Survey report on heavy metals in Ayurvedic medicines available in New Zealand

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ABBREVIATIONS

AvM	Ayurvedic medicine
BLL	Blood lead level
ESR	Institute of Environmental Science and Research Limited
HM	Heavy metal
ICP-MS	Inductively coupled plasma mass spectrometry
USP	United States Pharmacopeia
WHO	World Health Organization

EXECUTIVE SUMMARY

A significant increase in elevated blood lead levels from people exposed to Ayurvedic medicine containing high levels of lead and other heavy metals has been observed in New Zealand, beginning at the end of 2023. In response, it was decided to investigate contents of off the shelve Ayurvedic medicines available in New Zealand. Ayurvedic medicines are a subgroup of herbal medicines originating from the Indian subcontinent, where they are viewed as a legitimate alternative to conventional medicines. A survey funded by Health New Zealand was conducted to determine the prevalence and concentrations of detectable arsenic, cadmium, lead and mercury in ayurvedic medicines. Samples (n=75) were purchased from Indian ethnic retail stores in Auckland and Christchurch and online stores based in New Zealand.

Samples were analysed by inductively coupled plasma mass spectrometry, and 17 of the samples were also analysed as blind duplicates as a quality control measure. The results of the analyses were compared to the permissible limits of the heavy metals (arsenic, cadmium, lead and mercury) in herbal medicines recommended by the World Health Organization and the United States Pharmacopeia. There are no permissible limits for antimony, bismuth, copper, silver or tin in herbal medicines.

Fifty-eight (77%) samples were found to have detectable levels of at least one of arsenic, cadmium, lead, and mercury.

Arsenic was detected in 26 samples (35%), with only one sample containing arsenic at a concentration that exceeded the permissible limit (0.5 mg/kg) recommended by United States Pharmacopeia. The concentration of arsenic in this sample was 9800 mg/kg. With the exception of this one very high result, arsenic concentrations in Ayurvedic medicines in this survey were generally lower than in studies carried out in other countries

Cadmium was detected in 33 samples (44%) at concentrations ranging from 0.004 to 0.74 mg/kg. However, only two samples exceeded the permissible limit (0.3 mg/kg) recommended by the World Health Organization. The results of this survey largely align with those of the limited studies in other countries.

Lead was detected in 50 samples (67%) at concentrations ranging from 0.02 to 2.40 mg/kg, with none of the samples containing concentrations that exceeded the permissible limit recommended by the World Health Organization (10 mg/kg) and the United States Pharmacopeia (5 mg/kg). The lead concentrations found in this survey were generally lower than have been found in studies on Ayurvedic medicines conducted in other countries.

Mercury was detected in 17 AvM samples (23%) at concentrations ranging from 0.02 to 166 mg/kg, with 10 samples exceeding the permissible limit recommended by World Health Organization permissible limit (1 mg/kg). Eight of these 10 Ayurvedic medicines were manufactured by the same company. The results of this survey suggest that mercury levels in Ayurvedic medicines are lower than have been found in studies carried out in other countries.

As a result of this survey, regulatory action was undertaken by the appropriate government agencies with cooperation from the importer. Action was taken to remove from the NZ market products tested that exceeded the permissible limits and posed a health risk.

1. INTRODUCTION

Ayurvedic medicines (AvMs) are a subgroup of herbal medicines originating from the Indian subcontinent. Herbal medicines are viewed as a legitimate alternative to conventional medicines. Under the Medicines Act 1981, a herbal remedy is defined as:

> *a medicine (not being or containing a prescription medicine, or a restricted medicine, or a pharmacy-only medicine) consisting of-*
>
> *(a) any substance produced by subjecting a plant to drying, crushing, or any other similar process; or*
>
> *(b) a mixture comprising 2 or more such substances only; or*
>
> *(c) a mixture comprising 1 or more such substances with water or ethyl alcohol or any inert substance*
>
> (Medicines Act 1981, section 2)

Herbal remedies, including AvMs, are exempt from the requirements of the Medicines Act 1981 provided a therapeutic purpose is not intended or claimed for them through either advertising or labelling and provided they do not contain a substance classified as a medicine under the medicines legislation. AvMs are readily available as over-the-counter products as no prescription is required. There are no quality standards for herbal preparations/remedies in New Zealand as they do not need pre-market approval and are sold with minimal regulatory oversight.

Some AvMs have been found to contain high levels of heavy metals (HMs), which can present health risks to consumers (Hardin *et al.*, 2023; Liu *et al.*, 2019; Medsafe, 2024; Saper *et al.*, 2004; Saper *et al.*, 2008). In New Zealand, lead is the only heavy metal (HM) specifically included in the 'List of diseases notifiable by health practitioners and laboratories to the Medical Officer of Health', with lead absorption levels equal to or in excess of 5 µg/dL being notifiable (TeWhatuOra, 2024). Traditional medicines or cosmetics were the fifth most commonly identified non-occupational sources of lead exposure, resulting in 25 notifications from 2014 to 2022. The median blood lead level (BLL) in notified cases from the use of traditional medicines or cosmetics was 1.70 µg/dL (range 0.57–4.38 µg/dL). Since mid-October 2023, the National Public Health Service and the New Zealand National Poisons Centre have noted an increase in lead absorption notifications (n=19) due to the use of AvMs. The median BLL for these 19 cases was 92.00 µg/dL (range 5.40–220 µg/dL). All the AvMs taken by the notified cases were purchased overseas, mainly in India, and when analysed were also shown to contain very high levels of arsenic, lead or mercury (see Appendix A, Table A1). This raised concerns regarding the quality and safety of AvMs available in the New Zealand market.

1.1 PURPOSE AND SCOPE OF THE CURRENT SURVEY

The purpose of this survey was to determine the prevalence of detectable concentrations of arsenic, cadmium, lead and mercury in AvMs purchased from Indian ethnic retail stores in Auckland and Christchurch and online stores based in New Zealand. All AvM samples were also analysed for antimony, bismuth, copper, silver and tin as an information-gathering exercise.

Products that were considered in scope for this survey were:

- labelled as Ayurvedic medicines/remedies or herbal food supplements manufactured in India
- available over the counter, without a prescription
- intended to be used by adults only
- intended for oral use, such as tablets, powders, capsules, syrups or dried herbs.

Products that were considered out of scope for this survey included:

- herbal dietary supplements from chemist stores (Bargain Chemist, Chemist Warehouse) and supermarkets (Woolworths, Foodstuffs) that were not manufactured in India
- prescription medicines
- cosmetic products
- products intended for use by children, such as massage oils, shampoos and creams
- products imported from countries other than India
- products intended for dermal, ocular or auricular use
- products labelled as other types of alternative medicine, such as Unani, homeopathic, Chinese or Oriental medicine.

The results were compared to the permissible limits of HMs in herbal medicines recommended by the World Health Organization (WHO) and the United States Pharmacopeia (USP) (Inada *et al.*, 2023; WHO, 2007), which are summarised in Table 1. Permissible limits for antimony, bismuth, copper, silver, tin and total HMs in herbal medicines have not been established.

Table 1. Recommended permissible limits (mg/kg) of heavy metals in herbal medicines

Heavy metal	WHO	USP
Arsenic	N/A	0.5
Cadmium	0.30	0.5
Lead	10	5
Mercury	N/A	1 (total mercury)

WHO: World Health Organization, USP: United States Pharmacopeia, N/A: not applicable

2. MATERIALS AND METHODS

2.1 SELECTION OF AYURVEDIC MEDICINES

Before selecting the AvMs for inclusion in this survey, Indian ethnic retail stores were visited in Auckland and Christchurch to gain a sense of the kinds of AvMs that were stocked on the shelves. Simultaneously, an internet search was conducted to determine which AvMs were available through online stores based in New Zealand. This market intelligence was used to draft a scoping document for the survey.

AvMs were selected and sampled based on the recommendations of the scoping document drafted in June 2024. Sampling was limited to AvMs that are consumed orally and only by adults, as outlined in section 1.1. This is further supported by the fact that the recent cases of elevated BLLs in Auckland were mainly due to AvMs that had been consumed orally in capsule, tablet or powdered dosage forms.

2.2 NUMBER OF SAMPLES

AvM samples were collected from Indian ethnic retail stores in Auckland and Christchurch and from online stores based in New Zealand. A total of 75 samples were purchased from physical retail stores (*n* = 49) and online stores (*n* = 26). This was lower than the target number proposed in the sampling plan (*n* = 120) due to the limited availability of AvMs at the time of sampling. A second round of sampling was done to purchase products of different batch number to test the inter-variability in testing. Products of the same batch number were still available on the shelves and only three AvM products of different batch number were available and purchased from Christchurch supermarket. An overview of the sample breakdown is presented in Figure 1.

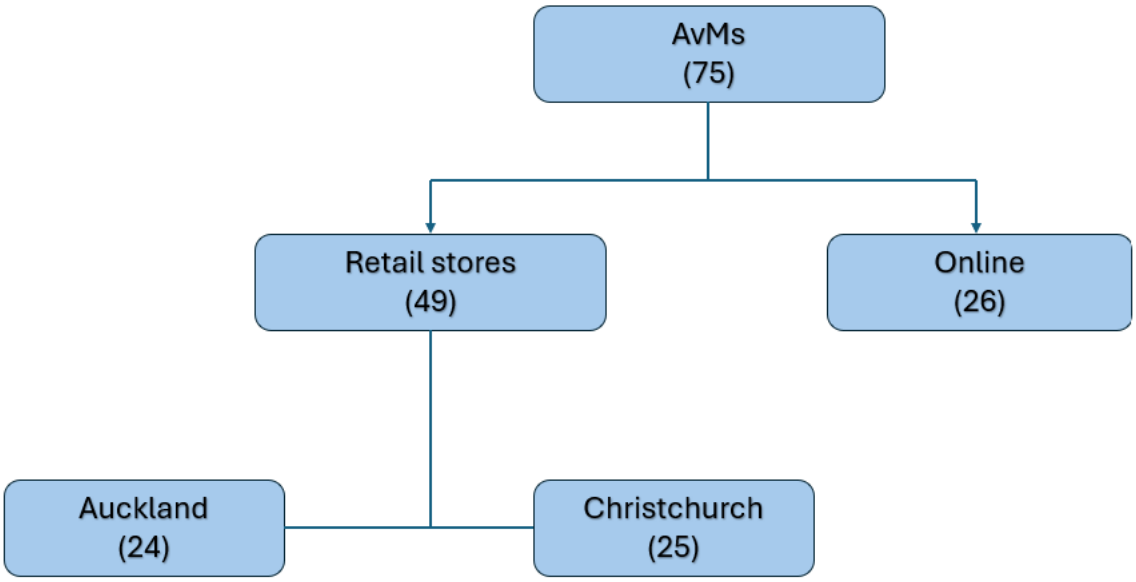

Figure 1. Breakdown of places where Ayurvedic medicine (AvM) samples were obtained from

2.3 SAMPLE PREPARATION

All the AvM samples were stored at room temperature in the Institute of Environmental Science and Research Limited's (ESR's) Food Chemistry Laboratory until preparation.

Tablets (approx. 10-15/sample) were pulverised using a mortar and pestle. To avoid cross-contamination, the mortar and pestle was washed with water and ethanol and air dried between samples. For capsules, the cap and body were separated and the contents were removed. For syrups, powders, resins and the contents of capsules, no further preparation was carried out.

Approximately 5 g of each AvM sample was transferred to an airtight and leak-proof 10 mL sample container. The sample containers were then shipped to the testing laboratory by courier.

0.5-0.55 g of material received by the testing laboratory was weighed into a polypropylene tube. To this, following reagents were added: 2.0 mL of deionised water, 2.5 mL of concentrated nitric acid, and 0.5 mL of concentrated hydrochloric acid. The tube was capped loosely, placed on a hot block preheated to 105 °C, and digested for 1 hour. After 1 hour, the tube was removed and allowed to cool for 15 minutes. The acidic digestate is topped up to 50 mL with deionised water, capped and mixed well by inverting several times to produce the completed digested solution.

As a precaution, the digested solution was filtered through a 1 µm filter to remove any insoluble material that might block the instrument

The filtered digest solution was then diluted further (10-fold) with 5% nitric/1% hydrochloric acid blank solution to reduce any high levels present and impact on the ICP-MS system.

2.4 TESTING

All samples were analysed for antimony, arsenic, bismuth, cadmium, copper, lead, mercury, silver and tin by Hill Labs, Hamilton, using inductively coupled plasma mass spectrometry (ICP-MS). Initial testing of some samples showed that certain elements were present at very high concentrations. Therefore, all the samples were subsequently diluted 10-fold for further analyses, which increased the detection limits 10-fold.

The detection limits for the HMs are summarised in Table 2.

Table 2. Detection limits for the heavy metals analysed in this survey

Heavy metal	Detection limit (mg/kg)
Antimony	0.10–1.0
Arsenic	0.01–1.0
Bismuth	0.01–0.01
Cadmium	0.004–0.04
Copper	0.05–0.50
Lead	0.02–0.20
Mercury	0.002–0.010
Silver	0.01–0.10
Tin	0.10–1.0

2.5 QUALITY CONTROL

All the samples were received at ESR in the original packaging. None of the samples or their packaging was tampered or damaged. The sub-samples were shipped to the testing laboratory directly by courier. The testing laboratory acknowledged the receipt of confirmation after receiving the samples. Seventeen samples were tested as blind duplicates to check the precision of the analyses.

3. RESULTS

3.1 ANALYTICAL TESTING

The concentration range of HMs in AvMs and number of samples containing HMs above the permissible limits by the WHO and USP are presented in Table 3 . Full analytical results are provided in Appendix A, Table A2.

Table 3. Concentration range (mg/kg) of heavy metals in the 75 Ayurvedic medicine samples and the numbers of samples above the permissible limits recommended by WHO and USP

Heavy metal	Number of samples at or above LOD	Range (lowest–highest)	Number of samples above permissible limits by WHO	Number of samples above permissible limits by USP
Antimony	2	0.11–26.0	NA	NA
Arsenic	26	0.12–9,800	NA	1
Bismuth	3	0.013–0.11	NA	NA
Cadmium	33	0.004–0.74	2	2
Copper	70	0.013–5200	NA	NA
Lead	50	0.02–2.40	0	0
Mercury	17	0.02–166	NA	10
Silver	15	0.014–675	NA	NA
Tin	12	0.12–1.10	NA	NA

LOD: limit of detection, WHO: World health Organization, USP: United Stated Pharmacopoeia, NA: not applicable

Of these 75 AvMs, 58 (77%) samples were found to contain at least one of arsenic, cadmium, lead and mercury at concentrations above the limit of detection.

Arsenic was detected in 26 AvM samples (35%), and one sample exceeded the permissible limit recommended by USP (0.5 mg/kg), having a concentration of 9,800 mg/kg. However, the arsenic concentrations detected in the AvMs included in this survey were generally lower than have been detected in AvMs investigated in studies carried out in other countries. Very high concentrations of arsenic have previously been detected in herbo-metallic AvMs (up to 480,000 mg/kg) and bhasmas (61,000 mg/kg) (Abollino *et al.*, 2018; Bhalla and Pannu, 2022). However, the AvM sample in which arsenic was detected at 9,800 mg/kg did not belong to either of these product types. (Saper *et al.*, 2004; Saper *et al.*, 2008) Some studies reported arsenic levels up to 8,100 mg/kg in one sample, which is similar to the high result detected in the current survey, while all other studies have reported lower levels of arsenic. (Abollino *et al.*, 2018) reported arsenic in concentrations of up to 479,000 mg/kg. Therefore, it appears that high levels of arsenic in AvMs are sporadic. Overseas evidence suggests that high levels of arsenic are more likely in herbo-metallic and bhasma AvMs.

Cadmium was detected in 33 AvM samples (44%), and two samples exceeded the permissible limits recommended by WHO (0.3 mg/kg) USP (0.5 mg/kg), having concentrations of 0.50 and 0.75 mg/kg, respectively. Very few studies have reported the presence of cadmium at detectable levels in AvMs, which largely aligns with the results of this survey (Nath *et al.*, 2020). However, other studies either did not include cadmium as an analyte of interest or was found below the limit of detection in their surveys of AvMs (Abollino *et al.*, 2018; Giacomino *et al.*, 2015).

Lead was detected in 50 AvM samples (67%), but none of these exceeded the permissible limits recommended by the WHO (10 mg/kg) or USP (5 mg/kg). The concentration of lead in

AvMs was in the range 0.02–2.40 mg/kg. In comparison to studies done in other countries, the lead concentrations in AvMs were lower in this survey (Abollino *et al.*, 2018; Giacomino *et al.*, 2015; Saper *et al.*, 2004; Saper *et al.*, 2008).

Mercury was detected in 17 AvM samples (23%), and 10 samples exceeded the permissible limit recommended by WHO (1 mg/kg), eight of which were manufactured by the same company. The concentration of lead in AvMs was in the range 1.17–160 mg/kg. High levels (28-104000 mg/kg) of mercury have been consistently reported in AvMs in other studies (Abollino *et al.*, 2018; Bhalla and Pannu, 2022; Giacomino *et al.*, 2015; Saper *et al.*, 2004; Saper *et al.*, 2008) and, overall, the results of this survey indicate that the mercury levels were lower in AvMs than reported in the studies conducted in other countries.

Three AvM products of different batch numbers were tested to check the inter-variability of results. Analyses results presented in Table 4 show that the levels of heavy metals, especially lead, mercury and silver were different between both the batches of each product. However, none of the samples exceeded the permissible limit for arsenic, cadmium, lead and mercury recommended by the WHO and USP.

Table 4: Concentration of heavy metals in AvM products of two different batch numbers

Sample no.	Antimony	Arsenic	Bismuth	Cadmium	Copper	Lead	Mercury	Silver	Tin
24Ayur-085	< 1.00	< 1.00	< 0.10	<0.04	3.30	< 0.20	1.17	1.03	< 1.00
24Ayur-086	< 1.00	< 1.00	< 0.10	< 0.04	4.50	< 0.20	3.20	< 0.10	< 1.00
24Ayur-083	< 1.00	< 1.00	< 0.10	0.09	25.00	3.20	3.30	0.37	< 1.00
24Ayur-087	< 1.00	< 1.0	< 0.10	0.11	24.00	2.80	12.70	< 0.10	< 1.00
24Ayur-084	< 1.00	< 1.00	< 0.10	< 0.04	3.60	< 0.20	5.60	10.60	< 1.00
24Ayur-091	< 1.00	< 1.00	< 0.10	< 0.04	4.40	2.20	12.00	4.40	3.10

3.2 QUALITY CONTROL

The results of the duplicate analyses of 17 AvMs are presented in Appendix A (Table A3). The results show that the difference between the analysis results were generally in good agreement, with the exception in few cases (undiluted vs 10x dilution) as highlighted in Appendix A (Table A3), indicating that the dilution of samples may have affected the reproducibility of the results.

4. CONCLUSION

In this survey, HMs were detected in most of the AvMs analysed. However, 13 samples (17%) of the 75 samples were found to contain concentrations that exceeded the permissible limits recommended by WHO and USP for mercury (10 AvMs), cadmium (two AvMs) and arsenic (one AvM). None of the AvM samples contained lead concentrations that exceeded the permissible limit, but lead had the highest prevalence rate of all the HMs detected in the AvMs. It should be noted that no permissible limits have been established for antimony, bismuth, copper, silver, tin or total HMs in herbal medicines.

From the results summarised in Appendix A (Table A1) of this report, it is evident that high levels of HMs (particularly lead and mercury) are of concern in AvMs purchased and self-imported by individuals for their personal use. However, such extremely high levels were not found in the AvMs tested in the current survey, with the exception of a single sample containing 9,800 mg/kg of arsenic. Follow-up noted that this product was no longer available in the stores. Relevant information of the products that had high exceedances were given to the appropriate government agency and, in collaboration with the importers, action was taken to remove these from the NZ market.

5. APPENDIX A: ANALYSIS RESULTS

Table A1. Concentrations (mg/kg or ppm) of heavy metals in Ayurvedic medicine samples collected by Health New Zealand from individuals in October 2023 to December 2024

These results have been adapted from a Health New Zealand unpublished report titled 'Elevated blood lead levels from traditional medicine – cluster summary, January 2025'.

Sample no.	Arsenic	Cadmium	Lead	Mercury
PHA24205/1	6.35	NA	6,000	9,130
PHA24111/1	2.91	0.50	32.00	64.20
PHA24111/2	3.71	0.10	210	21.20
PHA24111/3	1.01	0.06	2.00	0.50
PHA24185/1	9.22	0.14	218	13,800
PHA24185/2	2,010	0.28	1.40×10^5	60,600
PHA24185/3	5.00	0.20	110	16,800
PHA24264/1	2.77	NA	66.40	143.0
PHA24258/1	4,740	NA	3,530	13,300
LJB 237 ITIS TABLETS	180.20	NA	7,670	24,200
LJB 242 ITIS OINTMENT	20.3	NA	30,400	15,800
LJB 244 HALBO TABLET	NA	NA	142.00	NA
LJB 245 PAXID TABLET	NA	NA	13.50	NA
JCH115C	120	< LOD	93,500	NA

NA: not analysed, LOD: limit of detection
Results of samples where the heavy metal concentration was < LOD are not included in the table

Table A2. Concentrations (mg/kg or ppm) of heavy metals in the 75 Ayurvedic medicine samples analysed in this survey

Sample no.	Antimony	Arsenic	Bismuth	Cadmium	Copper	Lead	Mercury	Silver	Tin
24Ayur-001[a]	< LOD	0.39	< LOD	0.023	4.35	0.11	3.10[b]	0.07	0.15
24Ayur-002	< LOD	0.51	< LOD	0.14	2.10	0.14	< LOD	< LOD	< LOD
24Ayur-003	< LOD	0.45	< LOD	0.02	13.6	0.28	< LOD	< LOD	< LOD
24Ayur-004	< LOD	0.11	< LOD	0.02	5.80	0.96	< LOD	< LOD	< LOD
24Ayur-005	< LOD	0.10	< LOD	0.01	3.50	0.85	< LOD	< LOD	< LOD
24Ayur-006[a]	< LOD	< LOD	< LOD	0.02	5.55	0.15	0.12	0.63	0.16
24Ayur-007	< LOD	< LOD	< LOD	< LOD	< LOD	0.11	< LOD	< LOD	< LOD
24Ayur-008[a]	< LOD	0.85	0.06	0.11	20.00	2.55	20.85[b]	0.07	0.67
24Ayur-009[a]	25.50	9,800[c]	< LOD	0.15	5,200	1.15	64.0[b]	< LOD	4.15
24Ayur-010	< LOD	6.2	< LOD	0.04	3.00	0.37	< LOD	< LOD	< LOD
24Ayur-011[a]	< LOD	0.73	< LOD	0.038	10.35	0.66	160[b]	0.05	1.11
24Ayur-012[a]	< LOD	2.25	0.01	0.09	14.45	1.70	20.50[b]	0.10	6.0
24Ayur-013[a]	< LOD	0.73	< LOD	0.50[bc]	4.20	1.67	7.40[b]	3.25	2.30
24Ayur-014	< LOD	0.25	0.11	0.02	3.40	0.56	< LOD	0.02	0.16
24Ayur-015	< LOD	< LOD	< LOD	< LOD	3.50	0.30	0.47	< LOD	< LOD
24Ayur-016	< LOD	< LOD	< LOD	< LOD	1.20	0.60	< LOD	< LOD	< LOD
24Ayur-017	< LOD	< LOD	< LOD	0.006	0.42	0.11	< LOD	< LOD	< LOD
24Ayur-018[a]	< LOD	0.55	< LOD	0.042	13.15	0.50	0.06	675[a]	< LOD
24Ayur-019	< LOD	0.12	< LOD	0.015	1.00	0.08	< LOD	27	< LOD
24Ayur-020	0.11	< LOD	< LOD	0.007	0.013	6.30	< LOD	< LOD	3.50
24Ayur-021	< LOD	< LOD	< LOD	0.013	3.40	0.18	0.065	0.017	0.27
24Ayur-022	< LOD	0.23	< LOD	0.033	7.40	0.15	< LOD	0.70	0.12
24Ayur-023	< LOD	0.62	< LOD	0.062	5.10	0.44	< LOD	0.12	< LOD
24Ayur-024	< LOD	< LOD	< LOD	< LOD	2.20	0.16	< LOD	< LOD	< LOD
24Ayur-025	< LOD	< LOD	< LOD	< LOD	3.80	0.20	< LOD	< LOD	< LOD
24Ayur-026	< LOD	< LOD	< LOD	< LOD	6.10	0.20	< LOD	< LOD	< LOD
24Ayur-027	< LOD	< LOD	< LOD	0.13	2.00	0.70	< LOD	< LOD	< LOD
24Ayur-028[a]	< LOD	< LOD	< LOD	< LOD	4.00	< LOD	< LOD	< LOD	< LOD
24Ayur-029	< LOD	< LOD	< LOD	< LOD	5.20	0.60	< LOD	< LOD	< LOD

Sample no.	Antimony	Arsenic	Bismuth	Cadmium	Copper	Lead	Mercury	Silver	Tin
24Ayur-030[a]	< LOD	< LOD	< LOD	0.75[bc]	8.10	1.10	< LOD	< LOD	< LOD
24Ayur-031	< LOD	< LOD	< LOD	< LOD	3.60	< LOD	< LOD	< LOD	< LOD
24Ayur-032	< LOD	< LOD	< LOD	0.10	14.60	2.40	< LOD	< LOD	< LOD
24Ayur-033	< LOD	< LOD	< LOD	< LOD	4.30	< LOD	< LOD	< LOD	< LOD
24Ayur-034	< LOD	0.37	< LOD	0.082	4.20	0.76	< LOD	< LOD	< LOD
24Ayur-035	< LOD	< LOD	< LOD	< LOD	5.00	< LOD	< LOD	< LOD	< LOD
24Ayur-036	< LOD	< LOD	< LOD	< LOD	1.80	< LOD	< LOD	< LOD	< LOD
24Ayur-037	< LOD	< LOD	< LOD	0.04	3.00	0.40	< LOD	< LOD	< LOD
24Ayur-038[a]	< LOD	0.042	< LOD	0.007	0.15	0.28	< LOD	< LOD	< LOD
24Ayur-039	< LOD	0.018	< LOD	0.006	0.21	0.03	< LOD	< LOD	< LOD
24Ayur-040	< LOD	0.012	< LOD	< LOD	0.30	< LOD	< LOD	< LOD	< LOD
24Ayur-041	< LOD	0.017	< LOD	0.005	0.50	0.02	< LOD	< LOD	< LOD
24Ayur-042	< LOD	< LOD	< LOD	< LOD	0.12	0.02	0.002	< LOD	< LOD
24Ayur-043	< LOD	< LOD	< LOD	< LOD	5.40	< LOD	< LOD	< LOD	< LOD
24Ayur-044	< LOD	< LOD	< LOD	< LOD	2.40	0.30	< LOD	< LOD	< LOD
24Ayur-045	< LOD	< LOD	< LOD	0.15	7.00	2.00	0.11	< LOD	< LOD
24Ayur-046	< LOD	< LOD	< LOD	< LOD	1.50	< LOD	< LOD	< LOD	< LOD
24Ayur-047	< LOD	< LOD	< LOD	< LOD	4.00	0.20	< LOD	< LOD	< LOD
24Ayur-048	< LOD	< LOD	< LOD	< LOD	4.50	0.20	< LOD	< LOD	< LOD
24Ayur-049[a]	< LOD	< LOD	< LOD	< LOD	6.70	< LOD	< LOD	< LOD	< LOD
24Ayur-050	< LOD	< LOD	< LOD	< LOD	2.40	< LOD	< LOD	< LOD	< LOD
24Ayur-051	< LOD	< LOD	< LOD	< LOD	0.06	< LOD	< LOD	< LOD	0.17
24Ayur-052	< LOD	< LOD	< LOD	0.18	10.80	1.70	< LOD	< LOD	< LOD
24Ayur-053	< LOD	0.010	< LOD	< LOD	0.23	< LOD	< LOD	< LOD	< LOD
24Ayur-054	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
24Ayur-055	< LOD	< LOD	< LOD	< LOD	4.30	< LOD	< LOD	< LOD	< LOD
24Ayur-056	< LOD	< LOD	< LOD	0.07	11.00	1.40	< LOD	< LOD	< LOD
24Ayur-057	< LOD	0.018	< LOD	< LOD	0.08	< LOD	< LOD	< LOD	< LOD
24Ayur-058[a]	< LOD	0.042	< LOD	0.05	5.63	< LOD	< LOD	< LOD	< LOD
24Ayur-059[a]	< LOD	< LOD	< LOD	< LOD	10.40	0.70	< LOD	< LOD	< LOD
24Ayur-060	< LOD	< LOD	< LOD	0.14	14.00	1.50	< LOD	< LOD	< LOD
24Ayur-061	< LOD	< LOD	< LOD	< LOD	0.50	< LOD	< LOD	< LOD	< LOD

Sample no.	Antimony	Arsenic	Bismuth	Cadmium	Copper	Lead	Mercury	Silver	Tin
24Ayur-062	< LOD	< LOD	< LOD	< LOD	2.10	< LOD	< LOD	< LOD	< LOD
24Ayur-063	< LOD	< LOD	< LOD	< LOD	4.00	0.20	< LOD	< LOD	< LOD
24Ayur-064	< LOD	0.012	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
24Ayur-065	< LOD	< LOD	< LOD	< LOD	7.0	0.70	< LOD	< LOD	< LOD
24Ayur-066[a]	< LOD	< LOD	< LOD	< LOD	10.10	0.65	163[b]	< LOD	1.20
24Ayur-067	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
24Ayur-068[a]	< LOD	< LOD	< LOD	< LOD	0.26	< LOD	< LOD	< LOD	< LOD
24Ayur-069	< LOD	0.02	< LOD	0.005	0.30	0.02	< LOD	< LOD	< LOD
24Ayur-070	< LOD	< LOD	< LOD	< LOD	0.05	< LOD	< LOD	< LOD	< LOD
24Ayur-071[a]	< LOD	< LOD	< LOD	< LOD	5.15	0.35	< LOD	< LOD	< LOD
24Ayur-072	< LOD	0.016	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
24Ayur-083	< LOD	< LOD	< LOD	0.10	25.0	3.20	3.30[c]	0.37	< LOD
24Ayur-084	< LOD	< LOD	< LOD	< LOD	3.60	< LOD	5.60[c]	10.60	< LOD
24Ayur-085	< LOD	< LOD	< LOD	< LOD	3.30	< LOD	1.17[c]	1.03	< LOD
Minimum	0.11	0.12	0.013	0.005	0.01	0.02	0.02	0.01	0.12
Maximum	26.00	0.37	0.110	0.75	5,200	2.40	166	675	1.10

LOD: limit of detection

a: Mean of two values. If one of the two analysis results was < LOD, the LOD was substituted to calculate the mean value. If both analysis results were < LOD, the mean value was reported as < LOD.

b: Above the permissible limit recommended by the United States Pharmacopeia.

c: Above the permissible limit recommended by the World Health Organization.

Table A3. Concentrations (mg/kg) of heavy metals detected in the blind duplicate analyses of 17 Ayurvedic medicines

Sample no.	Antimony	Arsenic	Bismuth	Cadmium	Copper	Lead	Mercury	Silver	Tin
24Ayur-001	< 0.10	0.40	< 0.010	0.006	4.20	0.11	3.10	0.07	0.15
24Ayur-086*	< 1.00	< 1.00	< 0.10	< 0.04	4.50	< 0.20	3.20	< 0.10	< 1.00
24Ayur-006	< 0.10	< 0.10	< 0.010	0.012	5.60	0.10	0.14	0.84	0.16
24Ayur-073*	< 1.00	< 1.00	< 0.10	< 0.04	5.50	< 0.20	< 0.04	0.43	< 1.00
24Ayur-008	< 0.10	0.70	0.024	0.11	16.00	2.30	29.00	0.05	0.35
24Ayur-087*	< 1.00	< 1.0	< 0.10	0.11	24.00	2.80	12.70	< 0.10	< 1.00
24Ayur-009	26.00	9,900	< 0.10	0.17	5,200	1.20	70.00	< 0.10	4.80
24Ayur-088	25.00	9,700	< 0.10	0.14	5,200	1.10	58.00	< 0.10	3.50
24Ayur-011	< 0.10	0.47	< 0.010	0.037	10.0	0.63	152	0.012	1.13
24Ayur-089*	< 1.00	< 1.00	< 0.10	0.04	10.70	0.70	157	< 0.10	1.10
24Ayur-012	< 0.10	2.20	0.013	0.082	12.40	1.80	15.00	0.055	5.00
24Ayur-090*	< 1.00	2.30	< 1.00	0.10	16.20	1.60	26.00	0.13	6.80
24Ayur-013	< 0.10	0.46	< 0.010	0.01	4.000	1.15	3.00	2.10	1.57
24Ayur-091*	< 1.00	< 1.00	< 0.010	< 0.04	4.40	2.20	12.00	4.40	3.10
24Ayur-018*	< 1.00	< 1.00	< 0.10	< 0.04	13.30	0.50	< 0.10	730	< 1.00
24Ayur-074	< 0.10	0.15	0.04	0.045	13.00	0.52	0.022	620	< 0.10

Sample no.	Antimony	Arsenic	Bismuth	Cadmium	Copper	Lead	Mercury	Silver	Tin
24Ayur-028*	< 1.00	< 1.00	< 0.10	< 0.04	4.00	< 0.2	< 0.10	< 0.10	< 1.00
24Ayur-075*	< 1.00	< 1.00	< 0.10	< 0.04	4.00	< 0.2	< 0.10	< 0.10	< 1.00
24Ayur-030*	< 1.00	< 1.00	< 0.10	0.73	8.20	1.10	< 0.10	< 0.10	< 1.00
24Ayur-092*	< 1.00	< 1.00	< 0.10	0.76	7.70	1.10	< 0.10	< 0.10	< 1.00
24Ayur-038	< 0.10	0.043	< 0.010	0.006	0.15	0.30	< 0.010	< 0.010	< 0.10
24Ayur-076	< 0.10	0.041	< 0.010	0.008	0.15	0.30	< 0.010	< 0.010	< 0.10
24Ayur-049*	< 1.00	< 1.00	< 0.10	< 0.040	6.60	< 0.20	< 0.010	< 0.010	< 1.00
24Ayur-077*	< 1.00	< 1.00	< 0.10	< 0.040	7.0	< 0.20	< 0.010	0.54	< 1.00
24Ayur-058	< 0.10	0.043	< 0.010	0.004	0.06	< 0.020	< 0.010	< 0.010	< 1.00
24Ayur-078	< 0.10	0.042	< 0.010	0.005	0.06	< 0.020	< 0.010	< 0.010	< 1.00
24Ayur-059*	< 1.00	< 1.00	< 0.10	< 0.040	10.40	0.70	< 0.010	< 0.010	< 1.00
24Ayur-079*	< 1.00	< 1.00	< 0.10	0.060	11.20	0.70	< 0.010	< 0.010	< 1.00
24Ayur-066*	< 1.00	< 1.00	< 0.10	< 0.040	9.70	0.60	160.0	< 0.10	1.30
24Ayur-080*	< 1.00	< 1.00	< 0.10	< 0.040	10.50	0.50	166.0	< 0.10	1.10
24Ayur-068	< 0.10	< 0.01	< 0.010	< 0.004	0.27	< 0.02	< 0.010	< 0.010	< 0.10
24Ayur-081	< 0.10	< 0.01	< 0.010	< 0.004	0.25	< 0.02	< 0.010	< 0.010	< 0.10
24Ayur-071*	< 1.00	< 1.00	< 0.10	< 0.040	5.00	0.10	< 0.10	< 0.10	< 1.00
24Ayur-082*	< 1.00	< 1.00	< 0.10	< 0.040	5.20	0.30	< 0.10	< 0.10	< 1.00

* The sample is 10-fold diluted. This was done to reduce any high levels of heavy metals present that may impact the ICP-MS system.

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