

Analysis of Illicit Cannabis Vape Cartridges and Other Products for Chemical Contaminants



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KEY FINDINGS



Thirty-one illicit cannabis samples (24 vape cartridge and extract products, 3 flower samples, and 4 edible samples) and ten legal cannabis vape cartridges were analyzed for total THC and chemical contaminants (pesticides, heavy metals, residual solvents).



THC label claims: All legal vape samples had THC label claims compliant with Health Canada regulations (i.e. within $\pm 15\%$ of the label claim). Not all illicit samples had THC label claims, however, ten of the eleven illicit extract products that had THC labels claims were 16% - 24% lower than the amount claimed. All four edible products tested were 42% - 86% below the label claim.



Pesticides: None of the legal vape samples had pesticides detected at the Health Canada limits. The majority of illicit extract and flower products tested (25 of 27) had pesticides detected above Health Canada limits, in some cases three orders of magnitude above the limit.

OVERVIEW

The legalization of cannabis in Canada in 2018 set out to accomplish several things, including minimizing harm from use, establishing a safe and reliable supply chain, and enforcing public safety, education and protection. Since the introduction of the Cannabis Act and Regulations, the legal cannabis market has progressively been displacing illicit sources of cannabis (Statistics Canada 2023), though many cannabis users continue to access illicit cannabis (Rotermann 2020). Previous studies (OPP 2021, Eykelbosh 2021), including a study released by RPC (Botelho 2021), have demonstrated that cannabis products from illicit sources contain elevated levels of chemical and microbial contaminants and are grossly inaccurate with potency label claims. Moreover, a study from British Columbia (BC Cannabis Secretariat 2022) that looked at illicit cannabis flower and vape cartridges detected pesticides in all samples analyzed. A recent study by Health Canada (Gagnon 2023) also confirmed that illicit cannabis samples were plagued with pesticide contamination, with a 92% sample positivity rate.

With a rise in the popularity of vape products (Canadian Cannabis Survey 2022), continuing to understand the risks of cannabis vape products, particularly illicit vapes, is critical.

Due to the processing involved in making vape products and how they are packaged, there are additional concerns related to contamination from the use of solvents for extraction and the possibility of concentrating pesticides that may have been present in the flower material. Heavy metal contamination from processing or from vape cartridge heating elements/components and use of cutting agents are also a concern.

Whereas legal cannabis must be tested for contaminants, illicit cannabis does not need to follow Health Canada's Good Production Practices, greatly increasing the risk to cannabis users who choose to use illicit cannabis products.

SAMPLE COLLECTION AND ANALYSIS

LEGAL SAMPLES

Legal samples were obtained from Cannabis NB (Table 1). Every sample was from a different licensed producer and was THC-dominant.

TABLE 1: LEGAL SAMPLE SUMMARY

Cannabis Class	Sample Description	# of Samples
Extract	Vape Cartridge	10

ILLICIT SAMPLES

Illicit samples were legally obtained from Justice and Public Safety officers who transported the samples to the Research and Productivity Council (RPC) for testing. Although the focus of this study was on analysis of vape products, additional extract, flower, and edible samples were also provided (Table 2).

TABLE 2: ILLICIT SAMPLE SUMMARY

Cannabis Class	Sample Description	# of Samples
Extract	Vape Cartridge	18
	Shatter	3
	Hash	1
	Infused Pre-roll	2
Flower	Pre-roll	1
	Dried Flower	2
Edible	Chocolate	2
	Gummy	2

ANALYSIS

Cannabinoid, pesticide, heavy metal, and residual solvent analyses were conducted using validated, ISO 17025-accredited methods.



RESULTS | CANNABINOID LABEL CLAIMS

All illicit samples were tested for potency levels, including THC and THCA. Total THC values are presented in Table 3.

TABLE 3: ILLICIT SAMPLE CANNABINOID LABEL CLAIMS - VAPES, EXTRACTS, FLOWER, AND EDIBLES

Sample ID	Sample Type	Date Packaged	Label Claims (mg/g)	RPC Values	Percent Difference
			Total THC (mg/g)	Total THC (mg/g)	Total THC
Illicit 1	Vape cartridge	n/a	n/a	837	n/a
Illicit 2	Vape cartridge	n/a	920 - 960	742	-21.1%
Illicit 3	Vape cartridge	n/a	920 - 960	735	-21.8%
Illicit 4	Vape cartridge	n/a	n/a	796	n/a
Illicit 5	Vape cartridge	n/a	n/a	810	n/a
Illicit 6	Vape cartridge	n/a	920 - 960	728	-22.6%
Illicit 7	Vape cartridge	n/a	920 - 960	724	-23.0%
Illicit 8	Vape cartridge	n/a	920 - 960	792	-15.7%
Illicit 9	Vape cartridge	n/a	920 - 960	743	-21.0%
Illicit 10	Vape cartridge	n/a	n/a	813	n/a
Illicit 11	Vape cartridge	2023-08-16	960	809	-15.7%
Illicit 12	Vape cartridge	2023-06-30	879	731	-16.8%
Illicit 13	Vape cartridge	n/a	n/a	665	n/a
Illicit 14	Vape cartridge	n/a	n/a	764	n/a
Illicit 15	Vape cartridge	n/a	n/a	789	n/a
Illicit 16	Vape cartridge	n/a	n/a	797	n/a
Illicit 17	Vape cartridge	n/a	920 - 960	719	-23.5%
Illicit 18	Vape cartridge	n/a	n/a	644	n/a
Illicit 19	Shatter	n/a	779	641	-17.7%
Illicit 20	Shatter	n/a	751	642	-14.5%
Illicit 21	Shatter	n/a	n/a	748	n/a
Illicit 22	Hash	n/a	n/a	52.8	n/a
Illicit 23	Infused pre-roll	n/a	n/a	202	n/a
Illicit 24	Infused pre-roll	n/a	n/a	220	n/a
Illicit 25	Dried flower	n/a	n/a	183	n/a
Illicit 26	Pre-roll	n/a	n/a	144	n/a
Illicit 27	Dried flower	n/a	n/a	188	n/a
Illicit 28	Chocolate	2023-10-24	200 mg/piece	116 mg/piece	-42.0%
Illicit 29	Chocolate	n/a	600 mg/piece	272 mg/piece	-54.7%
Illicit 30	Gummy	n/a	50 mg/gummy	6.81 mg/gummy	-86.4%
Illicit 31	Gummy	n/a	125 mg/gummy	62.1 mg/gummy	-50.3%

*The mid-point value of each range (i.e. 940 mg/g for illicit 2) was used to calculate percent difference.

RESULTS | CANNABINOID LABEL CLAIMS



Illicit Vape Cartridges: As seen in Table 3, half of the illicit vape samples did not have THC label claims. For the 9 samples that did, they ranged between 16% and 24% lower than claimed. Being outside the $\pm 15\%$ variability limits that apply to legal product label claims, these products would not be compliant on the legal market.

Illicit Shatter: One of the three shatter samples tested (Illicit 20) had a THC label claim and fell just within the $\pm 15\%$ variability limits that apply to legal product label claims.

Illicit Hash: The one illicit hash sample (Illicit 22) submitted for testing had a very low total THC content at 53 mg/g. It was also low in other cannabinoids with a total CBD of 17 mg/g and total CBN of 20 mg/g. Compared to hash products available on the legal market (with most products ranging from 290 to 500 mg/g total THC based on a search of hash products available on the Ontario Cannabis Store website on July 30, 2024), the THC content of this sample is notably low.

Illicit Infused Pre-Rolls: The two illicit infused pre-rolls (Illicit 23 and 24) had total THC concentrations of 202 and 220 mg/g, respectively. Compared to infused pre-rolls available on the legal market (most are between 300 to 450 mg/g total THC based on a search of THC-infused pre-roll products available on the Ontario Cannabis Store website on July 30, 2024), the THC content of these illicit samples is low.

Illicit Dried Flower: The three illicit flower samples tested (Illicit 25, 26, and 27) had total THC values ranging between 144 and 188 mg/g.

Illicit Edibles (Chocolate, Gummy): The two illicit chocolate samples (Illicit 28 and 29) and the two illicit gummy samples (Illicit 30 and 31) had label claims that were 42% to 86% lower than the label claims. Illicit 30 tested at 6.81 mg/gummy, which is more than seven times lower than the claimed 50 mg/gummy.



RESULTS | CANNABINOID LABEL CLAIMS

All legal samples tested were THC-dominant products in which CBD concentrations were very low (less than 6 mg/g). Results are shown in Table 4.

TABLE 4: LEGAL SAMPLES CANNABINOID LABEL CLAIMS - VAPE CARTRIDGES

Sample ID	Date Packaged	Date Analyzed	Label Claims	RPC Values	Percent Difference	Label Claims	RPC Values	Percent Difference
			Total THC (mg/g)	Total THC (mg/g)	Total THC	Total CBD (mg/g)	Total CBD (mg/g)	CBD
Legal 1	2023-08-28	2024-05-15	800	760	-5.0%	< 5	5.48	n/a
Legal 2	2023-07-17	2024-05-15	916.5	783	-14.6%	< 5	2.88	n/a
Legal 3	2023-11-09	2024-05-15	869.4	794	-8.7%	1.6	3.35	109.4%
Legal 4	2023-09-14	2024-05-15	700	673	-3.9%	< 6	1.98	n/a
Legal 5	2023-10-06	2024-05-15	833.3	758	-9.0%	< 6	2.8	n/a
Legal 6	2023-08-24	2024-05-15	880	797	-9.4%	< 6	2.74	n/a
Legal 7	2023-06-14	2024-05-15	747	740	-0.9%	< 10	2.31	n/a
Legal 8	2023-10-25	2024-05-15	823	795	-3.4%	2.6	2.42	-6.9%
Legal 9	2023-10-04	2024-05-15	906	779	-14.0%	2.4	2.39	-0.4%
Legal 10	2023-02-02	2024-05-15	875	805	-8.0%	< 2.5	2.26	n/a



All legal samples had measured total THC concentrations within $\pm 15\%$ of the label claims.

Legal 4 also had THCV listed on the label at 100 mg/g, with a measured value of 96.1 mg/g (-3.9% difference).

Seven of the ten legal samples had CBD values reported as less than an indicated value. In these cases, a percent difference could not be calculated but the “less than” value was confirmed in six of seven samples. Legal 1 had a measured CBD value slightly above the claimed “< 5 mg/g”. Legal 3 had a low CBD label claim (1.6 mg/g), with the measured value more than double the label claim. This product falls outside of the $\pm 15\%$ variability limits for CBD displayed on a label for a cannabis extract product, as described in the Cannabis Regulations (SOR/2018-144).

RESULTS | PESTICIDES

The Cannabis Regulations state that cannabis must be free of pesticides. Limits of quantification (LoQ) for 96 pest control products in fresh and dried cannabis are provided in the document “Mandatory Cannabis Testing for Pesticide Active Ingredients – List and limits” (Health Canada 2019a). Moreover, the document “Mandatory Cannabis Testing for Pesticide Active Ingredients – Requirements” (Health Canada 2019b) requires that fresh and dried cannabis be tested for pesticide residues before it is used for extraction, formulation, or packaging and labelling. This ensures that legal cannabis used to make products like vapes does not have pesticides detected at the prescribed LoQs.



For the legal vapes in this study, it was confirmed that pesticide residues were below the Health Canada limit LoQs.

In contrast, a concerning 25 of 27 illicit samples tested had pesticide residues detected above the Health Canada limits (93% positivity rate). Across the 27 illicit samples tested for pesticides, 31 different pest control products were found above the Health Canada limits, with some testing orders of magnitude above the limit (Table 5). For example, Illicit 8 had myclobutanil present at 63 mg/kg, which is more than 3000 times above the Health Canada LoQ of 0.02 mg/kg for this pest control product.

TABLE 5: PESTICIDE CONCENTRATIONS (MG/KG) IN ILLICIT SAMPLES

Pesticide	Illicit 1	Illicit 2	Illicit 3	Illicit 4	Illicit 5	Illicit 6	Illicit 7	Illicit 8	Illicit 9
	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge
Acequinocyl		0.34	0.40			0.24	0.41		0.35
Azoxystrobin			0.03						
Bifenazate								1.39	
Bifenthrin									
Boscalid		0.48	1.06			0.55	0.62	15.8	0.62
Chlorphenapyr								1.69	
Chlorpyrifos									
Cypermethrin									
Cyprodinil								0.85	
Dimethoate									
Dimethomorph									
Dinotefuran									
Etoxazole									
Fenpyroximate									
Fenvalerate									
Fludioxonil		0.10					0.09	0.42	
Fluopyram		0.03	0.03			0.03	0.03	12.3	0.03
Hexythiazox									
Imidacloprid									
Malathion									
Metalaxyl									
Myclobutanil	0.07	1.64	1.45	0.04	0.03	1.29	1.74	63.0	1.46
Paclobutrazol		0.02				0.02	0.03	1.39	0.02
Permethrin								31.7	
Piperonyl butoxide									
Pyraclostrobin								1.15	
Pyrethrins								0.41	
Spinosad									
Tebuconazole									
Thiophanate-methyl									
Trifloxystrobin								7.47	

RESULTS | PESTICIDES

TABLE 5 (CONTINUED): PESTICIDE CONCENTRATIONS (MG/KG) IN ILLICIT SAMPLES

Pesticide	Illicit 10	Illicit 11	Illicit 12	Illicit 13	Illicit 14	Illicit 15	Illicit 16	Illicit 17	Illicit 18
	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge	Vape Cartridge
Acequinocyl			0.55	0.42	0.22	0.59	0.65	0.57	
Azoxystrobin									
Bifenazate	0.03		30.3	18.0	6.75	0.80	0.83		
Bifenthrin			4.51						
Boscalid			0.05	10.5	10.0	0.25	0.27	0.59	1.46
Chlorphenapyr	13.77	4.79	2.16	3.22	6.38	0.42	0.39		
Chlorpyrifos			0.72						
Cypermethrin			1.07						
Cyprodinil									
Dimethoate			0.04						
Dimethomorph									0.38
Dinotefuran			0.10						
Etoxazole			0.13						
Fenpyroximate			0.34						
Fenvalerate			35.5						
Fludioxonil								0.10	
Fluopyram	41.8		0.06	0.43	0.28	0.03	0.02	0.03	
Hexythiazox			4.68						
Imidacloprid	2.53		0.06		0.76				
Malathion			1.19						
Metalaxyl			0.14		0.05	0.06	0.06		
Myclobutanil	42.14	9.99	4.93	5.89	18.4	13.9	14.3	1.22	2.77
Paclobutrazol	1.76	0.06	0.03	0.09	1.39	0.28	0.29	0.03	0.15
Permethrin				44.5	21.2				
Piperonyl butoxide	1.45	4.91	0.89						
Pyraclostrobin				0.16	0.50				0.05
Pyrethrins					0.69				
Spinosad									
Tebuconazole			0.22						
Thiophanate-methyl									
Trifloxystrobin	0.03		2.51						



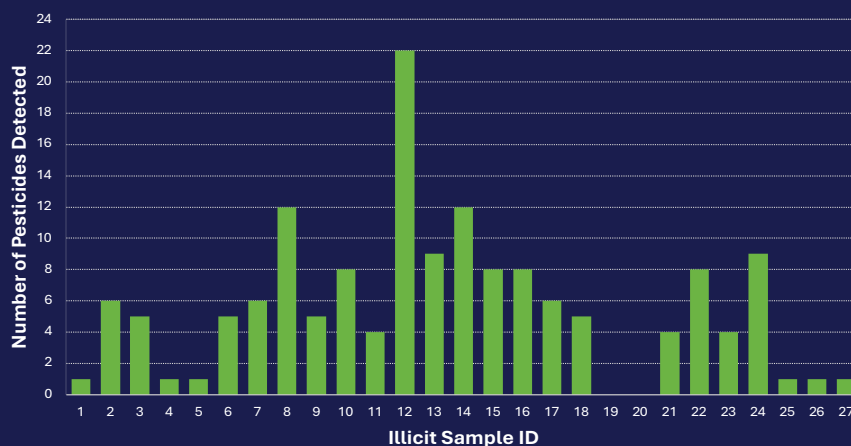
TABLE 5 (CONTINUED): PESTICIDE CONCENTRATIONS (MG/KG) IN ILLICIT SAMPLES

Pesticide	Illicit 19	Illicit 20	Illicit 21	Illicit 22	Illicit 23	Illicit 24	Illicit 25	Illicit 26	Illicit 27
	Shatter	Shatter	Shatter	Hash	Infused Pre-roll	Infused Pre-roll	Dried Flower	Pre-roll	Dried Flower
Acequinocyl			0.09	0.19	0.16	0.08		0.12	
Azoxystrobin									
Bifenazate						0.01			
Bifenthrin									
Boscalid			0.28	2.36	0.03	0.30			
Chlorphenapyr			7.78			0.05			
Chlorpyrifos									
Cypermethrin									
Cyprodinil									
Dimethoate									
Dimethomorph									
Dinotefuran									
Etoxazole									
Fenpyroximate									
Fenvalerate									
Fludioxonil									
Fluopyram				0.10					
Hexythiazox									
Imidacloprid						0.02	0.02		
Malathion									
Metalaxyl				0.39					
Myclobutanil			0.15	15.4	0.02	0.15			
Paclobutrazol				0.09		0.30			
Permethrin									
Piperonyl butoxide						0.21			
Pyraclostrobin				0.61	0.01	0.08			
Pyrethrins									
Spinosad				0.06					
Tebuconazole									
Thiophanate-methyl									0.05
Trifloxystrobin									



Sixteen samples had 5 or more pesticides detected above Health Canada limits, with Illicit 12 having 22 pesticides above Health Canada limits (see Figure 1). Illicit samples 8 and 10 had pesticide totals that exceeded 100 mg/kg (138 mg/kg and 104 mg/kg, respectively).

FIGURE 1: NUMBER OF PESTICIDES DETECTED IN EACH ILLICIT SAMPLE



RESULTS | PESTICIDES

As shown in Table 6, Myclobutanil was the most prevalent pesticide in illicit samples (22 positives), followed by Boscalid (17 positives), Acequinocyl (16 positives), Paclobutrazol (16 positives), Fluopyram (14 positives), and Chlorphenapyr (10 positives).

These results are consistent with recent studies conducted by Health Canada and the BC Cannabis Secretariat.

TABLE 6: FREQUENCY OF PESTICIDES IN ILLICIT SAMPLES

	Pesticide	Number of Illicit Samples with Pesticides Detected
1	Acequinocyl	16
2	Azoxystrobin	1
3	Bifenazate	8
4	Bifenthrin	1
5	Boscalid	17
6	Chlorphenapyr	10
7	Chlorpyrifos	1
8	Cypermethrin	1
9	Cyprodinil	1
10	Dimethoate	1
11	Dimethomorph	1
12	Dinotefuran	1
13	Etoxazole	1
14	Fenpyroximate	1
15	Fenvalerate	1
16	Fludioxonil	4
17	Fluopyram	14
18	Hexythiazox	1
19	Imidacloprid	5
20	Malathion	1
21	Metalaxyl	5
22	Myclobutanil	22
23	Paclobutrazol	16
24	Permethrin	3
25	Piperonyl butoxide	4
26	Pyraclostrobin	7
27	Pyrethrins	2
28	Spinosad	1
29	Tebuconazole	1
30	Thiophanate-methyl	1
31	Trifloxystrobin	3

RESULTS | METALS

All legal samples and all illicit extract and flower samples were tested for elemental impurities, including arsenic, cadmium, lead, and mercury. Results for legal vape samples are shown in Table 7 and those for illicit samples provided in Table 8.

TABLE 7: HEAVY METALS IN LEGAL VAPE CARTRIDGE SAMPLES

Sample ID	Arsenic	Cadmium	Lead	Mercury
	µg/g	µg/g	µg/g	µg/g
Legal 1	< 0.2	< 0.002	< 0.02	< 0.01
Legal 2	< 0.2	< 0.002	1.49	< 0.01
Legal 3	< 0.2	< 0.002	< 0.02	< 0.01
Legal 4	< 0.2	< 0.002	< 0.02	< 0.01
Legal 5	< 0.2	< 0.002	< 0.02	< 0.01
Legal 6	< 0.2	< 0.002	< 0.02	< 0.01
Legal 7	< 0.2	< 0.002	< 0.02	< 0.01
Legal 8	< 0.2	< 0.002	< 0.02	< 0.01
Legal 9	< 0.2	< 0.002	< 0.02	< 0.01
Legal 10	< 0.2	< 0.002	< 0.02	< 0.01



With the exception of Legal 2, which had lead detected at 1.49 µg/g, all metals were below the reporting limits. The lead may have leached into the cannabis vape distillate from the heating element in the vape cartridge or other packaging components. Stability studies, extractable/leachable studies and screening of components used for making vape cartridges would be useful for understanding more about the source of metal contamination.



RESULTS | METALS

TABLE 8: HEAVY METALS IN ILLICIT SAMPLES

Sample ID	Sample Type	Arsenic	Cadmium	Lead	Mercury
		µg/g	µg/g	µg/g	µg/g
Illicit 1	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 2	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 3	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 4	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 5	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 6	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 7	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 8	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 9	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 10	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 11	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 12	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 13	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 14	Vape Cartridge	< 0.2	< 0.002	0.17	< 0.01
Illicit 15	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 16	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 17	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 18	Vape Cartridge	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 19	Shatter	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 20	Shatter	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 21	Shatter	< 0.2	< 0.002	< 0.02	< 0.01
Illicit 22	Hash	0.6	0.037	1.54	< 0.01
Illicit 23	Infused Pre-roll	< 0.2	0.046	0.17	0.02
Illicit 24	Infused Pre-roll	< 0.2	0.032	0.03	< 0.01
Illicit 25	Dried Flower	< 0.2	0.008	< 0.02	< 0.01
Illicit 26	Pre-roll	< 0.2	0.040	0.13	< 0.01
Illicit 27	Dried Flower	< 0.2	0.191	< 0.02	< 0.01



As seen in Table 8, seven of the 27 illicit samples tested for heavy metals had values above the reporting limits. Depending on what regulatory impurity limits are used (e.g. EP/USP/ICH Q3D(R1) elemental impurity limits vs EP Cannabis Flower Monograph limits for non-medicinal cannabis) and depending on what value is chosen for the maximum daily dose of the product, the legal and illicit samples with heavy metals detected could pass or fail based on the specifications used.

RESULTS | RESIDUAL SOLVENTS

All extract samples were screened for ethanol, acetone, 2-propanol, 1-propanol, ethyl acetate, methanol, pentane, methyl tert-butyl ether, and heptane at a reporting limit of 0.2%. All values were less than 0.2% for illicit and legal extract samples.

CONCLUSIONS

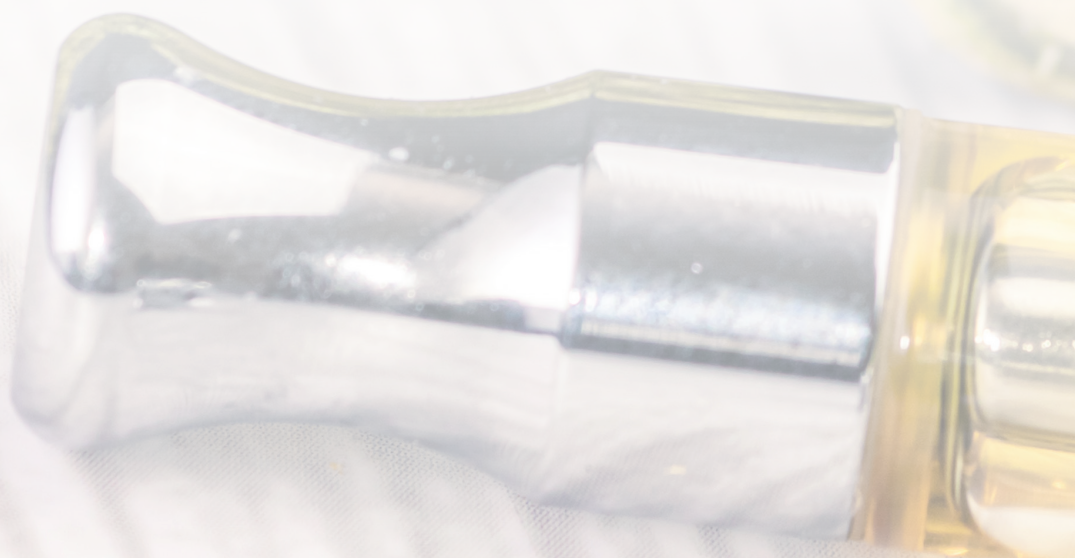
Illicit products do not adhere to Good Production Practices and carry additional risks to consumers. Pesticide contamination was pervasive in illicit samples analyzed in this study, with a 93% positivity rate. Additionally, results for illicit cannabis samples seized in New Brunswick are consistent with results from previous studies on illicit cannabis in Ontario and British Columbia, highlighting that contaminated illicit cannabis and cannabis products can be found throughout Canada.

THC label claims for illicit products continue to be inaccurate. In particular, the edibles tested in this study were well below label claims. However, some of these illicit edibles still contain THC quantities (per piece) that are well above the THC limit of 10 mg/package for edibles on the regulated market. Due to the possibility of higher THC, these illicit edibles pose additional risks from accidental ingestion, ingestion by a minor, or ingestion without knowing what dose is being consumed.

Legal cannabis products are tested for hazardous contaminants and potency and must pass stringent testing criteria before being released for sale. Moreover, the regulated cannabis market allows for investigations and recalls if the safety of a legal cannabis product comes into question; this cannot occur for illicit products. Consuming regulated, legal cannabis greatly reduces risk for consumers compared to consuming illicit cannabis.

ACKNOWLEDGEMENTS

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