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PESTICIDE CONTAMINATION OF CANNABIS IN THE LEGAL MARKET

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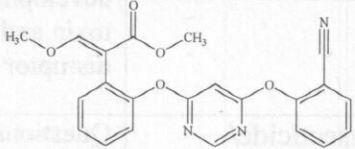
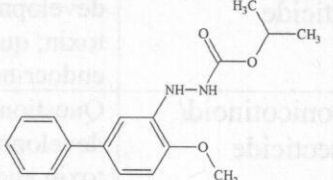
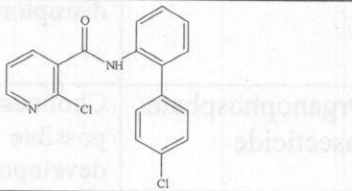
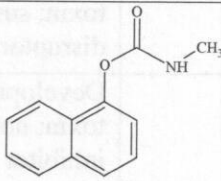
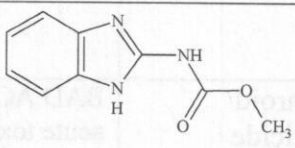
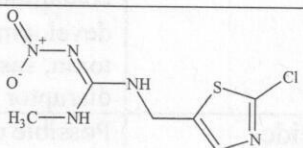
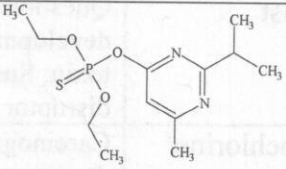
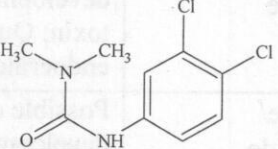
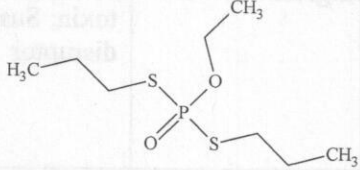
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Introduction: Washington State legalized cannabis for medical use in 1998, where it remained largely unregulated. Legalization of recreational cannabis in the state was passed by ballot initiative in 2012, but despite recommendations, no testing for pesticide contamination was mandated. Subsequently, efforts are underway to unify the prior medical market with the legal one. No current method is available for certification of organic culture techniques, and there are no Environmental Protection Agency guidelines on acceptable pesticide levels for a smoked product. This study was prompted by informal testing demonstrated pesticide residues in 5-10% of tested cannabis inflorescence samples, and their known passage into cannabis smoke.

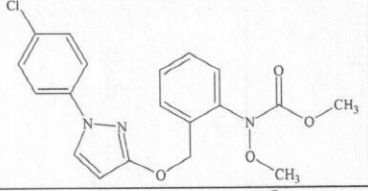
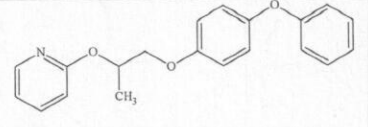
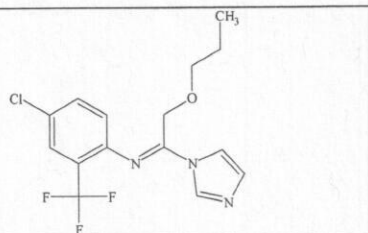
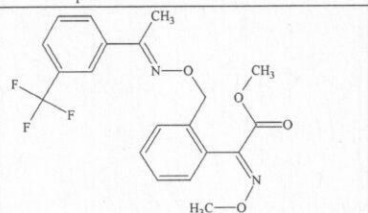
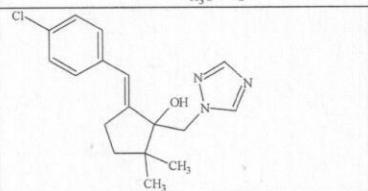
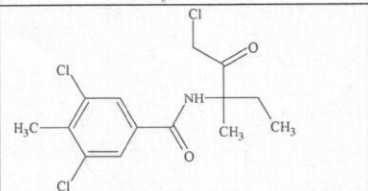
Methods: An initial test of 4 two-year old cannabis concentrates from legal storefronts were analyzed with 1 showing low-level presence of boscalid, diuron, piperonyl butoxide and myclobutanil. Subsequently, 26 distinct cannabis samples were purchased (24 concentrates, 2 cannabis inflorescence) from legal stores and passed via witnessed chain of command to a state certified legal licensed laboratory (Trace Analytics, Spokane, WA). Samples were homogenized, and extracted using a modified QuEChERS AOAC protocol. The supernatant was injected for LCMS-MS analysis. Detection was carried out using a Shimadzu LCMS-8050 triple quadrupole mass spectrometer with a Shimadzu Prominence HPLC. Approximately 200 analytes were measured with over 500 MRM transitions per run.

Results: Out of the 26 samples, 22 tested positively for pesticides (84.6%). Many harbored multiple contaminants, attaining levels in the 10s of thousands of parts per billion (ppb), exceeding the upper limit of quantification. These included 45 distinct agents of every class: insecticides, miticides, fungicides, synergists and growth regulators, including organophosphates, organochlorides, etc. One single extract, a candidate for folding into the medical market in Washington, demonstrated lower levels of azoxystrobin, triflumizole, and piperonyl butoxide, with extreme levels of carbaryl, boscalid, bifentazate, pyraclostrobin, fenpyroximate and myclobutanil, with documented toxicities as carcinogens, neurotoxins, cholinesterase inhibitors, developmental and reproductive toxins, and endocrine disruptors.

Conclusions: The unregulated commerce in cannabis and lack of available organic certification have resulted in widespread abuse of the legal system. Cannabis concentrates currently account for 50% of legal sales in WA, and are also the basis for a burgeoning commerce in cannabis edibles. These products present a clear and present danger, particularly to young patients with epilepsy and other neurological conditions. Future regulation and monitoring with allowance for organic certification and employment of integrated pest management techniques without synthetic pesticides are required approaches to rectify this looming public health threat.

Pesticide	Structure	Class/Usage	Toxicity
Azoxystrobin		Fungicide	Questionable developmental/reproductive toxin and endocrine disruptor
Bifenazate		Miticide	Slight acute toxicity, potential ground water contaminant, questionable developmental/reproductive toxin and endocrine disruptor
Boscalid		Fungicide	Possible carcinogen; Questionable developmental/reproductive toxin and endocrine disruptor
Carbaryl		Carbamate/ Insecticide	BAD ACTOR; Cholinesterase inhibitor; carcinogen; developmental/reproductive toxin; suspected endocrine disruptor
Carbendazim		Benzimidazole/ Fungicide	Possible carcinogen; questionable ground water contaminant; questionable developmental/reproductive toxin; suspected endocrine disruptor
Clothianidin		Neonicotinoid/ Insecticide	Questionable developmental/reproductive toxin; questionable endocrine disruptor
Diazinon		Organophosphate/ Insecticide/ Miticide	Unlikely carcinogen; cholinesterase inhibitor; developmental/reproductive toxin; suspected endocrine disruptor
Diuron (DCMU)		Herbicide/ Photosynthesis inhibitor	Carcinogen; developmental/reproductive toxin; suspected endocrine disruptor
Ethoprophos		Organophosphate/ Insecticide/ Nematicide	BAD ACTOR: Carcinogen; cholinesterase inhibitor; potential ground water contaminant; questionable developmental/reproductive toxin; questionable endocrine disruptor

Etoxazole		Miticide	Questionable developmental/reproductive toxin and endocrine disruptor
Fenpyroximate		Insecticide/ Miticide	Questionable developmental/reproductive toxin; questionable endocrine disruptor
Imidacloprid		Neonicotinoid/ Insecticide	Questionable developmental/reproductive toxin and endocrine disruptor
Malathion		Organophosphate/ Insecticide	Cholinesterase inhibitor; possible developmental/reproductive toxin; suspected endocrine disruptor;
Myclobutanil		Triazole/ Fungicide	Developmental/reproductive toxin; not cholinesterase inhibitor
Permethrin		Pyrethroid/ Insecticide	BAD ACTOR; Moderate acute toxicity, Carcinogen, potential ground water contaminant, questionable developmental/reproductive toxin, suspected endocrine disruptor
Piperonyl butoxide		Pesticide synergist	Possible carcinogen; Questionable developmental/reproductive toxin; Suspected endocrine disruptor
Propargite		Organochlorine/ Miticide	Carcinogen; developmental/reproductive toxin; Questionable endocrine disruptor
Propiconazole		Triazole/ Fungicide	Possible carcinogen; developmental/reproductive toxin; Suspected endocrine disruptor

Pyraclostrobin		Fungicide	Questionable developmental/reproductive toxin; Questionable endocrine disruptor
Pyriproxyfen		Pyridine/ Pesticide	Questionable developmental/reproductive toxin; Questionable endocrine disruptor
Triflumizole		Fungicide	Potential ground water contaminant; Questionable developmental/reproductive toxin; Questionable endocrine disruptor
Trifloxystrobin		Fungicide	Questionable developmental/reproductive toxin and endocrine disruptor
Triticonazole		Fungicide	Questionable developmental/reproductive toxin; Questionable endocrine disruptor
Zoxamide		Fungicide	Questionable developmental/reproductive toxin; questionable endocrine disruptor

Pesticides encountered in 26 cannabis samples in Washington State.

Data from: *American Herbal Pharmacopoeia Cannabis Inflorescence*, PAN Pesticides Database: http://www.pesticideinfo.org/Search_Products.jsp#ProdSearch, *Hemp diseases and pests*. Assay results from Trace Analytics, Spokane, WA. Structures from ACD/ChemSketch 2015.2.5