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Marijuana Equivalency in Portion and Dosage

An assessment of physical and pharmacokinetic relationships in marijuana production and consumption in Colorado

Prepared for the Colorado Department of Revenue

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Executive Summary

The original legislation to legalize and regulate marijuana in Colorado does not explicitly restrict marijuana concentrates and infused edibles. Over time, these marijuana products have become more popular, prompting new legislation to remedy the omission. House Bill 14-1361 now stipulates limits upon marijuana flower portions, "or their equivalent."

This study provides scientific and data driven evidence in order to understand these equivalencies. The results provide comparisons between marijuana flower, concentrates and infused products specifically for Colorado's marijuana market.

Equivalency can be viewed from three perspectives: production, dosing, and market price. The first perspective relates to physical production, where infused edibles or concentrates are traced back into their corresponding weight of flower or trim inputs. This enables the conversion from non-flower products into a common flower-based denominator, so that aggregate use can be measured across different marijuana product types.

The second perspective uses pharmacology to develop a dose-equivalent measure across product types. The results equate the dosing effects between inhaled and ingested marijuana products. Finally, the third perspective uses Colorado potency and market data to convert marijuana retail prices into their unit-THC equivalents. These THC-based prices are then compared across product types. A powerful and reassuring finding is that Colorado's market prices reflect, almost identically, the dosing equivalencies found in the pharmacological review. The pricing perspective is a new methodology, made possible by analyzing recently collected data from Colorado's retail marijuana market.

The information contained in this report is specific to Colorado in 2015. Production techniques are constantly evolving, and the marijuana included in this study was grown in Colorado and may not share similarities with product in other regions. Overall, the study is designed to meet the requirements of Colorado House Bill 14-1361 and focuses solely on the retail adult-use marijuana market in Colorado.

PHYSICAL EQUIVALENCY

Physical equivalencies were calculated in two ways – a THC equivalency, and a physical production equivalency. Physical equivalencies were calculated for the major concentrate and infused product manufacturing techniques, including butane hash oil, CO_2 oil, ethanol, and water. Physical production equivalency is calculated by isolating the marijuana trim and shake inputs and determining a yield ratio. The THC methodology provides an equivalent amount of THC in various forms of marijuana products based on recent state testing information Table ES-1 shows equivalency factors for both methodologies by solvent type.

The physical equivalencies in Table ES-1 show that between 347 and 413 edibles of 10mg strength can be produced from an ounce of marijuana, depending on the solvent type and production method. For concentrates, between 3.10 and 5.50 grams of concentrate are equivalent to an ounce of flower marijuana.

The THC equivalency factors in Table ES-1 can be interpreted as showing units with equivalent amounts of THC based on recent state testing data. For instance, given the uniform dosage amounts of edibles in Colorado,434 edibles of 10mg strength and one ounce of flower marijuana at average potency have an equivalent amounts of THC. For concentrates, between 6.91 and 8.50 grams of concentrate (depending on solvent) and an ounce of flower marijuana at average potency have an equivalent amount of THC.

Table ES-1. One Ounce Equivalents by Solvent Type

	1-Ounce Flower Equivalents			
	Physical Equivalency		THC Equivalency	
	Amount	Amount	Amount	Amount
	Edibles	Concentrate (g)	Edibles	Concentrate (g)
Solvent Type	(10mg)	(Avg. Potency)	(10mg)	(Avg. Potency)
Butane	391.07	5.46	434.35	6.91
CO2	346.96	4.84	434.35	8.07
Butter/Lipid	413.49	N/A	434.35	N/A
Ethanol	N/A	5.44	N/A	7.37
Water	N/A	3.10	N/A	8.50

Source: Author calculations based on metrc™ data.

The conversion factors described above are the first of their kind. They can be useful for state-level production management. The conversions allow units of infused edibles and concentrates to be denominated by flower weight, and then added to flower sales, in order to determine retail market demand and supply.

PHARMACOKINETIC EQUIVALENCY

An important compliment to the physical THC relationships identified in this study is the pharmacological perspective. If the purpose of the equivalency legislation is to limit transactions or possession to a reasonable "dose" of concentrates and marijuana products for residents and non-residents, then the medical effects described here will be useful to construct a set of equivalencies between marijuana product types.

Pharmacokinetic equivalency incorporates findings from medical and pharmacological publications to inform marijuana stakeholders about the dosing process. The authors created a new mathematical construct that can compare ingested and smoked marijuana products in a consistent manner.

The pharmacokinetic model compares inhaled and ingested products using a dose ratio. The calculations are based upon different uptake routes and speeds for the psychoactive compounds related to marijuana use (e.g., THC and 11-OH-THC). Other compounds, such as cannabinoids, are not included here because the legislation relates only to retail use. The base pharmacokinetic equivalency ratio is 1 to 5.71. This means that one milligram of THC in edible form, is equivalent to 5.71 milligrams of THC in smokable form.

Table ES-2. Pharmacokinetic Dosage Equivalency

	Average THC Potency	Effective Uptake Ratio	1 Gram Equivalent	1 Ounce Equivalent
Buds/Flower	17.1%	1.00	1 Gram	1 Ounce
Edibles	N/A	5.71	3 Servings	83 Servings
Concentrates	62.1%	1.00	0.28 Grams	7.72 Grams

Source: Author calculations based on metrc™ data.

Table ES-2 shows the pharmacokinetic equivalencies, and the corresponding serving equivalencies, using data from Colorado.

Pharmacokinetic equivalencies indicate that 83 ten-milligram infused edible products is equivalent to one ounce of marijuana flower in Colorado. About 7.72 grams of concentrate is equivalent to an ounce of flower marijuana.

MARKET PRICE EQUIVALENCY

For comparison, a third equivalency approach was developed by the study team. This is the "market price equivalency" method. As with the physical equivalencies, this methodology was previously not possible. We use metrc™ data to convert retail store market prices into a price per unit of THC across different products. These new THC-based prices reflect the inherent value of each product from a psychoactive dose viewpoint. They reveal the price that consumers are willing to pay for the psycho-active experience (the high) yielded from each type of product.

Table ES-3 below shows representative marijuana product pricing in Colorado's retail market. The top portion shows typical prices for the products themselves. The middle portion shows the price after conversion—in cents per milligram THC (¢/MG_{THC}). Finally, the bottom portion computes the price-ratio between products using the THC price measure.

Table ES-3 shows the price of marijuana flower, or buds, is $14.03 when purchased by the gram, or $264 when an ounce is purchased. When converted to THC, the same product costs 8.25 cents per milligram THC when purchased by the gram, and 6.10 ¢/MG_{THC} for an ounce, reflecting some volume-pricing. Similarly, a typical 100mg THC edible product costs $24.99, a 40mg product is $19.81, and a single-serve 10mg THC edible costs $6.60. When converted, the THC price for these products equals 24.99 ¢/MG_{THC}, 35.00 ¢/MG_{THC}, and 66.00 ¢/MG_{THC} respectively, for these goods. Finally, concentrates cost $55.00 for a typical 1 gram wax portion, and a typical 500mg vaporizing cartridge costs $66.00. The THC prices are 8.46 ¢/MG_{THC} and 18.86 ¢/MG_{THC}, respectively.

Using the THC prices, the edibles to flower price ratio is 3.03 (edible THC per flower THC) for the 100mg edible product, 3.00 for the 80mg product, and 4.24 for the 40mg product. The 10mg single-serving ratio is 8.00, which we believe reflects a minimum price for small portions.

The ratio for wax/shatter is 1.03 for a 1 gram container, and 2.28 for a 500mg vaporizer cartridge. The higher price ratio for vaporizing equipment may reflect higher packaging costs.

In general, the price ratios shown in Table ES-3 are notable because they match—quite closely—to the pharmacokinetic equivalency ratios. This means that although the market participants may not have completed their own pharmacokinetic research, they naturally have gravitated toward this result, based simply upon trial and error.

The remainder of this report provides details regarding the data, the methodologies, and previous scientific findings used to construct our results.

Table ES-3. THC Market Price Equivalencies

THC Market Price Ratios in Colorado					
Indicative Prices by Weight ($)					
Buds/Flower		1 Gram	1/8 Oz	1/4 Oz	1 Ounce
	Most Common	$14.03	$41.27	$82.54	$264.14
	Discounted	$12.38	$33.03	$66.06	$239.43
Edibles		100 MG	80 MG	40 MG	10 MG
	Edible Variety	$24.99	$19.81	$14.00	$6.60
Concentrates		1 Gram	500 MG	250 MG	
	Wax / Shatter	$55.00	--	--	--
	Vape Cartridge	--	$66.00	$46.00	--
Equivalent Market Price (Cents per MG THC)					
Buds/Flower		1 Gram	1/8 Oz	1/4 Oz	1 Ounce
	Most Common	8.25	6.94	6.94	6.10
	Discounted	7.28	5.55	5.55	5.53
Edibles		100 MG	80 MG	40 MG	10 MG
	Edible Variety	24.99	24.76	35.00	66.00
Concentrates		1 Gram	500 MG	250 MG	
	Wax / Shatter	8.46	--	--	--
	Vape Cartridge	--	18.86	26.29	--
THC Market Price Equivalencies (Price Ratios in THC Units)					
Buds/Flower		1 Gram	1/8 Oz	1/4 Oz	1 Ounce
	Most Common	1.00	1.00	1.00	1.00
Edibles		100 MG	80 MG	40 MG	10 MG
	Edible Variety	3.03	3.00	4.24	8.00
Concentrates		1 Gram	500 MG	250 MG	
	Wax / Shatter	1.03	--	--	--
	Vape Cartridge	--	2.28	3.19	--

Note: 1. Prices taken from a sample of online retail menus for Colorado stores.
2. Ratios may not necessarily apply to other states..

Source: Colorado Storefront menus, calculations by the report study team.

Overview and Motivation

The original legislation to legalize and regulate marijuana in Colorado for adult use did not include explicit purchase restrictions on marijuana concentrates and infused edibles. As these marijuana products grew more popular in 2014, up to 35 percent[1] of statewide retail sales, legislation was enacted under House Bill 14-1361 to remedy the omission. The legislation does so by stipulating limits upon marijuana flower portions, "or their equivalent."

This study provides unbiased, scientific information that can be used to suggest appropriate equivalencies between flower and alternative marijuana products. It is a summary of how different marijuana products are produced and consumed in accordance with House Bill 14-1361, which requires the state to conduct a study to establish equivalencies.

The information in this study can be used to convert concentrate and infused products into their flower weight equivalents from both a production and consumption viewpoint. From a production viewpoint, the findings can be used to translate marijuana product unit sales into their weight equivalent. This will improve the measurement of aggregate marijuana demand, by using a common denominator. From a consumption viewpoint, the findings here can be used to establish an equivalent "dose" amount between non-flower products and flower weight. Overall, the study is designed to meet the requirements of House Bill 14-1361 and focuses solely on the retail adult-use marijuana market. Issues related to medical marijuana are not addressed in this study.

PRODUCTION, PRICE, AND DOSING EQUIVALENCIES

This study investigates marijuana equivalencies from three perspectives: production, price, and dosing.

The first perspective is from a physical production viewpoint, where servings of infused edibles or concentrates are converted into the respective weight of marijuana flower or trim needed as inputs to production. To construct these equivalencies, average yield and potency is estimated by the consultants after a series of interviews with Marijuana Infused Product (MIP) manufacturers, and by analyzing the state's Marijuana Enforcement Tracking Reporting Compliance (metrc™) database to isolate input and output packages at MIPs for various concentrates and infused edibles. This metric will provide a bridge between concentrate and infused edible output and plant material inputs.

The second perspective computes equivalencies from a dosing viewpoint. The dosing perspective provides stakeholders with a pharmacological model that equates the dosing effect between inhaled and ingested marijuana products. The pharmacological approach resolves the disparity between weight-based THC content in marijuana products, so that a dose-equivalent measure can be established.

Finally, the third perspective computes the market price of THC across product types in the Colorado marketplace. The pricing perspective is a new methodology. It was made possible by manipulating recently collected data from Colorado's retail marijuana market. By using statewide inventory and testing data, the study team can convert retail marijuana store price for flower, concentrates, and infused edibles into a price with a common denominator—THC. The study team found that the pricing structure in stores reflects, almost exactly, the pharmacokinetic dosing equivalencies found in this report. This suggests that although no individual has explicitly measured the dosing effect of different products, that the marketplace reflects the dosing value for each product implicitly.

1 Based upon statewide retail sales, May – September 2014.