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Contamination of Cannabis Products for Human Consumption

What is the issue?

Due to reports in the popular media of contaminants in cannabis, there is increasing public and regulatory concern about products from not only the black market (e.g., “Black market B.C. weed tainted with pesticides, contaminants, testing show”¹), but also licensed (legal) producers (“Pre-rolled joints recalled over contamination concerns, Health Canada says”²). Due to the multiple forms in which cannabis is produced and consumed (smoked, vaporized, concentrates, oils, tinctures, etc.), policing its quality and safety can be difficult. At the same time, it is critical that cannabis users be protected from unintended, adverse effects from contaminants, particularly those who are using cannabis for medicinal reasons.³ For example, in several jurisdictions, cannabis is authorized for the treatment of seizures and movement disorders; however, Pinkhasova et al. report that some insecticides that may be used in cannabis production can affect genes important in signaling pathways linked to seizures.⁴

Surveys suggest consumers may have concerns about the contamination of cannabis products (e.g., about 28% of Australian adults believe that due to greater potency and the risk of various contaminants, hydroponic cannabis may be less safe than cannabis that is grown “naturally”).⁵ It is important that cannabis marketed to humans conform to high production standards to ensure its safety, particularly if it is to be used as a form of medical treatment. This includes testing for four main categories of possible contamination: 1) microbes, 2) plant growth regulators (fertilizers and pesticides such as fungicides and insecticides), 3) heavy metals, 4) solvents and 5) other contaminants.^{6 7} This rapid review will summarize published reports, as well as governmental regulation that have been implemented to control contamination in cannabis products sold legally in the Canada and the United States.

1) Microbes

As described by Russo, the risk of bacterial and insect contamination is probably greatest for illegal, indoor operations, less for cannabis grown in greenhouses, and least for outdoor cultivation.⁶ Although many molds may be relatively harmless, others such as *Aspergillus*, which has been reported in cannabis samples in various jurisdictions, may present a health threat when inhaled, particularly for those who are ill or immunocompromised.^{8 9}

A non-systematic literature review by Montoya et al. found three cannabis contaminants that can result in pulmonary infections (*Aspergillus* and *Penicillium* species, as well as *Fusarium Oxysporum*), one associated with epidermal infections (some *Penicillium* species), and three associated with enteric infections (*Escherichia coli* [E. coli], Salmonella, and Clostridium).¹⁰ In addition, Seltenrich points out that potentially carcinogenic mycotoxins can be produced by certain molds common to cannabis.³ For example, aflatoxin B1, produced by *Aspergillus flavus* and *A. parasiticus*, is known to be carcinogenic and to suppress growth and immune system functioning.¹¹

Vujanovic et al argue that biological and chemical contaminants in cannabis can not only threaten the health of other crops (e.g., through the spread of unwanted fungal species in agricultural regions), but can provoke “serious physical, mental, behavioral, and social health consequences in humans”.¹² In humans, cannabis contamination can result in fungal sensitization and infections, particularly in people who are immunocompromised.^{13 14 15} Health consequences can affect not only consumers but also those working in commercial cannabis production, storage and processing.¹⁶ Case reports have described life-threatening or serious cases of pulmonary aspergillosis, including a bone marrow transplant recipient, a colorectal cancer survivor, and two patients smoking cannabis for medicinal reasons (e.g., pain relief).¹⁷

Current practices to limit bacterial contamination focus largely on “clean” horticultural practices. In some jurisdictions, gamma-irradiation has been utilized to sterilize harvested material, although its safety and effects on the terpenoid content of cannabis are questionable.⁶

Under Canada’s Cannabis Regulations, legal producers must have each lot or batch tested by an independent laboratory using validated methods for the following: total yeast and mold (TAMC), total aerobic microbial count (TAMC), bile tolerant gram negative (BTGM), E. Coli, and Salmonella. Reference values must be drawn from appropriate international standards laid out in Schedule B of the Food and Drug Act (e.g., from the European Pharmacopoeia [EP] or the United States Pharmacopoeia [USP]). In addition to testing, the Cannabis Regulations describe production practices that should be taken to avoid contamination and on-going reporting requirements.²⁰ However, there is no requirement to report microbial test results on product labels.

Due to the lack of national guidelines, in the U.S. there is variation between states in standards for microbial testing and control. In Oregon, producers are required to test for only two organisms: E. Coli and Salmonella. Instead of testing for other microbes, the state requires producers to limit water activity (A_w) to less than 0.65, on the grounds that this should prevent microbial growth.²¹ As described by Seltenrich, this policy does not conform to the recommendations of a white paper on microbial testing by the independent Cannabis Safety Institute.[3] Although the Cannabis Safety Institute recommends limiting water activity during curing processes (to <0.6), in addition to testing for E. Coli and Salmonella, it proposes testing for four species of *Aspergillus* (*A. flavus*, *A. fumigatus*, *A. niger*, and *A. terreus*). The white paper does not recommend testing for aflatoxins, on the ground that they would be at least partly degraded by the heat of smoking or decarboxylation.²² It also notes solvents used for creating concentrates may have a sterilizing effect; as a result, testing requirements should be specific to the cannabis form.²²

In California, testing requirements vary according to whether it is inhalable cannabis, an inhalable cannabis product, or other cannabis products.²³ For all products, testing is required for E. Coli, Salmonella and mycotoxins. For inhalable products, tests must be conducted for four *Aspergillus* species, but producers have the liberty of choosing between three testing methods: live culture, polymerase chain reaction [PCR] to test for DNA of the target strain, or quantitative PCR. Unfortunately, as described by Seltenrich, all three methods have both strengths and weaknesses.³

Montoya et al. report that their searches found no reports of human pathogenic viral contamination of cannabis. However, as other crops have demonstrated contamination by various noroviruses, rotavirus, and enteroviruses, the possibility cannot be ruled out.¹⁰

2) Plant Growth Regulators

A variety of agents are used during cultivation to encourage growth and reduce pests, including fertilizers and pesticides (a category that includes fungicides and insecticides). A 2021 review by Pinkhasova et al. argue that pesticide exposure can trigger serious adverse neurological effects, particularly in people with (probably unknown) genetic susceptibilities.⁴ Protecting consumers from pesticide exposure is particularly important for those who are using it to treat or ameliorate medical conditions.

In Canada, Health Canada has produced a separate document outlining the mandatory pesticide testing that must be conducted by legal cannabis growers and producers.²⁴ Testing must be conducted by an independent, licensed laboratory using validated methods on a representative sample of each lot or batch for all pesticide active ingredients with an establish

limits of quantification (LoQ) standard. An accompanying *List and Limits* document specifies the 96 active ingredients that should be tested for and, where applicable, LoQs for fresh cannabis and plants, dried cannabis, and cannabis oil.²⁵ In addition to testing and reporting, producers must have an integrated plant management plan to reduce the reliance on pest control products and ensure only those 17 pesticides approved by Health Canada for cannabis are used. However, there is no requirement to report testing results on cannabis labels.²⁶ Furthermore, vigilance is required. A 2017 study of 144 samples from licensed cannabis producers found 26 (18%) showed the presence of unauthorized pest control products.²⁷

As is the case for microbial contamination, requirements for plant growth regulators vary between American states. In Washington state, screening for unapproved pesticides is required for medical cannabis but implementation of testing requirements for recreational products has been delayed by the COVID-19 pandemic.^{28 29} In Oregon, there is mandatory testing for a list of 59 analytes generated by working groups of experts, each with an action level based on the highest laboratory LoQ multiple by a factor of two.²¹ In California, cannabis testing is part of the state's Pesticide Residue Detection Program. As summarized by Valdes-Donoso et al, in California, all batches of legal cannabis must be tested for 66 pesticides, of which the tolerance for 21 is zero.³⁰

3) Heavy Metals

The cannabis plant is a hyperaccumulator, which means it is proficient in taking up metals that may be present in the soil or growing medium or from phosphorus-based fertilizers. Cannabis may also be cross-contaminated by metals during processing or, in some cases, by metal components of vape pens and other electronic vaporizers.^{3 31} Fortunately, uptake during growth typically occurs in specific areas already contaminated with metals and thus is seldom widespread.³² Metals that have been found in cannabis and/or cannabis products include cadmium (a carcinogen), lead (a neurotoxin), mercury (a neurotoxin), and arsenic (an endocrine disruptor and carcinogen).

Control of heavy metal contamination is critical in protecting the health of cannabis users. In 2007, the presentation of 35 adults to Leipzig, Germany, hospitals because of lead poisoning led to the study of locally-available cannabis. Of 597 people tested, 27.3% had blood lead concentrations requiring treatment and another 12.2% had levels indicating the need for monitoring.³³

In Canada, testing of cannabis products for heavy metals falls under the mandate of Schedule B of the Food and Drug Act, the same guidelines that are used for the production of pharmaceuticals.²⁰ The limits set out in Schedule B for cadmium, lead, arsenic and mercury were not developed specifically for cannabis, but are based on existing (USP or EP) guidelines and applied to inhaled cannabis goods.³⁴ As is the case for plant growth regulators, there is no requirement to report test results on products labels.

There is considerable variation in testing for metals between various American states. The Oregon guidelines address only microbes, pesticides, and solvents and there is no discussion of heavy metal contamination.²¹ In California, there are different limits for the four metals for inhaled and other cannabis goods, while Connecticut, Maryland, Nevada and New Mexico do not distinguish between mode of administration but provide recommendations in the form of amount per kilogram of body weight per day.³⁴

4) Solvents

Solvents may be used to extract cannabinoids from the cannabis flower and are the basis of creating cannabis concentrates. In the USP, 59 solvents are considered permissible to be used

in manufacturing herbal medicines and other drug products. However, there are limitations to the USP data: a) long-term data on toxicity and carcinogenicity are lacking for many permitted solvents, and b) solvents used by illegal operations, such as butane and propane, are missing.³ The issue of solvent contamination is particularly important for products such as dabs, cannabis concentrates that are volatilized on a hot platform and vaporized through a water pipe.³⁵ A number of small studies have reported high rates of solvent contamination in commercial concentrates, including those sold for medicinal purposes.^{35 36}

In Canada, between October 2019 and 2020, Health Canada had a list of residual limits (in parts per million) for cannabis oil products for 31 solvents.³⁷ As of 2021, however, producers were referred to Schedule B of the Food and Drug Act.²⁰ Limits vary according to the type of product and its intended use (e.g., topical, inhale or edible).

As with other contaminants, standards for solvent residuals vary between American states. In Oregon, for example, action levels are listed for 45 solvents while Maryland tests for 8, and New York allows only supercritical fluid extraction (e.g., CO₂).^{12 38}

5) Other Contaminants

If good practices are not followed, a variety of plant, metal or other materials can be introduced to cannabis during the time of growth, storage, or production (e.g., machine oils or parts, insect parts, rodent droppings, ash, etc.).¹⁰ In some cases, foreign matter may be deliberately added by unscrupulous, illegal operators. For example, in the UK, tiny glass beads were added to make the cannabis heavier and mimic the crystalline resin typical of a high-THC content. This “grit weed” was associated with a number of potential harms, including mouth sores and ulcers, persistent coughs, and chest tightness.³¹

Cannabis contamination with other psychoactive drugs is possible but appears to be rare. For example, at this point there have been no laboratory-confirmed reports of cannabis contamination with the high-potency opioid fentanyl or other narcotics.³⁹ A more common concern is contamination of cannabidiol (CBD) products with unreported or unexpectedly high levels of psychoactive tetrahydrocannabinol (THC).⁴⁰

Conclusions

Contamination of cannabis takes numerous forms and can be a significant health concern, especially for individuals with health problems or compromised immune systems. Deliberate contamination of cannabis product should occur only in the black market, as legal operators are under the obligation to conform to state or national safety standards utilized for food and drugs. Nonetheless, there are gaps in safety standards and the standards are only as strong as the level of enforcement. In Canada, there is a national testing and reporting system, which should ensure limited contamination and consistency between provinces/territories, although violations are documented. Thus, vigilance is nonetheless required to ensure cannabis producers meet the mandated standards and minimize contamination.

Footnotes

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