



Canadian Food
Inspection Agency

Agence canadienne
d'inspection des aliments

Pesticides and metals in grain-based products and vegan products – April 1, 2021, to March 31, 2022

Food chemistry – Targeted surveys – Final report



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Summary

Targeted surveys provide information on potential food hazards and enhance the Canadian Food Inspection Agency's (CFIA's) routine monitoring programs. These surveys provide evidence regarding the safety of the food supply, identify potential emerging hazards, and contribute new information and data to food categories where it may be limited or non-existent. They are often used by the agency to focus surveillance on potential areas of higher risk. Surveys can also help to identify trends and provide information about how industry complies with Canadian regulations.

Products of agricultural commodities may contain pesticide residues introduced from the environment or if the crops were treated with pesticides in the field, during transport and/or during storage to prevent damage from insects, moulds or other pests. These highly consumed products may also contain levels of metals from environmental sources^{1,2}. Though metals such as arsenic, cadmium, lead and mercury are not permitted to be added to foods, and manufacturers are responsible for measures aimed at reducing accidental introduction of these elements in foods (e.g., from lead solder in steel equipment), their presence is expected in foods, at very low levels, primarily as a result of their natural presence in the environment.

The main objectives of this targeted survey were to generate additional baseline surveillance data on the level of pesticide residues and metal levels in grain-based products and vegan products available on the Canadian market and to compare the detection rates of pesticides in this targeted survey to those recorded in previous surveys.

A total of 2048 samples of baked goods, breakfast cereal, pretzels, and vegan products were collected and tested for pesticides and metals. Pesticide residues were detected in 1275 (62%) of the samples. The overall compliance rate for pesticides in products tested in this survey was 99.4%. All of the 13 non-compliant results were associated with pesticide residues exceeding the general maximum residue limit (MRL) of 0.1 parts per million (ppm).

All of the survey samples collected were analysed for a suite of 19 metals. Only the data for metals of highest concern to human health at low levels of exposure are presented in this report, most notably: arsenic, cadmium, lead, and mercury. Arsenic and cadmium had the lowest and the highest overall detection rate, respectively. Although baked goods and breakfast cereals most frequently contained at least 1 of the toxic metals, the average levels of metals were similar for all the product types.

There are no maximum limits (MLs) set in Canada for metal levels in the products tested. All data generated were forwarded to Health Canada for human risk assessment and determined to pose no concern to human health. All non-compliant pesticide results obtained during the course of this survey were forwarded to the CFIA's Office of Food Safety and Recall (OFSR). The extent of the follow up actions taken by the agency was based on the level of the contamination and the resulting health concern as determined by a health risk assessment.

What targeted surveys are

Targeted surveys are used by the CFIA to focus its surveillance activities on areas of highest health risk. The information gained from these surveys provides support for the allocation and prioritization of the agency's activities to areas of greater concern. Originally started as a project under the Food Safety Action Plan (FSAP), targeted surveys have been embedded in our regular surveillance activities since 2013. Targeted surveys are a valuable tool for generating information on certain hazards in foods, identifying and characterizing new and emerging hazards, informing trend analysis, prompting and refining health risk assessments, highlighting potential contamination issues, as well as assessing and promoting compliance with Canadian regulations.

Food safety is a shared responsibility. We work with federal, provincial, territorial and municipal governments and provide regulatory oversight of the food industry to promote safe handling of foods throughout the food production chain. The food industry and retail sectors in Canada are responsible for the food they produce and sell, while individual consumers are responsible for the safe handling of the food they have in their possession.

Why we conducted this survey

Chemical hazards in foods can come from a variety of sources. Pesticides may be present as contaminants in the environment or they may be deliberately used by farmers to protect food and crops from pests. Different pest pressures and climatic conditions in food export countries may result in the potential use of pesticides that are not approved for use in Canada, or result in pesticide residues in products that do not meet established Canadian MRLs to be legally sold in Canada³. Inappropriate use of pesticides may pose a health risk to consumers, with the risk dependant on the type of pesticide, its concentration, the effects on the human body, and the length of exposure to the pesticide by the consumer.

Metals are naturally-occurring elements that may be present in very low amounts in rock, water, soil, or air. Therefore, finding these substances in food products is not unexpected as trace levels generally reflect normal accumulation from the environment^{4,5}. They may be present in finished foods due to their presence in the ingredients used to manufacture those foods, and/or may be unintentionally incorporated along the food production chain.

There are a number of metals that may be of concern to human health at certain levels of exposure. Most notably, arsenic, cadmium, lead, and mercury have been shown to have effects on human health, even at low levels of exposure. The results of only these metals of highest concern are presented in this report.

Grain based and vegan foods are products of agricultural commodities and may contain pesticide residues introduced from the environment or if the crops were treated with pesticides in the field, during transport and/or during storage to prevent damage from insects, moulds or other pests. The objective of this targeted survey was to obtain additional baseline data on the

levels of pesticides, arsenic, cadmium, lead and mercury in these types of products available on the Canadian market, and to compare the detection rate of pesticides in foods with previous targeted surveys.

What we sampled

A variety of domestic and imported baked goods (bread, bagels, English muffins, cakes, cookies, muffins, pancakes, pies, scones, waffles, etc.), breakfast cereals (adult, children and infant), pretzels, and vegan products (dairy alternatives and meat alternatives) available on the Canadian market were sampled between April 1, 2021, and March 21, 2022. Samples of products were collected from local/regional retail locations located in 11 major cities across Canada. These cities encompassed 4 Canadian geographical areas:

- Atlantic (Halifax and Moncton)
- Quebec (Montreal and Quebec City)
- Ontario (Toronto and Ottawa)
- West (Calgary, Saskatoon, Vancouver, Victoria and Winnipeg)

The number of samples collected from these cities was in proportion to the relative population of the respective areas. The shelf life, storage conditions, and the cost of food on the open market were not considered in this survey.

Table 1. Distribution of samples based on product type and origin

Product type	Number of domestic samples	Number of imported samples	Number of samples of unspecified ^a origin	Total number of samples
Baked goods	251	212	349	812
Breakfast cereals	100	449	59	608
Pretzels	1	152	11	164
Vegan products	123	193	148	464
Total	475	1006	567	2048

Table notes

^a Unspecified refers to those samples for which the country of origin could not be assigned from the product label or available sample information.

How samples were analyzed and assessed

Samples were analyzed by an ISO/IEC 17025 accredited food testing laboratory under contract with the Government of Canada. See Appendix A for a list of the pesticides included in the multi-residue pesticide method. Glyphosate and its metabolite aminomethylphosphonic acid (AMPA) were also tested for in 1584 samples of baked goods, breakfast cereals and pretzels

using separate methodology; vegan products were excluded from this analysis. Samples were also subjected to a multi-metal method that analyzes for 19 metals. The data for metals of highest concern to human health at low levels of exposure, most notably: arsenic, cadmium, lead, and mercury, are presented in this report. The results are based on the food products as sold and not necessarily as they would be consumed.

Results were assessed according to Canadian pesticide MRLs, established by the Pest Management Regulatory Agency (PMRA) of Health Canada and appear in their MRL database³. Pesticide MRLs were applied to the specified raw agricultural commodity as well as to any processed food product that contains the commodity unless otherwise specified. According to section B.15.002 (1) of the Food and Drug Regulations (FDR), in the absence of a specific MRL, residues of a pesticide or other agricultural chemical must not exceed the general MRL of 0.1 ppm.

Contaminants and other adulterating substances in foods have regulatory maximum levels that are established by Health Canada. In the absence of a specific maximum level, they assess the levels of arsenic, cadmium, mercury and lead on a case-by-case basis using the most current scientific data available.

Results of the survey

Pesticides

A total of 2048 samples of domestic and imported grain-based products and vegan products were tested for over 480 pesticides in this targeted survey. Pesticide residues were not detected in 773 samples (38%). Of the samples with detectable pesticide residues, 94.9% contained from 1 to 3 pesticide residues per sample. The maximum of 8 pesticide residues per sample occurred in samples of muesli cereal and raisin tea biscuits. A summary of the results by product type can be seen in Table 2.

Table 2. Results of pesticide testing in selected foods

Product type	Number of samples	Number (percentage) of samples with detected pesticide residue(s)	Number (percentage) of non-compliant samples
Baked goods	812	619 (76%)	6 (0.7%)
Breakfast cereals	608	404 (66%)	4 (0.7%)
Pretzels	164	126 (77%)	2 (1.2%)
Vegan products ^b	464	126 (27%)	1 (0.2%)
Total	2048	1275 (62%)	13 (0.6%)

Table notes

^b Excludes glyphosate testing.

When evaluated by commodity, the percentage of samples with pesticide residues detected ranged from 77% in pretzels to 27% in vegan products. Although vegan products were not tested for glyphosate, glyphosate was the pesticide with the highest overall detection rate. Piperonyl butoxide was the second most frequently detected pesticide. All results reported for these pesticides were compliant. The overall compliance rate for pesticides in the products tested was 99.4%. Compliance was assessed against the MRLs which were in place when the survey was carried out. There were 13 non-compliant results associated with 13 samples. Of the 13 non-compliant results, all were associated with pesticide residues exceeding the general MRL of 0.1 ppm. The average amount of residue detected in the non-compliant samples was 0.16 ppm.

Of the 2048 products tested, 1799 samples were conventionally grown and 249 products were labelled as “organic” (note that identification of samples as organic is based solely on the information on the product label). The detection rates were 62% and 81% respectively, for conventionally grown and organic products. The average amount of pesticide residues detected in the conventional and organic samples were 0.062 ppm and 0.018 ppm, respectively. None of the 13 non-compliant samples were organic samples.

All non-compliant results obtained during the course of this survey were forwarded to the CFIA's Office of Food Safety and Recall (OFSR) and to the CFIA Organic Office for follow-up. The CFIA conducted appropriate follow up activities to improve compliance which included further testing of similar products in subsequent years.

Metals

All 2048 samples collected were subjected to a multi-metal laboratory method that analyzes for 19 metals. Only the results of the metals of highest human health concern (arsenic, cadmium, lead and mercury) are presented in this report. Table 3 illustrates the level of these metals found in the products tested. Most (64%) of the survey samples contained 1 or more of these 4 metals.

Table 3. Detected levels of metals in selected foods

Product type	Number of samples	% positive for arsenic	Average level (range) of arsenic (ppm)	% positive for cadmium	Average level (range) of cadmium (ppm)	% positive for lead	Average level (range) of lead (ppm)	% positive for mercury	Average level (range) of mercury (ppm)
Baked goods	812	2	0.041 (<LOD-0.077)	21	0.019 (<LOD-0.119)	2	0.026 (<LOD-0.072)	2	0.0020 (<LOD-0.0104)
Breakfast cereals	608	7	0.079 (<LOD-0.555)	20	0.033 (<LOD-0.150)	2	0.047 (<LOD-0.255)	4	0.0010 (<LOD-0.0032)
Pretzels	164	1	0.059 (<LOD-0.151)	7	0.034 (<LOD-0.062)	0.1	0.023 (<LOD-0.024)	0.5	0.0006 (<LOD-0.0008)
Vegan products	464	0.2	0.025 (<LOD-0.028)	10	0.026 (<LOD-0.107)	3	0.024 (<LOD-0.046)	1	0.0017 (<LOD-0.0102)

Table notes

<LOD = Below the limit of detection (0.0005 - 0.01 ppm, depending on the laboratory and the analyte).

Note: Average values were calculated using only results for samples with quantifiable metal levels.

Arsenic and cadmium had the lowest and the highest overall detection rate, respectively. Although baked goods and breakfast cereals most frequently contained at least 1 of the toxic metals, the average levels of metals were similar for all the categories. Only 4 samples contained all 4 toxic metals, and 2 to 4 metals per sample were most frequently detected in breakfast cereals and vegan products (36% and 32% out of the positive samples, respectively). There are no regulations in Canada for the levels of these metals in the products tested. Health Canada determined that none of the products posed a health risk to consumers.

What the survey results mean

Table 4 compares this survey’s results with past survey data for pesticides^{6,7,8,9,10}. The non-compliance rate for this survey was within the range observed in other survey years. Although the detection rate appears to be higher than the detection rate reported for some other survey years, the differences can be attributed to the differences in the specific types of products tested. When compared to the overall detection rates (60% and 72%) in previous surveys that also included large proportion of grain products (2020 and 2016), the detection rate for this survey (62%) was comparable. It should be re-iterated that product types were selected due to their high likelihood of containing pesticide residues, and that the observed prevalence is not necessarily representative of the prevalence of pesticide residues in all foodstuffs available at retail.

Consistent with its extensive usage worldwide and in Canada, glyphosate accounted for 85% of positive results in grain-based products¹⁰. As observed in previous survey years, glyphosate and piperonyl butoxide were the most frequently detected pesticides. The highest average levels of pesticides were observed in vegan products. In general, the same types of non-compliant results found in the current survey were found in previous surveys in similar product types.

Table 4. Pesticide testing results from various survey years

Survey year	Number of samples	Number (percentage) of samples with detected pesticide residue(s)	Number (percentage) of non-compliant samples
2021	2048	1275 (62%)	13 (0.6%)
2020	1486	892 (60%)	31 (2.1%)
2019	2849	1446 (51%)	73 (2.9%)
2018	3348	1327 (40%)	22 (0.7%)
2016 ^e	3998	1189 (30%)	17 (0.4%)

Table notes

^e Glyphosate results were not included in the report; glyphosate was detected in 58% of samples; overall detection rate was 72%.

How to access the survey data

The data will be accessible on the [Open Government Portal](#).

References

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6. [2020-2021 Pesticides and Metals in bakery products, vegan products, fruit-based and vegetable-based products](#). 2024. Canada. Canadian Food Inspection Agency.
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8. [2018-2019 Pesticides and Metals in Selected Foods](#). 2020. Canada. Canadian Food Inspection Agency.
9. [2016-2017 Pesticides and Metals in Grain Products and Ready-to-Eat Meals](#). 2020. Canada. Canadian Food Inspection Agency. [including unpublished results]
10. [Glyphosate in Canada](#). 2020. Canada. Health Canada.

Appendix A

List of analytes (483) included in the PESTICIDE-GCLC multi-residue pesticide program used by the accredited laboratory in this survey

3-hydroxyCarbofuran	Demeton-S-methyl	Fosthiazate	Piperonyl butoxide
Acephate	Demeton-s-methyl sulfone	Fuberidazole	Piperophos
Acetamiprid	Demeton-s-methyl sulfoxide	Furalaxyl	Pirimicarb
Acetochlor	Des-ethyl Atrazine	Furathiocarb	Pirimiphos-ethyl
Acibenzolar-s-methyl	Desmedipham	Griseofulvin	Pirimiphos-methyl
Aclonifen	Desmetryn	Halofenozide	Pretilachlor
Alachlor	Di-allate	Haloxyfop	Primisulfuron-methyl
Alanycarb	Dialofos	Heptachlor	Prochloraz
Aldicarb	Diazinon	Heptachlor epoxide endo	Procymidone
Aldicarb Sulfone	Diazinon o analogue	Heptenophos	Prodiamine
Aldicarb sulfoxide	Dichlobenil	Hexachlorobenzene	Profenofos
Aldrin	Dichlofenthion	Hexaconazole	Profluralin
Allidochlor	Dichlofluanid	Hexaflumuron	Promecarb
Ametryn	Dichloran	Hexazinone	Prometon
Aminocarb	Dichlormid	Hexythiazox	Prometryne
Anilofos	Dichlorvos	Hydramethylnon	Pronamide
Aramite	Diclobutrazole	Imazalil	Propachlor
Aspon	Diclocymet	Imazamethabenz-methyl	Propamocarb
Atrazine	Diclofop-methyl	Imidacloprid	Propanil
Azaconazole	Dicofol	Indoxacarb	Propargite
Azinphos-ethyl	Dicrotophos	Iodofenphos	Propazine
Azinphos-methyl	Dieldrin	Ipconazole	Propetamphos
Azoxystrobin	Diethyl-ethyl	Iprobenfos	Propham
Benalaxyl	Diethofencarb	Iprodione	Propiconazole
Bendiocarb	Difenoconazole	Iprovalicarb	Propoxur
Benfluralin	Diflubenzuron	Isazophos	Prothioconazole
Benfuracarb	Dimethachlor	Isocarbamide	Prothiophos
Benodanil	Dimethametryn	Isofenphos	Pymetrozine
Benomyl	Dimethenamid	Isoprocab	Pyracarbolid
Benoxacor	Dimethoate	Isopropalin	Pyraclostrobin
Benzoximate	Dimethomorph	Isoprothiolane	Pyraflufen-ethyl
Benzoylprop-ethyl	Dimoxystrobin	Isoproturon	Pyrazophos
BHC Alpha	Diniconazole	Isoxathion	Pyridaben
BHC beta	Dinitramine	Kresoxim-methyl	Pyridalyl
Bifenazate	Dinotefuran	Leptophos	Pyridaphenthion
Bifenox	Dioxacarb	Lindane (gamma-BHC)	Pyridate
Bifenthrin	Dioxathion	Linuron	Pyrifenoxy
Biphenyl	Diphenamid	Lufenuron	Pyrimethanil
Bitertanol	Diphenylamine	Malaoxon	Pyriproxyfen
Boscalid	Dipropetryn	Malathion	Pyroxsulam
Bromacil	Diquat	Mandipropamid	Quinalphos
Bromophos	Disulfoton	Mecarbam	Quinomethionate

Bromophos-ethyl	Disulfoton sulfone	Mefenacet	Quinoxyfen
Bromopropylate	Diuron	Mepanipyrim	Quintozene
Bromuconazole	Dodemorph	Mephosfolan	Quizalofop
Bupirimate	Edifenphos	Mepronil	Quizalofop-ethyl
Buprofezin	Emamectin B1a	Metaflumizone	Schradan
Butachlor	Emamectin B1b	Metalaxyl	Secbumeton
Butafenacil	Endosulfan alpha	Metazachlor	Siduron
Butocarboxim	Endosulfan beta	Metconazole	Simazine
Butocarboxim sulfoxide	Endosulfan sulfate	Methabenzthiazuron	Simetryn
Butoxycarboxim	Endrin	Methamidophos	Spinetoram
Butralin	EPN	Methidathion	Spinosyn A
Butylate	Epoxiconazole	Methiocarb	Spinosyn D
Cadusafos	EPTC	Methiocarb sulfone	Spirodiclofen
Captafol	Esfenvalerate	Methiocarb Sulfoxide	Spiromesifen
Captan	Etaconazole	Methomyl	Spirotetramat
Carbaryl	Ethalfuralin	Methoprotryne	Spiroxamine
Carbendazim	Ethiofencarb	Methoxychlor	Sulfallate
Carbetamide	Ethiofencarb sulfone	Methoxyfenozide	Sulfentrazone
Carbofenthion	Ethiofencarb sulfoxide	Methyl-trithion	Sulfotep
Carbofuran	Ethion	Metobromuron	Sulprophos
Carbosulfan	Ethiprole	Metolachlor	TCMTB
Carboxin	Ethirimol	Metolcarb	Tebuconazole
Carfentrazone-ethyl	Ethofumesate	Metoxuron	Tebufenozide
Chlorantranilprole	Ethoprop	Metribuzin	Tebufenpyrad
Chlorbenside	Ethylan	Mevinphos-cis	Tebupirimfos
Chlorbromuron	Etofenprox	Mexacarbate	Tebuthiuron
Chlorbufam	Etoxazole	Mirex	Tecnazene
Chlordane cis	Etridiazole	Molinate	Teflubenzuron
Chlordane trans	Etrimfos	Monocrotophos	Temphos
Chlordimeform	Famoxadone	Monolinuron	Tepraloxydim
Chlorfenson	Fenamidone	Myclobutanil	Terbacil
Chlorfenvinphos (e+z)	Fenamiphos	Naled	Terbufos
Chlorfluazuron	Fenamiphos sulfone	Napropamide	Terbumeton
Chlorflurenol-methyl	Fenamiphos sulfoxide	Naptalam	Terbutryne
Chloridazon	Fenarimol	Neburon	Terbutylazine
Chlorimuron-ethyl	Fenazaquin	Nitenpyram	Tetrachlorvinphos
Chlormephos	Fenbuconazole	Nitralin	Tetraconazole
Chlorobenzilate	Fenchlorphos (Ronnell)	Nitrapyrin	Tetradifon
Chloroneb	Fenfuram	Nitrofen	Tetraiodoethylene
Chloropropylate	Fenhexamid	Nitrothal-isopropyl	Tetramethrin
Chlorothalonil	Fenitrothion	Norflurazon	Tetrasul
Chloroxuron	Fenobucarb	Novaluron	Thiabendazole
Chlorpropham	Fenoxanil	Nuarimol	Thiacloprid
Chlorpyrifos	Fenoxycarb	o,p'-DDD (o,p'-TDE)	Thiamethoxam
Chlorpyrifos-methyl	Fenpropathrin	o,p'-DDE	Thiazopyr
Chlorthiamid	Fenpropidin	o,p'-DDT	Thidiazuron

Chlorthion	Fenpropimorph	Octhilinone	Thiobencarb
Chlorthiophos	Fenpyroximate	Ofurace	Thiodicarb
Chlortoluron	Fenson	Omethoate	Thiofanox
Chlozolinate	Fensulfothion	Ortho-phenylphenol	Thiofanox sulfone
Clethodim	Fenthion	Oxadiazon	Thiofanox sulfoxide
Clodinafop-propargyl	Fentrazamide	Oxadixyl	Thiophanate-methyl
Clofentezine	Fenuron	Oxamyl	Tolclofos-methyl
Clomazone	Fenvalerate	Oxamyl-oxime	Tolfenpyrad
Cloquintocet-mexyl	Fipronil	Oxycarboxin	Tolyfluanid
Clothianidin	Flamprop-isopropyl	Oxychlorane	Tralkoxydim
Coumaphos	Flamprop-methyl	Oxyfluorfen	Triadimefon
Crotoxyphos	Flonicamid	p,p'-DDD (p,p'-TDE)	Triadimenol
Crufomate	Fluazifop-butyl	p,p'-DDE	Tri-allate
Cyanazine	Flubendiamide	p,p'-DDT	Triazophos
Cyanofenphos	Flucarbazone-sodium	Paclobutrazol	Tribufos
Cyanophos	Fluchloralin	Paraoxon	Trichlorfon
Cyazofamid	Flucythrinate	Paraquat	Tricyclazole
Cycloate	Fludioxonil	Parathion	Trietazine
Cycloxydim	Flufenacet	Parathion-methyl	Trifloxystrobin
Cycluron	Flufenoxuron	Pebulate	Trifloxysulfuron
Cyfluthrin (I,II,III,IV)	Flumetralin	Penconazole	Triflumizole
Cyhalothrin-lambda	Fluometuron	Pencycuron	Triflumuron
Cymoxanil	Fluorochloridone	Pendimethalin	Trifluralin
Cypermethrin	Fluorodifen	Penoxsulam	Triforine
Cyprazine	Fluoxastrobin	Permethrin (Total)	Trimethacarb
Cyproconazole	Fluquinconazole	Phenmedipham	Triticonazole
Cyprodinil	Flusilazole	Phenthoate	Vamidothion
Cyromazine	Flutolanil	Phorate	Vernolate
Dacthal (chlorthal-dimethyl)	Flutriafol	Phorate sulfone	Vinclozolin
delta-HCH (delta-lindane)	Fluvalinate	Phosalone	Zinophos
Deltamethrin	Folpet	Phosmet	Zoxamide
delta-trans-allethrin	Fonofos	Phosphamidon	
Demeton-O	Forchlorfenuron	Picolinafen	
Demeton-S	Formetanate	Picoxystrobin	