

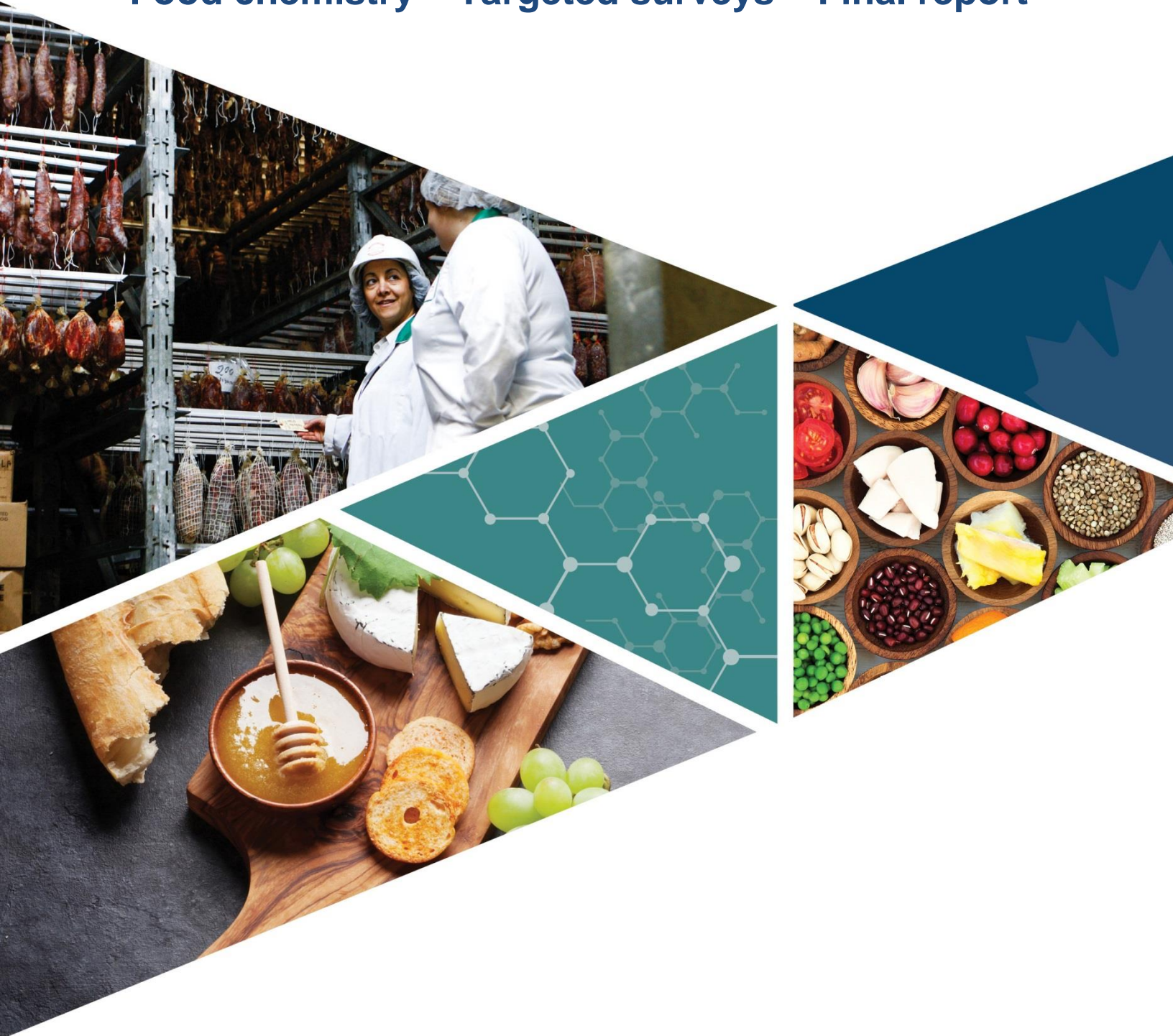


Canadian Food  
Inspection Agency

Agence canadienne  
d'inspection des aliments

# Polycyclic Aromatic Hydrocarbons in Selected Foods – April 1, 2019 to March 31, 2020

## Food chemistry – Targeted surveys – Final report



## 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.

Polycyclic aromatic hydrocarbons (PAHs) are products of the incomplete combustion of materials such as coal, oil, gas, wood and charbroiled meat. They are a common airborne pollutant and often contaminate crops. PAHs can also form in food during thermal processing. This survey analyses the 4 most toxic PAHs, including: benzo[a]pyrene, which has been classified as "carcinogenic to humans" by the International Agency for Research on Cancer (IARC), as well as benzo[a]anthracene, benzo[b]fluoranthene and chrysene, which have been classified as "possibly carcinogenic to humans" by the IARC<sup>1,2</sup>.

This targeted survey generated baseline surveillance data on the occurrence of PAHs in domestic and imported products on the Canadian market. The CFIA sampled and analyzed 296 products, including 34 infant formula, 114 nuts/nut butters and 148 olive oil samples. PAHs were detected in 61% of samples tested, with total PAH levels ranging from 0.001 parts per billion (ppb) to 3.25 ppb TEQ (Toxic Equivalency). Olive oils had the highest PAH levels and detection rate. Comparison of the data from this survey to that in the previous targeted surveys showed that the levels of PAHs in Canadian retail products are comparable to those previously reported.

In 4 pomace oil samples tested, the levels of PAH were below the Maximum Limit (ML) established by Health Canada. All levels of PAH found in the products tested in this survey were evaluated by Health Canada and deemed safe for consumption by Canadians; no product recalls were required.

## What are targeted surveys

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 did we conduct this survey

Polycyclic aromatic hydrocarbons (PAHs) are natural and unintentional by-products of the incomplete combustion of materials such as coal, oil, gas, wood and charbroiled meat<sup>1</sup>. As such, they can form in food during high-temperature processing and contaminate food through industrial air pollution.

PAHs include a wide range of chemicals with varying levels of carcinogenicity as classified by the IARC; this survey analyses the levels of the 4 most toxic PAHs. These 4 PAHs include the following: benzo[a]pyrene, which has been classified as “carcinogenic to humans” by the IARC, as well as benzo[a]anthracene, benzo[b]fluoranthene and chrysene, which have been classified as “possibly carcinogenic to humans” by the IARC<sup>1</sup>.

Maximum Residue Limits (MRLs) for PAHs levels have not yet been established by HC, although the European Food Safety Authority (EFSA) has established a MRL of 2 ppb in edible oils<sup>2</sup>. This survey was initiated in consultation with HC to establish further baseline surveillance data to complement and expand upon the data previously collected.

## What did we sample

A variety of domestic and imported products including infant formula, nuts/nut butters and olive oils were sampled between April 1, 2019 and March 31, 2020. Samples were collected from local/regional retail locations located in 11 major cities across Canada. These cities encompassed 4 Canadian geographical areas:

- Atlantic (Halifax, Moncton)

- Quebec (Montreal, Quebec City)
- Ontario (Toronto, 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 the 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 <sup>a</sup> origin	Total number of samples
Infant formula	0	31	3	34
Nuts/Nut butters	40	46	28	114
Olive oil	1	133	14	148
<b>Total</b>	<b>41</b>	<b>210</b>	<b>45</b>	<b>296</b>

<sup>a</sup> Unspecified refers to those samples for which the country of origin could not be assigned from the product label or available sample information

## How were samples analyzed and assessed

Samples were analyzed by ISO/IEC 17025 accredited food testing laboratories under contract with the Government of Canada. The samples were tested as sold, which means the product was tested as is and not prepared according to package instructions.

The list of compounds reported as part of this survey are shown in Table A-1 in the Appendix A of this report. The concentration of each PAH detected in a sample was multiplied by its respective Toxic Equivalency Factor (TEF) proposed by Nisbut and LaGoy<sup>3</sup>. Refer to Table A-1 in the Appendix A for the TEFs used in this survey. The calculated toxic equivalency (TEQ) concentrations of the individual compounds were added together to arrive at a total PAH level expressed as ‘parts per billion TEQ’, which is an estimate of the total relative toxic potency of all the PAHs detected in the sample. Table A-2 lists other PAH compounds monitored but not reported on in this survey.

Health Canada has established an ML of 3 ppb TEQ for PAHs level in olive-pomace oils (a unique type of oil, distinct from other olive oils such as virgin olive oil)<sup>4</sup>.

In the absence of established tolerances or standards for PAHs in foods, elevated levels of in specific foods may be assessed by Health Canada on a case-by-case basis using the most current scientific data available.

## What were the survey results

Of 296 products sampled in this survey, 61% (181) contained measurable levels of PAHs. Table 2 shows the range of PAH levels reported in the product types included in this survey.

**Table 2. Summary of targeted survey results on PAHs in selected products**

<b>Product type</b>	<b>Number of samples</b>	<b>Number of samples (%) with detected levels</b>	<b>Minimum PAH levels (ppb TEQ)</b>	<b>Maximum PAH levels (ppb TEQ)</b>	<b>Average PAH levels<sup>b</sup> (ppb TEQ)</b>
Infant formula	34	16 (47)	0.001	0.776	0.12
Nuts/Nut butters	114	44 (39)	0.001	2.93	0.17
Olive oil	148	121 (82)	0.002	3.25	0.24
<b>Total</b>	<b>296</b>	<b>181 (61)</b>	<b>0.001</b>	<b>3.25</b>	<b>0.21</b>

<sup>b</sup> Only positive results were used to calculate the average PAH levels

### **Infant formula**

Infant formula samples had the lowest average PAH levels. This category included milk-based and soy-based infant formulas. Although, the overall detection rate reported is 47%, soy-based formula samples did not have detectable levels of PAHs. PAHs were detected in 70% (16 out of 23 samples) of milk-based infant formula samples, with total PAH levels ranging from 0.001 ppb to 0.776 ppb TEQ.

### **Nuts/Nut butters**

Nuts/nut butters had the lowest detection rate (39%) of all product types included in this survey. Significant differences between individual nut/nut butter types were not observed. An individual sample of pumpkin seed butter contained higher-than-average PAH level (2.93 ppb TEQ). All the remaining products reported a total PAH level of less than 0.773 ppb TEQ.

### **Olive oil**

Olive oil samples had the lowest average PAH level and the highest detection rate (82%) of all product types included in this survey. Only 3 samples had elevated PAH levels. All the remaining olive oil samples had a total PAH level of less than 0.700 ppb TEQ. The selection of samples included 4 pomace oil samples with an average PAH level of 0.19 ppb TEQ and a maximum of 0.569 ppb TEQ.

## **What do the survey results mean**

Table 3 compares the data from this survey with that in the previous targeted surveys<sup>5,6</sup>. In general, the levels of PAHs found in this survey were comparable to, or lower than previously reported. Some of the differences observed are due to sample size and specific type of products tested.

PAHs were detected in fewer infant formula samples in this survey compared to the previous surveys years. As well, in this survey, soy-based formula samples did not have detectable levels of the 4 most toxic PAHs, while PAHs were found in at least half of the soy based formula

samples collected in previous survey years (58 to 86%). Although the reported detection rates for nuts/nut butters category differ between the survey years, they are comparable when sample size and product type is considered. A relatively small number of olive oil samples were collected in previous years, which may have contributed to different detection rates, however the PAH levels found in olive oil samples in this survey were within similar ranges.

Multiple sources of PAHs may exist. The raw ingredients may have been contaminated by environmental sources, however, processing temperature and technique may also contribute towards the presence of PAHs in these products<sup>7,8,9</sup>. For nuts and oils, PAH contamination has been linked to seed drying processes (air drying, smoke drying, seed roasting, and so on). In oils, these levels may be further increased during the oil production process, for example, refining of seed extracts. For this reason, fats and oils are usually reported to be one of the most contaminated matrices and they are considered to be the main contributors of daily intake of PAHs by ingestion<sup>7,8,9</sup>. Since vegetable oils have been reported to contain PAH contamination to varying degrees, it is not unexpected for fat-enriched foods, such as infant formula, to contain low levels of PAH. In addition to manufacturing conditions, environmental contamination is an important factor affecting PAHs content of milk powders<sup>10</sup>.

**Table 3. Minimum, maximum and average concentration of PAHs in selected products across various studies**

Product type	Survey year	Number of samples	Number of samples (%) with detected levels	Minimum PAH levels <sup>d</sup> (ppb TEQ)	Maximum PAH levels <sup>d</sup> (ppb TEQ)	Average PAH levels <sup>c,d</sup> (ppb TEQ)
Infant formula	2019	34	16 (47)	0.001	0.776	0.12
Infant formula	2016	105	65 (62)	0.001	32.26	0.61
Infant formula	2014	40	36 (90)	0.002	0.553	0.11
Nuts/Nut butters	2019	114	44 (39)	0.001	2.93	0.17
Nuts/Nut butters	2016	395	150 (38)	0.002	8.17	0.24
Nuts/Nut butters <sup>e</sup>	2014	12	12 (100)	0.002	0.103	0.031
Olive oil	2019	148	121 (82)	0.002	3.25	0.23
Olive oil	2018	9	9 (100)	0.004	0.377	0.063
Olive oil	2015	15	6 (40)	0.71	2.49	1.28

<sup>c</sup> Only positive results were used to calculate the average PAHs levels

<sup>d</sup> TEQs were calculated using the 4 most toxic PAHs and their respective TEFs

<sup>e</sup> Smaller product selection; butters and hazelnuts only

In 4 of the pomace oil samples tested, the levels of PAH were 100% compliant with the ML established by Health Canada. There are no regulations in Canada for the other products sampled in this survey. All levels of PAH found in the products tested were deemed safe for consumption by Canadians and no product recalls were required. Future PAH surveys will look to broaden the CFIA's baseline knowledge on the levels present in smoked and roasted products.

## References

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8. Paris, A., Ledauphin, J., Poinot, P., Gaillard, J.-L. (2018). [Polycyclic aromatic hydrocarbons in fruits and vegetables: Origin, analysis, and occurrence.](#) Environmental Pollution, 234, pp. 96-106.
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# Appendix A

**Table A-1. Toxic Equivalency Factors used in this survey**

<b>Polycyclic Aromatic Hydrocarbon</b>	<b>Toxic Equivalency Factor</b>
Benzo[a]anthracene	0.1
Benzo[b]fluoranthene	0.1
Benzo[a]pyrene	1
Chrysene	0.01

**Table A-2. Other<sup>†</sup> PAHs compound tested by the accredited laboratory**

<b>Polycyclic Aromatic Hydrocarbon</b>
Acenaphthene
Acenaphthylene
Anthracene
Benzo[g,h,i]perylene
Benzo[k]fluoranthene
Dibenzo(a,h)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
Naphthalene
Phenanthrene
Pyrene

<sup>†</sup>Other than those reported in this survey and listed in Table A-1