

Endotoxin exposures during harvesting and processing cannabis at an outdoor cannabis farm

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Abstract Legalization of medicinal and recreational cannabis use in numerous states within the USA has resulted in the increased commercial cultivation of cannabis. Outdoor cannabis farming operations present a variety of potential physical, chemical, and biological hazards that currently remain uncharacterized. Worker exposures to endotoxins were evaluated at an outdoor US cannabis farm during harvesting and processing activities. Endotoxin area air sample concentrations ranged from below the limit of detection to 15 endotoxin units per cubic meter (EU/m³). Endotoxin breathing zone measurements (2.8–37 EU/

m³) were below the Dutch Expert Committee on Occupational Safety occupational exposure limit of 90 /m³. During confidential medical interviews, no adverse health effects were reported by workers while harvesting or processing cannabis. Further endotoxin exposure assessments should be performed especially in larger, indoor cannabis operations where a confined environment may result in higher endotoxin exposures than observed in this outdoor environment.

Keywords Endotoxin · Exposure assessment · Cannabis · Marijuana

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1 Introduction

As of November 2018, 33 states and the District of Columbia have passed laws that legalize cannabis, commonly known as marijuana, for medicinal use. Eight states and the District of Columbia have also approved cannabis for recreational use. In 2016, the cannabis industry in the USA had an estimated 7 billion dollars in sales with approximately 150,000 employed in the industry (Borchardt 2017).

Despite increased state legalization, research on occupational health issues in the US cannabis industry has remained limited. In June 2015, the National Institute for Occupational Safety and Health (NIOSH) Health Hazard Evaluation (HHE) program received a request from the United Food and Commercial Workers International Union to evaluate potential hazards associated with harvesting and processing cannabis at an outdoor farm located in the State of Washington, which legalized cannabis for medicinal (1998) and recreational (2012) use. The 5-acre farm grew cannabis, vegetables, and fruits utilizing organic practices and without pesticide use. The farm grew *C. sativa*, *C. indica*, and a *C. sativa/indica* hybrid.

In August 2015, a preliminary site visit was conducted to learn about the growing operation and to identify potential hazards. Confidential medical interviews were also conducted with all the employees and the owner/operator. In October 2015, a second site visit was conducted during harvesting to evaluate the hazards identified during the initial visit.

Endotoxins are found throughout the agricultural industry and production of agricultural commodities, including hemp (Fishwick et al. 2001a). Endotoxins are released from the cell wall of gram-negative bacteria during bacterial cell lysis or division. A previous study of the European hemp industry has shown that workers can be exposed to respirable dusts during work-related disturbance activities and levels of endotoxin were up to 200-fold higher than the Dutch Expert Committee on Occupational Safety (DECOS) occupational exposure limit (OEL) of 90 EU/m³ (Fishwick et al. 2001b). Chronic health effects that have been associated with airborne endotoxin exposures include asthma, chronic bronchitis, bronchial hyper-reactivity, chronic airway obstruction, hypersensitivity pneumonitis, and organic dust toxic syndrome (Duquenne et al. 2013; Rylander 2006). Exposure to *C. sativa* hemp dust has also been

previously shown in textile working populations to be a risk factor for respiratory morbidity (Fishwick et al. 2001b).

The farm's workforce consisted of the owner/operator and three employees and cultivated approximately 40 cannabis plants. By harvest, the plants had routinely grown upward of 3 m (10 ft) tall and 2.5–3.7 m (8–12 ft) wide. Harvesting the plants included using hand pruners to cut the colas (large branches) and transfer to the big leafing area, a process of removing large leaves that do not contain trichomes. The resulting stems containing flowers were dried in a separate enclosed structure. Destemming was the process of removing dried flowers prior to final flower trimming. A previous exposure assessment at the farm showed approximately 45% of the bacterial biodiversity was derived from gram-negative, endotoxin-producing bacteria (Green et al. 2018). The objective of this study was to characterize potential endotoxin exposures and identify work tasks that result in exposures during cannabis processing.

2 Methods

Breathing zone air samples ($n = 12$) and area air samples ($n = 11$) were collected at an air flow rate of 2 L per minute on the owner/operator and all three employees during their entire work shift for 3 days. Each sample was collected using three-piece 37-ml closed-face cassettes, preloaded with 0.45-mm-pore-size endotoxin-free polycarbonate filters. Endotoxin samples were analyzed by the NIOSH contract laboratory for endotoxin content using the kinetic-chromogenic procedure with the limulus amoebocyte lysate assay (Cambrex BioScience Walkersville Inc., Walkersville, MD, USA). For these analyses, one EU was equivalent to 0.053 nanograms of endotoxin. The limit of detection (LOD) was 0.50 EU per sample. For quality control, five field blanks and 16 media blanks were also submitted for analysis. In 2010, DECOS recommended a health-based OEL for airborne endotoxin of 90 EU/m³ as an 8-h time-weighted average (DECOS 2010).

2.1 Confidential medical interviews

The owner/operator and all three employees were interviewed about their health and safety concerns

related to cannabis processing. Cannabis work history and exposure, use of personal protective equipment, and symptoms (including rash and other allergic reactions which have been previously shown to be associated with cannabis exposure) were recorded (Decuyper et al. 2015). Employees were also asked about long-term health and safety concerns related to their job.

3 Results

The evaluation was conducted over a consecutive 3-day period, and tasks performed each day varied slightly (Table 1). Temperature and average humidity readings were recorded for day one (43–52 °F and 79%), day two (52–59 °F and 92%), and day three (53–64 °F and 84%). Days one and three had no precipitation, but day two had consistent mist and rainfall conditions throughout the working day with nearly one-quarter inch of total precipitation. Day two tasks were not limited due to precipitation because all tasks were performed inside the hoop house or the drying building. All meteorological conditions were obtained via a local airport report. All tasks were performed either in a hoop house or in an enclosed drying structure to reduce wetness from rainfall and sped subsequent drying times.

Table 1 Breathing zone air sampling for endotoxins

Job/activity	Sample time (min)	Total volume (l)	Concentration (EU/m ³)
<i>Harvesting—day one</i>			
Employee 1	466	950	37
<i>Big leafing/gross trimming—day one</i>			
Employee 2	471	938	20
Employee 3	469	934	22
Employee 4	466	928	24
<i>Big leafing/gross trimming/destemming—day two</i>			
Employee 1	415	818	6.1
Employee 2	414	798	2.9
Employee 3	418	812	3.8
Employee 4	409	795	2.8
<i>Destemming/hand trimming—day three</i>			
Employee 1	486	951	17
Employee 2	479	964	15
Employee 3	480	929	21
Employee 4	483	940	19
DECOS OEL			90

3.1 Endotoxin

Breathing zone endotoxin air sampling results ranged from 2.8 to 37 EU/m³ (Table 1). Endotoxin concentrations were highest for the owner/operator and all three employees on day one, when harvesting occurred. On day one, Employee 1, who harvested the cannabis plant, had slightly higher endotoxin exposure (37 EU/m³) than employees 2, 3, and 4, who performed big leafing activities nearby in the same hoop house (range = 20–24 EU/m³). Day two (meteorological conditions included consistent precipitation) had the lowest endotoxin concentrations for the owner/operator and all three employees (range = 2.8–6.1 EU/m³). Employee exposures on day three were slightly less than those on day one. No samples exceeded the DECOS recommended limit of 90 EU/m³.

Endotoxin concentrations in area air samples (Table 2) ranged from not detectable to 15 EU/m³. The highest area air sample endotoxin concentrations were found in the hoop house on the first day of sampling during harvesting and big leafing activities. Endotoxin was not detected in the three outdoor area air samples collected outside the drying building. All field blank samples were below the LOD. However, one media blank sample was positive for endotoxins (2.97 EU per filter).

Table 2 Area air sampling for endotoxin

Job/activity	Sample time (min)	Total volume (l)	Concentration (EU/m ³) ^a
<i>Harvesting/big leafing/gross trimming—day one</i>			
Front of harvesting hoop house	435	860	13
Back of harvesting hoop house	434	868	15
Trimming area of drying house	450	895	ND
Next to drying plants in drying house	450	909	ND
Outside new drying house	421	836	ND
<i>Big leafing/gross trimming/destemming—day two</i>			
Trimming area of drying house	423	830	ND
Next to drying plants in drying house	412	812	ND
Outside new drying house	409	795	ND
<i>Destemming/hand trimming—day three</i>			
Trimming area of drying house	522	1022	1.5
Next to drying plants in drying house	525	1016	1.7
Outside new drying house	504	978	ND
DECOS OEL			90

ND = not detected

^aThe minimum detectable concentration of endotoxin ranged from 0.51 EU/m³ to 0.63 EU/m³

3.2 Confidential medical interviews

Three employees at the farm and the owner/operator were interviewed. They reported prior work with cannabis with a range of less than 1 year to 17 years. All interviewed employees reported performing several tasks at the farm including cultivating, cutting, and trimming of cannabis. Employees were also asked whether they experienced symptoms that might be related to working with cannabis. None reported any symptoms or health effects.

4 Discussion

This study was conducted at an outdoor cannabis grow operation utilizing organic practices that did not include pesticides. Typical cannabis grow operations are often indoors, and pesticide use is more prevalent. While this workplace represents a small percentage of cannabis grow operations, our results provide insight into potential endotoxin exposures that may be applicable across the industry.

Data on occupational endotoxin exposures in outdoor agricultural settings are limited. One recent

study evaluating general public endotoxin exposures in an agricultural US county reported an outdoor endotoxin geometric mean exposure of 1.93 EU/m³ (Pavilonis et al. 2013). The airborne endotoxin concentrations at this cannabis farm were generally well below occupational exposures found in indoor agricultural settings such as observed by Thilsing et al. (2015) in an indoor flower greenhouse (range 0.84–1100 EU/m³); Dutkiewicz et al. (2001) in two indoor herb processing plants (median endotoxin concentration 3×10^5 EU/m³); and Fishwich et al. (2001a) in an indoor hemp processing plant (mean endotoxin concentration 1.9×10^4 EU/m³).

Endotoxin concentrations were lower on day two when compared to day one and day three concentrations. Even though day two activities were all performed inside wooden structures, the lower concentrations may have been due to increased environmental moisture which is supported by all three area samples collected on day two being below the LOD.

The HHE final report included an expanded exposure assessment (ergonomic hazards, microbial biodiversity, and Delta-9-tetrahydrocannabinol) and is available to the public (NIOSH 2017). The microbial biodiversity results were discussed in a previous

publication (Green et al. 2018). To our knowledge, this is the first characterization of potential endotoxin exposures in the cannabis industry and represents the identification of endotoxin exposure potential within an emerging industry.

5 Conclusion

Although employees at this small outdoor organic cannabis farm reported no health effects, our findings indicate that the employees have exposures to low levels of endotoxin. While no adverse health effects were reported by workers while harvesting or processing cannabis, the sample size was small. Further exposure assessments and surveillance are needed to better characterize exposures and adverse health effects in the industry.

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