The Food & Environment Research Agency

Analyses of lead levels in tea

Report for the UK Food Standards Agency (FS102115)

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Date:	March 2015
Client:	Food Standards Agency, Aviation House, 125 Kingsway, London, WC2B 6NH
Client's project no.	FS102115
Fera's Project no.:	B2FG
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Distribution:	1. G. Shears. FSA 2. I. Smith, FSA 3. N. Brereton, Fera 4. E. Bradley, Fera

UKAS TESTING
1642

Summary

This study was carried out to address the urgent need to gather more data on levels of lead (Pb) in tea, to inform current EU discussions on a proposed maximum limit of 1 mg/kg Pb in tea ('dried leaves and stalks, fermented or otherwise of Camellia sinensis').

Levels of Pb were quantified in 51 samples of black and green tea leaves (previously tested as part of a FSA pyrrolizidine alkaloids survey). These samples were also analysed as tea liquid (drink), after steeping the tea leaves for both a shorter and a longer brew time, following an agreed protocol. 11 different varieties of dried tea (including a white tea) from different tea growing regions were also purchased and analysed to ensure there was good geographic and tea-type coverage.

Preliminary investigations were carried out on a small number of samples. Firstly, tea bags taken from two packets of tea were analysed to check the level of variation in Pb within each pack. Further studies included investigating: the effect of using deionised water (Milli-Q) versus tap water to steep the tea; extended brewing times and the effects a second brew (re-steeping) had on Pb levels in the tea liquid.

Quantification of Pb in all samples was carried out using inductively coupled plasma - mass spectrometry (ICP-MS). Other elements of interest were also monitored - Al, As, Cd, Cr, Cu, Mn and Ni. The methodologies used were UKAS accredited to ISO 17025.

The average variability of Pb levels in 10 tea bags from a single pack was approximately 11% RSD. For the samples tested in the preliminary work, there were no differences observed in Pb levels in the brewed tea when tap water was used to steep the tea versus deionized water. As a result, to ensure a consistent approach, deionized water was used to steep the tea throughout the study. Extending the brewing time from 15 seconds to 20 minutes did not result in a change in Pb levels in the tea liquid, for the two samples tested. However, Pb levels in these tea liquids were below the quantification limit (<0.7 µg/L). Two of the high level samples in the main study did show an increase in Pb levels in the tea liquid following the longer of the two brew times (4 min). Re-steeping tea leaves for a second time resulted in lower Pb levels in the tea liquid compared to the levels measured in the first brew.

The levels of Pb in the 51 dry tea samples ranged from 0.125 to 2.56 mg/kg. The highest levels were found in several of the green tea varieties, where 5 samples out of the 9 tested contained Pb at levels above the proposed maximum level of 1 mg/kg.

Results for the 11 additional dry teas ranged from 0.177 (Assam tea) to 1.96 mg/kg (Oolong tea). 5 of the samples (3 green and 2 black teas), all from China, were found to be above 1 mg/kg.

The levels found in the tea liquid (brewed tea) were very low, with approximately half the results being less than the detection limit (<0.2 µg/L). Two samples contained Pb levels above 1 µg/L and the highest level, 2 µg/L, was found in a sample of green tea (Chinese Sencha).

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Abbreviations

ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
LoD	Limit of Detection
LoQ	Limit of Quantitation
QA	Quality Assurance
QC	Quality Control
UKAS	United Kingdom Accreditation Service
FAPAS	Food Analysis Performance Assessment Scheme

1. Introduction

Pb is a toxic metal present in the environment naturally and as a result of human activities, such as mining, manufacturing and burning fossil fuels. Pb accumulates in the body over time, affecting almost every organ and system in the human body, particularly the central nervous system. A major route of human exposure to Pb is through the diet. Pb enters the food chain as a result of uptake by plant roots or deposition on foliage from contaminated water, soil and air. Contamination during food processing and packaging is another possible source.

Tea has the potential to be an important contributor to dietary exposure to Pb and the UK is one of the highest consumers of tea. A limit of 1 mg/kg of Pb in tea had been tentatively proposed by the European Commission in mid-2014. This proposed limit was intended specifically for 'the dried leaves and stalks, fermented or otherwise of Camellia sinensis'. Black tea, green tea and white tea are all harvested from Camellia sinensis, differing only in the way they are processed. However, the regulation has been put on hold as the UK, along with other Member States, have identified a need to gather more data on Pb levels in tea before a possible maximum limit is discussed further. This study was designed to address this requirement in regard to Pb levels in retail teas, so enabling the FSA to determine how this will translate into consumer exposure to Pb, from tea specifically, and determine whether a maximum limit is appropriate for risk management.

To save time and costs, 51 tea samples already collected and stored at Fera for the FSA pyrrilodizine alkaloids survey, were analysed for Pb. Other elements of interest (Al, As, Cd, Cr, Cu, Mn and Ni) were also monitored and results for these are presented in Appendix 2. Quantification was by inductively coupled plasma- Mass spectrometry (ICP-MS) using UKAS accredited methods (ISO 17025). All samples analysed were from the Camellia sinensis tea variety and had been purchased based on market share data obtained from the 2013 Mintel report 'Tea and other hot drinks'. Fera also purchased 11 retail tea samples from different tea growing regions (China, Africa, Japan and India) to ensure that there was also good geographic and tea type coverage to investigate how Pb levels differed. The purpose of this study was to investigate Pb levels in a broad range of retail teas and brewed tea as drunk, to ascertain UK consumer exposure from this source. The purpose was not to provide brand name information and compare performance against a specific standard, as

the UK has not yet adopted one. The results will also inform EU Commission technical discussions as to whether a maximum limit is required for Pb in tea and if this will have significant benefit to consumer safety.

The first part of the study, Phase 1, involved analysing the dry tea leaves. The variability of Pb levels within a pack was also investigated in two packs of tea to determine whether analysing a single tea bag could be considered representative of the whole pack. In Phase 2, tea samples were brewed for both a shorter and a longer brew time, following an agreed protocol. The resulting tea solutions were then analysed. The brewing protocols were chosen to be appropriate and specific to each sample type; so for example a different method was used to brew the green tea to that used for black tea. The methods were fixed however, within each product type to allow comparisons to be made. See Appendix 1 for Phase 2 brewing protocols. The protocols were agreed in discussion with FSA and in consultation with tea industry representatives to ensure they were realistic.

Three preliminary studies were also carried out in Phase 2 to establish whether (1) deionised (Milli-Q) water could be used for the Phase 2 brewing study, rather than tap water. This would ensure background element levels were low and consistent during the study. (2) The relationship between longer brewing times and the levels of Pb in the brewed tea was investigated over 6 time points ranging from 15 seconds to 20 minutes and (3) determining Pb levels in brewed tea after steeping tea leaves for a second time. See Appendix 1 for Phase 2 preliminary study brewing protocols.

2. Methodology

2.1 SAMPLES

51 dry retail tea samples (42 black tea and 9 green tea) previously purchased by HallMark Meat Hygiene Ltd and received by Fera for the FSA pyrrilodizine alkaloids survey, plus 11 retail dry tea samples (6 black, 4 green and 1 white tea) purchased by Fera, were sub-sampled into plastic, acid-cleaned containers and labelled with unique LIMS codes.

2.1.1 Sample preparation: Phase 1 (dry leaf)

For the tea bag samples, one tea bag was taken from each pack and only the tea leaves (not the tea bag) were analysed. No preparation was required for the loose teas. To measure the variation of Pb levels in tea within a pack, two packs of tea were selected. The contents of 10 tea bags taken from each pack were analysed separately.

2.1.2 Sample preparation: Phase 2 (brewed tea) preliminary studies:

(a) Deionised water v tap water. The packs of tea selected for this test were known to contain medium to high levels of Pb, as determined in Phase 1 of the study. Six tea bags taken from a pack of black tea and six from a pack of green tea were used for this test. Each tea bag was steeped for 3 minutes in the same volume of either boiling/hot potable tap water (250 ml) or boiling/hot deionised Milli-Q water (250 ml). Aliquots of the resulting tea solutions were transferred to labelled vials and stored frozen until ready for analysis.

(b) Migration of Pb with longer brewing times. Two packs of tea bags (black tea) known to contain medium to high levels of Pb, as determined in Phase 1, were selected. One tea bag from each of the packs was steeped in boiling deionised water (250 ml) and aliquots (2 ml) of tea liquid were sampled at 6 timed intervals (15 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes and 20 minutes). Each aliquot was transferred to a labelled vial and stored frozen until ready for analysis. This procedure was repeated using a tea bag from the second pack of tea.

(c) Second extractions. Two packs of medium to high Pb level loose tea (1 black and 1 green) were selected. A portion (2 or 3 tsp) of tea leaves, taken from one of the packs, was steeped in boiling/hot deionised water (500 ml) for 3 minutes. An aliquot of the resulting tea liquid (5 ml) was collected, transferred to a vial and stored frozen until ready for analysis. The remaining liquid was strained to waste and the tea leaves re-steeped, following the same procedure as before, for a further 3 minutes and an aliquot (5 ml) collected and stored frozen. This procedure was repeated using tea from the second pack.

2.1.3 Sample preparation: Phase 2 (brewed tea) main study

51 tea samples were brewed using deionised water, following a protocol appropriate to the product type (see table below). An aliquot of tea liquid (5 ml) was removed at the shorter brewing time point and then a second aliquot (5 ml) taken at the longer time point. Each aliquot of tea liquid was frozen separately until ready for analysis.

Product type	Volume of water added	Temperature of water	Brew times	Volume transferred for Pb analysis
Tea bag black x 1	250 ml	100 ºC	30 sec	5 ml
			3 min	5 ml
Loose tea black x 3 tsp	500 ml	100 ºC	2 min	5 ml
			5 min	5 ml
Tea bag green x 1	250 ml	80 ºC	30 sec	5 ml
			3 min	5 ml
Loose tea green x 2 tsp	500 ml	80 ºC	1 min	5 ml
			4 min	5 ml

2.2 ANALYSIS

The analytical procedures used to measure Pb (Al, As, Cd, Cr, Cu, Mn and Ni) in this study were UKAS accredited (ISO17025). To minimize background contribution, deionized (Milli-Q 18.2 MΩ cm) water, Aristar grade reagents and acid cleaned plasticware were used throughout.

2.2.1 Analysis: Phase 1 (dry tea)

Aliquots (0.2 g) of tea leaves were weighed into allotted digestion vessels and a mixture (4:1) of nitric acid (HNO_3) and hydrochloric acid (HCl) was added (2 ml). The vessels were capped and the contents digested under high temperature and pressure using a single reaction chamber microwave digester system (UltraWAVE, Milestone). The resulting solutions were transferred to pre-marked plastic test tubes and diluted to 10 ml with deionised water. The digest solutions were then diluted 5-fold with an internal standard (rhodium, 12 µg/L) prior to measurement by an Agilent 7700x ICP-MS. Calibration standards were prepared from NIST-traceable element stock solutions using the same acid combination and internal standard as the diluted digest solutions.

2.2.2 Analysis: Phase 2 (brewed tea)

All the tea liquids resulting from the deionized water versus tap water experiment (2.1.2 a) were microwave digested to dissolve particulates only evident in the tap water-brewed tea. The digestion method used has been described above, in 2.2.1, except. 3 ml aliquots of tea liquid were digested, rather than 0.2 g. All subsequent brewing protocols involved the use of deionised water, resulting in clear tea liquids

where no digestion was required. The analysis method for these samples is described below:

Aliquots (1 ml) of tea liquid were pipetted into plastic auto sampler tubes and diluent (1 ml) containing HNO_3 (1 % v/v), HCl (0.5 % v/v) and internal standard (rhodium, 12 µg/L) was added to each tube. The solutions were measured for the elements of interest using an Agilent 7700x ICP-MS. Calibration standards were prepared from NIST-traceable element stock solutions using the same acid combination and internal standard as the sample solutions.

3. Quality Assurance (QA)

A 10 % audit (in duplicate) was performed within the study. Each analytical batch contained a minimum of 3 procedural blanks, a spiked sample (for recovery estimate purposes) and Certified Reference Materials (CRMs). Successful participation in FAPAS proficiency tests during the study period provided further confidence in the data. QA criteria are summarised below.

3.1 LoD and LoQ

The LoD was defined as three times the standard deviation of the signal from reagent blanks (taken through the entire analytical procedure) when subsequently corrected for sample weight and dilution. The LoQ was defined as ten times the standard deviation of the signal from reagent blanks (taken through the entire analytical procedure) when subsequently corrected for sample weight and dilution.

3.2 INSTRUMENT STABILITY

Analyses included re-measurement of a calibration standard at regular intervals during the analytical run. To pass this check, the results for the re-measured standard had to be within ± 20 % of the initial value.

3.3 SPIKE RECOVERY

Data were accepted if the recovery of spike for each analyte was within 80 to 120 %.

3.4 CRM DATA

Accepted results had to be within 25 % of the certified value. Where indicative values were shown on certificates, measured concentrations had to be within a factor of $\pm$2 of the quoted value. Data were accepted if results for the majority of reference materials passed the criteria above.

3.5 REPLICATE AGREEMENT

Replicate values for a given sample had to have a Relative Standard Deviation (RSD) ≤ 20 % or a standard deviation of ≤ LoQ, whichever was greater.

4. Results

Tables 2 shows the QA data for Pb obtained during this study; including CRM results, spike recoveries, detection limits and measurement uncertainty. Table 3 shows z-scores from Fera's participation in proficiency testing schemes during the last 12 months. The sample results and preliminary study results for Pb are reported in Tables 4 to 16. Other element sample data are supplied for information only in Appendix 2. Element concentrations between the LoD and LoQ are pre-fixed with the tilde symbol '~' to indicate that they are semi-quantitative results.

4.1 QA RESULTS

Reported data satisfied the QA/QC criteria described in Section 3 of this report.

4.2 SAMPLE RESULTS

4.2.1 Phase 1 preliminary study -variability of Pb in dry tea leaves

At the start of the study, the variability of Pb levels within two selected packs was assessed. 10 tea bags were tested per pack and the % RSDs were found to be 9% and 12 %. This indicated that the levels of Pb in a pack of tea bags were sufficiently homogenous for data from a single tea bag to be representative of the larger pack. As a result, tea from single tea bags was used in the remainder of the study.

4.2.2 Phase 2 preliminary study – deionized water v tap water

For the samples tested in the preliminary Phase 2 work to look at Pb levels in tea brewed using deionised versus tap water; levels were found to be either very low or not detected. The experiment was repeated using a sample of green tea known (from Phase 1 results) to contain a higher Pb level (2.5 mg/kg Pb in the dry tea leaves). Results from this brewed tea were above the LoD, but still very low (approximately 1-2 µg/L). There were no differences observed in Pb levels when tap water was used to steep the tea versus deionized water. Consumers would typically use tap water to make tea, but trace element levels in tap water can vary. As deionised water gave equivalent results to tap water, deionised water was used for all subsequent Phase 2 brewing studies to ensure a consistent approach. Deionised water also gave a clearer brew, without particulates, which meant the liquids could be analysed without the need for digestion. The removal of the digestion step improved the detection limit for Pb from 1 µg/L to 0.2 µg/L.

4.2.3 Phase 2 preliminary study – migration of Pb with longer brewing times

Extending the brewing time from 15 seconds to 20 minutes did not result in a change in Pb levels in the tea liquid, for the two sets of samples tested. However the levels in the tea liquid were either very low or not detected. There was some evidence in the main brewing study that when levels in the brewed tea were sufficiently high to be quantifiable, the longer of the two brew times resulted in higher levels of Pb in the tea liquid. For example, Pb levels in one loose green tea sample increased from 1.7 µg/L (at 1 min) to 2.3 µg/L (at 4 min).

4.2.4 Phase 2 preliminary study – second extractions

Results showed that for the two loose tea samples brewed for a second time, Pb levels decreased by approximately 60 % compared with the levels found in the first brew.

4.2.5 Phase 1 main study – dry leaf analysis

The levels of Pb in the 51 dry tea leaf samples (Phase 1) ranged from 0.125 to 2.56 mg/kg. The highest levels were found in several of the green tea varieties, where 5 samples out of the 9 tested contained Pb at levels above the proposed maximum level of 1 mg/kg. Pb levels in the 11 retail dry teas from different tea growing regions ranged from 0.177 mg/kg (Assam tea) to 1.96 mg/kg (Oolong tea). 5

of the samples (3 green and 2 black teas), all from China, were found to be above 1 mg/kg.

4.2.6 Phase 2 main study – brewed tea

The levels found in the tea liquid from the 51 dry tea leaf samples were very low, with approximately half of the results being less than the detection limit (<0.2 µg/L). Two samples contained Pb levels above 1 µg/L and the highest level, 2 µg/L, was found in a sample of green tea (Chinese Sencha).

Table 1. ICP-MS operating conditions

Parameter	Agilent 7700x
ICP Power (W)	1550
Nebuliser gas flow rate (L/min)	1.05
Plasma mode	General purpose
Tuning	Autotune*
Nebuliser type	Glass Concentric
Interface cones	Nickel
Spray chamber temp (°C)	2
Peri-pump speed (rpm)	0.1
MS Acquisition setting	Single point, peak hopping
Collision cell mode	
No gas	^{27}Al, ^{111}Cd, ^{208}Pb.
Helium	^{52}Cr, ^{55}Mn, ^{60}Ni, ^{63}Cu, ^{75}As
Internal standard	^{103}Rh

* Instrument driven optimisation to attain “robust conditions”. These relate to the levels of oxides (~ 1 %) and double charged species (< 1.5 %) present in the plasma.

Table 2. Pb QA data obtained during the study

Pb QA mean data from Phase 1 (dry tea leaf analysis) mg/kg

NIES 7 Tea leaves		INCT-OBTL-5 Tobacco		ZC73013 Spinach	
Measured	Certified	Measured	Certified	Measured	Certified
0.64	0.80	1.74	2.01	12.5	11.1

		LoD	LoQ	Rec %	*MU %
		0.001	0.003	93	14

Pb QA mean data from Phase 2 (brewed tea analysis) µg/L

ERMCA010a Drinking water		NIST 1640 Natural water		NIST 1643e Water		SLRS4 Riverine water	
Measured	Certified	Measured	Certified	Measured	Certified	Measured	Certified
101	95	28.7	27.89	19.4	19.2	0.10	0.086

				LoD	LoQ	Rec %	*MU %
				0.2	0.7	107	14

* Based on performance in proficiency tests, using a coverage factor of 2 (95% confidence level)

Table 3. FAPAS proficiency testing results obtained for Pb during the last 12 months

Date	Matrix	FAPAS Round	Pb z-score
Feb-Mar 14	Vegetable puree	07207	0.4
Mar-May 14	Grapefruit	07210	-0.3
Apr-May 14	Milk Powder	07211	0.0
Jun-Jul 14	Tomato paste	07214	-0.1
Aug-Sep 14	Powdered rice	07219	-0.3
Sep-Oct 14	Edible oil	07220	0.0
Nov-Dec 14	Wine	07224	0.1
Jan-Feb 15	Fruit juice	07227	0.3

Interpretation of z-scores:

With a normal distribution, statistically approximately 95% of z-scores will be in the 'satisfactory' range of $-2 \leq z \leq 2$. Whilst z-scores outside this range are to be expected, (1 in 20), these are deemed 'questionable' and further investigation is required as part of our quality procedures.

Table 4. Phase 1 - Pb concentration in dry black tea leaves from tea bags

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb mg/kg
S14-010546	Assam tea	Assam	Black	Tea bag	0.193
S14-010550	Blended tea	Not stated	Black	Tea bag	0.372
S14-010552	Every day tea	East Africa/India/Sri Lanka	Black	Tea bag	0.137
S14-010811	Ceylon tea	Sri Lanka	Black	Tea bag	0.481
S14-010740	Strong tea	Not stated	Black	Tea bag	0.428
S14-010647	Extra Strong tea	Not stated	Black	Tea bag	0.196
S14-010556	Rich tea	Not stated	Black	Tea bag	0.145
S14-010584	Strong tea	Not stated	Black	Tea bag	0.249
S14-010592	Tea	Not stated	Black	Tea bag	0.172
S14-010593	Decaffeinated tea	Not stated	Black	Tea bag	0.185
S14-010724	Decaffeinated tea	Not stated	Black	Tea bag	0.165
S14-010725	Regular tea	Not stated	Black	Tea bag	0.169
S14-010727	Fresh tea	Not stated	Black	Tea bag	0.139
S14-010766	Mellow tea	Not stated	Black	Tea bag	0.202
S14-010583	English breakfast tea	Not stated	Black	Tea bag	0.144
S14-010776	Every day tea	Not stated	Black	Tea bag	0.125
S14-010729	Tea	Not stated	Black	Tea bag	0.165
S14-010548	Estate tea	Kenya	Black	Tea bag	0.442
S14-010554	Decaffeinated tea	Not stated	Black	Tea bag	0.184
S14-010589	Blended tea	Africa/Asia/Assam	Black	Tea bag	0.736
S14-010590	Tea	Africa/Assam	Black	Tea bag	0.180
S14-010731	Tea	Not stated	Black	Tea bag	0.187
S14-010732	Extra strong tea	Not stated	Black	Tea bag	0.272

Table 4. Phase 1 - Pb concentration in dry black tea leaves from tea bags continued

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb mg/kg
S14-010557	Earl Grey tea	Not stated	Black	Tea bag	0.199
S14-010591	Every day tea	China	Black	Tea bag	0.927
S14-010549	Tea	Assam/East Africa	Black	Tea bag	0.140
S14-010553	Tea for hard water	Not stated	Black	Tea bag	0.646
S14-010683	Tea	Not stated	Black	Tea bag	0.164

Table 5. Phase 1 - Pb concentrations in dry black tea leaves from loose tea

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb mg/kg
S14-010582	Tea	Not stated	Black	Loose	0.191
S14-010544	Tea	Not stated	Black	Loose	0.159
S14-010726	Tea	Not stated	Black	Loose	0.219
S14-010730	Tea	Not stated	Black	Loose	0.170
S14-010779	Earl Grey tea	Not stated	Black	Loose	0.317
S14-010545	Assam tea	Assam	Black	Loose	0.263
S14-010735	English breakfast tea	Not stated	Black	Loose	0.709
S14-010736	Earl Grey tea	Not stated	Black	Loose	0.868
S14-010551	tea	Not stated	Black	Loose	0.152
S14-010758	Breakfast Earl Grey tea	Not stated	Black	Loose	0.609
S14-010760	English breakfast tea	Not stated	Black	Loose	0.460
S14-010587	Every day tea	Not stated	Black	Loose	0.159
S14-010588	tea	Not stated	Black	Loose	0.642
S14-010597	English breakfast tea	Not stated	Black	Loose	0.372

Table 6. Phase 1 - Pb concentrations in dry green tea leaves from tea bags

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb mg/kg
S14-010656	Green tea	Not stated	Green	Tea bag	1.363
S14-010649	Green tea	Not stated	Green	Tea bag	2.560
S14-010560	Green tea	Not stated	Green	Tea bag	0.189
S14-010561	Lemon green tea	Not stated	Green	Tea bag	0.200
S14-010547	Decaffeinated green tea	Asia	Green	Tea bag	1.542
S14-010733	Green tea	Not stated	Green	Tea bag	0.913
S14-010734	Lemon green tea	Not stated	Green	Tea bag	1.222

Table 7. Phase 1 - Pb concentrations in dry green tea leaves from loose tea

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb mg/kg
S14-010806	Organic green tea	Japan	Green	Loose	0.955
S14-010701	Sencha green tea	China	Green	Loose	1.870

Table 8. Phase 1 - Pb concentrations in dry tea leaves from different tea growing regions

Fera LIMS code	Description	Region	Type	Packaging	Pb mg/kg
S14-054418	Organic white tea	China	Black	Tea bag	0.928
S14-054420	Lapsang Souchong tea	China	Black	Tea bag	1.664
S14-054424	Jasmine tea	China	Black	Loose	1.200
S14-054419	Oolong green tea	China	Green	Tea bag	1.959
S14-054427	Gunpowder green tea	China	Green	Loose	1.429
S14-054417	Mao Feng green tea	China	Green	Loose	1.242
S14-054423	Darjeeling tea	India	Black	Loose	0.287
S14-054426	Assam tea	India	Black	Tea bag	0.177
S14-054425	Sencha tea	Japan	Green	Loose	0.216
S14-054422	Kenyan tea	Kenya	Black	Tea bag	0.497
S14-054421	Ceylon tea	Sri Lanka	Black	Tea bag	0.566

Table 9a. Variability in dry black tea from 10 tea bags in a single pack (analysed in duplicate)

Fera LIMS code	Description	Pb in dry tea (mg/kg)			
S14-010592a	Teabag 1	0.157	0.156	**Mean**	**0.198 ± 0.021**
S14-010592b	Teabag 2	0.138	0.163	**RSD %**	**12**
S14-010592c	Teabag 3	0.181	0.164		
S14-010592d	Teabag 4	0.156	0.174		
S14-010592e	Teabag 5	0.176	0.166		
S14-010592f	Teabag 6	0.226	0.177		
S14-010592g	Teabag 7	0.200	0.144		
S14-010592h	Teabag 8	0.151	0.150		
S14-010592i	Teabag 9	0.170	0.198		
S14-010592j	Teabag 10	0.159	0.162		

Table 9b. Variability in dry green tea from 10 tea bags in a single pack (analysed singly)

Fera LIMS code	Description	Pb in dry tea (mg/kg)		
S14-010561a	Teabag 1	0.210	**Mean**	**0.207 ± 0.019**
S14-010561b	Teabag 2	0.212	**RSD %**	**9**
S14-010561c	Teabag 3	0.179		
S14-010561d	Teabag 4	0.193		
S14-010561e	Teabag 5	0.205		
S14-010561f	Teabag 6	0.207		
S14-010561g	Teabag 7	0.244		
S14-010561h	Teabag 8	0.215		
S14-010561i	Teabag 9	0.220		
S14-010561j	Teabag 10	0.181		

Table 10. Phase 2 preliminary study – Pb concentrations in tea steeped with deionised v tap water

Fera LIMS code	Type	Packaging	Pb in dry tea (µg/kg)	Water type	Pb in tea liquid (µg/L)		
					Teabag 1	Teabag 2	Teabag 3
S14-010591	Black	Tea bag	927	Deionised water	<1	<1	<1
S14-010591	Black	Tea bag	927	Potable tap water	<1	~1	<1
				Procedural blank	<1	<1	
S14-010649	Green	Tea bag	2560	Deionised water	~1	~1	~1
S14-010649	Green	Tea bag	2560	Potable tap water	~2	~1	~1
				Procedural blank	<1	<1	

Table 11. Phase 2 preliminary study – Migration of Pb following longer brewing times

Fera LIMS code	Type	Packaging	Pb in dry tea (µg/kg)	Pb in tea liquid (µg/L)					
				15 sec	1 min	2 min	5 min	10 min	20 min
S14-010548	Black	Teabag	442	~0.3	~0.3	~0.3	~0.4	~0.3	~0.4
S14-010553	Black	Teabag	646	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

Table 12. Phase 2 preliminary study – Pb concentrations in re-steeped tea

Fera LIMS code	Type	Packaging	Pb in dry tea (µg/kg)	Pb in tea liquid (µg/L)	
				1st infusion	2nd infusion
S14-010760	Black	loose	460	~0.4	<0.2
S14-010806	Green	loose	955	1.2	~0.4

Table 13. Phase 2 - Pb concentrations in tea brewed from black tea bags

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb µg/L	
					30 sec brew	3 min brew
S14-010546	Assam tea	India	Black	Tea bag	<0.2	<0.2
S14-010550	Blended tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010552	Every day tea	East Africa/India/Sri Lanka	Black	Tea bag	<0.2	<0.2
S14-010811	Ceylon tea	Sri Lanka	Black	Tea bag	~0.3	~0.5
S14-010740	Strong tea	Not stated	Black	Tea bag	<0.2	~0.2
S14-010647	Extra Strong tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010556	Rich tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010584	Strong tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010592	Tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010593	Decaffeinated tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010724	Decaffeinated tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010725	Regular tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010727	Fresh tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010766	Mellow tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010583	English breakfast tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010776	Every day tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010729	Tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010548	Estate tea	Kenya	Black	Tea bag	<0.2	<0.2
S14-010554	Decaffeinated tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010589	Blended tea	Africa/Asia/Assam	Black	Tea bag	~0.3	~0.4
S14-010590	Tea	Africa/Assam	Black	Tea bag	<0.2	<0.2
S14-010731	Tea	Not stated	Black	Tea bag	<0.2	<0.2

Table 13. Phase 2 - Pb concentrations in tea brewed from black tea bags continued

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb µg/L 30 sec brew	Pb µg/L 3 min brew
S14-010732	Extra strong tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010557	Earl Grey tea	Not stated	Black	Tea bag	<0.2	<0.2
S14-010591	Every day tea	China	Black	Tea bag	<0.2	<0.2
S14-010549	Tea	Assam/East Africa	Black	Tea bag	<0.2	<0.2
S14-010553	Tea for hard water	Not stated	Black	Tea bag	<0.2	<0.2
S14-010683	Tea	Not stated	Black	Tea bag	<0.2	<0.2

Table 14. Phase 2 - Pb concentrations in tea brewed from black loose tea

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb µg/L 2 min brew	Pb µg/L 5 min brew
S14-010582	Tea	Not stated	Black	loose	<0.2	<0.2
S14-010544	Tea	Not stated	Black	loose	<0.2	<0.2
S14-010726	Tea	Not stated	Black	loose	<0.2	<0.2
S14-010730	Tea	Not stated	Black	loose	<0.2	<0.2
S14-010779	Earl Grey tea	Not stated	Black	loose	~0.3	~0.3
S14-010545	Assam tea	India	Black	loose	<0.2	<0.2
S14-010735	English breakfast tea	Not stated	Black	loose	~0.5	~0.6
S14-010736	Earl Grey tea	Not stated	Black	loose	0.7	0.9
S14-010551	tea	Not stated	Black	loose	<0.2	<0.2
S14-010758	Breakfast Earl Grey tea	Not stated	Black	loose	~0.6	~0.7
S14-010760	English breakfast tea	Not stated	Black	loose	~0.4	~0.4
S14-010587	Every day tea	Not stated	Black	loose	<0.2	<0.2
S14-010588	tea	Not stated	Black	loose	~0.5	~0.5
S14-010597	English breakfast tea	Not stated	Black	loose	~0.2	~0.3

Table 15. Phase 2 - Pb concentrations in tea brewed from green tea bags

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb µg/L	
					30 sec brew	3 min brew
S14-010656	Green tea	Not stated	Green	Tea bag	~0.4	~0.6
S14-010649	Green tea	Not stated	Green	Tea bag	<0.2	~0.6
S14-010560	Green tea	Not stated	Green	Tea bag	<0.2	<0.2
S14-010561	Lemon green tea	Not stated	Green	Tea bag	<0.2	<0.2
S14-010547	Decaffeinated green tea	Asia	Green	Tea bag	~0.3	~0.6
S14-010733	Green tea	Not stated	Green	Tea bag	~0.5	~0.7
S14-010734	Lemon green tea	Not stated	Green	Tea bag	~0.5	0.8

Table 16. Phase 2 - Pb concentrations in tea brewed from green loose tea

Fera LIMS code	Description	Region/Country of Origin	Type	Packaging	Pb µg/L	
					1 min brew	4 min brew
S14-010806	Organic green tea	Japan	Green	loose	0.8	1.2
S14-010701	Sencha green tea	China	Green	loose	1.7	2.3

Appendix 1. Phase 2 tea brewing protocol

1. Preliminary tests

(1a) Water test

It was agreed that using deionised water to make the tea would give better consistency across the brewing tests - levels of trace elements in tap water could potentially vary from day to day. However, consumers don't typically use deionised water at home to make their tea; therefore to determine if using deionised water to make tea gives comparable results (in terms of Pb levels) to tea made with tap water, the following test will be carried out:

1. Select 6 tea bags from 1 box of tea
2. Place 1 of the tea bags into an acid cleaned conical flask
3. Add 250 ml of boiling (100ºC) tap water to the flask and leave to brew, uncovered for 3 minutes
4. Stir twice with a plastic spoon to ensure the tea is uniformly distributed (as indicated by colour) and immediately remove approx. 5 ml using a pipette
5. Transfer to a labelled Nunc vial ready for analysis
6. Repeat this process (steps 2 to 5) twice using new tea bags each time to produce 3 samples of tea
7. Repeat steps 2 to 6 with 3 new tea bags but replace tap water with deionised (Millipore) water.

Type of water used	Tea brand X	Volume of boiling water added	Brew time	Collect aliquot for Pb analysis
Tap water	Tea bag 1	250 ml	3 min	5 ml
Tap water	Tea bag 2	250 ml	3 min	5 ml
Tap water	Tea bag 3	250 ml	3 min	5 ml
Deionised water	Tea bag 1	250 ml	3 min	5 ml
Deionised water	Tea bag 2	250 ml	3 min	5 ml
Deionised water	Tea bag 3	250 ml	3 min	5 ml

(1b) Brewing time

Brands may supply recommended brewing times, but typically consumers adjust brewing times according to their personal preference. To investigate the relationship between brewing time and the levels of Pb in the tea drink, the following test will be carried out:

1. Select 2 brands of tea (black tea bag with a medium to high Pb level)
2. Take 1 tea bag from 1 brand and place into an acid clean plastic conical flask

Add 250 ml of boiling water (tap/deionised tbc), leave to brew for 5 seconds, stir twice with a plastic spoon and transfer 2 ml to a labelled Nunc vial for testing

3. Keep the timer going and after 1 minute, swirl the flask once and transfer 2 ml to another labelled Nunc vial for testing
4. Continue in this way collecting additional aliquots at time points 2 min, 5 min, 10 min and 20 min
5. Repeat steps 2 to 4 using a new tea bag from the second brand

Brand X Brew time	Volume of boiling water added	Collect aliquot		Brand Y Brew time	Volume of boiling water added	Collect aliquot for Pb analysis
0	250 ml			0	250 ml	
15 sec	-	2 ml		15 sec	-	2 ml
1 min	-	2 ml		1 min	-	2 ml
2 min	-	2 ml		2 min	-	2 ml
5 min	-	2 ml		5 min	-	2 ml
10 min	-	2 ml		10 min	-	2 ml
20 min	-	2 ml		20 min	-	2 ml

(1c) Second extractions

Teas are often brewed several times by adding more water at an appropriate temperature. The following procedure tests the effect a second brew has on Pb levels in the tea drink:

1. Select 2 brands of tea (1 loose black tea and 1 loose green tea that have a medium to high Pb level)
2. Take 3 teaspoons of loose tea and place into an acid clean plastic conical flask
3. Add 500 ml of boiling water (tap/deionised tbc) and leave to brew for 3 minutes
4. Stir twice with a plastic spoon and transfer 5 ml through a plastic tea strainer directly into a labelled Nunc vial for testing
5. Tip out the remaining liquid to waste, through the plastic tea strainer so that the tea leaves are not lost. Tip the tea leaves back into the conical flask

6. Add 500 ml of hot/boiling water (tap/deionised tbc) which can also be used to rinse through any tea leaves remaining in the tea strainer back into the flask
7. Leave to brew for 3 minutes and then repeat steps 4 to 5 so that 2 separate samples of tea are collected for testing
8. Repeat steps 2 to 6 using 3 tsp of loose tea from the second brand and a clean conical flask

Brand	Quantity of tea	Volume of hot/boiling water added	Brew time	Temperature of water	Collect aliquot for Pb analysis
Brand X black loose tea 1st brew	3 tsp	500 ml	3 min	100 ºC	5 ml
2nd brew		500 ml	3 min	100 ºC	5 ml
Brand Y green loose tea 1st brew	3 tsp	500 ml	3 min	80 ºC	5 ml
2nd brew		500 ml	3 min	80 ºC	5 ml

2. Phase 2 – Brewed tea (from the 51 dried tea samples)

(2a) Tea bags – black

1. Add 1 tea bag to an acid clean plastic conical flask
2. Add 250 ml boiling (100 ºC) water (deionised, Millipore), leave to brew for 30 seconds, stir twice with a plastic spoon to ensure the tea is uniformly distributed (as indicated by colour), remove 5 ml using a pipette and transfer to a labelled Nunc vial for testing
3. Keep the timer going and after 3 minutes, stir twice with a plastic spoon and transfer 5 ml to another labelled Nunc vial for testing

(2b) Loose tea – black

1. Add 3 heaped tsp of tea (weight recorded) to an acid clean plastic conical flask
2. Add 500 ml boiling (100 ºC) water (deionised, Millipore), leave to brew covered for 2 minutes, stir twice with a plastic spoon to ensure the tea is uniformly distributed (as indicated by colour) remove 5 ml using a pipette and pass through a plastic tea strainer directly into a labelled Nunc vial ready for testing
3. Keep the timer going and after 5 minutes, stir twice with a plastic spoon and transfer 5 ml through a plastic tea strainer to another labelled Nunc vial for testing

(2c) Tea Bags – green

1. Add 1 tea bag to an acid clean plastic conical flask
2. Add 250 ml hot (80 ºC) water (deionised, Millipore), leave to brew for 30 seconds, stir twice with a plastic spoon to ensure the tea is uniformly distributed (as indicated by colour), remove 5 ml using a pipette and transfer into a labelled Nunc vial ready for testing
3. Keep the timer going and after 3 minutes, stir twice with a plastic spoon and transfer 5 ml to another labelled Nunc vial for testing

(2d) Loose tea – green

1. Add 2 heaped tsp of tea (weight recorded) to an acid clean plastic conical flask
2. Add 500 ml hot (80 ºC) water (deionised, Millipore), leave to brew covered for 1 minute, stir twice with a plastic spoon to ensure the tea is uniformly distributed (as indicated by colour), remove 5 ml using a pipette and pass through a plastic tea strainer directly into a labelled Nunc vial ready for testing
3. Keep the timer going and after 4 minutes, stir twice with a plastic spoon and transfer 5 ml to another labelled Nunc vial for testing

Product type	Volume of water added	Temperature of water	Brew times	Volume transferred for Pb analysis
(2a) Tea bag black x 1	250 ml	100 ºC	30 sec	5 ml
			3 min	5 ml
(2b) Loose tea black x 3 tsp (weight recorded)	500 ml	100 ºC	2 min	5 ml
			5 min	5 ml
(2c) Tea bag green x 1	250 ml	80 ºC	30 sec	5 ml
			3 min	5 ml
(2d) Loose tea green x 2 tsp	500 ml	80 ºC	1 min	5 ml
			4 min	5 ml

Appendix 2. Other element data – Al, Cr, Ni, Cu, As, and Cd

Trace element QA/QC data obtained for Phase 1 (dry tea leaf analysis)

Certified reference material (n = 8)	mg/kg	Al	Cr	Mn	Ni	Cu	As	Cd
NIES 7	Measured	743	0.13	672	5.64	6.3	0.02	0.025
Tea leaves	Certified	775	0.15	700	6.5	7.00	None	0.030
INCT-OBTL-5	Measured	1963	6.45	189	7.32	9.6	0.76	2.71
Tobacco	Certified	1980	6.30	180	8.5	10.1	0.668	2.64
ZC73013	Measured	537	1.35	38.3	0.80	7.9	0.23	0.15
Spinach	Certified	610	1.40	41	0.92	8.9	0.23	0.15
	LoD	0.1	0.02	0.1	0.2	0.05	0.02	0.001
	LoQ	0.3	0.07	0.3	0.7	0.17	0.07	0.003
	Recovery %	98	103	100	102	102	106	100
	*Measurement uncertainty %	15	25	13	25	15	17	18

MU estimations are based on Fera's performance in proficiency tests, using a coverage factor of 2 (95% confidence level).

* Currently FAPAS do not run proficiency tests for Ni. MU has been estimated as being less than or equal to the worst case value.

Trace element QA/QC data obtained for Phase 2 (brewed tea liquid analysis)

Certified reference material (n = 4)	µg/L	Al	Cr	Mn	Ni	Cu	As	Cd
ERM - CA010a	Measured	213	50.4	52	49.3	85.8	55.5	0.025
Hard Drinking Water	Certified	208	48.0	48	48.0	none	55.0	none
NIST 1640	Measured	54	40.9	128	27.5	94.3	27.11	25.24
Natural water	Certified	52	38.6	122	27.4	85.2	26.67	22.79
NIST 1643e	Measured	143	21.6	39	59.8	23.6	59.52	7.09
Water	Certified	138	19.9	38	60.89	22.2	58.98	6.41
SLRS4 - 2108825	Measured	54	0.49	4	0.7	2.0	0.70	0.014
riverine water	Certified	54	0.33	3.37	0.67	1.81	0.68	0.012
	LoD	5	0.1	1	0.2	0.1	0.01	0.005
	LoQ	17	0.3	3	0.7	0.3	0.03	0.017
	Recovery %	107	108	111	105	103	102	101
	Measurement uncertainty %	15	25	13	25*	15	17	18

MU estimations are based on Fera's performance in proficiency tests, using a coverage factor of 2 (95% confidence level).

* Currently FAPAS do not run proficiency tests for Ni. MU has been estimated as being less than or equal to the worst case value.

FAPAS proficiency testing results obtained during the last 12 months (z-scores)

Date	Matrix	FAPAS Round	Al	Cr	Mn	Cu	As	Cd
Feb-Mar 14	Vegetable puree	07207						0.7
Mar-May 14	Grapefruit	07210						0.1
Apr-May 14	Milk Powder	07211					-0.7	0.1
Apr-Jun 14	Soft drink	07212		-0.2		-0.2	-0.2	0.2
Jun-Jul 14	Tomato paste	07214						-0.1
July-Sep 14	Infant Formula	07216	0.7	-0.5				
Aug-Sep 14	Powdered rice	07219					-0.1	0.1
Sep-Oct 14	Edible oil	07220				0.0	0.4	
Nov-Dec 14	Wine	07224				-0.2		0.1
Jan-Feb 15	Fruit juice	07227						0.6

Ni is not part of the FAPAS testing scheme

Interpretation of z-scores:

With a normal distribution, statistically approximately 95% of z-scores will be in the 'satisfactory' range of $-2 \leq z \leq 2$. Whilst z-scores outside this range are to be expected, (1 in 20), these are deemed 'questionable' and further investigation is required as part of our quality procedures.

Variability in dry black tea leaves from 10 tea bags in a single pack mg/kg

Fera LIMS code	Type	Packaging	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010592a	Black	Tea bag 1	1246	5.05	1446	4.6	12.1	0.03	0.031
S14-010592a			1099	4.50	1372	4.3	11.9	0.03	0.032
S14-010592b	Black	Tea bag 2	1129	4.41	1406	4.5	12.2	0.03	0.031
S14-010592b			1114	5.24	1339	4.3	12.3	0.03	0.031
S14-010592c	Black	Tea bag 3	1284	4.38	1493	4.4	12.4	0.03	0.031
S14-010592c			1115	4.08	1369	4.2	11.9	0.03	0.030
S14-010592d	Black	Tea bag 4	1294	4.22	1483	4.3	12.0	0.03	0.030
S14-010592d			1104	4.67	1363	4.4	12.2	0.04	0.033
S14-010592e	Black	Tea bag 5	1132	4.54	1403	4.5	12.4	0.04	0.032
S14-010592e			1127	4.01	1354	4.2	12.1	0.03	0.031
S14-010592f	Black	Tea bag 6	1078	4.01	1370	4.3	12.1	0.03	0.034
S14-010592f			1155	4.37	1439	4.3	12.2	0.03	0.033
S14-010592g	Black	Tea bag 7	1122	4.36	1319	4.4	12.3	0.03	0.033
S14-010592g			1269	4.36	1520	4.3	12.2	0.03	0.031
S14-010592h	Black	Tea bag 8	1227	5.36	1479	4.5	12.0	0.04	0.030
S14-010592h			1075	4.50	1299	4.3	12.2	0.03	0.030
S14-010592i	Black	Tea bag 9	1082	4.70	1344	4.4	12.4	0.03	0.031
S14-010592i			1091	4.27	1352	4.2	12.0	0.03	0.033
S14-010592j	Black	Tea bag 10	1124	4.61	1367	4.2	11.6	0.03	0.032
S14-010592j			1094	4.60	1370	4.3	12.0	0.03	0.032
		mean	**1148**	**4.51**	**1394**	**4.3**	**12.1**	**0.03**	**0.031**
		RSD %	**6**	**8**	**4**	**3**	**2**	**10**	**3**

Variability in dry green tea leaves from 10 tea bags in a single pack mg/kg

Fera LIMS code	Type	Packaging	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010561	Green	Tea bag 1	1584	0.37	550	1.3	12.0	0.03	0.020
S14-010561	Green	Tea bag 2	1645	0.29	533	1.2	11.9	0.03	0.023
S14-010561	Green	Tea bag 3	1708	0.30	556	1.2	11.3	0.04	0.017
S14-010561	Green	Tea bag 4	1601	0.28	558	1.1	12.0	0.03	0.017
S14-010561	Green	Tea bag 5	1653	0.29	584	1.2	12.0	0.03	0.017
S14-010561	Green	Tea bag 6	1723	0.27	556	1.2	12.5	0.03	0.018
S14-010561	Green	Tea bag 7	1716	0.30	587	1.2	12.4	0.03	0.016
S14-010561	Green	Tea bag 8	1704	0.28	587	1.2	12.4	0.03	0.023
S14-010561	Green	Tea bag 9	1626	0.29	527	1.1	11.8	0.03	0.021
S14-010561	Green	Tea bag 10	1489	0.30	524	1.2	11.6	0.03	0.017
		mean	**1645**	**0.30**	**556**	**1.2**	**12.0**	**0.03**	**0.019**
		RSD %	**4**	**10**	**4**	**4**	**3**	**8**	**15**

Element concentrations in 51 dry tea samples mg/kg

LIMS	Description	Region/Country of Origin	Type	Packaging	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010546	Assam tea	India	Black	Bag	764	22.24	750	8.87	15.5	~0.04	0.035
S14-010550	Blended tea	Not stated	Black	Bag	1499	3.75	1006	3.53	13.8	~0.04	0.020
S14-010552	Every day tea	East Africa/India/Sri Lanka	Black	Bag	675	3.76	780	4.26	12.8	~0.03	0.020
S14-010811	Ceylon tea	Sri Lanka	Black	Bag	1101	0.41	681	5.90	18.5	<0.02	0.010
S14-010740	Strong tea	Not stated	Black	Bag	1416	3.30	868	3.76	15.4	~0.04	0.017
S14-010647	Extra Strong tea	Not stated	Black	Bag	815	10.65	841	5.78	13.2	0.07	0.025
S14-010556	Rich tea	Not stated	Black	Bag	722	4.40	436	5.30	12.1	~0.05	0.015
S14-010584	Strong tea	Not stated	Black	Bag	1031	4.37	1264	4.63	12.0	~0.04	0.024
S14-010592	Tea	Not stated	Black	Bag	1079	3.83	1164	4.67	11.4	~0.03	0.030
S14-010593	Decaffeinated tea	Not stated	Black	Bag	1300	4.09	1292	4.88	13.1	~0.03	0.022
S14-010724	Decaffeinated tea	Not stated	Black	Bag	1514	6.37	1467	5.11	10.8	~0.04	0.026
S14-010725	Regular tea	Not stated	Black	Bag	1201	4.95	1402	4.36	11.8	~0.04	0.031
S14-010727	Fresh tea	Not stated	Black	Bag	801	1.75	1525	5.87	11.0	~0.04	0.033
S14-010766	Mellow tea	Not stated	Black	Bag	1087	4.25	1909	4.82	12.1	~0.05	0.043
S14-010583	English breakfast tea	Not stated	Black	Bag	1004	4.10	868	4.06	12.2	~0.03	0.025
S14-010776	Every day tea	Not stated	Black	Bag	1785	4.54	1135	4.36	11.4	~0.02	0.008
S14-010729	Tea	Not stated	Black	Bag	620	2.76	839	4.09	13.0	~0.02	0.026
S14-010548	Estate tea	Kenya	Black	Bag	592	1.50	754	4.17	14.5	~0.02	0.015
S14-010554	Decaffeinated tea	Not stated	Black	Bag	1326	7.06	1153	5.01	13.1	~0.05	0.029
S14-010589	Blended tea	Africa/Asia/Assam	Black	Bag	1357	5.49	921	4.32	14.3	~0.06	0.035
S14-010590	Tea	Africa/Assam	Black	Bag	1309	5.13	1382	5.18	12.8	~0.05	0.035
S14-010731	Tea	Not stated	Black	Bag	1336	7.44	1232	4.84	12.9	~0.04	0.027
S14-010732	Extra strong tea	Not stated	Black	Bag	872	3.52	871	4.73	15.1	~0.03	0.036
S14-010557	Earl Grey tea	Not stated	Black	Bag	1299	3.42	719	3.96	12.2	~0.03	0.015
S14-010591	Every day tea	China	Black	Bag	1102	3.68	872	4.51	15.0	~0.06	0.019
S14-010549	Tea	Assam/East Africa	Black	Bag	534	3.17	573	4.86	14.0	~0.02	0.016
S14-010553	Tea for hard water	Not stated	Black	Bag	833	4.46	754	4.60	12.4	~0.04	0.019

Element concentrations in 51 dry tea samples mg/kg

LIMS	Description	Region/Country of Origin	Type	Packaging	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010683	Tea	Not stated	Black	Bag	914	4.48	1081	4.64	11.9	~0.04	0.026
S14-010582	Tea	Not stated	Black	Loose	1218	4.32	1668	4.80	12.2	~0.03	0.039
S14-010544	Tea	Not stated	Black	Loose	911	3.96	1507	4.61	11.9	~0.03	0.033
S14-010726	Tea	Not stated	Black	Loose	937	4.46	1678	5.45	11.0	~0.04	0.036
S14-010730	Tea	Not stated	Black	Loose	961	3.73	1074	5.66	12.2	~0.02	0.022
S14-010779	Earl Grey tea	Not stated	Black	Loose	897	0.32	453	4.72	18.2	<0.02	0.014
S14-010545	Assam tea	India	Black	Loose	688	11.68	709	7.92	15.0	~0.03	0.030
S14-010735	English breakfast tea	Not stated	Black	Loose	1171	0.46	202	4.11	25.3	~0.03	0.027
S14-010736	Earl Grey tea	Not stated	Black	Loose	1131	0.42	643	5.02	19.0	~0.05	0.048
S14-010551	tea	Not stated	Black	Loose	845	5.23	844	4.94	12.4	~0.03	0.021
S14-010758	Breakfast Earl Grey tea	Not stated	Black	Loose	1201	0.49	935	2.56	21.8	~0.05	0.018
S14-010760	English breakfast tea	Not stated	Black	Loose	1198	0.24	799	1.55	20.3	~0.04	0.009
S14-010587	Every day tea	Not stated	Black	Loose	912	5.64	1074	5.01	12.9	~0.04	0.025
S14-010588	tea	Not stated	Black	Loose	902	1.36	453	4.06	24.4	~0.03	0.041
S14-010597	English breakfast tea	Not stated	Black	Loose	713	0.68	488	4.96	16.6	<0.02	0.012
S14-010806	Organic green tea	Japan	Green	Loose	948	0.42	906	3.85	8.8	0.09	0.036
S14-010656	Green tea	Not stated	Green	Bag	2991	2.15	1519	4.33	17.8	0.15	0.057
S14-010649	Green tea	Not stated	Green	Bag	2750	0.68	1245	6.30	23.5	0.34	0.092
S14-010560	Green tea	Not stated	Green	Bag	1357	1.77	1344	3.10	11.3	~0.04	0.035
S14-010561	Lemon green tea	Not stated	Green	Bag	1635	0.40	540	0.85	12.4	~0.03	0.021
S14-010701	Sencha green tea	China	Green	Loose	1631	0.62	1389	4.82	11.2	0.11	0.050
S14-010547	Decaffeinated green tea	Asia	Green	Bag	2966	1.01	1201	3.44	18.8	0.14	0.063
S14-010733	Green tea	Not stated	Green	Bag	1124	1.34	1045	4.64	13.3	0.07	0.040
S14-010734	Lemon green tea	Not stated	Green	Bag	1609	1.01	1130	3.86	13.3	0.11	0.054

Element concentrations in 11 dry tea samples from different tea growing regions mg/kg

LIMS	Description	Region/Country of origin	Type	Packaging	Al	Cr	Mn	Ni	Cu	As	Cd
S14-054418	Organic white tea	China	Black	Bag	1967	0.37	1513	6.02	13.4	0.08	0.093
S14-054420	Lapsang Souchong tea	China	Black	Bag	1695	0.81	807	7.53	26.6	0.16	0.100
S14-054424	Jasmine tea	China	Black	Loose	704	0.92	772	6.86	15.9	0.13	0.109
S14-054419	Oolong green tea	China	Green	Bag	1581	0.27	2151	1.39	7.9	0.10	0.039
S14-054427	Gunpowder green tea	China	Green	Loose	847	0.33	985	3.37	12.4	0.12	0.050
S14-054417	Chinese green tea	China	Green	Loose	518	0.42	739	7.22	15.3	0.09	0.046
S14-054423	Darjeeling tea	India	Black	Loose	541	0.23	321	5.43	16.5	~0.03	0.005
S14-054426	Assam tea	India	Black	Bag	636	4.32	702	4.34	15.1	~0.03	0.028
S14-054425	Sencha tea	Japan	Green	Loose	590	0.13	686	5.42	6.3	~0.02	0.019
S14-054422	Kenyan tea	Kenya	Black	Bag	486	1.69	730	3.46	16.2	<0.02	0.018
S14-054421	Ceylon tea	Sri Lanka	Black	Bag	919	0.41	268	4.28	26.6	<0.02	0.018

Element concentrations in brewed tea µg/L

Fera Code	Description	Region/Country of origin	Type	Packaging	Brew time	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010546	Assam tea	India	Black	bag	30 sec	1649	4.2	1523	20	28	0.05	0.026
S14-010546	Assam tea	India	Black	bag	3 min	2873	252.4	2935	186	30	0.27	0.087
S14-010776	Every day tea	Not stated	Black	bag	30 sec	1630	5.8	849	10	11	<0.01	~0.006
S14-010776	Every day tea	Not stated	Black	bag	3 min	6509	22.5	3539	38	28	~0.02	~0.015
S14-010589	Blended tea	Africa/Asia/Assam	Black	bag	30 sec	2749	5.7	1419	17	32	0.09	0.026
S14-010589	Blended tea	Africa/Asia/Assam	Black	bag	3 min	5104	10.6	2729	33	39	0.24	0.032
S14-010811	Ceylon tea	Sri Lanka	Black	bag	30 sec	5993	2.6	2751	66	86	0.08	~0.015
S14-010811	Ceylon tea	Sri Lanka	Black	bag	3 min	6918	2.9	3222	76	84	0.09	~0.016
S14-010550	Blended tea	Not stated	Black	bag	30 sec	3234	3.4	1664	16	29	0.03	~0.016
S14-010550	Blended tea	Not stated	Black	bag	3 min	5757	6.4	3228	31	38	0.07	0.028
S14-010724	Decaffeinated tea	Not stated	Black	bag	30 sec	4313	4.1	2898	25	28	~0.03	0.025
S14-010724	Decaffeinated tea	Not stated	Black	bag	3 min	7287	7.1	5817	46	34	0.06	0.037
S14-010554	Decaffeinated tea	Not stated	Black	bag	30 sec	3299	3.6	2032	22	20	0.05	0.024
S14-010554	Decaffeinated tea	Not stated	Black	bag	3 min	5798	6.6	4134	42	27	0.11	0.039
S14-010593	Decaffeinated tea	Not stated	Black	bag	30 sec	2677	3.0	1971	21	24	~0.02	~0.014
S14-010593	Decaffeinated tea	Not stated	Black	bag	3 min	5972	7.0	5073	52	40	0.06	0.032

Element concentrations in brewed tea µg/L

Fera Code	Description	Region/Country of origin	Type	Packaging	Brew time	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010557	Earl Grey tea	Not stated	Black	bag	30 sec	3196	2.9	1408	15	32	~0.02	~0.015
S14-010557	Earl Grey tea	Not stated	Black	bag	3 min	4626	4.4	2228	23	38	0.04	0.021
S14-010731	Tea	Not stated	Black	bag	30 sec	1890	3.4	1371	11	17	~0.02	~0.015
S14-010731	Tea	Not stated	Black	bag	3 min	5247	9.5	3980	33	32	0.05	0.040
S14-010597	English breakfast	Not stated	Black	bag	30 sec	2262	2.2	1301	41	31	0.05	0.027
S14-010597	English breakfast	Not stated	Black	bag	3 min	2921	2.8	1927	57	34	0.05	0.036
S14-010548	Estate tea	Kenya	Black	bag	30 sec	1972	2.0	3125	26	38	0.03	0.018
S14-010548	Estate tea	Kenya	Black	bag	3 min	1430	1.6	2625	21	23	0.04	~0.017
S14-010591	Every day tea	China	Black	bag	30 sec	2797	4.4	1854	20	34	0.08	~0.010
S14-010591	Every day tea	China	Black	bag	3 min	4102	6.6	2846	28	34	0.15	~0.014
S14-010552	Every day tea	East Africa/India/Sri Lanka	Black	bag	30 sec	502	0.5	615	8	11	<0.01	~0.017
S14-010552	Every day tea	East Africa/India/Sri Lanka	Black	bag	3 min	1216	1.4	1700	16	17	~0.03	0.019
S14-010732	Extra strong tea	Not stated	Black	bag	30 sec	1951	3.6	1978	22	36	~0.02	0.030
S14-010732	Extra strong tea	Not stated	Black	bag	3 min	3490	6.6	3914	42	46	0.08	0.065
S14-010647	Extra Strong tea	Not stated	Black	bag	30 sec	2262	3.6	2322	21	31	0.16	0.029
S14-010647	Extra Strong tea	Not stated	Black	bag	3 min	3276	5.4	3812	35	35	0.23	0.043
S14-010729	Tea	Not stated	Black	bag	30 sec	1698	1.7	2178	20	34	0.03	0.034
S14-010729	Tea	Not stated	Black	bag	3 min	2719	3.0	4135	36	40	0.04	0.053
S14-010549	Tea	Assam/East Africa	Black	bag	30 sec	807	0.7	864	13	19	~0.01	~0.011
S14-010549	Tea	Assam/East Africa	Black	bag	3 min	1428	1.5	1875	24	23	0.03	0.018
S14-010725	Regular tea	Not stated	Black	bag	30 sec	3397	3.5	3081	21	31	0.03	0.031
S14-010725	Regular tea	Not stated	Black	bag	3 min	5831	6.8	6044	45	43	0.06	0.063
S14-010740	Strong tea	Not stated	Black	bag	30 sec	3277	3.1	1539	16	34	0.04	~0.012
S14-010740	Strong tea	Not stated	Black	bag	3 min	6265	5.9	3529	32	44	0.07	0.022
S14-010583	English breakfast	Not stated	Black	bag	30 sec	2428	2.3	1841	17	32	0.03	0.022
S14-010583	English breakfast	Not stated	Black	bag	3 min	4530	37.3	3823	48	31	0.10	0.034
S14-010590	Tea	Africa/Assam	Black	bag	30 sec	3255	3.6	2583	19	32	~0.03	0.022
S14-010590	Tea	Africa/Assam	Black	bag	3 min	5701	6.8	5179	41	46	0.05	0.052
S14-010592	Tea	Not stated	Black	bag	30 sec	2834	9.6	2293	20	26	~0.03	0.020
S14-010592	Tea	Not stated	Black	bag	3 min	5034	5.7	4796	38	38	0.04	0.047

Element concentrations in brewed tea µg/L

Fera Code	Brand	Region/Country of origin	Type	Packaging	Brew time	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010683	Tea	Not stated	Black	bag	30 sec	2219	3.1	2260	20	28	~0.03	0.020
S14-010683	Tea	Not stated	Black	bag	3 min	3467	5.4	3697	35	36	0.06	0.046
S14-010553	Tea for hard water	Not stated	Black	bag	30 sec	1450	1.8	1119	14	18	~0.01	~0.013
S14-010553	Tea for hard water	Not stated	Black	bag	3 min	2672	3.6	2216	24	25	0.03	0.017
S14-010727	Fresh tea	Not stated	Black	bag	30 sec	3462	4.0	5020	26	40	0.03	0.039
S14-010727	Fresh tea	Not stated	Black	bag	3 min	4730	6.2	7894	47	49	0.07	0.071
S14-010766	Mellow tea	Not stated	Black	bag	30 sec	3116	4.0	4102	29	31	0.04	0.035
S14-010766	Mellow tea	Not stated	Black	bag	3 min	4792	6.6	7417	51	38	0.09	0.073
S14-010556	Rich tea	Not stated	Black	bag	30 sec	1403	2.6	1009	25	26	0.03	~0.016
S14-010556	Rich tea	Not stated	Black	bag	3 min	2184	2.2	1923	47	34	0.08	0.025
S14-010584	Strong tea	Not stated	Black	bag	30 sec	2606	3.0	2236	17	26	~0.02	0.018
S14-010584	Strong tea	Not stated	Black	bag	3 min	4634	5.8	4552	31	33	0.05	0.024
S14-010582	Tea	Not stated	Black	loose	2 min	7860	9.9	8985	60	70	0.07	0.080
S14-010582	Tea	Not stated	Black	loose	5 min	8057	10.4	10101	64	63	0.08	0.072
S14-010544	Tea	Not stated	Black	loose	2 min	7034	9.1	9413	58	53	0.08	0.068
S14-010544	Tea	Not stated	Black	loose	5 min	7446	11.2	12383	59	42	0.10	0.078
S14-010726	Tea	Not stated	Black	loose	2 min	5001	5.5	7779	53	44	0.06	0.063
S14-010726	Tea	Not stated	Black	loose	5 min	5079	5.7	8626	56	41	0.09	0.065
S14-010730	Tea	Not stated	Black	loose	2 min	6356	7.4	7682	72	61	0.07	0.042
S14-010730	Tea	Not stated	Black	loose	5 min	6748	7.7	8403	86	56	0.10	0.060
S14-010779	Earl Grey tea	Not stated	Black	loose	2 min	3629	0.6	1215	40	44	0.04	~0.013
S14-010779	Earl Grey tea	Not stated	Black	loose	5 min	4650	29.3	1859	66	44	0.09	0.027
S14-010545	Assam tea	India	Black	loose	2 min	3166	8.7	3070	55	51	0.06	0.045
S14-010545	Assam tea	India	Black	loose	5 min	3640	10.9	4070	68	49	0.09	0.068
S14-010735	English breakfast tea	Not stated	Black	loose	2 min	6188	0.9	813	49	107	0.13	0.034
S14-010735	English breakfast tea	Not stated	Black	loose	5 min	7047	1.1	1066	58	99	0.15	0.035
S14-010736	Earl Grey tea	Not stated	Black	loose	2 min	3618	0.7	1339	32	43	0.24	0.056
S14-010736	Earl Grey tea	Not stated	Black	loose	5 min	4935	0.9	2080	47	47	0.33	0.075
S14-010551	Tea	Not stated	Black	loose	2 min	4244	6.0	4355	52	50	0.06	0.057
S14-010551	Tea	Not stated	Black	loose	5 min	5540	8.6	6709	77	43	0.11	0.059

Element concentrations in brewed tea µg/L

Fera LIMS code	Brand	Region/Country of origin	Type	Packaging	Brew time	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010760	English breakfast	Not stated	Black	loose	2 min	5975	0.8	2801	14	67	0.20	~0.011
S14-010760	English breakfast	Not stated	Black	loose	5 min	6638	0.8	3426	16	67	0.21	~0.016
S14-010758	Breakfast Earl Grey	Not stated	Black	loose	2 min	6762	1.9	3737	27	88	0.31	0.020
S14-010758	Breakfast Earl Grey	Not stated	Black	loose	5 min	7841	2.5	4984	32	85	0.37	0.026
S14-010587	Every day tea	Not stated	Black	loose	2 min	6739	11.6	8123	62	73	0.13	0.063
S14-010587	Every day tea	Not stated	Black	loose	5 min	6898	12.2	9204	71	60	0.13	0.072
S14-010588	tea	Not stated	Black	loose	2 min	4774	1.8	2352	45	106	0.13	0.056
S14-010588	tea	Not stated	Black	loose	5 min	5212	2.1	2895	51	79	0.17	0.070
S14-010656	Green tea	Not stated	Green	bag	2 min	3155	0.7	1227	19	49	0.12	0.030
S14-010656	Green tea	Not stated	Green	bag	5 min	6632	1.5	2488	35	87	0.28	0.046
S14-010649	Green tea	Not stated	Green	bag	30 sec	573	<0.1	198	5	8	0.07	~0.009
S14-010649	Green tea	Not stated	Green	bag	3 min	2685	~0.3	944	24	28	0.36	0.037
S14-010560	Green tea	Not stated	Green	bag	30 sec	1421	0.7	1164	8	18	<0.01	0.017
S14-010560	Green tea	Not stated	Green	bag	3 min	2701	1.3	2201	15	29	~0.02	0.028
S14-010561	Lemon green tea	Not stated	Green	bag	30 sec	1482	~0.1	332	3	17	~0.01	~0.010
S14-010561	Lemon green tea	Not stated	Green	bag	3 min	2745	~0.3	610	5	27	~0.02	0.018
S14-010547	Decaffeinated green	Asia	Green	bag	30 sec	2262	0.4	808	14	40	0.09	0.020
S14-010547	Decaffeinated green	Asia	Green	bag	3 min	5566	1.0	1925	28	79	0.20	0.042
S14-010733	Green tea	Not stated	Green	bag	30 sec	1914	1.4	1444	24	32	0.08	0.033
S14-010733	Green tea	Not stated	Green	bag	3 min	3167	2.4	2509	41	48	0.17	0.046
S14-010734	Lemon green tea	Not stated	Green	bag	30 sec	1901	1.3	1114	17	25	0.10	0.025
S14-010734	Lemon green tea	Not stated	Green	bag	3 min	3512	2.1	1908	29	41	0.17	0.040
S14-010806	Organic green tea	Japan	Green	loose	1 min	1900	0.4	1436	24	11	0.19	0.025
S14-010806	Organic green tea	Japan	Green	loose	4 min	3386	0.5	2482	37	18	0.40	0.047
S14-010701	Sencha green tea	China	Green	loose	1 min	1812	0.3	883	17	15	0.19	0.037
S14-010701	Sencha green tea	China	Green	loose	4 min	3191	0.4	1399	30	23	0.32	0.045

Phase 2 preliminary study - Elements concentrations in tea steeped with deionised v tap water µg/L

Water	Fera LIMS code	Description	Type	Packaging	Al	Cr	Mn	Ni	Cu	As	Cd
Deionised	S14-010591	Every day	Black	bag	618	11.2	464	46	50	<0.4	<0.05
Deionised	S14-010591	Every day	Black	bag	464	6.2	328	30	34	<0.4	<0.05
Deionised	S14-010591	Every day	Black	bag	541	8.0	403	40	41	<0.4	<0.05
Deionised	Procedural blank				<5	<0.1	<1	<3	<2	<0.4	<0.05
Deionised	S14-010649	Green tea	Green	bag	518	<0.1	166	37	65	~0.5	~0.06
Deionised	S14-010649	Green tea	Green	bag	481	2.4	167	39	55	~0.7	<0.05
Deionised	S14-010649	Green tea	Green	bag	528	4.3	176	51	68	~0.6	<0.05
Deionised	Procedural blank				<5	<0.1	<1	~6	~7	<0.4	<0.05
Tap	S14-010591	Every day	Black	bag	285	11.7	238	43	79	<0.4	<0.05
Tap	S14-010591	Every day	Black	bag	568	10.1	471	47	101	<0.4	<0.05
Tap	S14-010591	Every day	Black	bag	443	7.2	365	36	363	~0.4	<0.05
Tap	Procedural blank				<5	<0.1	<1	<3	21	<0.4	<0.05
Tap	S14-010649	Green tea	Green	bag	436	<0.1	197	39	196	~0.8	~0.07
Tap	S14-010649	Green tea	Green	bag	390	0.8	182	32	177	~0.9	<0.05
Tap	S14-010649	Green tea	Green	bag	525	<0.1	232	45	106	~1.1	~0.09
Tap	Procedural blank				~7	~0.2	<1	<3	129	<0.4	<0.05
				LoD	5	2	1	3	2	0.4	0.05
				LoQ	17	7	3	10	7	1.3	0.17

Phase 2 preliminary study - Migration of elements following longer brewing times µg/L

Fera LIMS code	Description	Type	Packaging	Brew time	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010548	Estate tea	Black	bag	**15 sec**	1091	1.1	1704	15.8	27.1	~0.02	0.018
S14-010548	Estate tea	Black	bag	**1 min**	1419	1.6	2513	22.2	30.9	0.03	0.025
S14-010548	Estate tea	Black	bag	**2 min**	1739	2.1	3335	30.0	34.4	0.04	0.029
S14-010548	Estate tea	Black	bag	**5 min**	1847	2.3	3897	34.0	33.2	0.04	0.039
S14-010548	Estate tea	Black	bag	**10 min**	1835	2.4	4268	34.8	30.8	0.06	0.035
S14-010548	Estate tea	Black	bag	**20 min**	1819	2.5	4567	37.1	30.4	0.05	0.039
S14-010553	Tea for hard water	Black	bag	**15 sec**	1941	3.1	1518	17.3	28.2	~0.02	0.020
S14-010553	Tea for hard water	Black	bag	**1 min**	3127	4.5	2596	29.7	38.8	~0.03	0.031
S14-010553	Tea for hard water	Black	bag	**2 min**	3716	5.5	3353	38.2	41.3	0.05	0.043
S14-010553	Tea for hard water	Black	bag	**5 min**	3928	6.1	3851	42.0	41.0	0.06	0.042
S14-010553	Tea for hard water	Black	bag	**10 min**	4029	6.4	4188	45.4	39.2	0.06	0.051
S14-010553	Tea for hard water	Black	bag	**20 min**	3760	6.3	4312	45.0	35.1	0.07	0.040

Phase 2 preliminary study - Element concentrations in re-steeped tea µg/L

Fera LIMS code	Description	Type	Packaging	Brew	Al	Cr	Mn	Ni	Cu	As	Cd
S14-010806	Organic green tea	Green	loose	**1st infusion**	3586	0.5	2861	42.6	19.6	0.46	0.068
S14-010806	Organic green tea	Green	loose	**2nd infusion**	731	~0.1	477	6.8	5.8	0.09	~0.013
S14-010760	English Breakfast tea	Black	loose	**1st infusion**	6249	0.8	3392	14.8	70.2	0.18	~0.015
S14-010760	English Breakfast tea	Black	loose	**2nd infusion**	720	~0.1	695	2.6	16.7	0.04	<0.005