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Preventing Artificial Adulterants and Natural Contaminants in Cannabis Production: Best Practices

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BACK OF THE ENVELOPE CALCULATIONS

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Introduction

This document and its associated spreadsheets identify the most common sources of artificial adulterants and natural contaminants in cannabis production. We identify best practices in monitoring and preventing adulterants and contaminants during the entire product lifecycle, and discuss the feasibility of implementing them. We also discuss various ways that the Washington State Liquor Control Board (WSLCB) could monitor the process to ensure a safe and reliable product for consumers.

It should be noted at the outset that very few existing cannabis cultivation and processing operations comply with industry best practices, largely because the historically illicit market encouraged operators to compromise on plant health and contaminant safety. Thus, existing cannabis farming operations employ a hodgepodge of techniques that maximize yield but may not ensure a safe, reliable product. Washington's regulated environment will require that operators implement a degree of professionalism and regularity. The WSLCB can provide licensed producers and processors with a solid base of best practices to comply with Board regulations protecting consumer health and safety. In doing so, it will help set standards for other states that may move forward with cannabis legalization.

What are adulterants/contaminants and how can they affect the health of the cannabis user?

Like any crop, cannabis may be tainted by two groups of potentially hazardous substances. The first group is natural contaminants, which primarily consist of microbial toxins in soil, toxins that are activated when cannabis is burned, and less commonly, heavy metals such as mercury in metal-rich soils. The second group, artificial adulterants, is the residues of substances that were intentionally introduced by the grower. These are primarily pesticides, miticides, and fungicides used to protect the crop, and (more rarely) substances intended to enhance the psychoactive effects of cannabis.[1]

Natural contaminants include inert substances that become toxic upon the burning of cannabis, as well as harmful bacteria and fungi from the air and soil. Burning cannabis creates at least 200 thermal degradation products in smoke not found naturally in cannabis, including toxins such as acetaldehyde, ammonia, benzene, carbon monoxide, hydrogen cyanide, nitrosamines, and tars.[2] Bacterial contaminants in marijuana cigarettes supplied by the National Institute of Drug

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[1] Ethan Russo, *Cannabis and Cannabinoids: Pharmacology, Toxicology, and Therapeutic Potential*, 2002

[2] GJ Huber, "Marijuana and Tobacco Smoke Gas-Phase Cytotoxins," *Pharmacology, Biochemistry, and Behavior*," 1991

Abuse (NIDA) include pathogenic Klebsiella pneumonia, Enterobacter cloacae, Streptococcus, and some Bacillus species. [3] From black-market marijuana, researchers have isolated Salmonella muenchen, Thermoactinomyces candidus, Thermoactinomyces vulgaris, and Micropolyspora faeni.[4] Spores of fungi may also infest cannabis because of improper growing and storage, in addition to molds either inadvertently acquired or deliberately added to enhance the plant's psychotropic effects.[5]

Farmers may spray plants with artificial adulterants during cultivation, leaving chemical residues on harvested cannabis. Adulterants found during lab testing include sulfur dusts, copper sulfate, mercury compounds, lead arsenates[6], and a wide variety of pesticides, miticides, and fungicides.[7] In 2006, the Scientific Institute of Public Health in Belgium issued an early warning message stating that users in France, Belgium, and the Netherlands reported adulteration of their cannabis with substances including glass particles, mold, sand, bulb glass, and glass wool.[8] While such practices seem rare at the present time, cannabis has in the past been adulterated with various substances designed to increase its psychoactivity, including opium, camphor, tobacco, betel nut, foxglove leaves, henbane leaves, and Datura leaves.[9]

Cannabis that contains these contaminants and adulterants may cause respiratory problems in immuno-compromised individuals, and cancers of the aerodigestive tract.[10] Contaminants have been conclusively linked to a number of hospital visits in the United States and Europe (for severe headaches, impaired eyesight, breathing difficulties), while studies of the chemical composition of cannabis have shown conclusively that black-market strains generally carry more microbiological contaminants than cannabis provided by the National Institute of Drug Abuse and other government agencies.[11] This may be due to the fact that law enforcement pressure creates an incentive for growers to maximize the potency of cannabis plants by spraying or otherwise adulterating the finished product.

How are adulterants and contaminants introduced and spread?

Artificial adulterants such as pesticides, miticides, and fungicides are intentionally applied to crops to deal with pests and disease, whereas natural contaminants are

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[3] CM Sparacino, "Chemical and Biological Analysis of Marijuana Smoke Condensate," *NIDA Research Monograph*, 1990

[4] DN Taylor, "Salmonellosis Associated with Marijuana," *New England Journal of Medicine*, 1982

[5] Ibid, Russo

[6] In Germany in 2008 there was a report of 29 patients admitted to the hospital in the Leipzig area for lead poisoning as a consequence of smoking adulterated cannabis.

[7] Yu S-L, "Fungi Collected from Cannabis Sativa Grown in USDA Gardens at the University of Mississippi," University of Mississippi, 1973

[8] Gary Potter, *World Wide Weed: Global Trends in Cannabis Cultivation and Its Control*, 2011

[9] Ibid, Russo

[10] JT Ungerleider, "Contamination of Marihuana Cigarettes with Pathogenic Bacteria – Possible Source of Infection in Cancer Patients," *Cancer Treatment Reports,* 1982

[11] Ibid.

usually introduced accidentally via wind, ventilation, or gravity. Plants may also be inadvertently contaminated via human interaction with the plant by means of contaminated tools, hands, infrastructure (i.e., pots and trellises) and watering containers. Additionally, non-crop work adjacent to the farm, such as building construction or road repairs, may put contaminants into the air or soil. Fertilizers and other inputs to the crop may carry contaminants beyond those disclosed on the product label. Inadvertent contamination may occur as a result of poor storage practices. For example, rat poison stored in a fertilizer shed might be transferred to the hands of a worker and then to the product during processing or packaging.

Essentially anything that touches the product through its lifecycle may add a contaminant to the plant's rooting area, leaf canopy, or finished product. The intensity of contaminants may also increase independent of human interaction. For example, a low concentration of mold spores in a finished product may become unacceptably high if the product is stored in an environment that is wet and warm. Depending on level of spore count, moisture level, and temperature, mold growth can begin to develop in finished, packaged product commencing on the day of packaging and continuing during months of storage.
If an organic certification were available it would address many adulterant and contaminant issues as most of the harmful adulterants simply are not allowed to be used in organics. However, no certification is now available, and research is sparse on the effects and safety limits of organic PMFs intended for human consumption. It is unclear whether cannabis crops could be certified organic under the USDA's National Organic Program regulations.

I. Best Practices for Preventing Adulterants and Contaminants

Operational skill and care are the keys to avoiding the use of artificial adulterants and contaminants. Some of the required steps are obvious; others are less so. Continuity of management, dependability of staff, and a business culture that supports continuous growth will foster the ability of a company to adhere to best practices.

Standard Operating Procedures (SOP)

A standard operating procedure is written documentation of the steps in a task, as well as any supporting information required to accomplish the task. An SOP can be used to create accountability and consistency during the production process.[12] Consistency provides stability to production teams and reduces mistakes that can lead to contamination.[13] Each key best practice area listed below should have an

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[12] Western Region Alliance on Beef Quality Assurance, "A Guide to Writing Standard Operating Procedures," 2008

[13] University of California Cooperative Extension, "Standard Operating Procedures," http://ucanr.edu/sites/placernevadasmallfarms/Resources/Managing_Risk/SOP/ (accessed June 8, 2013)

SOP to ensure the reliability of the finished product.[14] The WSLCB might consider requiring the submission of SOPs with license applications and renewals.

II. Set-Up

Genetic Sourcing

Plants for production can come from three sources: seed, clone or tissue culture. Seeds are naturally 50/50 male and female, but some companies now specialize in feminization, where they guarantee all female plants.[15] A clone is a cutting from one plant that is rooted and allowed to grow into a self-sufficient plant. Clones are genetically identical to the plants from which they were cut.[16] Tissue culture is a relatively new practice with cannabis, but is common in agriculture. Tissue is cut from a plant and put into a petri dish where it can be stored for years, cleansed of disease, and duplicated into another identical plant. The result is genetically the same as a clone, but with purification.[17]

Mother rooms, seed stock, and tissue culture labs may also be the source of contamination. A contaminated plant transferred from the propagation area to the production area could transmit contaminants to the rest of the crop. It also may be genetically weak and draw undesired attention from pests to an otherwise healthy crop.

Since operators choose fertilizers and pesticides based on the identity of the plant intended to be grown (the varietal), care must be taken to ensure that stock is exactly what was intended, as well as free from pest, disease, or fungus.

Facility/Block Design and Crop Plan

Whether the crop is being grown indoors in a warehouse, under the sun inside a greenhouse, or outdoors in an open space, properly designing and planning the design of facilities and crops can prevent contamination.

Facility design must take into account propagation, vegetation, flowering, drying, curing, processing, packing and storage. Since air currents carry contaminants, ventilation is a key concern for growing operations. Penetration of the work and grow areas by light and rain are also important. Light and heat, which may benefit plant health in one stage of the process, may be deleterious and foster contaminants at another stage. Drainage, both in fields and inside facilities, is critical to reduce stagnant water. Both man-made and naturally occurring contaminants are

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[14] Wythe Morris, "GAP Training Session: Writing an SOP," Virginia Cooperative Extension (accessed June 8, 2013)

[15] "Why Do I Not Want Male Marijuana Plants?," growweedeasy.com (accessed June 12, 2013)

[16] Alina Krukova, "Marijuana Seeds vs. Clones," http://blog.sfgate.com/smellthetruth/2013/03/27/seeds-vs-clones/, Mar. 27, 2013

[17] HE Sommer, *Plant Tissue Culture: Methods and Applications in Agriculture*, 1981

dangerous, and the operator needs to be vigilant in controlling and reducing all the mechanisms that may cause them to spread to the crop. Propagation areas must be designed and managed correctly, with consideration given to climate, work flow, sterilization, record keeping, and generally good management practices like the ones listed below.

Building materials and infrastructure components

Effort must also be expended in the selection of building materials. For example, pressure treated wood, which contains arsenic, should not be used for staking plants. High Volatile Organic Compound (HVOC) paints should not be used in places where plants might come in contact with its fumes.[18] Stainless steel tables should be used for processing so that surface areas can be easily seen and cleaned. Care should be taken to ensure that material in the infrastructure of the operation is suitable for touching cannabis and that it is easily sterilized. Management should have oversight of all construction materials and construction projects to consider their potential impact on crops or the spread of contaminants throughout a facility. The source and the possible toxicity of all materials must be known. Every point that raw materials can touch should be considered as a contamination point.

Wind-borne contaminants and site selection

Since contaminants may be carried to a crop by wind, site selection is important. An outdoor farm should not neighbor a garbage dump or even a heavily travelled dusty road that could blow contaminants onto exposed crops. Operators of outdoor farms should consider whether neighboring properties and crops could carry contaminants. It is also important to know if neighboring farms have pest, disease and fungus issues. If needed, windcloth can be used to decrease the potential for windborne contaminations.

Not all indoor locations are suitable for growing cannabis. For example, a warehouse grow operation, even if internally ideal, could draw air from a neighboring an oil refinery. Even car exhaust can be a contaminant if it enters an indoor growing operation from a heavily trafficked road.

Soil and water testing

Heavy metals, bacteria and fungus can be present in source water so it is imperative that water be tested not only for its mineral content (which affects plant health), but also for chemical toxins and pathogens. Water sources could consist of trucked-in water, well water, spring water, city water, irrigation water and even rainwater.

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[18] US Environmental Protection Agency, "Section A. Clean Air Act Requirements," http://www.epa.gov/dfe/pubs/pwb/tech_rep/fedregs/regsecta.htm, 1990

Operators should pay attention to prior land use, even if the land has been used for agriculture. It is also important to know what was previously farmed on that soil, whether it was certified organic, and what products might have been used. Soils should be tested for fertility, toxic chemicals, heavy metals, and pathogens. Soil and other media brought to the property (including topsoil, compost, commercial potting soil, and inert soil-less media like coco fiber, peat, and rockwool) might have contained additives and conditioners and fertilizers. Typically commercial soil and private compost companies test their products, but it is important for licensees to ensure the absence of contaminants from prior uses.

Adulterant and contaminant storage

Great care should be taken to maintain separate storage areas for items that can be applied to plants and items not intended for plants. Bleach, for example, which can be used for sterilizing, is a toxin and must be stored in an entirely separate area from chemicals and products intended for application to the crop. Separate storage areas must be located at a safe distance from each other and should be situated so as to minimize the need to carry potential contaminants across areas where plants are grown or processed. Air currents should be considered as well when siting dry material contaminants that could become airborne and carried to plant areas. Storage areas should be orderly and inventories should contain product expiration dates should be maintained to ensure that expired products are discarded. For example, bleach, Windex, and rodent control should be kept separate from neem oil, fertilizer and plant tools, far from any growing, raw or finished, product.

Indoor Growing vs. Outdoor Growing vs. Greenhouse Growing

Contrary to popular belief, indoor-grown cannabis is not necessarily "cleaner" than greenhouse-grown or sun-grown cannabis. Best management practices can be established for all cannabis growing methods. All things being equal, it is easier to manage a healthy plant outdoors than indoors because the natural predators, beneficial bacteria, and full-spectrum sunlight that exist outside all lower the need for artificial adulterants and reduce the chance of contamination from neighboring plants. That being said, certain types of contaminants (windborne, for example) can be easier to manage indoors.

Key indoor concerns:

1. Pests and disease may become trapped inside the facility.
2. Recycling air may increase contamination concerns. Many sophisticated indoor grows have "closed systems" whereby the same air is conditioned and recirculated. These systems require CO2 enrichment which can be a by-product of burning propane or natural gas. If indoor grows do not have proper climate control, they may become ripe for the growth of harmful molds.

3. Indoor farming does not allow for natural predators to balance pest populations.
4. Indoor environments are not a guarantee against environmentally caused crop failures. Climate control is only as good as the equipment that drives it; the operation is jeopardized when equipment breaks down.
5. Indoor growing requires more skill to ensure plant health and resistance to pest and disease

Key greenhouse concerns:

1. Greenhouses fall somewhere between outdoor farms and indoor growing environments.
2. Since the climate must be controlled mechanically in most situations, greenhouses share some of the same concerns as do indoor grows. For example, fans can draw contaminants from outside. However, greenhouses have some flexibility in ventilation options, so that recontamination from air recycling may be lessened. Greenhouses may also have their side-walls rolled up when the climate is right and allow for free exchange of air and free flow of beneficial insects. They also allow penetration by the sun, increasing the plants' capacity for photosynthesis.

Key outdoor Concerns:

1. Outdoor plants are exposed to the elements. Adverse weather can place undue stress on the plant. Rain, hail, and wind can damage plants. Wet mature flowers can mold after a heavy rain even before harvesting.
2. Outdoor plants are exposed to air currents carrying potential contaminants.

Cleanliness/Sterilization

All surface areas touched by the cannabis plant or its products should be kept sterile. These include plant containers, trellises, stakes, netting, hoses, pumps, tanks, sprayers, pruners, machine harvesters and their affiliated tools (bucking boards, bins, etc.), harvesting hangers, carts, screens, drying and curing rooms and containers, processing rooms, tables, tools (scissors, scales, graders, etc.), and the packaging material storage room. The sterilization medium should not itself be a contaminant (for example, bleach can kill bacteria, but residues are harmful to human health).

III. Growing

Climate

Proper environmental conditions including air temperatures, humidity, and root temperatures are required for healthy plant growth through all cultivation stages. Healthy plants with strong immune systems have higher resistance to pests and disease, and therefore require fewer adulterants and are less likely to acquire natural contaminants. Generally speaking, summer growing conditions in eastern Washington are more suitable for growing cannabis than are conditions in western Washington. Eastern Washington is warmer, drier and has less rain. This does not mean that cannabis can't be grown in western Washington, either outside or in greenhouses, but the environmental conditions are far less suitable. Western Washington outdoor growers will have to contend with cooler and wetter conditions, which can create weakened plants and encourage mold growth.

Storage of products used for cannabis farming also requires a specific climate. For example, beneficial bacteria, beneficial insects, and aerobic teas all have optimal temperature and humidity ranges. If the proper conditions are met, aerobic bacteria can turn anaerobic and cause disease. Products can spoil and grow mold. Likewise, with finished cannabis products each product will have a defined optimal temperature and humidity. Edibles may need refrigeration and flowers will need to be kept cool, with moderate humidity. Throughout the production lifecycle there are many touchstone conditions at each stage of development. Generally speaking, cannabis prefers warm (70-90 degrees) and dry growing conditions (25-50% relative humidity). During propagation, humidity is ideally 50-80% and temperature 80-90 degrees.

Product Flow

Since the risk of contamination increases with every day that the developing plant and the product remain in production, efficiency should be a goal. Considerations of product flow should drive facility design in order to prevent contamination of younger material by older material. The plant should be coming into production from the propagation area where it should have come into existence free of pest, disease and fungus, as well as true to its label as to its genetic source. It then heads "downstream" from the most vulnerable area of the operation. The plant on its way to vegetation should not be walked through a flowering room because the room contains older plants that may be compromised. Mature plants should be isolated from younger plants, to protect against the risk that they could spread any acquired disease. As the plant finishes its vegetative growth, it should be moved into flower, harvest, drying/curing, processing, and packing. The product should physically flow "downstream" to the final climate controlled storage area where it will be packed and sealed, ready for market.

Crop layout

Air flow is important for proper transpiration and prevention of a hospitable habitat for pests. One foot of separation in walkways between plant canopies is adequate, additional distance is a waste of space. This one-foot spacing would create plant canopies just touching at maturity in rows. Indoor plants can be grown on dedicated tables where each canopy fills the surface area of the table . Ideally, plants should have shorter life cycles to limit the presence of old, sick plants, and should be spaced so that workers can easily get to all areas of the plant. Plant maturity size is capped by when the plant enters its flowering stage, which will occur when the light exposure shortens to 12 hours a day. The diminished photoperiod triggers the plant into flowering since the grower has approximated a fall season which is the natural time for plant reproduction. Once flowering is initiated the plant will only grow in size for 2-3 more weeks. How a plant is pruned, trained, and trellised also plays a role in the airflow through the plant and how groups of plants are laid out. Typically, pests will start on a weak plant and travel as their populations and colony matures, so it is very important to have individual plant inspection and quarantine abilities.

Plant Health

Yield v. Health

Healthy plants have strong immune responses. Therefore, ensuring optimal plant,. Health - thereby lessening the need for chemical intervention – is a leading best practice for avoiding the presence of artificial adulterants in the product. Although common- sense business practices favor cannabis cultivators with high yields of top-quality product, high yields do not necessarily mean top quality, and pushing the plant to produce a higher yield can add stress to the plant that will result in lower quality. Many cultivators 'push' their plants with heavy fertilization, special additives, foliar feeding, extra lighting, enriched carbon dioxide, extra water, aggressive pruning and training, and high transpiration rates. These techniques can result in higher yields but may degrade the finished product. The health of the plant is connected to its quality as it will grow to its true genetic potential when it is healthy.. Keeping the plant's life path as close to its natural state while gently optimizing its growth environment is a preferred balance compared with attempting to push the plant up to its maximum yield (or beyond).

Plant Stress

Because of its illegality and value, cannabis has been grown under conditions to no legal consumable plant would ever be subjected. More is not necessarily better. There is a threshold where the plant can become vulnerable to pest and disease due to stress. Many high-performing cannabis gardens fall prey to pests and disease simply because the conditions were too intense, weakening the immune responses of the plants. Measuring the stress on a plant requires subtle observations of the plant's general health and knowledge of what historical stressors the plant is still carrying. Color, vascular pressure, the "reach" of the sunleaves as they track the light, water consumption, fertilizer consumption, growth rate, and plant structure are all indicators of general plant health.

Integrated Pest Management (IPM)

IPM means understanding pest threats and developing a prevention plan. The UN's Food and Agriculture Organization defines IPM as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms."[19]

Key Concerns for IPM:

1. Growers must know the native pests, their reproductive rates and how they thrive. Some nationally common pests and disease include spider mites (thrips, whiteflies, fungal gnats, root aphids, aphids, budworms, powdery mildew, botrytis, pythium, phytothera, and fusarium. Pests and disease are to be avoided because they can require or encourage the use of pesticides and fungicides which may be unhealthy for human consumption. Infested plants are also unhealthy plants and unhealthy plants make for a lower-quality product.
2. Growers must know the natural predators and commercial bio-controls for the local pests. Commercial bio-controls are predator insects, bacteria and fungus commercially bred for agriculture. Know how these predators interact with each other.
3. Each grower must have a plan in place to preventatively control pest introduction, starting with clean seed, clone, or tissue culture stock.
4. Growers must measure levels of pest habitation regularly, and set a level that requires quarantine of plant matter.
5. Growers must schedule preventative pest control measures, balancing plant health, plant growth phases, and pest reproductive phases.
6. Each grower must have a plan for low impact pest control, including designation of pre-harvest intervals(the latest date before harvest that a pesticide may be safely used), use the least invasive controls needed to ensure a minimal impact on the plant from the intervention, and use the most consumer-safe methods possible.

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[19] Waheed Bajwa and Marcos Kogan, "Compendium of IPD Definitions: What is IPM and how is it defined in the Worldwide Literature?," http://www.ipmnet.org/ipmdefinitions/index.pdf, 2002

7. Companion planting is the practice of growing plants that naturally deter pests alongside the cannabis. Various species of companion plants inhibit specific pests.
8. Pesticides, miticides, and fungicides can be grouped into three levels of danger and admissibility: unacceptable under any circumstance, acceptable with a proper pre-harvest interval (PHI), and acceptable or based on below a maximum threshold of concentration levels. For instance, Dioxin and DDT are unacceptable contaminants at any levels. Neem oil is an acceptable adulterant with the proper application rates and pre-harvest timing; and Dead thrips are acceptable at low concentration levels. The attached spreadsheets indicate how they are all categorized.
9. There are no pesticides and fungicides currently regulated for use on cannabis, so pre-harvest intervals have not been established. There are non-regulated insecticides like neem oil, soap, and essential oils that are not necessarily prohibited for use on cannabis, but there are no official pre-harvest intervals determined for their use in cannabis. It is, however, not recommended to spray any liquid on cannabis plants in late flowering (after week 5) as it can promote mold growth. If best practices are adhered to, and an IPM program executed properly, there should not be any reason to spray late-flowering cannabis plants.

A strong IPM program will result in complete management of pest populations. It is not uncommon for production crops to be finishing with live bio-controls intact and only a few spraying events early in the plant's life before application of bio-controls.

IV. Harvesting

Harvest is a stage in the product life cycle that is very vulnerable to contamination since the plants are being handled heavily, moved, and hung in the dry chamber.

Key Concerns:

1. Growers must maintain cultivation climate through harvest, limit neighboring work that could create contaminants, and be aware of air and wind currents.
2. Growers must use clean and frequently sterilized tools. Hairnets, hats, non-loose clothing, masks and gloves can greatly reduce chances of contamination.
3. Growers must ensure that employees who have infectious diseases do not work around the plants. and ensure that all workflow areas are clean to prevent contamination.

4. Each grower must ensure that staff is following a harvest sequence and rhythm. All products should be properly labeled for traceability, moved in a short time to the dry room once cut, and properly cut in sequence.
5. Growers must maintain dry rooms in clean and sterile conditions. Atmospheric controls should be primed prior to commencing harvest so as materials go into the room the proper conditions are in place. There is much debate about the best way to dry and cure cannabis, but the one thing everyone agrees on is that the first ½ of plant water weight should be removed within 48 hours to lower the chance of mold growth. Re-entering these climate-controlled rooms should only be done for inspecting the progress of the dry phase and great care should be taken to prevent contamination.
6. Infested, damaged, moldy or otherwise unusable product obtained from the drying process must be quarantined and tracked for compliance. Infested matter should be placed in a sealed container upon detection and removed from the harvest process to a quarantine designated area where it should be dried down and saved for audit reasons. When workers return to harvest, a thorough cleaning should proceed where hands are washed, gloves replaced, tools sterilized, and clothes misted with an alcohol solution.

V. Drying and Curing

The harvested cannabis plant should be moved quickly to the drying room. Once there, crop drying should commence as soon as possible. Ideally, most moisture should be pulled from the materials in the first 24-48 hours. Care should be taken to prevent long periods of time at warm and wet conditions, which can foster growth of bacteria and fungus. Curing conditions should ensure that the product neither dries nor moistens while temperatures are between 50-70 degrees Fahrenheit. Curing should commence at a moisture level between 8-12% when the product is near dry. Curing should finish at a product moisture content that is desired for packaging. This desired level can vary by preference of producer, but should generally be between 6-10%.

There is much debate over the proper way to dry and cure, but – most importantly – habitats for mold and bacteria growth must be reduced. The most important element is rapid removal of water weight (1/2 water weight removed within a minimum of 48 hours). Some operators choose to remove the water even faster. Any movement of materials in the drying and curing process should follow the same care as the harvest process, and if the product is moved into another container or room, the new facility must also be sterilized. Humidity levels need to remain low enough to inhibit mold growth in the curing stage.

The chamber in which the drying and curing takes place needs to be nearly air tight in order to keep the climate under control and limit the access of contaminants. Given that the room must be sterilized and free of contaminants, the walls should be easy to clean and free of any contamination.

VI. Processing, Packaging and Storage

The processing stage, like harvest, is vulnerable to contaminants. The climate of the processing and packing rooms should mimic the ideal conditions for the product inside its sealed package.

Key concerns:

1. The room must be entirely enclosed to facilitate climate control which is needed to maintain optimal packaging moisture levels.
2. The room and its entire infrastructure must be easy to clean and sterilize. Stainless steel tables, floor drains and Marlite-paneled walls aid in the ease of cleaning and sterilization.
3. Filtered positive air pressure over work areas will reduce the risks of contamination and worker exposure to breathing dust particulate from processing the product.
4. Hairnets, hats, masks, gloves, and non-loose clothing are highly recommending in the processing phase of the product life cycle, as it is the most vulnerable point, as well as the last chance to detect contamination prior to packaging.
5. Processing should feed directly into packaging to prevent overhandling of product and reduce exposure to contaminants.
6. Great care should be taken to ensure unusable products and by-products are placed in clean and sterile containers that can be sealed. This includes trim, Grade A flowers, and Grade B flowers.
7. The product should be at an optimal moisture level (approx. 6-10% for cannabis flowers) prior to entering the package and the processing room environment should not add moisture. The packaging material should be acclimated to the processing room's ideal temperature and humidity (approximately 35-50% humidity and 60-70 degrees Fahrenheit).
8. Once the product is packaged in sealed containers it should be stored in a clean, cool, dark, and secure area.
9. Most all products would benefit from low temperatures and low light with low-to-moderate humidity.

VIII. Auditing and Inspection

Testing for PMFs and contaminants should be executed, although minimally, at cultivation sites by pulling sun leaf samples at various times in the plant grow cycle. Random audits may be enough to encourage compliance and identify negligent operators. The reason for testing the live sun leaf at various intervals in the plant life cycle is to detect the improperly applied PMF before its half-life is over and it becomes undetectable.

Cultivation site visits will allow the enforcement officer to inspect fertilizer, PMF, and cleaning supply inventories, and identify unapproved chemicals. A visual inspection of the operation will also inform the officer of the number of pests the company is dealing with and will allow the officer to interview management about its control measures. During this visit, the officer can make sure that management has trained staff to adhere to best practices.

For all of these reasons, it is important, that the WSLCB seek to grant licenses to qualified operators who will adhere to best practices. Although the tasks is daunting, efforts could be made via a questionnaire testing the level of growing/processing knowledge and inquiring into the team's experience, with confirmation that management has a thorough facility/crop design and an operating plan. Knowing that the applicant has the experience and means to succeed will minimize the potential for a needed remediation of failed audits.

The more the operation tracks key metrics, the easier it will be for the WSLCB to deeply audit and remotely inspect licensees. While contaminant/PMF best practices come with associated costs, best practices create a consistent, quality product that drives consumer demand. Strategically or random-timed testing of live leaf tissue should dissuade operators or catch operators that take this route.

IX. Ongoing Education

Various agricultural publications exist for producers to stay abreast of new products and general agricultural best practices. If a trade association does not yet exist for licensed cultivators and processors it certainly will come into being soon, and will ideally serve as a forum to spread awareness about best practices and methods to prevent PMFs and contaminants. It may serve the WSLCB to provide a forum or bulletin board for all licensees to share information. In 2012, California saw an outbreak of a rare pest that was initially misdiagnosed as a disease, but in the end turned out to be a broad mite. In that case, the broad mite infestation news spread in fragmented ways from grower to grower to hydroponic store to dispensary and so forth. A WSLCB website would be a legitimate place for this type of information to be shared. A public government-hosted setting in this context could be very helpful. Perhaps it could also be sent around as an e-newsletter on a quarterly basis. The WSLCB could also host workshops where licensees and enforcement officers could share information. It must be noted that some operators will see the information they have as proprietary. While this sentiment should be respected as far as it goes, enforcement officers would be the best conduit for the spread of general issues of concern for all operators.