Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

FOOD SAFETY ACTION PLAN

REPORT

2011-2012
TARGETED SURVEYS - CHEMISTRY

Pesticides and Metals in Intra-Provincially Traded Fresh Fruits

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Special Surveys
Chemical Evaluation
Food Safety Division
Canadian Food Inspection Agency
1400 Merivale Road
Ottawa Ontario Canada
K1A 0Y9

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Executive Summary

Targeted surveys are used by the Canadian Food Inspection Agency (CFIA) to both support for the prioritization of the Agency's activities to areas of greater concern and provide scientific evidence to address areas of lesser concern. Originally started under the Food Safety Action Plan (FSAP), targeted surveys are a valuable tool for generating essential information on certain hazards in foods, identifying/characterizing new and emerging hazards, informing trend analysis, prompting/refining human health risk assessments, assessing compliance with Canadian regulations, highlighting potential contamination issues, and promoting compliance.

The main objectives of the pesticides and metals in intra-provincially traded fresh fruits targeted survey were to:

- generate baseline surveillance data for pesticide residues and metals in cherries, grapes, pears and small berries, grown and sold in the same province;
- compare pesticide residue levels in small berries with results of the 2009-2010 FSAP Pesticides in Fresh Fruits and Vegetables survey; and
- compare and contrast pesticide residue and metal levels to those reported for domestically produced, inter-provincially traded and imported foods in the same growing season as reported under the 2010-2012 National Chemical Residue Monitoring Program (NCRMP).

This survey targeted cherries, grapes, pears and small berries that are traded intra-provincially (foods sold within the province in which they are grown). In total, 435 samples of fresh fruits (84 cherry, 37 grape, 56 pear, and 258 small berries) were collected in eight of the ten provinces and were analyzed for over 400 different pesticide residues.

The overall compliance rate for pesticides in this survey was 96.6%. The cherry, grape and pear samples were 100% compliant with existing Canadian maximum residue limits (MRLs) for pesticides. Most (94.2%) of the small berries were compliant with existing MRLs for pesticides. The survey results were compared by commodity to 2010-2012 data from the CFIA's NCRMP (same growing season for FSAP and NRCMP implies similar climatic conditions, pest pressures and pesticide usage). The compliance rate for cherries (100%), grapes (100%), pears (100%) and small berries (94.2%) were somewhat higher in the current survey than the compliance rates for these commodities under the NCRMP (95.7% for cherries, 97.0% for grapes, 98.5% for pears, 93.6% for small berries).

A total of 434 fruit samples were analyzed for arsenic, cadmium, mercury and lead. In general, the results for all four of the metals of concern were similar to the values reported in the 2010-2012 NCRMP.

In this survey, there were 15 violative samples - all were blackberry samples containing captan; three of these samples also contained cypermethrin. All violations were assessed and appropriate follow-up actions reflecting the magnitude of the health risk were taken..

1 Introduction

1.1 Targeted Surveys

Targeted surveys are used to gather information regarding the potential occurrence of chemical residues, contaminants, and/or natural toxins in defined commodities. The surveys are designed to answer specific questions. Therefore, unlike monitoring activities, testing of a particular chemical hazard is targeted to commodity types and/or geographical areas.

Due to the vast number of chemical hazards and food commodity combinations, it is not possible, nor should it be necessary, to use targeted surveys to identify and quantify all chemical hazards in foods. To identify food-hazard combinations of greatest potential health risk, the CFIA uses a combination of scientific literature, media reports, and/or a risk-based model developed by the Food Safety Science Committee, a group of federal, provincial and territorial subject matter experts in the area of food safety.

As part of CFIA's core activities, many agricultural commodities are currently being monitored under the National Chemical Residue Monitoring Program (NCRMP) for the presence of pesticide residues and metals. This monitoring is conducted on imported and inter-provincially traded (federally registered) commodities which fall under the *Canadian Agricultural Products Act* (CAP Act). This survey complements the activities of the NCRMP by targeting fresh fruits that fall outside the purview of the CAP Act, and are not generally tested under the CFIA's core monitoring activities.

1.2 Acts and Regulations

1.2.1 Pesticides

Health Canada's Pest Management Regulatory Agency (PMRA) is responsible for the registration and regulation of pesticides and for specifying maximum residue limits (MRLs) under the *Pest Control Products Act (PCPA).* Specified MRLs appear in Health Canada's MRL Database[1]. Each MRL is set for a specific pesticide and food commodity combination, and is the maximum amount of residue expected to remain in or on crops (such as vegetables, fruits, grains, and nuts) when a pesticide is used according to label directions. MRLs are set at a level far below the level of residue that could present a human health concern[2].

MRLs are set for food commodities sold in Canada, and apply to the product whether imported or produced domestically[3]. An MRL usually applies to the identified raw agricultural food commodity, as well as to processed food products made from that raw commodity. In the absence of a specific MRL for a particular commodity, pesticide residues must comply with the Canadian general MRL of 0.1 parts per million (ppm) as stated in section B.15.002 (a)/(b) of the *Food and Drug Regulations*[4]. Follow-up actions for non-compliant products are initiated in a manner that reflects the magnitude of the health concern. Actions may include, notification of the producer or importer, follow-up inspections, additional directed sampling, and recall of products.

1.2.2 Metals

Certain maximum levels (MLs) exist for metals in food in the Canadian *Food and Drug Regulations* (*FDR*), where they are referred to as tolerances. There are also a number of MLs that do not appear in the regulations and are referred to as standards that do not appear in the regulations and are referred to as standards; these can be viewed on Health Canada's website (http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/contaminants-guidelines-directives-eng.php). Tolerances and standards are established as a risk management tool, and generally for foods that can significantly contribute to total dietary exposure to a particular chemical. Note that some of the regulatory tolerances for arsenic and lead in Table 1 of Division 15 of the FDR are in the process of being updated by Health Canada (http://www.hc-sc.gc.ca/fn-an/consult/2014-beverages-lead-arsenic-plomb-boissons/document-consultation-eng.php); other tolerances in Table 1 Division 15, particularly those for lead and arsenic, are also prioritised for updating in the future.

Health Canada has not established tolerances or standards for arsenic, cadmium, lead, or mercury in the products evaluated in this survey. However, in the absence of applicable tolerances or standards, foods sold in Canada are still subject to Section 4(1)(a) of the *Food and Drugs Act*, which provides the basis for taking enforcement actions when foods contain a poisonous or harmful substance, whether intentionally added or present from anthropogenic or natural sources, at a level that would pose a safety concern to human health. Elevated levels of metals may be assessed by Health Canada's Bureau of Chemical Safety (BCS) on a case-by-case basis using the most current scientific data available. If the BCS identifies a potential safety concern with a particular result, the CFIA can exercise follow-up actions. Follow-up actions are initiated in a manner that reflects the magnitude of the health concern. Actions may include, notification of the producer or importer, follow-up inspections, additional directed sampling, and recall of products.

For lead in particular, as part of Health Canada's overall lead reduction strategy, the Food Directorate carries out activities in support of the objective of reducing dietary lead exposure to levels that are as low as reasonably achievable (ALARA principle). Information on this strategy is available on Health Canada's website (http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/lead_strat_plomb_strat-eng.php).

1.2.3 Organics

In Canada, domestic or imported organic products are permitted to carry the "organic" claim when certified according to the *Canadian Organic Product Regulations* (OPR)[5]. Like conventional products, organic products are subject to the pesticide MRLs established under the PCPA. The *Organic Products System Permitted Substances List*[6] (also referred to as *CAN/CGSB 32.311*) referenced in the OPR stipulates which substances are permitted for use in or on organic foods. Organic products with detectable levels of pesticides not permitted for use under the OPR are referred to the appropriate CFIA Program for follow-up.

2 Survey Details

2.1 Pesticides

Fresh fruit crops are subject to various pest and disease pressures which impact their production. Pesticides are an important tool used in food production because pests such as insects, bacteria, fungi, and other organisms can have devastating effects on the quantity and quality of the fruit. Different pest pressures and climatic conditions in fruit-producing areas may result in different types of pesticides being used. Although pesticides play an important role in agriculture by protecting food and crops from pests, inappropriate use of pesticides may pose a human health risk.

2.2 Metals of Concern

Metals are naturally-occurring elements that may be present in trace amounts in rock, water, soil, or air. The degree of uptake by plants or animals in contact with metals is dependent on the nature of the metal, the environment, and the biology of the organism exposed to that metal. Elevated levels of metals can result from natural phenomenon (e.g. weathering of rock, minerals in soil, forest fires), as well as human activities such as mining, improper disposal of waste, or other industrial processes.

Arsenic, cadmium, lead, and mercury have been shown to have effects on human health[7], following long term exposure. The detection of metals of concern, namely arsenic, cadmium, lead, and mercury, in fruits is not unexpected as trace levels generally reflect typical background accumulation from the environment. There are no maximum levels for arsenic, cadmium, lead and mercury in fresh fruits.

2.2.1 Arsenic

Arsenic is an element that can be present in the environment naturally through erosion and weathering of soils, or may enter the environment as the result of industrial processes and pollution. Arsenic can be found naturally in a variety of different foods at low levels (such as meat, seafood, dairy products, baked goods, grains, vegetables, and fruits[8]), generally due to accumulation from the environment (i.e. air, water, and soil).

Long term exposure to high levels of arsenic in its inorganic form may lead to chronic health effects, including damage to the kidneys, liver, lungs, and skin, as well as an increased risk of cancers of the bladder and lungs[9]. Although there is scientific evidence that the toxicity is dependent on its chemical form, only total arsenic was measured in this survey.

2.2.2 Cadmium

Cadmium can be found in the earth’s crust and is generally found in combination with other inorganic compounds. Contamination of the environment with cadmium may be due to natural erosion and weathering of the rocks and soil, or may result from the presence of cadmium in industrial and municipal wastes, galvanized products, sewage sludge, and fertilizers.

Dietary exposure to cadmium is most commonly associated with the consumption of shellfish, liver, and kidney meats[10]. Chronic dietary exposure to cadmium may cause kidney damage, bone mineral density loss and hypertension[11].

2.2.3 Lead

Lead occurs naturally in the earth's crust and may also be present as a result of its many industrial uses. Battery production is currently the largest global market for lead[12]. Lead was historically present in the environment and in foods at higher levels due to its previous uses in gasoline, paint, and solder used in food cans, plumbing and plumbing materials.

Ongoing exposure to even very small amounts of lead can be harmful, especially to infants and young children, who have higher absorption rates of ingested lead and less effective renal excretion. Infants and children also usually have a higher exposure to lead on a body weight basis compared to adults[13] and are considered to be at higher risk because they are particularly vulnerable to the adverse effects of lead on the development of the central nervous system. Other health effects associated with elevated lead exposure may include anaemia, hypertension, kidney toxicity, and delayed onset of puberty[12].

2.2.4 Mercury

Mercury is a metal that can be found naturally in rocks, soil, and volcanic emissions. It can also be deposited into the environment from industrial activities such as coal-fired power generation, mining, smelting, and waste incineration.

In the general population, the major sources of exposure to mercury occur through the consumption of certain fish species and from dental amalgam[14]. Elevated exposure to mercury may result in effects on the central and peripheral nervous system, effects on the development of the central nervous system, or effects on the immune system[15].

2.3 Rationale

According to Statistics Canada data from 2009, cherries, table and wine grapes, pears and small berries are grown on about two-thirds of the land dedicated in Canada for fruit production[16]. These fruits are frequently sold and consumed locally (at a variety of locations including grocery stores, roadside stands and farmers' markets or be picked directly by consumers), and with the exception of small berries, have not been examined in previous targeted surveys. The amount of fruit available for consumption of Canadians is 74.43 kg/person/year[16]. All of these commodities are subject to various pest pressures and are commonly grown and sold within provincial boundaries.

While the CFIA's NCRMP program tests for residues in various commodities, its scope is limited to imported products and domestic products that are sold across provincial borders. Food safety surveillance of intra-provincially traded produce generally falls under provincial jurisdiction. The provinces may conduct their own sampling and testing regimes for fresh fruits produced in or imported into their province. The present targeted survey was designed by the CFIA, in consultation with provincial partners, to generate baseline surveillance data on pesticide residues and metals in intra-provincially traded fresh fruits.

2.4 Sample Distribution

In this survey, a total of 435 fresh produce samples were collected from pick-your-own farms, roadside farm stands, farmers markets, specialty stores, and grocery stores in eight provinces. Not all commodities or product types were available in all locations where sampling occurred; the number of samples of a particular crop assigned to a targeted province was based mainly on crop production statistics.

2.5 Method Details

Samples in the current survey were analyzed by ISO 17025 accredited food testing laboratories under contract with the Government of Canada. Sufficient quantities of sample were collected to allow for the three different analytical methodologies (two multi-residue pesticides methods and a multi-metal analysis) to be performed on each sample.

Table 1. Summary of Method Performance Parameters

Method	Lab	Year	Number of Pesticides	LOD (ppm)	Reporting Limit (ppm)
GC-MS*	A,B,C	2009-2012	304	0.01 - 0.17	
LC-MS**	A	2011-2012	149	0.001 – 0.005	
LC-MS**	B	2011-2012	154	0.005 – 0.10	
LC-MS**	C	2011-2012	152	0.00015 – 0.0012	
LC-MS***	D	2009-2010	146	0.005 – 0.01	0.010 (for all pesticides except aclonifen, chlorthiamid, chlorbromuron, cycloxydim, pyridalyl and quizalofop which had an limit of 0.10 ppm)

GC-MS*: see Appendix A for more details
LC-MS**: see Appendix B, Table 1 for more details
LC-MS***: see Appendix B, Table 2 for more details

The laboratories used inductively coupled plasma mass spectrometry (for arsenic, cadmium, and lead analysis) and cold vapor atomic fluorescence spectroscopy (used for mercury analysis) for detection of metal analytes in the samples. Method limits of detection (LOD) and limits of quantitation (LOQ) for the metals can be found in Appendix C.

Unless otherwise specified, the compliance rate is per sample. The compliance rate refers to the percentage of samples with residue levels at or below the applicable MRL.

2.6 Limitations

This survey was designed to provide a snapshot of the levels of pesticide residues and metal levels in intra-provincially traded fresh fruits available for sale in Canada and has the potential to highlight commodities that warrant further investigation. The limited sample sizes analyzed represent a small fraction of the products available to consumers, and therefore, care must be taken when interpreting and extrapolating these results. Samples are picked up at retail locations and it may not be possible to verify where the products were grown, so some inter-provincially traded fruits may have been sampled and analyzed by error.

A number of products in the survey have been identified as organic. Organic products are certified to the *Organic Product Regulations* by a certification body recognized by the CFIA.

3 Results and Discussion

3.1 Overview of Pesticide Results

In total, 435 samples of intra-provincially traded fresh fruits were sampled. This included 84 cherry, 37 grape, 56 pear, and 258 small berries samples. The overall compliance rate was 96.6%. There were 15 violative samples - all were blackberry samples containing captan; three of these samples also contained cypermethrin. There is no specific MRLs for captan or cypermethrin in blackberries, so all the violations were associated with exceeding the general 0.1 parts per million (ppm) MRL (as specified in the *Food and Drug Regulations*). All violations were assessed and appropriate follow-up actions reflecting the magnitude of the health risk were taken. Please refer to Appendix D for a summary of pesticide residue violations in samples in this survey.

Table 2 presents the number of samples per product type, and the number and percentage of samples with non-detectable and detectable levels of pesticides. Samples with compliant residues refer to samples with detectable levels of pesticides that were at or below the applicable MRLs. The compliance rate was 100% for cherries, grapes and pears, and 94.2% for small berries.

Table 2. Summary of pesticide results by commodity type in order of decreasing compliance rate

Commodity	Number of Samples	Number of Samples with No Detected Pesticide Residues (Percentage)	Number of Samples with Compliant Residues (Percentage)	Number of Samples with Residues in Violation (Percentage)
Cherry	84	6 (7.1)	78 (92.9)	0 (0)
Grape	37	3(8.1)	34 (91.9)	0 (0)
Pear	56	19 (33.9)	37 (66.1)	0 (0)
Small Berries	258	65 (25.2)	178 (69.0)	15 (5.8)

A total of 63 different pesticides were detected on fruit samples analyzed in this targeted survey. The detected pesticide residues include both compliant and violative residues. The maximum number of pesticide residues detected per commodity ranged from six in grapes to twelve in small berries.

Three samples in this survey were categorized as organic including one cranberry, one blueberry and one grape sample. Two of these samples (cranberry and blueberry) did not contain detectable pesticide residues. All samples identified in accompanying documentation as organic were compliant with applicable pesticide MRLs. However, the residue detected is not a permitted substance as per the Organic Production Systems Permitted Substances Lists[5], and thus may not meet the organic certification requirements[6].

3.2 Pesticide Results by Product Type

The following sections present the results for pesticides per product type. See section 3.4 for a comparison to the NCRMP data.

3.2.1 *Pesticides in Cherries*

A total of 84 fresh cherry samples were analyzed in this targeted survey. Six samples (7.1%) did not have detectable pesticide residues. The compliance rate was 100%, and no follow-up action was required.

There were 29 different pesticide residues found in 78 cherry samples. The specific detectable pesticide residues found in cherry samples are illustrated in Figure 1. Approximately 18% of the samples with detectable pesticide residues contained one or two pesticide residues. The remaining 82% of samples with detectable pesticide residues contained from three to a maximum of ten pesticide residues per sample. Only one sample contained ten pesticide residues.

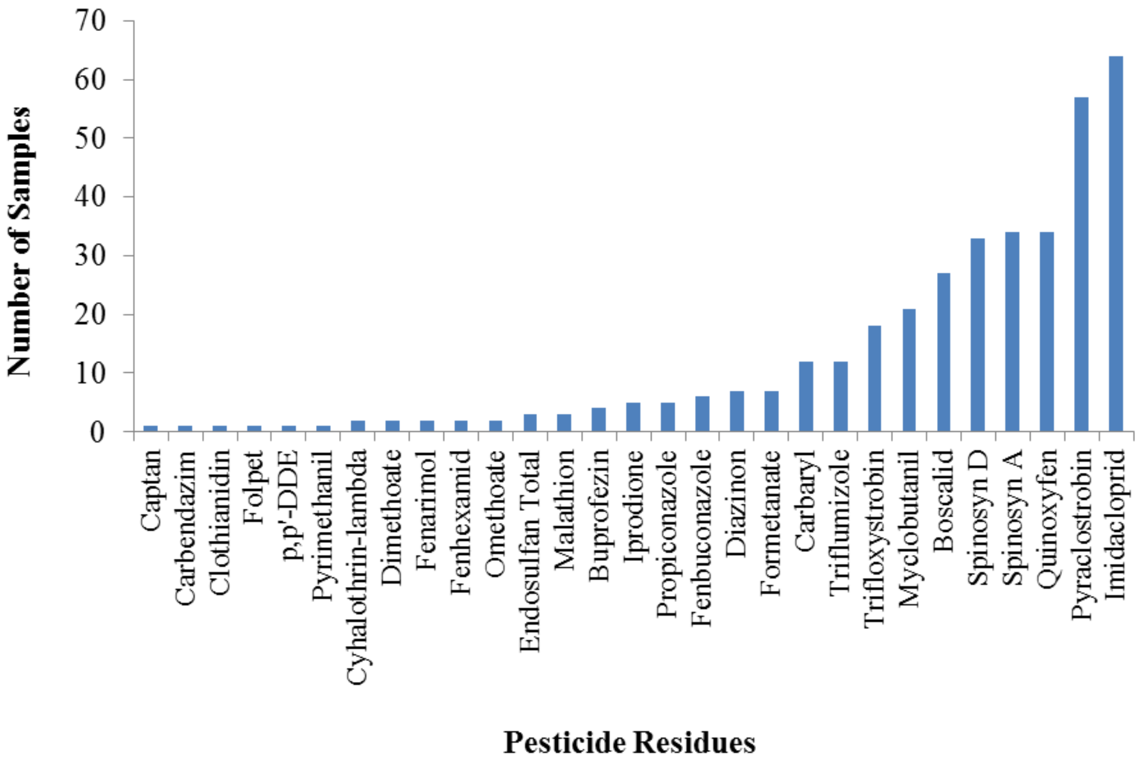


Figure 1. Frequency of detection of pesticides residues in cherry samples (arranged in increasing order of the number of samples testing positive for a particular residue)

3.2.2 *Pesticides in Grapes*

A total of 37 grape samples were analyzed in this targeted survey. Three samples (8.1%) did not have detectable pesticide residues. The compliance rate was 100%, and no follow-up action was required.

Twenty-three distinct pesticide residues were found in 34 grape samples. The specific detectable pesticide residues found in grape samples are illustrated in Figure 2. Thirty-eight percent of samples with detectable pesticide residues contained one or two pesticide residues. The remaining 62% of samples with detectable pesticide residues contained from three to a maximum of six pesticide residues per sample. Two grape samples contained six pesticide residues.

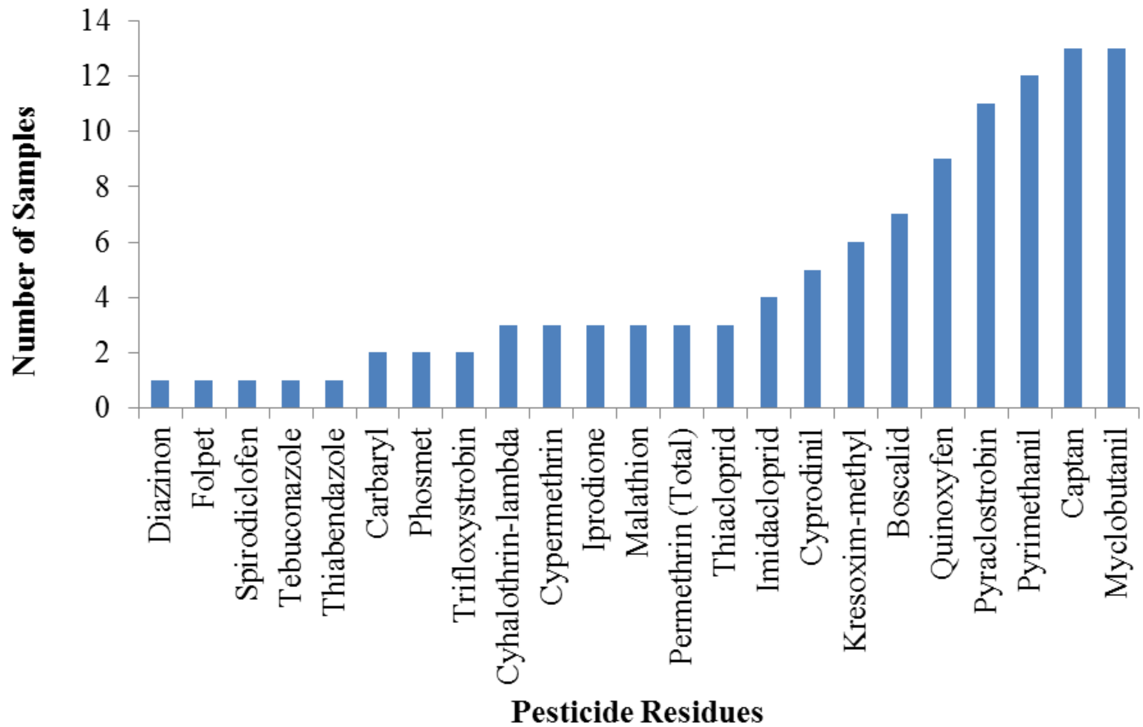


Figure 2. Frequency of detection of pesticides residues in grape samples (arranged in increasing order of the number of samples testing positive for a particular residue)

3.2.3 *Pesticides in Pears*

A total of 56 fresh pear samples were analyzed in the present targeted survey. Nineteen samples (33.9%) did not have detectable pesticide residues. The compliance rate was 100%, and no follow-up action was required.

Twenty-eight distinct pesticide residues were found in pear samples. The specific detectable pesticide residues found in 37 pear samples are illustrated in Figure 3. Approximately 76% of the samples with detectable pesticide residues contained one or two pesticide residues. The remaining 24% of samples with detectable pesticide residues contained from four to a maximum of seven residues per sample. Only one pear sample contained seven pesticide residues.

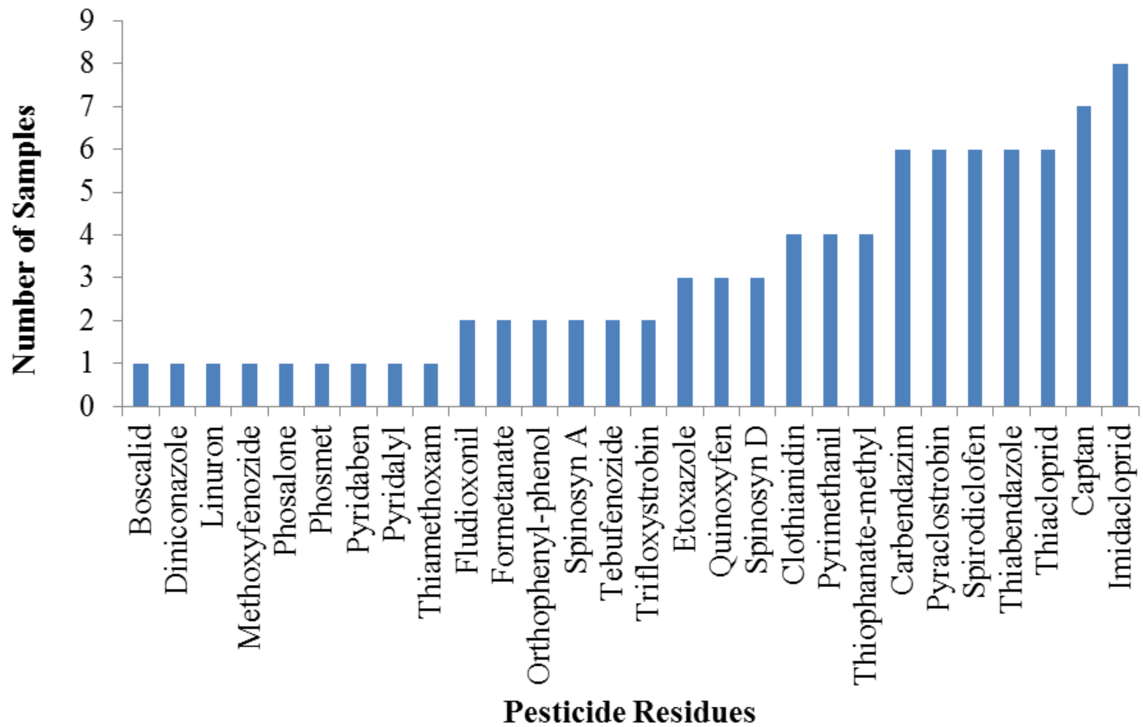


Figure 3. Frequency of detection of pesticides residues in pear samples (arranged in increasing order of the number of samples testing positive for a particular residue)

3.2.4 *Pesticides in Small Berries*

A total of 258 small berry samples (including blackberries, blueberries, cranberries, raspberries, Saskatoon berries, and strawberries) were analyzed. Blueberries had the highest (82) and Saskatoon berries had the lowest (13) number of samples. Fifty-nine samples (22.9%) did not have detectable pesticide residues. Cranberries had the highest (56%) and strawberries had the lowest (9%) percentage of samples which did not contain detectable residues. The compliance rate for small berries samples was 94.2%. All pesticide violations in small berries were evaluated and appropriate follow-up actions were pursued.

Forty-seven distinct pesticide residues were found in the small berry samples. This is not unexpected as the range of different berry types and pest pressures associated with the different growing conditions across the country would warrant a wider variety of pest control products being used. The specific detectable pesticide residues found in small berry samples are illustrated in Figure 4. Approximately 33% of the samples with detectable pesticide residues contained one or two pesticide residues per sample. The remaining 67% of the samples with detectable pesticide residues contained three to a maximum of twelve pesticide residues per sample. Two samples of small berries contained twelve pesticide residues per sample.

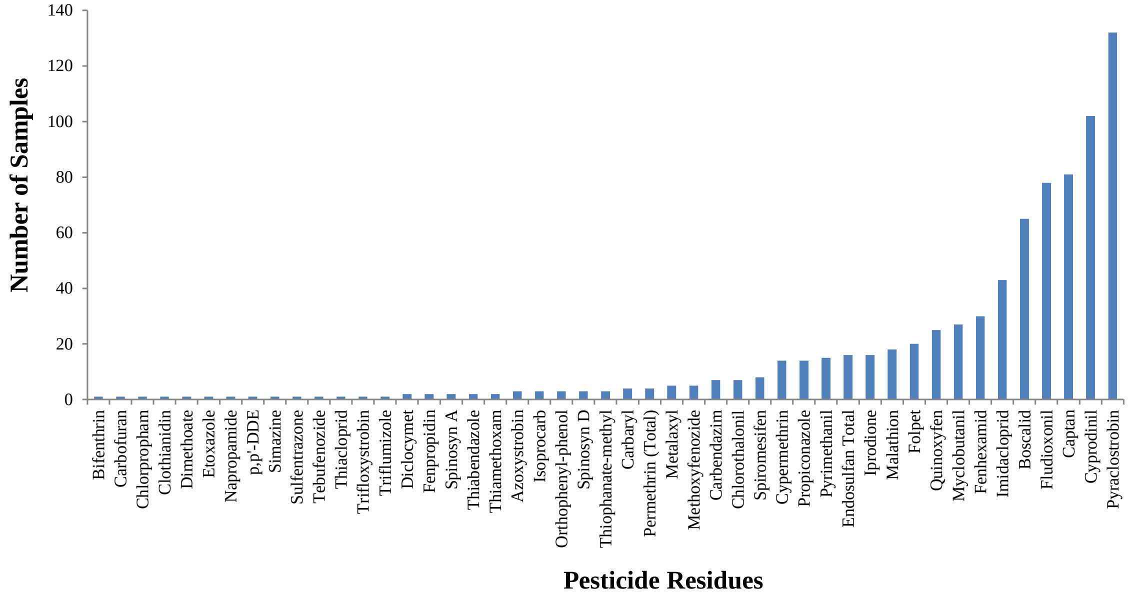


Figure 4. Frequency of detection of pesticides residues in small berry samples (arranged in increasing order of the number of samples testing positive for a particular residue)

3.3 Comparison of the Pesticide Results in the Current Survey to the 2009-2010 Targeted Pesticides Survey and the 2010-2012 NCRMP

The summary of the comparison of the current survey's results to the results of the NCRMP and the previous targeted survey conducted in 2009-2010 are shown in Table 3. The current targeted survey on pesticides focussed on fruit grown and traded within the same province in Canada while the NCRMP includes fresh fruit samples grown domestically and traded between provinces, or imported from other countries. This may account for some differences observed between the targeted survey and NCRMP results. As climatic conditions and pest pressures vary from year-to-year and this may impact the type and number of pesticides applied, targeted survey and NCRMP[17] data for the same time period were compared and contrasted to account for this variability.

Table 3.Comparison of 2010-11 targeted survey, 2009-2010 targeted survey and 2010-2012 NCRMP sample results

Study	Number of Samples	Number of Samples with No Detected Pesticide Residues (Percentage)	Number of Samples with Compliant Residues (Percentage)	Number of Samples with Residues in Violation (Percentage)	Maximum Number of Pesticide Residues per Sample	Number of Samples with One or Two Detected Pesticide Residues per Sample (Percentage)
Cherry						
Current Survey	84	6 (7.1)	78 (92.9)	0 (0)	10	14 (18)
2010-2012 NCRMP	93	4 (4.3)	85 (91.4)	4 (4.3)	12	15 (20)
Grape						
Current Survey	37	3(8.1)	34 (91.9)	0 (0)	6	13 (38)
2010-2012 NCRMP	299	29 (9.7)	261 (87.3)	9 (3.0)	15	47 (17)
Pear						
Current Survey	56	19 (33.9)	37 (66.1)	0 (0)	7	28 (76)
2010-2012 NCRMP	259	45 (17.4)	210 (81.1)	4 (1.5)	12	52 (21)
Small Berries						
Current Survey	258	65 (25.2)	178 (69.0)	15 (5.8)	12	64 (33)
Previous Survey[18]	943	476 (50.5)	464 (49.2)	3 (0.3)	9	371 (79)
2010-2012 NCRMP	456	43 (9.4)	427 (84.2)	29 (6.4)	16	89 (22)

In general, the results of the targeted survey and NCRMP testing are similar in terms of the high compliance rates (greater than 93%) and the type of pesticide residues detected. The violation rate and the maximum number of residues per sample are lower in the current survey than in the NCRMP. The NCRMP includes fresh fruit grown domestically and traded between provinces, or imported from other countries while the targeted surveys focus on fruits grown and sold in the same province.

Cherries, grapes and pears were not among the commodities analyzed in the previous targeted survey[18], so comparison with the current survey results was not possible. Small berries were included in the previous and current targeted surveys. Similar pesticide residues in small berries were observed in the previous and current targeted surveys. From Table 2, it can be observed that the positive rate and the maximum number of pesticides per sample were lower in the previous survey than in the current survey – the LC/MS method used in the current survey is more sensitive (i.e. has a lower detection limit) so a higher rate of detection is expected. The violation rate is lower in the previous survey than in the current survey.

3.4 Overview of Metals Results

In total, 434of the domestically grown, intra-provincially traded fresh fruits were tested for total arsenic, cadmium, mercury and lead. Lead was the most commonly detected metal while cadmium was detected in the least number of samples. Cadmium and mercury were associated with the highest and lowest observed levels, respectively. A summary of the results of the metals of concern is presented in Table 4.

Table 4: Summary of metal results by metal and type of fruit (arranged in alphabetical order)

	Fruit	Number of Samples Analyzed	Number (%) of Samples with Metal Detected	Minimum Level of Metal Detected (ppm)	Maximum Level of Metal Detected (ppm)	Average* Level of Metal Detected (ppm)
Arsenic	Cherry	84	31 (84)	0.0056	0.02	0.0118
	Grape	37	14 (38)	0.0041	0.0114	0.0084
	Pear	56	11 (20)	0.0048	0.0123	0.0076
	Small Berries	257	93 (36)	0.0041	0.0565	0.0111
Cadmium	Cherry	84	0 (0)	-	-	-
	Grape	37	0 (0)	-	-	-
	Pear	56	4 (7)	0.0025	0.0058	0.0044
	Small Berries	257	99 (38)	0.002	0.56	0.0149
Lead	Cherry	84	13 (15)	0.001	0.54	0.0451
	Grape	37	13 (35)	0.0012	0.0036	0.0021
	Pear	56	13 (23)	0.0015	0.01	0.0036
	Small Berries	257	126 (49)	0.001	0.25	0.0085
Mercury	Cherry	84	21 (25)	0.0001	0.002	0.0009
	Grape	37	1 (3)	-	0.00031	-
	Pear	56	3 (5)	0.00012	0.0006	0.00037
	Small Berries	257	93 (36)	0.0001	0.005	0.00057

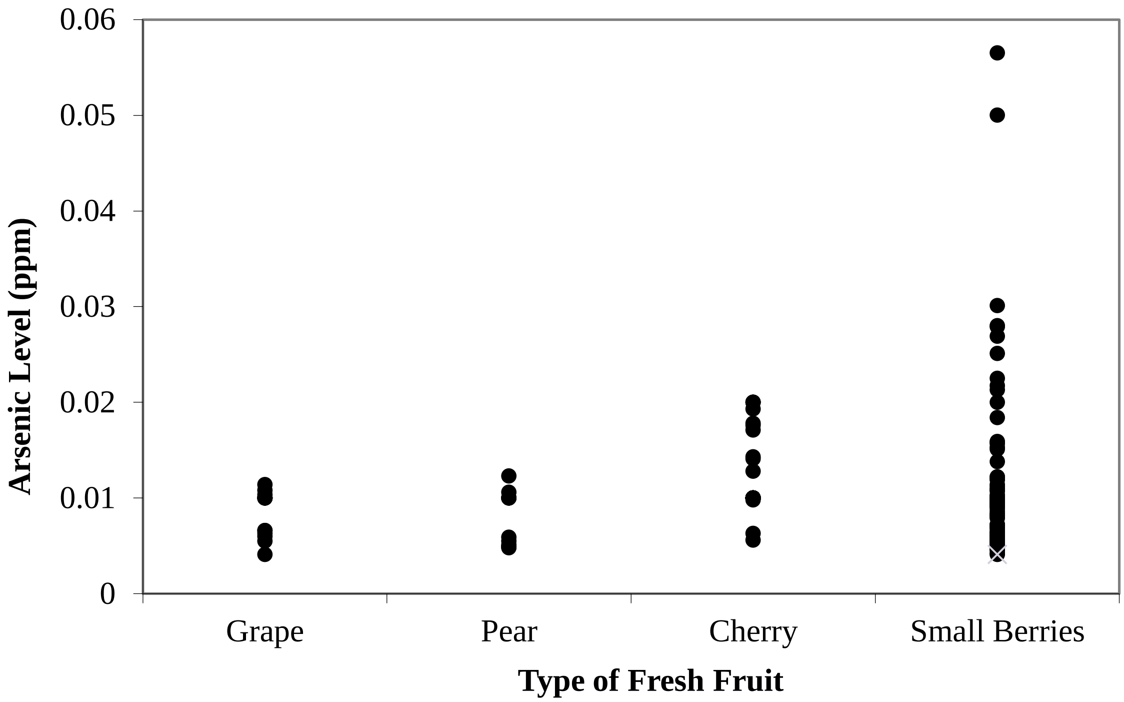
There are no established maximum levels for arsenic, cadmium, lead and mercury in fresh fruits so compliance to a numerical maximum level could not be evaluated. Health Canada determined that the levels of metals found in this survey were not considered to pose a concern to human health. No follow up actions were required. All data generated were shared with Health Canada and with the provinces for use in performing human health risk assessments.

3.5 Results by Metal

The following sections present the results for arsenic, cadmium, lead, and mercury. See section 3.6 for a comparison to the NCRMP data.

3.5.1 *Arsenic*

The distribution of arsenic levels in the fresh fruits tested is presented in Figure 6. Arsenic was not detected in 285 samples (65.7%) of the samples. The observed arsenic levels ranged from 0.0041 ppm to 0.0565 ppm. Arsenic was detected in all fruits tested; the highest and lowest percentages of samples with detectable arsenic were in cherries (84%) and in pears (20%), respectively. Grapes and small berries were associated with the lowest and the highest observed average and maximum arsenic levels, respectively. The two highest arsenic levels were observed in two samples of raspberries.

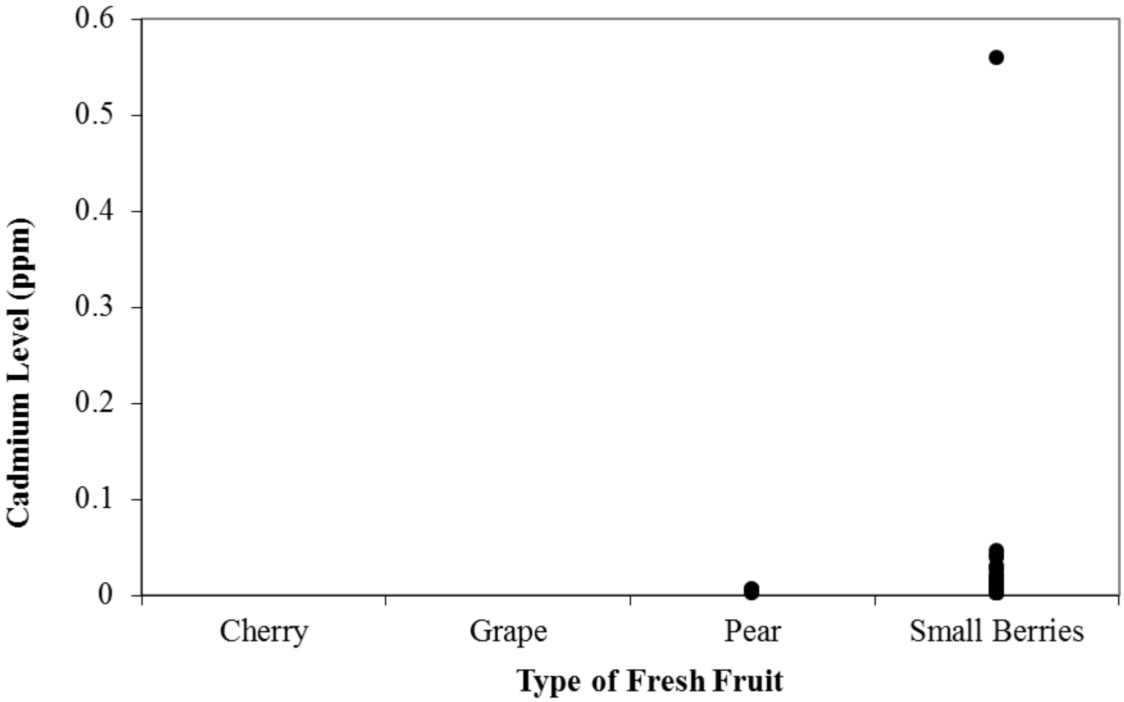


Note: only levels above the limit of detection are displayed in the graph.

Figure 6. Distribution of arsenic levels by type of fresh fruit (arranged in order of increasing arsenic level)

3.5.2 *Cadmium*

The distribution of cadmium levels in the fresh fruits tested is presented in Figure 7. Cadmium was not detected in 331 samples (76.3%) of the samples. The observed cadmium levels ranged from 0.0020 ppm to 0.5600 ppm. Cadmium was not detected in cherries or grapes. The highest percentage of samples with detectable cadmium was in small berries (38%). Small berries were associated with the highest cadmium levels. The highest observed cadmium level was observed in a raspberry sample, which also contained an elevated level of arsenic.

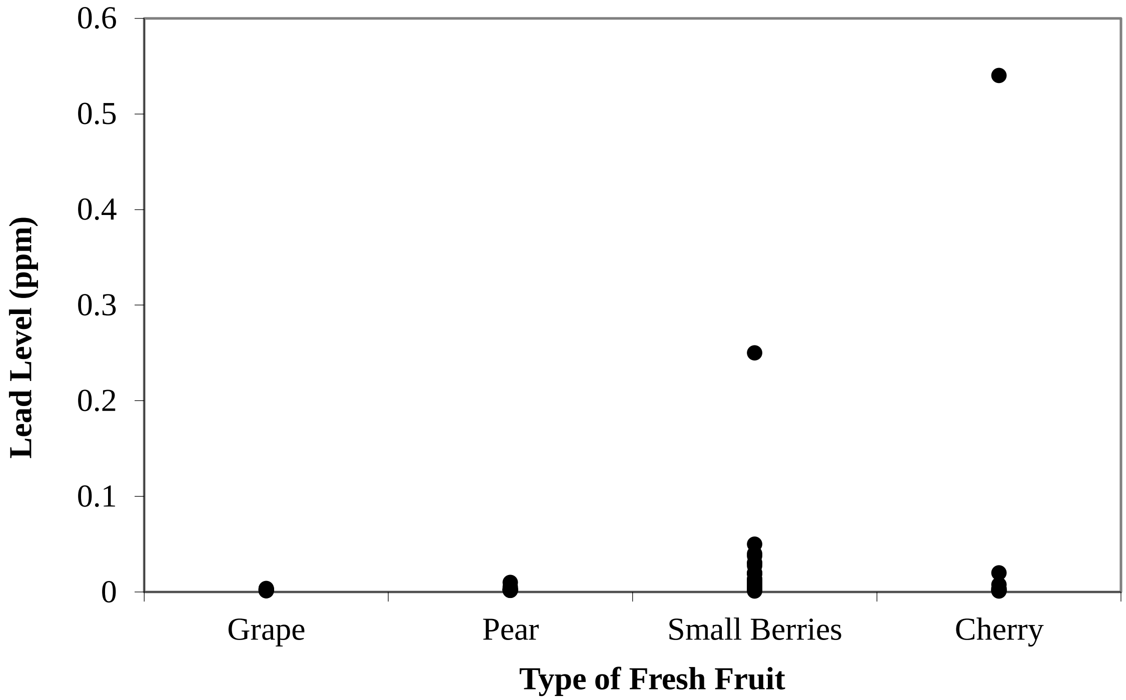


Note: only levels above the limit of detection are displayed in the graph.

Figure 7. Distribution of cadmium levels by type of fresh fruit (arranged in order of increasing cadmium level)

3.5.3 *Lead*

The distribution of lead levels in the fresh fruits tested is presented in Figure 8. Lead was not detected in 269 samples (62.0%) of the samples. The observed lead levels ranged from 0.0010 ppm to 0.5400 ppm. Lead was detected in all fruits tested; the highest and lowest percentages of samples with detectable lead were in small berries (49%) and in cherries (15%), respectively. Grapes and cherries were associated with the lowest and the highest observed average and maximum lead levels, respectively. The highest lead level was observed in a cherry sample.

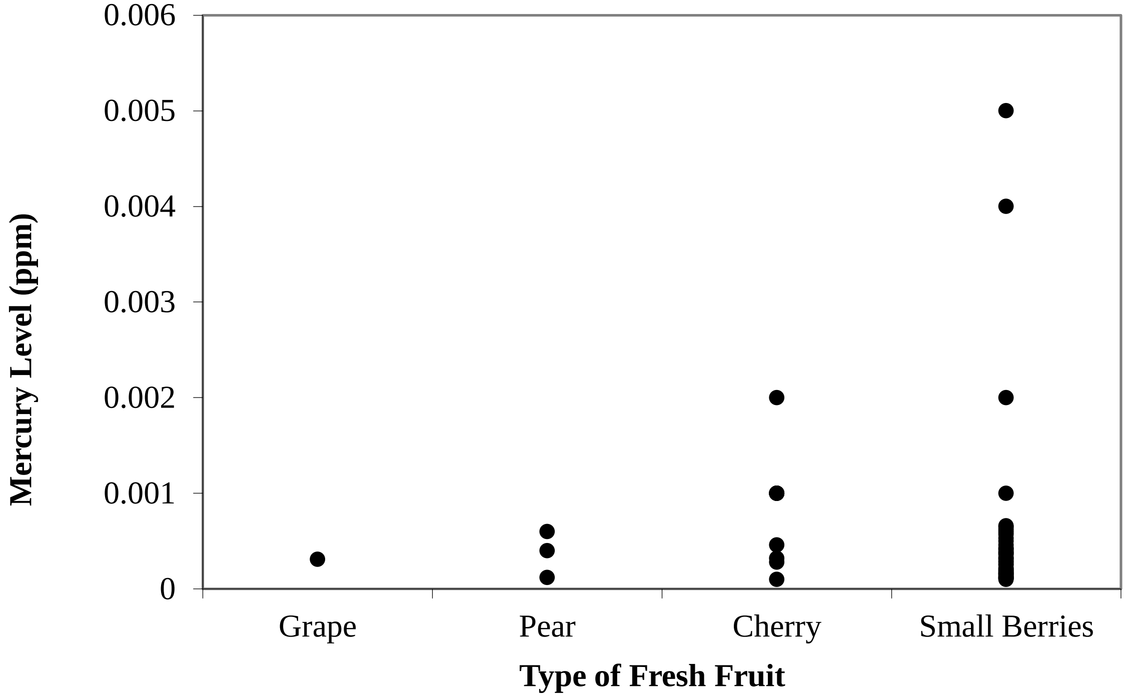


Note: only levels above the limit of detection are displayed in the graph.

Figure 8. Distribution of lead levels by type of fresh fruit (arranged in order of increasing lead level)

3.5.4 *Mercury*

The distribution of mercury levels in the fresh fruits tested is presented in Figure 9. Mercury was not detected in 316 samples (72.8%) of the samples. The observed mercury levels ranged from 0.00010 ppm to 0.00500 ppm. Mercury was detected in all fruits tested; the highest and lowest percentages of detectable mercury were in cherries (25%) and in grapes (3%), respectively. Grapes and small berries were associated with the lowest and the highest observed average and maximum mercury levels, respectively.



Note: only levels above the limit of detection are displayed in the graph.

Figure 9. Distribution of mercury levels by type of fresh fruit (arranged in order of increasing mercury level)

3.6 Comparison of the Metal Results in the Current Survey to the 2010-2012 NCRMP

In this section, the metal results of this targeted survey were compared to the 2010-2012 NCRMP results. The current targeted survey on metals focussed on fruit grown and traded within the same province in Canada while the NCRMP includes fresh fruit samples grown domestically and traded between provinces, or imported from other countries. This may account for some differences observed between the targeted survey and NCRMP results. As climatic conditions and pest pressures vary from year-to-year that may impact the type and number of pesticides applied, targeted survey and NCRMP data for the same time period were compared and contrasted. The summary of the comparison of the current FSAP survey results to the 2010-2012 NCRMP sample results are shown in Table 5.

Table 5. Comparison of 2010-11 targeted survey (TS) and 2010-2012 NCRMP sample results

Type of Fruit	Data Source	Number of samples	Arsenic	Cadmium	Lead	Mercury
Percentage of Positive Samples						
Cherry	TS	84	36.9	0.0	15.5	25.0
	NCRMP	57	36.8	1.8	40.4	12.3
Grape	TS	37	37.8	0.0	35.1	2.7
	NCRMP	191	36.1	4.2	46.1	8.4
Pear	TS	56	19.6	7.1	23.2	5.4
	NCRMP	147	33.3	23.1	36.7	4.1
Small Berries	TS	257	36.2	38.5	49.0	36.6
	NCRMP	267	40.8	52.8	43.6	7.1
Maximum Levels (ppm)						
Cherry	TS	84	0.0200	-	0.5400	0.00200
	NCRMP	57	0.0300	0.0720	0.0200	0.00200
Grape	TS	37	0.0114	-	0.0036	0.00031
	NCRMP	191	0.1070	0.0430	0.0900	0.00240
Pear	TS	56	0.0123	0.0058	0.0100	0.00060
	NCRMP	147	0.1200	0.0790	0.1100	0.01300
Small Berries	TS	257	0.0565	0.5600	0.2500	0.00500
	NCRMP	267	0.0500	0.6300	0.0400	0.00600
Average Levels (ppm)						
Cherry	TS	84	0.0118	-	0.0451	0.00091
	NCRMP	57	0.0119	-	0.0045	0.00114
Grape	TS	37	0.0084	-	0.0021	-
	NCRMP	191	0.0151	0.0111	0.0072	0.00084
Pear	TS	56	0.0076	0.0044	0.0036	0.00037
	NCRMP	147	0.0199	0.0094	0.0086	0.00334
Small Berries	TS	257	0.0111	0.0111	0.0085	0.00057
	NCRMP	267	0.0111	0.0200	0.0040	0.00084

In general, when comparing the targeted survey results to the NCRMP results for all metals, the TS results were similar to or lower than the NCRMP results for similar commodities. The positive rate for mercury in cherries and small berries was higher in the TS survey than in the NCRMP study. The maximum levels of lead in small berries, and lead in cherries were higher in the TS surveys than in the NCRMP surveys. The average levels of lead in cherries and small berries were higher in the TS surveys than in the NCRMP surveys.

4 Conclusions

The 2011-2012 Pesticides and Metals in fresh fruit targeted survey generated baseline data on the levels of pesticide residues and metals in cherries, grapes, pears, and small berries grown and sold in the same province. A total of 435 samples of fresh fruits were purchased at pick-your-own farms (pre-packaged fruit only), roadside farm stands, farmers markets, specialty, and grocery stores. Detectable pesticide residues were found in all types of fruits.

The compliance rate for pesticides in all samples analyzed in the survey was 96.6%. All cherry, grape and pear samples were compliant with existing Canadian pesticide MRLs. There were 15 violative blackberry samples each containing captan; three of these samples also contained cypermethrin. All pesticide violations were evaluated and appropriate follow-up actions were pursued.

Data collected in this targeted survey on intra-provincially traded cherries, grapes, pears and small berries were compared to relevant commodities in the 2009-2010 Pesticides in Fresh Fruits and Vegetables survey and/or the 2010-2012 NCRMP data, where feasible. The compliance rates, number and type of pesticide residues found in fresh fruits sampled in this survey are comparable to results obtained in the previous targeted survey and in the NCRMP.

Of the three organic samples in this survey, one sample of organic grapes contained a very low level of a pesticide residue. This result was forwarded to the appropriate program for follow-up.

A total of 434 samples were also tested for arsenic, cadmium, lead and mercury. Lead was the most commonly detected metal and was associated with the highest observed levels. Cadmium was detected in the least number of samples, but mercury was associated with the lowest levels detected.

In general when comparing the targeted survey results to the NCRMP results for all metals, the FSAP results were similar to or lower than the NCRMP results for similar commodities.

Health Canada determined that the levels of detected arsenic, cadmium, mercury and lead in samples of fresh fruit did not pose a human health concern.

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6 Appendix A

Combined list of analytes (304) targeted by the GC-MS multi-residue pesticide methods used by the laboratories in this survey

2-phenylphenol (ortho-phenylphenol)	Cyfluthrin (I,II,III,IV)	Fludioxonil	Pebulate
3-OH Carbofuran	Cyhalothrin-lambda	Flumetralin	Penconazole
Acephate	Cypermethrin	Fluorochloridone	Pendimethalin
Acibenzolar-s-methyl	Cyprazine	Fluorodifen	Pentachloroaniline
Alachlor	Cyproconazole	Flusilazole	Permethrin (Total)
Aldicarb	Cyprodinil	Fluvalinate	Permethrin cis
Aldicarb Sulfone	Cyromazine	Folpet	Permethrin trans
Aldicarb sulfoxide	Dacthal (chlorthal-dimethyl)	Fonofos	Phenthoate
Aldrin	delta-HCH (delta-lindane)	Heptachlor	Phorate
Allidochlor	Deltamethrin	Heptachlor epoxide endo	Phorate sulfone
Ametryn	delta-trans-allethrin	Heptanophos	Phosalone
Aminocarb	Demeton-O	Hexachlorobenzene	Phosmet
Aramite	Demeton-S	Hexaconazole	Phosphamidon
Aspon	Demeton-S-methyl	Hexazinone	Piperonyl butoxide
Atrazine	Des-ethyl Atrazine	Imazalil	Pirimicarb
Azinphos-ethyl	Desmetryn	Iodofenphos	Pirimiphos-ethyl
Azinphos-methyl	Di-allate	Iprobenfos	Pirimiphos-methyl
Azoxystrobin	Dialofos	Iprodione	Prochloraz
Benalaxyl	Diazinon	Iprodione metabolite	Procymidone
Bendiocarb	Diazinon o analogue	Isazophos	**Prodiamine**
Benfluralin	Dichlobenil	Isofenphos	Profenofos
Benodanil	Dichlofluanid	**Isoprocarb**	Profluralin
Benzoylprop-ethyl	Dichloran	Isopropalin	Promecarb
BHC Alpha	Dichlormid	Isoprothiolane	Prometon
BHC beta	Dichlorvos	Kresoxim-methyl	Prometryne
Bifenox	Diclobutrazole	Leptophos	Pronamide
Bifenthrin	Diclofenthion	Lindane (gamma-BHC)	Propachlor
Biphenyl	Diclofop-methyl	Linuron	Propanil
Bromacil	Dicofol	Malaoxon	Propargite
Bromophos	Dicrotophos	Malathion	Propazine
Bromophos-ethyl	Dieldrin	Mecarbam	Propetamphos
Bromopropylate	Diethatyl-ethyl	Metalaxyl	Propham
Bufencarb	Dimethachlor	Metazachlor	Propiconazole
Bupirimate	Dimethoate	Methamidophos	Propoxur
Buprofezin	Dinitramine	Methidathion	Propyzamide
Butachlor	**Dioxacarb**	**Methiocarb**	Prothiophos
Butralin	Dioxathion	**Methiocarb sulfoxide**	Pyracarbolid
Butylate	Diphenamid	**Methomyl**	Pyrazophos
Captafol	Diphenylamine	Methoprotryne	Pyridaben
Captan	Disulfoton	Methoxychlor	Quinalphos
Captan metabolite	Disulfoton sulfone	Methyl - trithion	Quinomethionate
Carbaryl	Edifenphos	Methyl Pentachlorophenyl sulphide	Quintozene

Carbetamide	Endosulfan alpha	Metobromuron	**Schradan**
Carbofenthion	Endosulfan beta	Metolachlor	Secbumeton
Carbofuran	Endosulfan sulfate	Metribuzin	Simazine
Carbosulfan	Endrin	Mevinphos-cis	Simetryn
Carboxin	EPN	Mevinphos-trans	Sulfallate
Chlorbenside	EPTC	Mexacarbate	Sulfotep
Chlorbenzilate	Erbon	Mirex	Sulprophos
Chlorbromuron	Esfenvalerate	Monocrotophos	TCMTB
Chlorbufam	Etaconazole	Monolinuron	Tebuconazole
Chlordane cis	Ethalfluralin	Myclobutanil	Tecnazene
Chlordane trans	Ethion	Naled	Terbacil
Chlordimeform	Ethofumsate	Nitralin	Terbufos
Chlorfenson	Ethoprophos	Nitrapyrin	Terbumeton
Chlorfenvinphos (e+z)	Ethylan	Nitrofen	Terbutryne
Chlorflurenol-methyl	Etridiazole	Nitrothal-isopropyl	Terbutylazine
Chloridazon	Etrimfos	Norflurazon	Tetrachlorvinphos
Chlormephos	Fenamiphos	Nuarimol	Tetradifon
Chloroneb	Fenamiphos sulfone	o,p'-DDD (o,p'-TDE)	Tetraiodoethylene
Chloropropylate	Fenamiphos sulfoxide	o,p'-DDE	Tetramethrin
Chlorothalonil	Fenarimol	o,p'-DDT	Tetrasul
Chlorpropham	Fenbuconazole	Octhilinone	Thiobencarb
Chlorpyrifos	Fenchlorophos (Ronnel)	Omethoate	Tolclofos-methyl
Chlorpyriphos-methyl	Fenfuram	Oxadiazon	Tolyfluanid
Chlorthiamid	Fenitrothion	Oxadixyl	Triadimefon
Chlorthion	Fenpropathrin	**Oxamyl**	Triadimenol
Chlorthiophos	**Fenpropimorph**	Oxycarboxin	Tri-allate
Chlozolinate	Fenson	Oxychlordane	Triazophos
Clomazone	Fensulfothion	Oxyflurofen	Tribufos
Coumaphos	Fenthion	p,p'-DDD (p,p'-TDE)	Tricyclazole
Crotoxyphos	Fenvalerate	p,p'-DDE	Trifloxystrobin
Crufomate	Flamprop-isopropyl	p,p'-DDT	Triflumizole
Cyanazine	Flamprop-methyl	Paraoxon	Trifluralin
Cyanophos	Fluchloralin	Parathion	Vernolate
Cycloate	Flucythrinate	Parathion-methyl	Vinclozolin

Note: Pesticides highlighted in bold are detected in both the GC-MS and LC-MS analytical methods.

7 Appendix B

Table B1. Combined list of analytes (154) targeted in the LC-MS multi-residue pesticide methods used by the laboratories in this survey

3-hydroxy Carbofuran	Diniconazole	**Linuron**	Pyrifenox
Acetochlor	**Dioxacarb**	Mepanipyrim	Pyrimethanil
Aclonifen	Dipropetryn	Mephosfolan	Pyriproxyfen
Aldicarb	Diuron	Methabenzthiazuron	Quinoxyfen
Aldicarb Sulfone	Dodemorph	**Methidathion**	Quizalofop
Aldicarb sulfoxide	Emamectin	**Methiocarb**	Quizalofop-ethyl
Azaconazole	Epoxiconazole	Methiocarb sulfone	**Schradan**
Benomyl	Ethiofencarb	**Methiocarb sulfoxide**	Spinosad A
Benoxacor	Ethiofencarb sulfone	**Methomyl**	Spinosad D
Bitertanol	Ethiofencarb sulfoxide	Methoxyfenozide	Spirodiclofen
Bromuconazole	Ethirimol	Metolcarb	Spiromesifen
Butafenacil	Ethoprop	Metoxuron	Spiroxamine
Butocarboxim sulfoxide	Etofenprox	**Mexacarbate**	Sulfentrazone
Cadusafos	Etoxazole	Molinate	Tebufenozide
Carbaryl	Fenamidone	**Monocrotophos**	Tebufenpyrad
Carbendazim	Fenazaquin	Napropamide	Tebupirimfos
Carbofuran	Fenhexamid	Naptalam	Tepraloxydim
Carbosulfan	Fenoxanil	Neburon	Tetraconazole
Carfentrazone-ethyl	Fenpropidine	Ofurace	Thiabendazole
Chlorbromuron	**Fenpropimorph**	**Oxadixyl**	Thiacloprid
Chloridazon	Fenpyroximate	**Oxamyl**	Thiamethoxam
Chlorimuron-ethyl	Fentrazamide	Oxamyl oxime	Thiazopyr
Chloroxuron	Fluazifop-butyl	**Oxycarboxin**	Thiodicarb
Chlorthiamid	Flucarbazone-sodium	Paclobutrazol	Thiofanox
Chlortoluron	Flutolanil	Pencycuron	Thiofanox sulfone
Clodinafop-propargyl	Flutriafol	Penoxsulam	Thiofanox sulfoxide
Cloquintocet-mexyl	Forchlorfenuron	Picolinafen	Thiophanate methyl
Clothianidin	Formetanate	Picoxystrobin	**Tolyfluanid**
Cyanofenphos	Fosthiazate	Piperophos	Tralkoxydim
Cycloxydim	Fuberidazole	Pretilachlor	Trichlorfon
Cycluron	Furathiocarb	Primisulfuron-methyl	**Tricyclazole**
Demeton-s-methyl sulfone	Haloxyfop	**Prodiamine**	Trietazine
Demeton-s-methyl sulfoxide	Imazamethabenz-methyl	**Propoxur**	Trifloxysulfuron
Desmedipham	Imidacloprid	Pymetrozine	Triforine
Diclocymet	Indoxacarb	Pyraclostrobin	Trimethacarb
Diethofencarb	Iprovalicarb	Pyraflufen-ethyl	Zinophos
Difenoconazole	Isocarbamide	Pyridalyl	Zoxamide
Dimethametryn	**Isoprocarb**	Pyridaphenthion	
Dimethomorph	Isoxathion	Pyridate	

Note: Pesticides highlighted in bold are included in both the GC-MS and LC-MS methods.

Table B2. List of analytes (146) targeted by the LC-MS pesticide multi-residue method used by the CFIA Calgary laboratory in the 2009-10 FSAP survey

Acetochlor	Epoxiconazole	Molinate	Thiamethoxam
Aclonifen	Ethiofencarb	Napropamide	Thiazopyr
Aldicarb	Ethiofencarb sulfone	Naptalam	Thiodicarb
Aldicarb sulfone	Ethiofencarb sulfoxide	Neburon	Thiofanox
Aldicarb sulfoxide	Ethirimol	Ofurace	Thiofanox sulfone
Azaconazole	Ethoprop	**Oxamyl**	Thiofanox sulfoxide
Benomyl[b]	Etofenprox	Oxamyl-oxime	Thiophanate-methyl[b]
Benoxacor	Etoxazole	Paclobutrazol	Tralkoxydim
Bitertanol	Fenamidone	Pencycuron	Trichlorfon
Bromuconazole	Fenazaquin	Penoxsulam	Trietazine
Butafenacil	Fenhexamid	Picolinafen	Trifloxysulfuron
Butocarboxim	Fenoxanil	Picoxystrobin	Triforine
Carbaryl	Fenpropidine	Piperophos	Trimethacarb
Carbendazim	**Fenpropimorph**	Pretilachlor	Zinophos
Carbendazim d_3	Fenpyroximate	Primisulfuron-methyl	Zoxamide
Carbendazim d_4	Fentrazamide	**Prodiamine**	
Carbofuran	Fluazifop-butyl	Propoxur	
Carbofuran d_3	Flucarbazone-sodium[a]	Pymetrozine	
Carbosulfan[c]	Flutolanil	Pyraclostrobin	
Carfentrazone-ethyl	Flutriafol	Pyraflufen-ethyl	
Cadusafos	Forchlorfenuron	Pyridalyl	
Chlorimuron ethyl	Formetanate[a]	Pyridaphenthion	
Chloroxuron	Fosthiazate	Pyridate	
Chlortoluron	Fuberidazole	Pyrifenox	
Clodinafop-propargyl	Furathiocarb	Pyrimethanil	
Cloquintocet-mexyl	Haloxyfop	Pyriproxyfen	
Clothianidin	3-Hydroxycarbofuran	Quinoxyfen	
Cyanofenphos	Imazamethabenz-methyl	Quizalofop	
Cycloxydim	Imidacloprid	Quizalofop ethyl[f]	
Cycluron	Indoxacarb	**Schradan**	
Demeton-s-methyl sulfone	Iprovalicarb	Spinosad A[d]	
Demeton-s-methyl sulfoxide	Isocarbamide	Spinosad B[d]	
Desmedipham	**Isoprocarb**	Spirodiclofen	
Diclocymet[a]	Isoxathion	Spiromesifen	
Diethofencarb	Mepanipyrim	Spiroxamine[e]	
Difenoconazole	Mephosfolan	Sulfentrazone	
Dimethametryn	Methabenzthiazuron	Tebufenozide	
Dimethomorph	**Methiocarb**	Tebufenpyrad	
Diniconazole	Methiocarb sulfone	Tebupirimfos	
Dioxacarb	**Methiocarb sulfoxide**	Tepraloxydim	
Dipropetryn	**Methomyl**	Tetraconazole	
Diuron	Methoxyfenozide	Thiabendazole	
Dodemorph	Metolcarb	Thiabendazole	
Emamectin	Metoxuron	Thiacloprid	

Note: Pesticides highlighted in bold are detected in both the GC-MS and LC-MS analytical methods.

8 Appendix C

List of Metals, LODs and LOQs in the Multi-Residue Metals Analysis

Metal	Laboratory A		Laboratory B		Laboratory C	
	LOD (ppm)	LOQ (ppm)	LOD (ppm)	LOQ (ppm)	LOD (ppm)	LOQ (ppm)
Aluminum	0.1	0.1	0.09	0.3	0.02	0.02
Antimony	0.02	0.02	0.003	0.01	0.002	0.002
Arsenic	0.0005	0.0005	0.004	0.01	0.003	0.003
Boron	0.05	0.05	0.001	0.005	0.04	0.04
Beryllium	0.02	0.02	0.02	0.07	0.006	0.006
Cadmium	0.002	0.002	0.002	0.007	0.001	0.001
Chromium	0.01	0.01	0.02	0.08	0.001	0.001
Cobalt			0.001	0.004		
Copper	0.03	0.03	0.02	0.07	0.008	0.008
Iron	0.3	0.3	0.3	1.0	0.01	0.01
Lead	0.002	0.002	0.001	0.004	0.001	0.001
Magnesium	0.05	0.05	0.02	0.08	0.01	0.01
Manganese	0.02	0.02	0.02	0.06	0.003	0.003
Mercury	0.0001	0.002	0.0015	0.005	0.0004	0.0004
Molybdenum	0.02	0.02	0.002	0.008	0.002	0.002
Nickel	0.01	0.01	0.005	0.02	0.003	0.003
Selenium	0.02	0.02	0.003	0.01	0.01	0.01
Tin	0.02	0.02	0.1	0.5	0.004	0.004
Titanium	0.05	0.05	0.008	0.03	0.02	0.02
Zinc	0.1	0.1	0.09	0.3	0.006	0.006

9 Appendix D

Summary of pesticide residue violations found in the 2011-2012 Intra-Provincially Traded Fresh Fruit Survey

Sample Type	Province	Pesticide Residue	Detected Amount (ppm)
Blackberry	Nova Scotia	Captan	0.14
Blackberry	Quebec	Captan	0.3234
Blackberry*	British Columbia	Captan	0.706
		Cypermethrin	0.311
Blackberry*	British Columbia	Captan	0.691
		Cypermethrin	0.221
Blackberry*	British Columbia	Captan	0.742
		Cypermethrin	0.324
Blackberry	British Columbia	Captan	0.804
Blackberry	British Columbia	Captan	2.515
Blackberry	British Columbia	Captan	0.436
Blackberry	British Columbia	Captan	2.635
Blackberry	British Columbia	Captan	1.281
Blackberry	British Columbia	Captan	1.080
Blackberry	British Columbia	Captan	0.767
Blackberry	British Columbia	Captan	0.444
Blackberry	British Columbia	Captan	1.439
Blackberry	British Columbia	Captan	4.123

* This sample contained two violative residues. All other violative samples were associated with a single violative residue.