Hemp Plant Extract Contract Compendium

In this compendium, the Seed CX economic team provides an overview of the cash market practices and how this is tied to the specific contract specs that we constructed. To establish our contracts, we spoke to 50 participants in the hemp derived CBD industry. We are eager to hear thoughts, comments or questions from those active in the hemp industry in order for us to continually improve our offering to the market. We want to hear your feedback!

(1) How is hemp extract priced on Seed's trading platform?

Typically, the raw plant material is sold by a farmer to the processor (usually via a privately negotiated forward contract). The processor then sells the extract (either in oil or isolate form) to a formulator. Hemp

(A) Extract is priced on the **concentration of 'active CBD'**, whereby active CBD = CBD + α(CBD-A), α =0.877. Active CBD is is the aggregate CBD and CBD-A, which is the (inactive) acid form of CBD. In the 'active CBD' price, CBD-A is adjusted by a discount to account for the molecular weight of the carboxylic functionality since one gram of CBD-A, once de-carboxylated, equates to 0.877 grams of CBD. There was some discussion about whether to include the cost of decarboxylation or for 'wastage' in the process. However, the general consensus within the industry was that the cost of decarboxylation was minimal (since it is purely heating) and although the process of decarboxylation is not 100% effective, participants felt that this was the fairest and least partial number. While a majority of those surveyed priced their product based on this method, a minority of producers employed additional pricing strategies.[1]

While CBD concentration constitutes the main driver of price, small premiums in the price per gram of CBD present in the extract. Each additional stage of processing or refinement leads to an increase in the price per gram of CBD. For example, a 50% extract will likely be priced higher per gram of CBD than a 25% extract as it will have gone through an additional stage of processing, the cost of which needs to be accounted for in the final price. That being said, products that have gone through the same levels of refinement but exhibit slightly different concentration will be priced nearly identically due to the fact that they both have incurred the same cost of production. For example, a 45% extract and a 55% extract that have gone through the same refinement processes will exhibit nearly identical prices per gram of CBD[2].

A simple, theoretical pricing model is constructed in the following figure which looks at the price per gram of CBD as a function of the concentration. The price per gram of CBD remains relatively flat for similar concentration, with fixed increases in price for each additional stage of processing and refinement of the product to achieve higher concentrations. A step wise function is observed with each additional jump representing an additional stage of processing.

[1] We do note that we found that there was not complete uniformity as to how hemp extract was priced. Notably, some participants quoted hemp extract based on the price per gram of 'active cannabinoids' (including CBD). However, these participants either directly or indirectly base this 'cannabinoid' price on the price of active CBD. For example, in several interviews the price of the hemp extract was formulated internally on the percentage of CBD i.e. if these participants want to sell a gram of CBD at $10 and CBD makes up 90% of total cannabinoids, the quoted price will be $9 per gram of 'cannabinoids'.
Equally, in surveys with market participants, a minority of buyers and sellers quoted prices per gram of hemp extract volume, rather than price per gram of 'active CBD.' However, these participants revealed that in every conversation with prospective buyers or sellers, the price is recalculated as the price per gram of CBD. For example, a hemp extract priced at $17 a gram of hemp extract that contains 15.9% CBD, is recalculated in normal marketing channels as $107 a gram of CBD.

[2] A minority of participants also add a small premium to the price of a gram of CBD as the extract becomes more concentrated. The rationale here is that a more concentrated extract is more valuable given that it has a high value to weight ratio. Additionally, it may be easier reformulate for buyers and retailers. Even if the two products have gone through the exact same refinement processes, the higher concentrate extract may exhibit a slightly higher price purely due to the perception of consumers that the higher number is always better.

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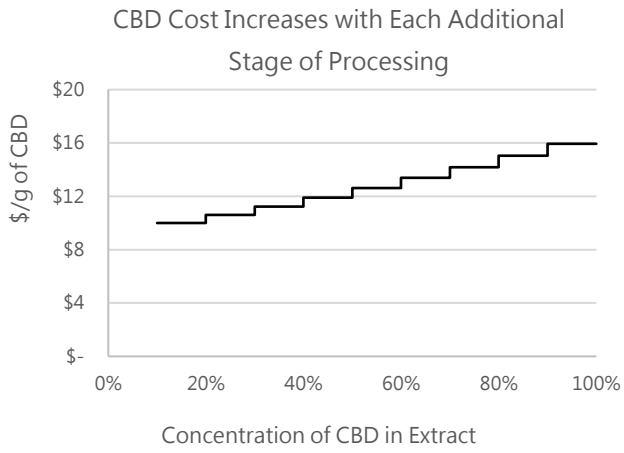

The premium (or discount) for isolate (per gram of CBD) observed in the market ranged substantially This basis is not widely consistent, in part because of the opacity of the market. The price difference per gram of CBD versus oil largely exists because of the differential costs of production that occur in manufacturing isolate and extract. One factor that may lead to an isolate premium is that there is proportionally more wastage of CBD as you further concentrate the extract. This is because isolating a specific cannabinoid (in this case CBD) is wasteful given that they are all very similar in terms of gravitation weight. As such, when you pull out cannabinoids to isolate the CBD, you are also pulling out CBD. It is salient to note that it is feasible that the isolate can be converted into oil (once diluted and mixed with terpenes); however, some producers note that this is an inferior product as it does not possess the full range of available compound within the plant which may call for a discount.

What we found was that the market premium or discount for isolate has not stabilized sufficiently to establish a fixed value. As such, we are allowing the market to decide by separating isolate as a separate contract on the same product.

(B) Hemp extract must also meet certain **minimum standards**, specifically of:

- Pesticides/Herbicides/Fungicides
- Residual solvent
- Heavy metals
- Bacterial, microbial and fungal content
- Mycotoxin (mold)
- No greater than 0.3% THC

Seed has ensured that the quality standards enumerated above describe the quality standards used in transactions in the hemp extract commodity in normal cash marketing channels. When considering grades, the key is not define a product that is the lowest common denominator. At the same time, the lower the quality of deliverable supply, the harder it is to squeeze the market if there is a bad year (although note that our quality factors revolve not typically affected by seasonal differences). We will provide a more detailed analysis of these minimum standards in a future blog and an overview of the tests currently being conducted by labs throughout the United States.

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(2) Contract specifics

Contract Size: The contract size is 500 grams of active CBD, whereby active CBD = CBD + α(CBD-A), α =0.877. Seed spoke to hemp derived CBD participants of varying sizes. The consensus from the largest participants was that they did not want anything smaller than 500 grams. The smallest participants appreciated the flexibility of a 500 gram trading unit.

Price quoting: Invoice amounts are based on the tenth of a percentage i.e. 85.1% etc[3]. Based on interviews with participants, an equal subsection simply rounded to the nearest percent, however as the contract became increasingly more concentrated and the size of the contract increasingly larger, there was a wider preference to price based on the closest tenth of a percent of active CBD.

Paper work to accompany transactions: All packages must contain (i) third party Certificate of Analysis (COA) (ii) Hemp cultivation license from a relevant department of agriculture or foreign equivalent for internationally grown industrial hemp (this is important since government regulations requires that the hemp material comes from a legally grown hemp plant).

(3) The future

In terms of market dynamics that may influence the contract specifications in the next 24 months, the Seed economics team has identified several factors (but which are currently not incorporated into the current contract specifications).

(i) Cannabinoid and Terpenoid profile

Several cash market participants believe that a premium will eventually emerge for more desirable cannabinoid and terpenoid profiles. However, given that the precise interaction of these additional compounds with CBD is unknown, this is not currently a pricing factor.

(ii) Origin of material premiums

Given the 2014 Farm Bill Act and the increasing availability of American grown material, there is a growing discussion around the origin of hemp material and hemp extract. Some participants mentioned that they believe that an 'origin' premium may exist for American hemp extract over imported extract.

(iii) Extraction method

There are two types of extraction methods: (a) Alcohol (either ethanol or isopropanol) (b) CO2 Super Fluid Extraction. Alcohol extractions (either ethanol or isopropanol) requires less initial capital investment than CO2 extraction[4] and is cheaper run by run[5]. CO2 is still a solvent. It is however, traceless, as it doesn't remain in the product and is undetectable. From interviews with industry participant about extraction methods, the majority used exclusively CO2 extraction. Some participants in the market consider C02 extraction "healthier", however both ethanol and isopropanol are considered are class 3 solvents. In

[3] Seed allows for a deviation from the contract size by 5% which allows for a margin of deviation in the concentration.
[4] For CO2 extraction, a CO2 extractor needs to be bought. These vary in size and price. In comparison, the primary equipment required for ethanol extraction is a mixing bucket (to mix the ethanol with the hemp material), a strainer and a filtration device to remove the ethanol.
[5] Principally, the alcohol used during extraction can be reused in multiple extractions.

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addition, ethanol and isopropanol is used in the winterization process (including in CO2 extractions). In interviews, one participant reported ethanol being sold at a 10% discount to CO2.

(iv) Processing levels

In terms of the manufacturing process of CBD:

(i) CBD-A is initially **isolated** from the plant through extraction.

(ii) Once extracted, CBD may be purified by **winterization**, which removes the plant cell wall components which were extracted along with the cannabinoids and terpenes.

(iii) **Purification/distillation** may be achieved, primarily, by two different processes. One is chemical and the other is mechanical. Chromatography is the primary chemical purification method and it utilizes the molecular interaction as it travels over a stationary phase while dissolved in a mobile phase.[6] The separated components are collected in individual fractions and then the solvent is removed to yield purified CBD. Conversely, mechanical separation relies on physical parameters instead of chemical. It is much more difficult to get to a single molecule through this process, but companies are doing it. The best instrument to use for this application is a wiped film short path distillation apparatus.

Several participants note the existence of small premiums for each additional level of processing.

[6] Note that this practice is identical to the analytical technique that labs use to test for potency. In the analytical case, they are only performing this on a micro scale, so it is a much easier process.

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Testing standards addendum

By Chris Emerson (Chief Scientific Officer) and Edward Woodford (CEO)

To date, there is no specified, unified standard for industrial hemp extract has been established. However, the industry has coalesced around standards that we have leant on to establish hemp extract minimum grade standards traded on Seed. The purpose of this document is to explain the rationale and theory behind each grading standard.

Lab Selection

Seed has only partnered with labs that have received ISO certification or are in the process of receiving ISO 17025 accreditation. All labs were vetted for their ability to accept CBD samples from across the United States.[7] Seed conducted on site audits in its lab certification process, including but not limited to: assessing quality assurance systems, chain of custody documentation, training standards of lab analysis, assessing throughput and calibration procedures of machines. Seed conducts on a regulatory basis, randomized controls on samples, sending samples to multiple labs and assessing the standard deviation of the results. We will publicize anonymized data of these randomized ring tests on a regular basis, once we have collected a significant number of data points.

Default tests

1. Cannabinoid potency

All samples must contain less than 0.3% THC, since this is legally mandated at the federal level under Section 7606 of the Agricultural Act, 2014. We specify that Gas Chromatography (GC) is ***not*** used, in favor of High Performance Liquid Chromatograpohy (HPLC), since current HPLC methods allow for the non-destructive analysis of full cannabinoid content. The total THC content is calculated as an aggregate of the total THC and THCA content.

For all samples, Seed tests THC, THCA, CBD, CBDA and CBN. We specify that HPLC is used, although we are continually comparing this method (and associated results) with LC/MS.

Seed also tests for the 'Active CBD' potency as it is the main pricing mechanism within the hemp market. It is calculated as the aggregate total of CBD and CBDA content. During complete decarboxylation, 1g of CBDA is converted into 0.877g of CBD. The decarboxylation process uses temperature and/or pressure to release CO_2 form CBDA, which results in a change in the molecular mass between the two compounds. This artifact results in a discount on total CBDA content based on the factor of 0.877.

2. Residual Solvent

The US pharmacopeia has set guidelines as to how much of a particular solvent a person can be exposed to on a daily basis without developing complications due to overexposure. This is a consideration in the production of

[7] This is a salient point because for example, state licensed MED laboratories in Colorado can only accept hemp and hemp derived products that are in the state tracking, seed to sale METRC system. Hemp participants are not legally required to use the METRC system and is only open to Colorado based companies.

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hemp derived CBD extracts since solvents used in extraction or refinement, if concentrated, can harm those who are exposed to it.

Solvents are divided into three classes, based on the severity of exposure. Different solvents have different chemical properties and have different physiological effects when consumed or inhaled. Toxicology profiles have been developed for these compounds, analyzing adsorption, distribution, metabolism, excretion, and toxicity (collectively referred to using the acronym ADMET). This suite of processes is used to define how dangerous a given chemical is and what levels of exposure are permitted.[8]

- Class 1 organics should never be used.
- Class 2 organics are not recommended for use outside of a Good Manufacturing Practice environment where these substances are tightly controlled and continuously monitored due to their dangerous effects.
- Class 3 are solvents that present no known human health hazard at levels normally accepted in pharmaceuticals. However, there are no long-term toxicity or carcinogenicity studies for many of the solvents in Class 3, and so safe levels for chronic use of these products have not been established.

Class 3 solvents commonly used for making extracts are isopropanol, ethanol, acetone, heptane, and ethyl ether and are regarded as presenting low toxic potential. Permitted daily exposure limits (PDEs) for these solvents have been published, and they have been shown to have low acute toxicity and no genotoxicity in studies on animals and in humans, and so are permitted at reasonable levels. Propane and Butane, two of the major solvents used for preparing extracts, are not on the Class 3 list but are regarded as safe.

Under WAC Chapter 314-55-104, the parts per million for one gram of finished extract cannot exceed 500 ppm of residual solvent or gas when quality assurance tested per RCW 69.50.348, which is about 10 times lower than the limits set forth for Class 3 residual solvents by the FDA/International Conference on Harmonization. This recommendation is based on a 10 gram per day consumption level for a 50 kg person (50 mg/day). Extracts made from food grade ethanol, glycerin, propylene glycol, or CO2 of at least 99% purity do not require residual solvent testing.

The International Conference of Harmonization has published guidelines for residual solvents that may be used in the production of pharmaceuticals for human use. These are excellent guidelines for regulated industries, but do not address the current need for hemp extract oil standards.[9] The closest correlating industry for hemp extract is the US medicinal and recreational cannabis industry. Across those states, of these states there is not a cohesive set of standards pertaining to permissible solvent use or acceptable solvent limits. One the most sophisticated and long standing residual solvents testing standards was established by the Colorado Department of Public Health & Environment (CDPHE), who consulted with multiple experts nationwide on self limits. We therefore firstly relied on current standards established by the CDPHE:

[8] Specifically, a judgment has been using the ADMET frame of reference. For example, you could have a chemical that is not absorbed readily, but has little to no metabolism, so the body isn't able to excrete it and it accumulates leading to toxic levels over time. This might lead to a very low threshold allowance.
[9] http://www.ich.org/fileadmin/Public_Web_Site/ICH_Products/Guidelines/Quality/Q3C/Step4/Q3C_R5_Step4.pdf

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Residual Solvent	Acceptable limit per gram
Butane	< 800 ppm
Heptane	< 500 ppm
Benzene	< 1 ppm
Toluene	< 1 ppm
Hexane	< 1 ppm
Total Xylenes (m, p, o-xylenes)	< 1 ppm

ppm = parts per million

However, in consultation with industry participant, Seed also specifies the following additional residual solvent limits since they are commonly tested and regarded as quality standards by the industry. The solvents below are commonly employed either in the extraction process or in later processing stages of refinement:

Residual Solvent	Acceptable limit per gram
Isopropanol	< 400 ppm
Ethanol	< 1000 ppm
Acetone	< 500 ppm
Propane	< 800 ppm

ppm = parts per million

To establish the limits, we leant on California's Department of Industrial Relations personal exposure limits (PEL) for these compounds at STP (standard temperature and pressure, 25 degrees celsius, 760 mmHG (1 atm)). By relying on these PEL's, the implicit assumption of these limits is that the average consumer is not going to be ingesting or inhaling more than a gram / day. Our acceptable limits are the same as those established by the Department of Industrial Relations except for propane which indicates a limit of 1000 ppm. However, the Seed team felt that it was more appropriate to establish the same limit as butane.

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Tests upon request

1. Microbial

Microbes are typically found in all natural products, therefore tolerance limits for microbial and fungal species are consistent with local, state, and federal regulations. The delivered Hemp CBD must be demonstrated to contain no E. coli and salmonella. The presence of mold and yeast must be less than 10,000 colony forming units (CFU) per gram.

In terms of background as to how this standard was decided, it is important to note that both Colorado and Washington require Cannabis to be tested for microbiological contamination. However, they have instituted very divergent rules for how to implement such testing. Colorado State produced a set of guidelines based on recommendations in the American Herbal Pharmacopoeia's Cannabis Monograph. These, in turn, were drawn largely from guidelines specified by the American Herbal Products Association (AHPA). We therefore leant on these guidelines. In establishing our standards, we also considered a variety of other potential microbes including pseudomonas, aspergillas, mucor, penicillium, and thermophilic actinomycetes, Gam negative bacteria, however these tests were not requested by industry participants. In fact, it was felt that it would be very rare for an extract to fail even the most rudimentary of microbial tests because the pressure, heat and/or solvents used in processing would kill any microbes.

2. Chemical residue screen (pesticides, fungicide etc.)

Pesticide application rules states that pesticides must be used in accordance with their labeling. Pesticide labels target a specific crop or a group of crops. To date, the Environmental Protection Agency (EPA) has not classified any pesticides for use on hemp. However, numerous states, including the Colorado Department of Agriculture (CDA) has published and continually updates a list of allowable products that enable Colorado growers to use pesticides in accordance to regulations.[10] Due to the precedent of chemical residues found in cannabis, the focus has been on this list of chemical residues. There are 385+ chemical residues that are out on the market, so actually being able to identify what residues are present is impossible unless you are testing for all known pesticides. This would prohibitively expensive and is not a logical approach to solving this problem. As such, we established an aggregate list of the most common chemical residue that have been known to be used by cannabis cultivators during growth lifecycle. The possibility does exist that cross-contamination from neighboring fields could occur, but those are not going to be tested for. We are continually reviewing out list as cultivators start to use different products that do not have the most watched for compounds, either innocently or intentionally.

Having established the list of pesticides that will be tested upon request, we need to establish acceptable limits. These have not been established by the ECFR. Residual limits differ across different products i.e. the limit of Myclobutanil differs between almonds and spinach – see here. As such, we rely on the acceptable limits per gram established by Voelker from the Cannabis Safety Institute.[11]

[7] A pesticide working group began meeting in early 2016 in Colorado. As of June 1, a list of pesticides that will be tested for by the CO labs has been determined.

[11] http://cannabissafetyinstitute.org/wp-content/uploads/2015/06/CSI-Pesticides-White-Paper.pdf

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Chemical Residue	Acceptable limit per gram
Acequinocyl	0.1 ppm
Bifenazate	0.1 ppm
Befenthrin	0.1 ppm
Chlormequat chloride	0.1 ppm
Cyfluthrin	0.1 ppm
Daminozide	0.1 ppm
Etoxazole	0.1 ppm
Daminozide	0.1 ppm
Fenoxycarb	0.1 ppm
Imazalil	0.1 ppm
Imidacloprid	0.1 ppm
Myclobutanil	0.1 ppm
Paclobutrazol	0.1 ppm
Pyrethrins	0.1 ppm
Spinosad	0.1 ppm
Spiromesifen	0.1 ppm
Spirotetramat	0.1 ppm
Trifloxystrobin	0.1 ppm

ppm = parts per million

3. Mycotoxins

Mycotoxins are toxins produced by mold or fungus and can be very dangerous if imbibed. Mycotoxin analysis is conventionally conducted with Liquid chromatography or ELISA (Enzyme-Linked Immunosorbent Assay), but most labs do not employ this later technique. The mycotoxin quality test is not required by Seed largely because hemp "has inherent antibacterial properties, is dried well, and is usually then heated during processing or use. This makes it as safe as any agricultural product could possibly be. Nevertheless, these conditions do not rule out all microbial threats."[12] In addition, "aflatoxins are a variety of mycotoxin produced mainly by two species of Aspergillus (A. flavus, and A. parasiticus). Because Aspergillus is ubiquitous, aflatoxins are as well, and many industries have set baseline levels for acceptable amounts of aflatoxin contamination. However, the conditions

[12]http://cannabissafetyinstitute.org/wp-content/uploads/2015/06/Microbiological-Safety-Testing-of-Cannabis.pdf

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necessary for the production of significant levels of aflatoxin are not present on Cannabis." [13] In addition, "it is worth pointing out that cannabinoids have been found to have strong antifungal properties."

Upon request, the following standards must be met:

Mycotoxin	Allowable Limit (ppm)
Aflatoxin B1	<0.020
Aflatoxin B2	<0.020
Aflatoxin G1	<0.020
Aflatoxin G2	<0.020
Ochratoxin	<0.020

ppm = parts per million

4. Heavy Metals

Cannabis is known to accumulate metals when grown in soil contaminated with heavy metals.[14]

Seed tests for mercury (Hg), cadmium (Cd), arsenic (As), and lead (Pb), which are the most prevalent heavy metal contaminants in the environment. However, given this context, we do not mandate a heavy metal test since none of the heavy metals prevalent would be extracted through common extraction processes (CO2 and alcohol) and further distillation leaves behind. One of the most sophisticated and long standing heavy metal testing standards was established by the Colorado Department of Public Health & Environment (CDPHE) in consultation with multiple experts nationwide. We therefore firstly relied on current standards established by the CDPHE[15]:

Metal Contaminant	Allowable Limit (ppm)
Lead	<10 ppm
Arsenic	<10 ppm
Cadmium	<4.1 ppm
Mercury	< 2.0 ppm

ppm = parts per million

5. Terpenoid profile

Seed has not established minimum quality levels of terpenes, however we offer participants the ability to request terpenoid tests for their own edification.

[13] http://cannabissafetyinstitute.org/wp-content/uploads/2015/06/Microbiological-Safety-Testing-of-Cannabis.pdf
[14] Shi, G; Cai, Q; Biotechnology Advances, 2009, 27, 555-561.
[15] https://www.leafly.com/news/industry/leaflys-state-by-state-guide-to-cannabis-testing-regulations

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