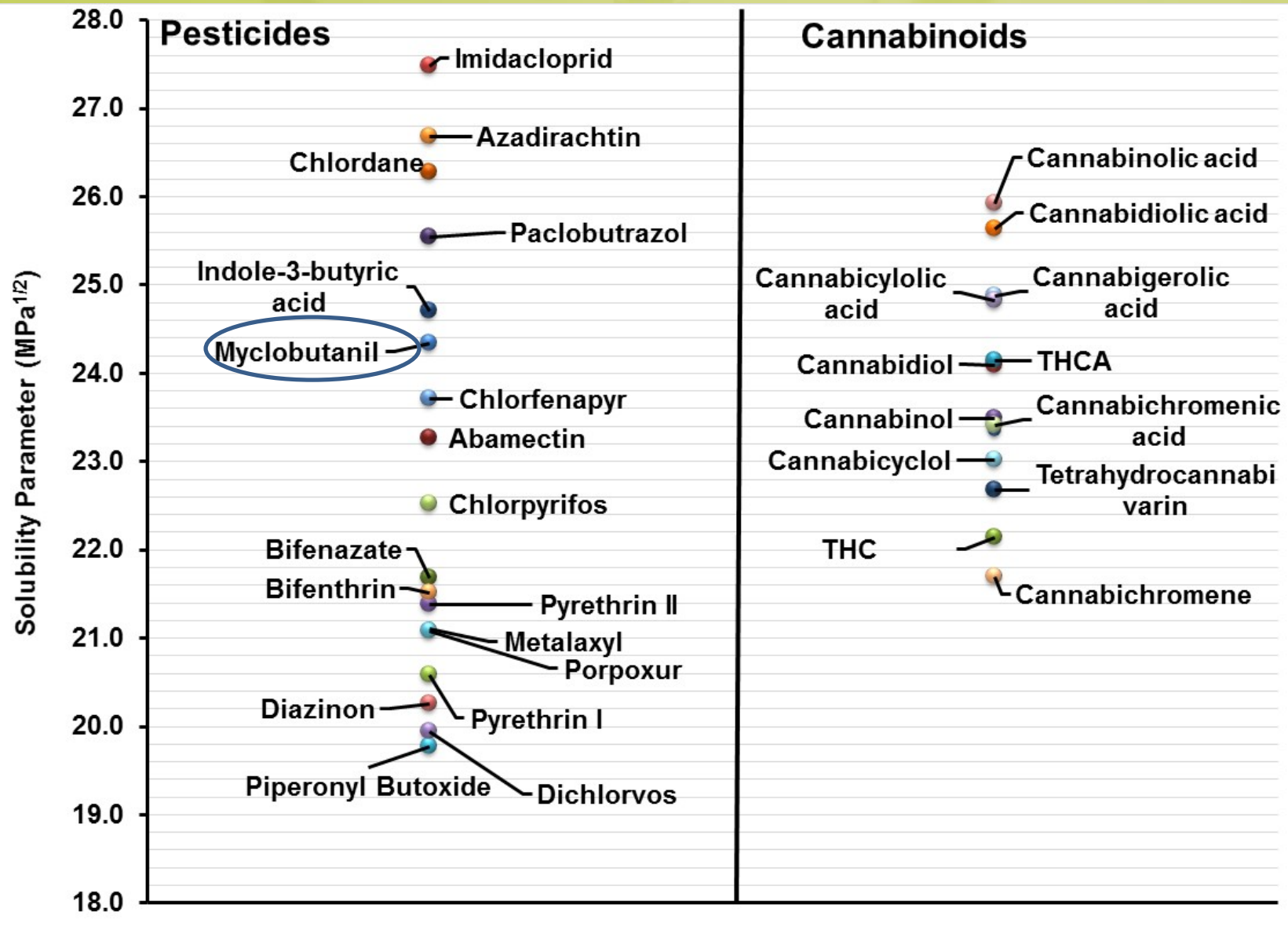
COMPARISON BETWEEN TARGET SOLUTE δ AND SOLVENT δ



Relative Solubility Parameter Values for Cannabis Compounds and Various Extraction Solvents



Pesticides vs. Cannabinoid Solubility Parameters



CURRENT CANNABIS ANALYTICAL REQUIREMENTS

Pesticides

LC and GC with MS or ECD

Terpenes

LC-MS or GC-MS

Heavy Metals

ICP, ICP-MS

Residual Solvents

GC or GC-MS

Moisture content

Moisture balances

Potency

LC or GC (also with MS detection)

Micro-organisms

Petri plates or qPCR

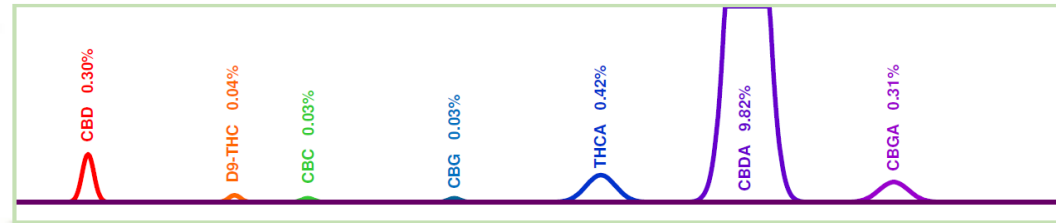
Test Certificate No.: 12537_CN
Sample: Wife Flower @ Harvest
Matrix: Bud

Customer: Chris Smith
Green Remedy
chris@greenremedy.com
502-533-8682

Date Received: 10/4/2016
Test Date: 10/4/2016
Technician: LA/JFD

CANNABINOID PROFILE [Procedure WI-10-04]:

This test method was performed in accordance with the requirements of ISO/IEC 17025. These results relate only to the test article listed in this report. Reports may not be reproduced except in their entirety.

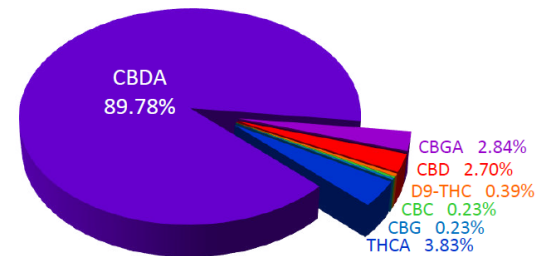


Total Cannabinoids Measured

Test	Weight %	Conc.
CBD	0.30%	2.96 mg/g
THCV	< 0.01%	< 0.10 mg/g
Δ9-THC	0.04%	0.43 mg/g
CBC	0.03%	0.25 mg/g
CBN	< 0.01%	< 0.10 mg/g
CBG	0.03%	0.25 mg/g
THCA	0.42%	4.19 mg/g
CBDA	9.82%	98.23 mg/g
CBGA	0.31%	3.11 mg/g
CBDV	< 0.01%	< 0.10 mg/g
Max THC	0.41%	4.10 mg/g
Max CBD	8.91%	89.10 mg/g
Total Active	0.39%	3.89 mg/g
Total	10.94%	109.41 mg/g

- CBD
- THCV
- D9-THC
- CBC
- CBN
- CBG
- THCA
- CBDA
- CBGA
- CBDV

Distribution of Cannabinoids



VISUAL AND MICROSCOPIC INSPECTION [Procedure WI-10-03]:

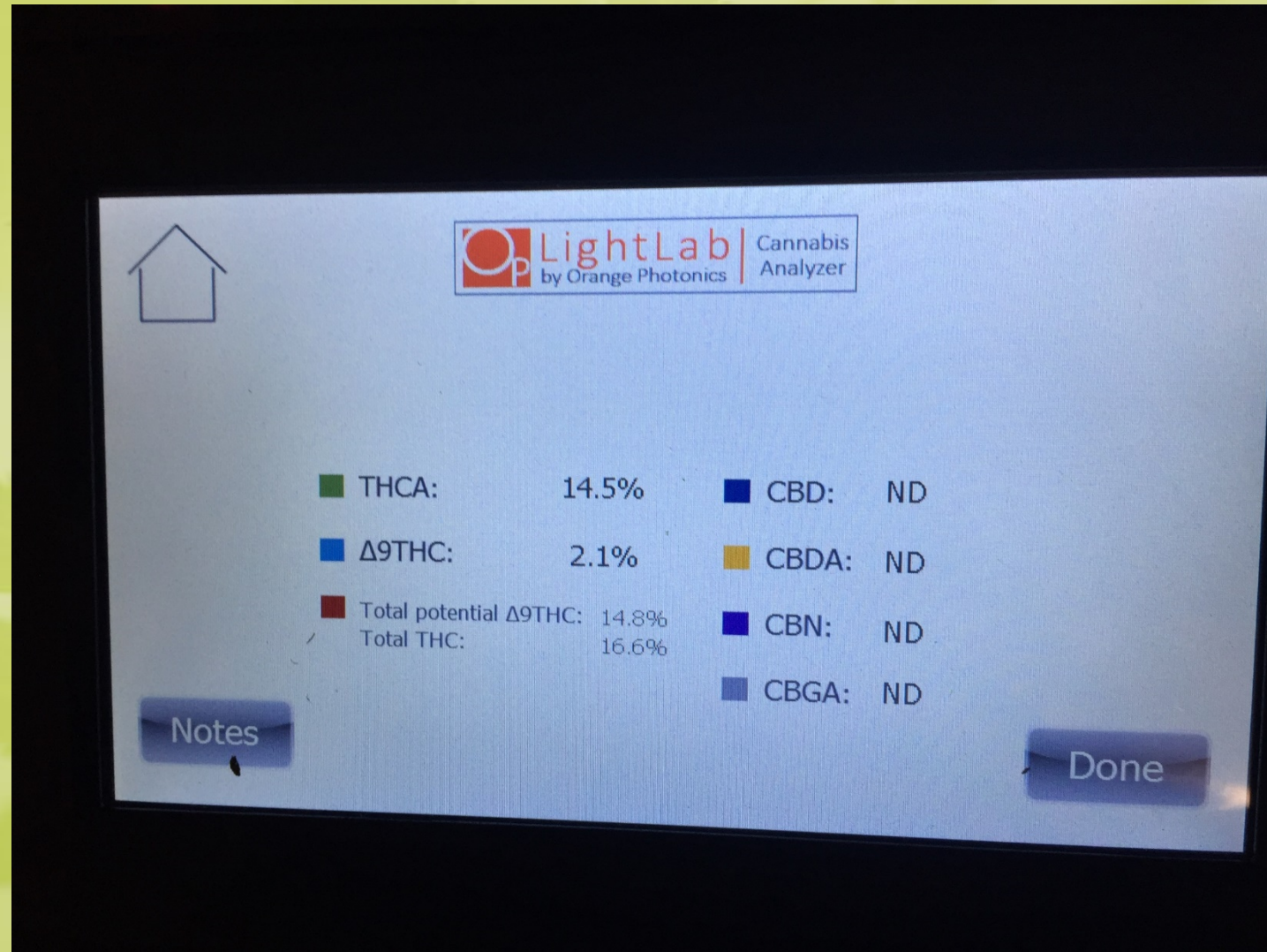
Inspection Comments: None



LABLIGHT PORTABLE HPLC ANALYZER



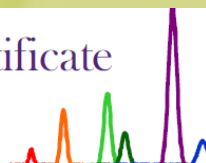
RESULTS FROM HPLC FOR "SOUR DIESEL" CANNABIS



RESIDUAL SOLVENTS ASSAY FOR HEMPSON - CHINA



Test Certificate



Test Certificate No.: 10337_VC

Sample: Hempson Oil

Matrix: Concentrate

Customer: Andrew Godfrey

Hempson Bio-Tech

andrew@hempsonoil.com

609-658-1461

Date Received: 7/7/2016

Test Date: 7/7/2016

Technician: JFD

VOLATILE ORGANIC SOLVENTS (VOCs)

This test method was performed in accordance with the requirements of ISO/IEC 17025. These results relate only to the test article listed in this report. Reports may not be reproduced except in their entirety.

Ret. Time [min]	Area [mV.s]	Amount [ppm]	Compound Name	Solvent Limits ²
0.8	1.6	ND	propane	-
0.992	1.9	ND	butane	800
1.108	20.6	83.4	methanol	3000
1.46	0.5	ND	pentane	5000
1.541	1530.0	3777.8	ethanol	5000
1.779	137.6	385.8	acetone	5000
1.903	4.3	10.1	isopropanol	5000
2.481	7.0	19.7	hexane	290
3.476	5.5	7.5	heptane	5000

Hemp Seed Oil – Supercritical Fluid Chromatography



HempFarm® premium cold-pressed hemp seed oil is selected for quality, purity, and optimal taste. Enjoy naturally healthy omegas 3, 6 & 9, plus anti-inflammatory GLA. This versatile oil is deliciously fresh & nutty tasting.

Directions: Take 1+ tablespoons daily for health. Add to meals, get creative!

Fatty Acid Profile per 15ml (1tbsp)

Fatty Acid	Weight (g)	Percent (%)
Linoleic Acid (LA) (Omega 6)	7.748	55.340
Alpha Linolenic Acid (ALA) (Omega 3)	2.546	18.185
Oleic Acid (Omega 9)	1.433	10.235
Palmitic Acid	0.806	5.755
Gamma Linolenic Acid (GLA) (Omega 6)	0.553	3.950
Stearic Acid	0.316	2.260
Stearidonic Acid (SDA) (Omega 3)	0.165	1.175
Arachidic Acid	0.109	0.778
Conjugated Linoleic Acid (CLA)	0.062	0.444
C18:1 cis isomers	0.050	0.355
Behenic Acid	0.039	0.280
C20 cis-11-eicosenoic	0.036	0.259
Lignoceric Acid	0.018	0.126
Myristic Acid	0.011	0.076

Nutrition Information

Nutrition Information

Servings per bottle: 16.6 Serving size: 15ml

	Per Serving 15ml	%DI* Per Serving	Per 100ml
Energy	520kj 130Cal	6% -	3467kj 867Cal
Protein	<0.1g	<1%	<0.1g
Fat, Total	14g	20%	93.3g
Saturated	1g	4%	6.7g
Trans	0g	-	0g
Polyunsaturated	11g	-	73.3g
Monounsaturated	1.5g	-	10g
Carbohydrate	<0.1g	<1%	<0.1g
Sugars	<0.1g	<1%	<0.1g
Sodium	<0.1mg	<1%	<0.1mg

Quantities stated above are averages only. *Percentage Daily Intakes are based on an average adult diet of 8700kj. Your daily intake may be higher or lower depending on your energy needs. Store in a cool, dry place, away from light. Keep refrigerated once opened. Best used within 90 days of opening.

Analytical SFC-MS Analysis of Commercial Hemp Seed Oils

Data collection and analysis methodology

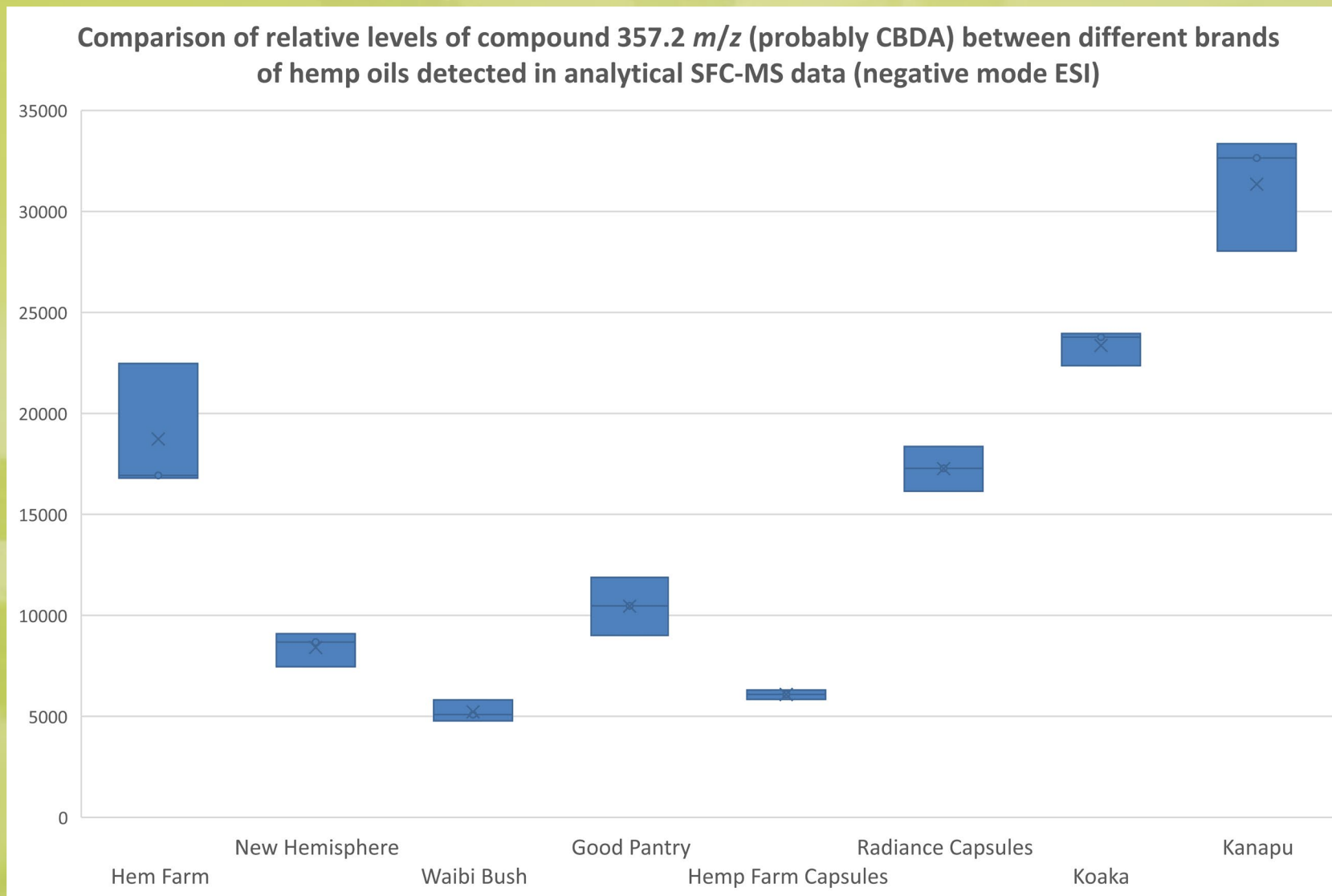
- Eight brands of commercially Available Hemp Oils were chosen for the analysis.
- Three samples of each oil were taken and analysed separately.
- Oils were dissolved in chloroform.
- Analysis was carried out using a Waters UPC² and Waters QTOF G2-XS in positive ESI mode.
- Chromatography was carried out using a Waters BEH 2x150mm column and methanol (0.1% wt./wt. ammonium acetate) as polar modifier.
- Data processing was carried out using Progenesis Q1 and R statistical software packages.



Waters UPC² System – Callahan Innovation



Relative Cannabinoid Content in Commercial Hemp Oils



Should
Listed
Cannabis



s Be
ls of
s ?

LAN

ION

CONTAMINATED CBD ISOLATE



NEED FOR THE FOLLOWING PHYSICOCHEMICAL DATA

- **Accurate Solute Boiling and Melting Points under Pressure and Vacuum**
- **Solute Liquid or Solid Density – Ambient and as a Function of P and T**
- **Solute Solubility Data in Various Solvent Media (T and P)**
- **Critical Parameters for Solutes and Solvents (P_c , T_c , ρ_c)**
- **Vapor Pressure Data of Cannabinoid and Terpenes**
- **Solubility Parameters of Solutes and Solvents**
- **Equation-of-State for Individual Cannabis Components**
- **Effect of Co-Extractives on the Extraction of Cannabis Constituents**
- **Properties of Mixed Fluid Extractants (artisan extractions)**

Cannabis Extracts - Physical and Chemical Properties (MSD, SDS DEA)

Appearance*

Odor

Odor Threshold

pH

Melting Point*

Initial Boiling Point/Range*

Flash Point

Evaporation Rate

Flammability(solid, gas)

Upper Flammability/Explosive Limits

Vapor Pressure*

Vapor Density

Relative Density

Solubility*

Partition Coefficient: n-Octanol/Water

Auto-ignition Temperature

Decomposition Temperature

Viscosity

Explosive Properties

Oxidizing Properties

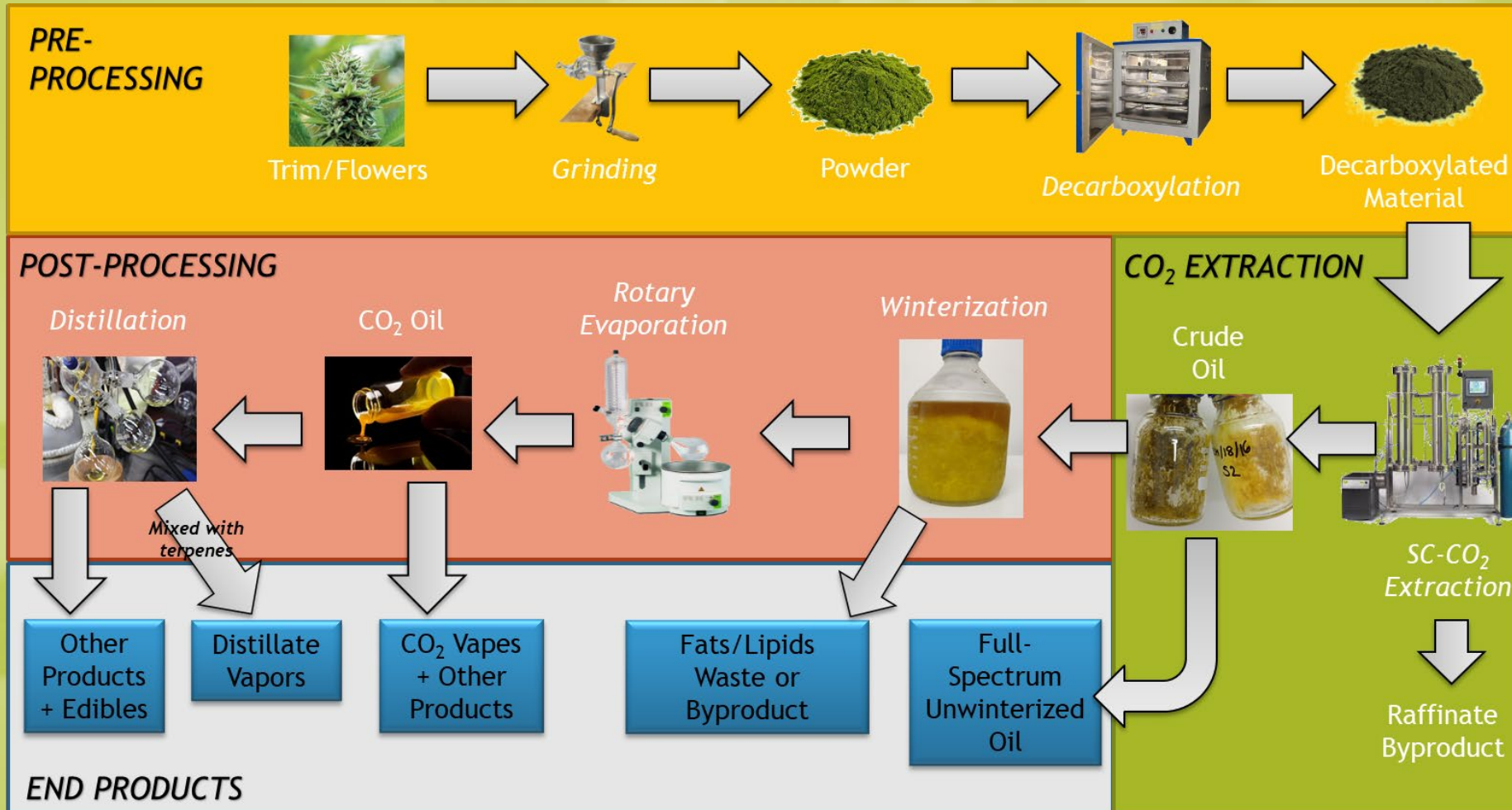
Calculated Physical Properties of Δ^9 -Tetrahydrocannabinol

Property	Value	Unit	Source
$\Delta_f G^\circ$	82.78	kJ/mol	Joback Calculated Property
$\Delta_f H^\circ_{\text{gas}}$	-398.00	kJ/mol	Joback Calculated Property
$\Delta_{\text{fus}} H^\circ$	44.85	kJ/mol	Joback Calculated Property
$\Delta_{\text{vap}} H^\circ$	83.13	kJ/mol	Joback Calculated Property
$\log P_{\text{oct/wat}}$	5.74		Crippen Calculated Property
P_c	1665.97	kPa	Joback Calculated Property
T_{boil}	845.82	K	Joback Calculated Property
T_c	1074.44	K	Joback Calculated Property
T_{fus}	577.96	K	Joback Calculated Property
V_c	0.97	m ³ /kg-mol	Joback Calculated Property

Temperature Dependent Properties

Property	Value	Unit	Temperature (K)	Source
$C_{p,\text{gas}}$	878.15	J/mol×K	845.82	Joback Calculated Property

Cannabis/Hemp Processing and Resultant End-Products



august 2019

cannabis products

The Industry Resource for Legal Cannabis Edibles & Beverages

FUNDAMENTALS OF QUALITY

*R&D and production insights into
alcohol-alternative beverages, hard
candy and mints, chocolate, and more*



PRODUCT FORMULATION FOR “FOOD” MATRICES

EXAMPLE FOOD MATRICES:

- **Lipophilic – Vegetable Oils, MCT, Chocolates, Essential Oils**
- **Carbohydrate – Glassy Sugars, Gummies, Honey**
- **High Water Content – Coffee, Tea, Beer, Citrus Drinks, Water**
- **Polymeric Matrix – Chewing Gum, Starches**

MANY TYPES OF HEMP EXTRACT INFUSIBLES



FOOD-RELATED CANNABIS PRODUCTS



Dixie Elixirs – Candy Products Using CO₂- THC- Extracts





ENDOCA

CBD CHEWING GUM

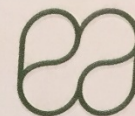
150mg CBD

(heated/decarboxylated)

Peppermint 10pcs | 15mg CBD per gum

**CHEWING GUM INCREASES
THE BIOAVAILABILITY OF CBD**

100% Organic | Zero Chemicals | Sugar Free



ENDOCA

CBD CHEWING GUM

150mg CBD

(heated/decarboxylated)

Peppermint 10pcs | 15mg CBD per gum

**CHEWING GUM INCREASES
THE BIOAVAILABILITY OF CBD**

100% Organic | Zero Chemicals | Sugar Free

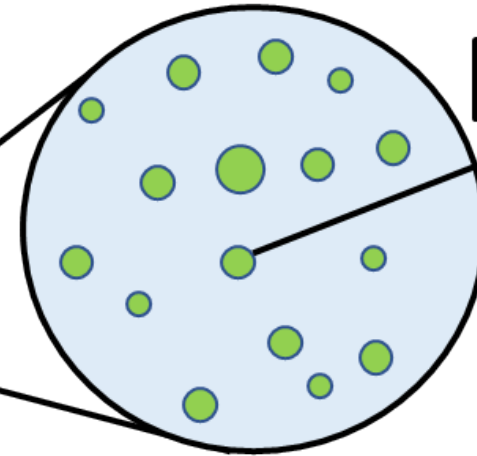
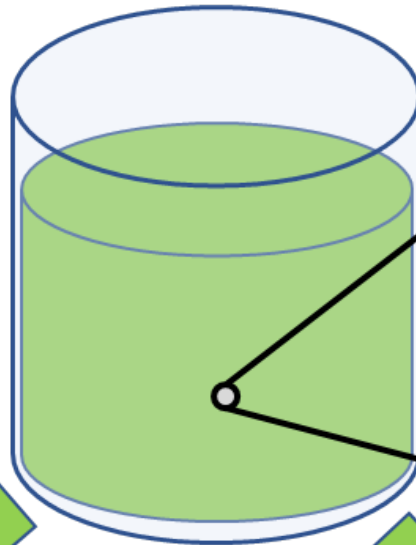
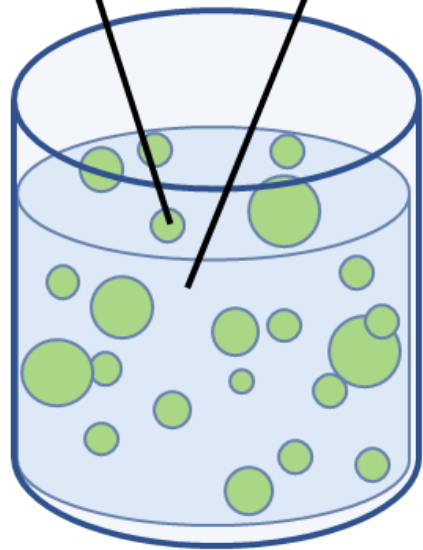
CBD/THC/Oil

Water

NANOEMULSIONS FOR CANNABIS PRODUCTS

30,000 psi.
3 passes

~100 nm



Hemp Extract Coffee
FULL SPECTRUM



Natures Edge
COFFEE & TEA



HEMP-DERIVED
GOLD FORMULA



340mg per bag

Dark Roast

NET WT. 12oz WHOLE BEAN



Natures Edge
COFFEE & TEA



Natures Edge
COFFEE & TEA

#ARcannabis



CBD Coffee Bar

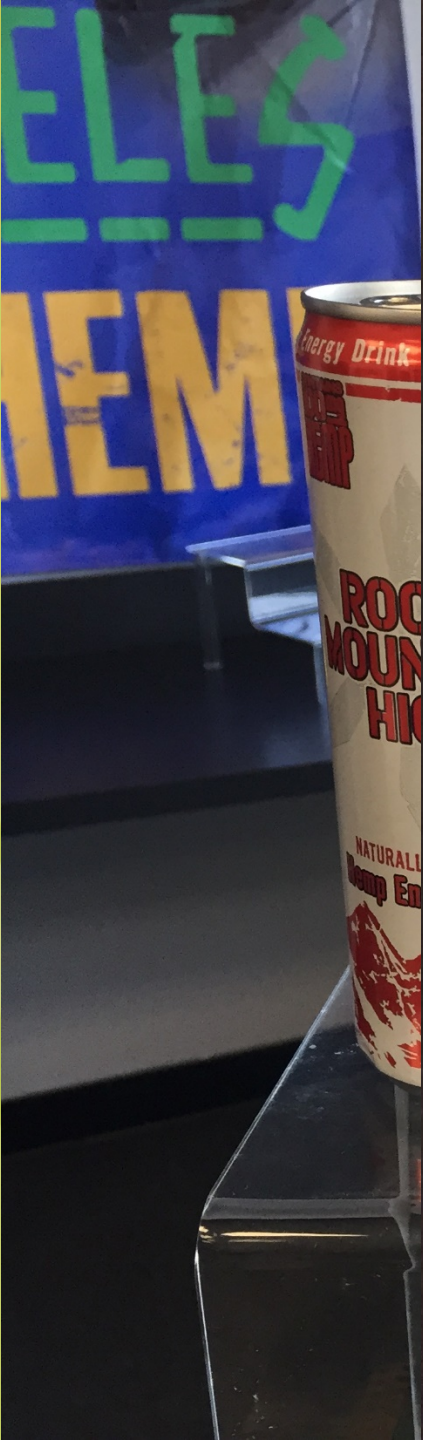


e	22	W A R M	Americano (espresso + hot water + milk to taste)	16	19	Caffe Latte (espresso + 2 parts milk + 1 part froth)
nded ice)	22		Cappuccino (espresso + 1 part milk + 1 part froth)	18	21	Mocha (espresso + chocolate + foamy milk)
locks ice)	22		Flat White (espresso + foamy milk)	18	21	Red Cappuccino (rooibos espresso + foamy milk)

THE DOUBLE SHOT

ESPRESSO BAR





HEMPANOL PRODUCTS COMBINING CO₂ – HEMP EXTRACT WITH CO₂ – OREGANO, -TURMERIC , AND - BASIL EXTRACTS





**50% Hemp Seed Extract + 50% Flower/Leaf CO₂ Extract – A
Cannabinoid – Based Nutraceutical Product**



ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect



The relationship between cannabis/hemp use in foods and processing methodology

Jerry W King

A diversity of commercial food products can be made from cannabis and hemp extracts, using both crude or winterized 'oils', distillates, and isolates, as documented in the literature. The manufacturing of these food-related end products involves processes such as extraction, phase separation, and distillation under vacuum. There is preference for consumer-friendly solvents that are generally regarded as safe (GRAS) such as carbon dioxide, ethanol, water, and propane or butane; and triglyceride-based oils. Frequently CO₂ is preferred as a solvent because it is environmentally benign, consumer-friendly, and selective as an extraction solvent. Here, we invoke solubility parameter theory (SPT) to explain the solubility/miscibility behavior of the above solvents toward cannabinoid, terpene, and non-polar contaminating solutes that must be removed using the above processes. This approach can also be used in formulating various food products, in which cannabis extracts and distillates are infused into a food matrix. Note is made of the fact that the infused cannabinoids are converted under the influence of heat and over time to other cannabinoids. Considering the difficulty of retaining terpenes during the above processing steps, back-addition of terpenes is frequently practiced. Numerous examples are provided of foods that are infused with defined cannabis/hemp extracts and distillates, and an example of an appropriate analysis and requisite labeling associated with a cannabinoid-infused product provided.

Address

CFS, 1965 E Spinel Link #7, Fayetteville, AR 72701, United States

Corresponding author: King, Jerry W (kingjw100@hotmail.com)

Current Opinion in Food Science 2019, 28:32–40

This review comes from a themed issue on **Innovations in food science**

Edited by **Alejandro Marangoni**

<https://doi.org/10.1016/j.cofs.2019.04.007>

2214-7993/© 2018 Elsevier Inc. All rights reserved.

Introduction

The medical benefits of cannabis particularly in the management of pain [1] are well documented, particularly in the management of seizure control, chronic pain, and

alleviation of the side-effects of chemotherapy. A Technavaio [2] survey reports the global market for cannabis edible products for 2017 was \$8.4 billion and will grow at a rate of 25% over the period of 2018–2022 reaching perhaps an estimated \$25.7 billion. This prognostication indicates that the cannabis food infused products will account for 60% of the marketplace. Despite the many cited benefits of cannabis therapy, the use of edible products toward those goals remains under scrutiny, and both Federal and State control in the USA. This may be partially understandable considering the wide variety of food products, in which cannabinoid extracts have been added including everyday commodities such as teas or coffees, pizza, lollipops, breakfast cereals, gummy consistent products, chocolate cookies/brownies, beef jerky, and even more recently, beer, wine, hemp-infused milks, barley-based sodas, health beneficial-honeys, and fortified sports products [3]. The formulation of such products is a challenge to the food and nutritional specialist in the formulation of their final product since the cannabis 'oils' utilized are bitter oils and are 'tar-like' in their viscosity and consistency. The addition of flavor-bearing ingredients to make such final product formulations appealing to consumers is becoming also becoming a standard procedure. Curiously, 'CBD oil' has also been consumed as an appetite suppressant [4].

The natural consequence is the rise of CBD as a food ingredient which is only just beginning to emerge from the shadow of cannabis prohibition, presenting a legal challenge for those food producers hoping to add it to their products. Infusion of phyto-cannabinoids into liquid fluids such as milks, teas, coffees, citrus-based drinks, and flavored-bottled or oxygenated-bottled waters. US sales of beverages infused with hemp-derived CBD are predicted to reach \$600 million in 2019, and approach \$1billion in 2020, with water accounting for two thirds of the market. For example, in today's marketplace, there are a variety of ways that hemp and hemp-derived ingredients are being used in beverages. Two energy drinks—Canna Energy and Rocky Mountain High-label their hemp as 'hemp seed oil extract' and 'hemp seed extract,' respectively, making no reference to the CBD content. Elev8 Brands, sells a coffee infused with hemp protein, as well as tea that contains hemp seed oil. Soda makers such as Sprig as well as Cannabidiol Creations use CBD isolates in their formulations.

As is commonly known, any final product consumed in the USA must not contain more than 0.3% THC

King JW, The relationship between cannabis/hemp use in foods and processing methodology, Current Opinion in Food Science, 28, 32-40 (2019), <https://doi.org/10.1016/j.cofs.2019.04.007>

CANNABIS-HEMP PACKAGING OPTIONS



COMPATIBILITY BETWEEN PACKAGING AND CANNABIS-INFUSED PRODUCTS

cannabis
products

The Industry Resource for Developing Legal Cannabis Edibles & Beverages

DEVELOPING BEVERAGES AND GUMMIES

Plus supply-chain insights on
terpenes, safe packaging, filling
equipment and more



The image shows a silver bottle of Ceria Brewing Co. Grainwave White Ale. The label is dark blue with white and gold text. It says "FIRST RELEASE", "CERIA BREWING CO.", and features a profile of a woman with a laurel wreath. Below that, it says "DE-ALCOHOLIZED CANNABIS BEER" and "Grainwave WHITE ALE". To the right of the bottle is a pile of bright orange, square-shaped gummies.

| the new frontier of product development |





**Lavender
Massage Oil**

• Full Spectrum CBD Oil •
Contains 100 mg. CBD per oz.



RED BARN HEMP

FOR HEALING • FOR FAMILY • FOR LIFE

8 oz.

redbarnhemp.com



**Lavender
Massage Oil**

• Full Spectrum CBD Oil •
Contains 100 mg. CBD per oz.



CONCENTRATE CONTAINERS





“Mai Tai” Butane Extract - Diamonds & Sauce - 73.5% THCA - 0% CBD - 82.3% Total Cannabinoids

**ALL SILICONE
CONTAINER**



**ALL ACRYLIC
CONTAINER**



Hinged Black Pigmented Container w/ Silicone Inserts

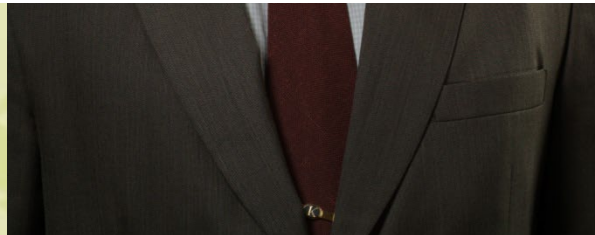
**POLYOLEFIN OR
NYLON SHELL**



**SILICONE
INSERT**



**Thank You – Any
Questions?**



**Jerry W. King
CFS**

Fayetteville, AR, USA 72701

Phone: 1-479-251-1970; 1-479-445-8819 (cell)

kingjw100@hotmail.com