Guide for Lead-Adulterated Spice Identification and Tracking

Source: Splendidtable.org

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Overview:

Food adulteration occurs when a food product is falsified, usually by adding artificial substances to augment the quantity or the perceived quality of the product for economic gains. Spices are among the five most commonly adulterated foods. Spices are easy to adulterate because they are often sold in their ground, powdered form, so the addition of non-spice powders may be easy to conceal. Spices may be adulterated with benign, non-toxic powders intended to add quantity (e.g., grain flour) that compromise the potency and effectiveness of the spice for culinary purposes but pose no health threat. Other adulterants, however, such as the addition of dyes to enhance the color of spices, may be highly toxic (e.g., lead chromate or lead oxide powder).

The purpose of this document is to provide guidance for governmental, non-governmental, and research organizations interested in assessing adulterated spices in a country, specifically spices adulterated with toxic lead-containing compounds. There are two objectives: i) to assess the scope of the problem of adulterated spices by designing and conducting national spice sampling and testing, and ii) to understand the incentives for adulteration and the primary actors responsible for adulteration once the scope of the problem has been established. This document has been developed based on first-hand experience with the identification and tracking of adulterated spices in Bangladesh, India, and the Republic of Georgia.

This document assumes that prior data has been collected or studies have been published that indicate that adulterated spices are a likely source of lead exposure in the focal country and that such data can be used to narrow the candidate spices of concern. Relevant data, in order of importance, may include: i) population-based lead exposure studies that link certain spices to a greater likelihood of lead exposure among a large cohort of people, ii) clinical lead poisoning cases that indicate that certain spices are the most likely contributor to the individual's lead poisoning, iii) studies indicating that certain spices have higher lead levels than others, and iv) international food safety recalls that indicate elevated lead concentrations among certain spices from a certain country of origin. While there is no "safe" limit for lead in spices, >2.5-10ppm lead is considered a threshold of concern in South Asia. Human consumption patterns, nutritional status, and the type of lead compound and its bioaccessibility all impact the extent to which the lead content of a spice results in lead poisoning. Publicly available data from the New York City Department of Health and Mental Hygiene, along with food recall history, all suggest that spices originating from Georgia, Bangladesh, Pakistan, Nepal, Morocco, and India, may pose a concern.

Objective 1: Assess the scope of the problem of adulterated spices by designing and implementing a national spice sampling and testing program

See Appendix A for an example from recent testing in Georgia.

Step 1. What: Determining which Spices to Sample and Test

Determining which spices to sample and test involves of a consideration of the spice variety (e.g., marigold, turmeric, chili) and the form the spice is sold in (e.g., packaged, branded or unbranded, or loose, powdered or whole spice). For efficiency, the spice types and forms with the highest likelihood of adulteration should be sampled and screened first. Depending on the lead concentration results from those high-risk spices, further sampling can be done to expand the effort to moderate or lower risk spices. For example, in India, the evidence available suggests that loose turmeric (powder and whole dried roots) have far greater likelihood of containing excessively high lead levels than chili powder, with maximum lead levels 5-10 times greater for

turmeric. Therefore, our team decided that for our initial screen to assess the scope of the problem, we would only sample turmeric at a national level. Based on those results, we could decide if sampling chili would make sense in those geographic regions where lead-tainted turmeric posed a threat. This reduced our sampling costs in half and the turmeric data indicated that one state in India, not the entire country, should be the focus for turmeric and other spice adulteration.

Spice variety: Sampling every type of spice available would be very expensive and cumbersome, often cost-prohibitive and simply not worth the effort. Determining which spices to sample should start with a review of data collected from population-based studies, clinical data, international recalls, national food safety data (if the country performs routine testing), and other studies. The New York City Department of Health and Mental Hygiene, along with food recall history, indicate that marigold and marigold-containing spices, followed by turmeric are the spices of most concern for excessive lead levels. These spices, with their yellow hue, are most commonly adulterated with yellow dyes like lead chromate. Additional, less robust data have indicated that chili powders may be adulterated with red dyes like lead oxide.

Spice form: "Spice form" refers to how the spice is sold (branded, packaged, or loose) and if it is processed (whole spice or processed spice). Most often, loose processed spices have the highest likelihood of adulteration. To the extent possible, sample loose spice at every stage of processing (e.g., most spices have a whole fresh, whole dried, and powdered form). This aids in the determination of when adulteration occurs. Once the spice variety has been decided, some basic research into the processing steps for that specific spice and visits to local markets can help in deciding which forms are most commonly sold for retail and wholesale. In the case of turmeric, it is a root that undergoes several processing stages: drying, polishing, and grinding. Turmeric roots are commonly sold to the public in retail markets as loose powder. For wholesale, however, loose turmeric that is dried and/or polished but still whole is the most typical form. Fresh turmeric roots that are neither dried nor polished are available at very few wholesale or retail markets. Therefore, sampling fresh root (if available), dried root, polished root, and ground powder and subsequently testing for lead and chromium concentrations allows for the best insights. For example, from this sampling we determined that fresh and dried roots are lead-free, but that lead chromate is evident in polished roots and powder. Further research was still needed to determine if lead chromate was added only to polished roots or also to powder, but this sampling technique clarified which forms of turmeric were safe.

Deciding whether or not to sample packaged and branded spices may be informed by budget, context, and goals. If budget is unlimited, sampling branded spices can be useful. When sampling branded spices, it is only necessary to sample from each available brand once at first (or if more than once, check to be sure the lot numbers differ). If budget is limited but packaged/branded spices are the most common form of spice sold and purchased by local people, then sampling these is important. Often, in lower income countries where adulteration is common, packaged/branded spices are not purchased by the majority of the population. Rather, they are only affordable to the small population of high-income individuals. If budget is limited but there is one or two nationally-renowned brands selling spices for the domestic and/or export market, sampling this/these brands can be advantageous when working toward solutions. For example, if a top brand is selling lead-tainted spices (especially if these spices are being exported), this can create such a scandal and put pressure on the company to clean up its act. This occurred in Bangladesh. After finding that the top national brand was selling lead-tainted turmeric to both the local domestic market and internationally, the outcry was so huge that this company purchased an inductively-coupled plasma mass spectrometer (ICP-MS) to detect lead and ensure that adulterated spices do not enter their supply chain. Although this was helpful for those who could

afford the branded turmeric, the loose turmeric market continued to sell lead chromate-adulterated spice. Sometimes, a company will recover from a product adulteration scandal by becoming an ally and working to improve the entire supply chain (not just their specific suppliers) and lower the risk of adulteration for all.

Step 2. "Where": Defining the Sampling Frame

Once a decision made about which type of spice and which form of spice will be sampled, decisions need to be made about where spice sampling will take place (the sampling frame).

The question of "where" has two levels: first, where in the country should sampling occur, and second at what establishments should sampling occur.

Step 2a) Where in the country (geographic unit):
If distribution and sale patterns are known to be geographically variable, choose regions that would maximize the variety of spice origins sampled and that represent as complete of a picture as possible without redundancies. Our initial work in Bangladesh indicated that of all 60+ districts in Bangladesh, 9 districts produced more than half of the nation's turmeric and one wholesale market represented turmeric from all different regions of the country. Therefore, rather than sampling from all 60+ districts and attempting an overly complicated nationally representative sampling scheme, we focused our efforts on the 9 districts and wholesale markets that sold all turmeric varieties.

If distribution and sale patterns are not known in the focal country, then choose as few cities/districts to sample from that capture geographic diversity and are most populous. This may result in sampling redundancies (e.g., spices of the same origin being sampled multiple times), but will provide the best picture of the scope of the problem for most people, and will also highlight if there are geographic areas of concern. We followed this approach in Georgia, selecting the most populous city/cities across all 9 administrative regions to be the geographic unit of focus.

Step 2b) Which establishments to sample from (sampling unit):
Possible options include: point of retail sale, point of wholesale, point of processing, and point of production. The decision about where to sample, like most decisions, has multiple considerations including budget and background knowledge about the adulteration problem and spice distribution patterns. For the initial stage, points of retail/wholesale are the recommended best places to start. If possible, sampling only from points of wholesale would be most efficient since any spice sold wholesale would also be sold at retail and therefore sampling both markets would be duplicative.

Some formative research should be conducted with key stakeholders knowledgeable about the distribution of the spices of concern to identify the key retail and wholesale markets to sample from. If information is not available, sampling from the largest retail and wholesale markets in each of the selected geographic units would be advisable.

Step 3. "How": Defining the Sampling Strategy

Based on step 2 above, a decision needs to be made about which establishments will be the sampling unit in order to proceed to step 3. Since markets (informal markets/bazaars) typically sell loose spices they are often the best place to do initial sampling. This discussion will assume these markets are the sampling unit.

The best strategy for sampling spices from markets will depend on budget and background knowledge, but we recommend maximizing variation in spice origins/processing to provide the most information most efficiently. At an informal market or bazaar, one must decide which vendors to sample from. The strategy can be probability-based (e.g., systematic or random), or non-probability-based (e.g., convenience or purposive).

Probability-based sampling is often more complicated than necessary when screening spices for adulteration to understand the scope of the problem. Random sampling and systematic sampling would require listing of all vendors at the market, and then randomly choosing or choosing every "nth" vendor, for example, where "n" is decided based on the likely total number of vendors.

Non-probability convenience sampling is typically not advisable since, as the name implies, it involves sampling based on convenience only (e.g., sampling from the first vendor at the front of the market).

Non-probability purposive sampling (e.g., maximum variation sampling) is the approach we recommend and have followed in Georgia, Bangladesh, and India. In purposive/maximum variation sampling, the goal would be to visit as many vendors as needed to purchase spices that represent maximal diversity in spice origin and processing. Duplicate samples of spices from the same producer that have undergone processing by the same individuals should be minimized as they would be redundant. Therefore, some initial formative work should be done at each market to ask vendors about who they source from and to identify those spices of different sources.

Step 4. Sample Data Collection

When collecting each spice sample, inquire about and record basic information about each sample (see Appendix B). Such information may vary based on the sub-objectives and interests, but the following information is recommended at a minimum:

- Geographic unit (region/district/city)
- Market name
- Market size (e.g., number of spice-selling vendors)
- Vendor information (name/ contact information, often provided on a receipt, for follow-up questions in case samples from that vendor are found to contain lead)
- Sample ID (unique to every sample, develop a ID code system *a priori*)
- Sample date
- Spice name/variety (e.g., turmeric or utsko suneli)
- Spice form (e.g., loose powdered, loose whole dried root/flower, packaged powdered, etc.)
- Selling price per kg
- Source information (location of production, harvest year, location of processing, names of organizations or entities involved with production or processing)

For the national sampling, asking few questions is helpful so as to not raise suspicion. It also makes sampling quicker, which is often advantageous since vendors may be busy. To the extent possible, determine when the market is least busy and plan to collect samples during those quiet periods. However, do not be discouraged if vendors are not willing or able to answer questions about sourcing. Once the lead results are known, those questions can be targeted to only those vendors involved in the sale of lead-tainted spices.

Additionally, to reduce suspicion among vendors, it is advantageous to deploy several individuals as sample collectors instead of relying only on one person. If one person goes to many vendors to

purchase spices and ask questions, vendors may start to get suspicious. Although this type of research may not require human subjects approval, it is advisable to prepare a pre-amble or short description of who you are and why you are so interested in buying many spices to dispell rumors.

Step 5. Sample Testing Method(s)

Once samples have been collected, they can be stored in polythene sealable baggies until testing can be performed. Labeling should be done with permanent markers twice on each bag, once with tape and once directly on the bag. Double labeling is recommended because oils from spices can exude and cause labeling to fade, especially if samples are stored more than a few months.

Depending on budget and available testing technology, testing for lead concentrations can be performed via laboratory methods (e.g., inductively-coupled plasma mass spectrometry) or via field methods (e.g., portable x-ray fluorescence analyzers). Inductively-coupled plasma mass spectrometry (ICP-MS) is the gold standard because is give a quantitative measure of metals concentrations but such testing may not be available in every country. Moreover, testing can cost $30 or more per analyte (e.g., some laboratories charge separate fees for testing lead and chromium). Ideally, both lead concentrations and also chromium concentrations would be assessed. Testing for both metals allows for the determination if lead chromate is the likely adulterant since lead and chromium should have roughly a 1:1 molar ratio given that the molecular formula of lead chromate is $PbCrO_4$. Note that the molar mass of is higher for lead than chromium so a 1:1 molar ratio is not the same as 1 ppm lead for every 1 ppm of chromium. Such a molar ratio calculation needs to take the molar masses of lead and chromium into account.

Portable or bench x-ray fluorescence analyzers (XRFs) can provide an excellent semi-quantitative screening method, typically at lower costs per sample and analyte than ICP-MS. The main benefits of using XRF are that there are no costs for consumables per test, minimal training required (no laboratory skills needed), and the results are rapid (within a few minutes). The main drawbacks of using XRF are that the upfront capital cost is high, and the limits of detection are high, especially for chromium, making molar ratios incalculable below ~250 ppm lead. There are also issues measuring lead and arsenic so the analyzer will erroneously report arsenic in the presence of lead even though there is no arsenic. Although not an issue for spices, for any media (such as soil) known to have high lead and arsenic concentrations, XRF would not be a good tool. Even though XRF can be used to measure spice metals concentrations in the field (in the case at the market), we recommend conducting measurements after field sample collection for more accurate measurements and to minimize concern from individuals selling spices at markets. We also recommend screening spices first with XRF then re-analyzing lead-containing spices with ICP-MS to obtain a quantitative measure.

Objective 2: To understand the incentives for adulteration and the primary actors responsible for adulteration once the scope of the problem has been established

Once the sampling and testing results are known, it is possible to determine i) if adulterated spices pose a risk at all in the country, and ii) geographically where the risk of lead-tainted spices is highest. Note that the geographic region where most lead-tainted spices are sold may or may not be the same region where adulteration is taking place.

Follow-up work to understand the supply chain better and to understand the incentives for adulteration, along with the producers, processors, or vendors responsible for adulteration might include the following two steps.

Step 1. Focused spice sampling and testing

Further spice sampling and testing in the geographic region deemed to be highest risk of lead-tainted spices. If the initial sampling and testing focused only on markets, expanding this more focused, the second round of testing should include local producers and processors. Identifying and visiting local producers and processors can be critical to understanding the supply chain as well (as in step 2 below).

It might be necessary to better define the bounds of the geographic region with highest likelihood of lead-tainted spices by dividing the geographic area into smaller units and visiting more cities. For example, in Georgia, from the national sampling, we determined that the Adjara region seemed to be the most likely center of the adulteration problem. Since we had only visited two cities in Adjara in the initial sampling, we sub-divided the region further and sub-selected 8-10 cities to visit and sample from to further understand the lead levels.

Step 2. Conducting semi-structured interviews and observations with key supply chain members.

Use a snowball sampling approach to identify who might be knowledgeable about or responsible for adulteration (see Appendix C for some possible questions to ask). A snowball sampling approach means that you talk with one individual and then from that individual identify who to speak with next. For example, start with the vendor selling the lead-tainted spices and inquire further about that vendor's source of spices and any information about processing and production. Next, visit the producer and processor of that vendor's spices. Many individuals in different roles in the supply chain should be identified and interviewed because not everyone will be a good informant (knowledgeable or willing to speak). To the extent possible, once the point of adulteration is known, spending some time to build rapport with people in that sector can help ensure that the people will be willing to talk about the adulteration issue and the incentives driving it. Spending time with these individuals also opens up the possibility to observe how the adulterant is added.

Because of the sensitive nature of food adulteration, it is usually helpful to avoid asking directly about adding substances to spices. However, it can be helpful to try saying something at the end of an interview that acknowledges awareness about the issue but does not place blame on the individual being interviewed. For example, "We appreciate the high quality of your spices even more than ever because we have learned that some vendors aren't so attentive to quality and sell spices that have been mixed with something else. Do you know anything about this?"

It is helpful to also explore the supply chain of the adulterant (e.g., lead chromate). Where is it being sold? Is its availability driving geographic patterns in adulteration or is some other factor responsible? Would there be ways to restrict the sale of lead chromate or is it a purely informal good? See Appendix C for some ideas about questions to ask.

Once more information is known about who, how, and why spice adulteration is occurring, it is important to move quickly to solutions that will reduce the public health burden. In Bangladesh, it was helpful to first create awareness about the health threat of the adulterant, as that is often not known. Producers, processors, sellers, and consumers were all informed about the threat. Those responsible for adulteration were given an opportunity to change their practices and stop using

lead chromate. Brainstorming sessions were conducted to help them identify new ways of creating a quality spice without adulteration. Then, the government food safety agency conducted its own testing and punished any individuals selling adulterated turmeric.

APPENDIX A: Spice sampling and testing plan for Georgia

1. Overview

The following research questions and sampling strategy focuses only on wholesale/retail spice bazaars in the country. From this data, we can identify who else to target across the supply chain to make the study more complete (see the Bangladesh study as an example). If we expand to make the study more complete, interviews and sampling would include the following: consumers, farmers, grinders, spice packager/companies serving domestic/export markets, lead chromate vendors, lead chromate consumers, government officials (in food safety/chemical management).

2. Research questions

Since numerous cases of lead poisoning have been linked to lead-contaminated spices in Georgia, the goal of this study is to ascertain the current extent of lead contamination in spices obtained from bazaars in each of the 10 administrative regions of Georgia. Here are 4 research questions that we can answer:

1. How do lead concentrations in spice bazaars vary geographically at bazaars across the 10 administrative regions of Georgia?
2. How do lead concentrations vary by spice type and production origin?
3. What is the predominant type of lead in the spices (e.g., lead chromate)?
4. What are marigold-related sourcing patterns at bazaars in each of the regions?

3. Background

The recent limited data suggest the following related to the above research questions:

- spice lead concentrations are higher from bazaars in western Georgia
- lead concentrations are highest in pure marigold or spice mixes containing marigold, and lower for non-marigold-containing spices
- the lead in the spices is lead chromate added mostly to marigold-containing spices for color
- small-scale farms throughout the country primarily supply marigold but price is high and supply is low. It is currently unclear how many wholesale bazaars exist, how many large-scale farms of marigold (if any), and how much marigold is imported from Turkey or other countries (if any)

4. Methods

Sample spices from the bazaars in each of the administrative regions of Georgia.

4.1 Bazaar selection

I propose that we use a "purposive sampling" approach (a non-probability approach to select based on criteria related to geographic spread) and select bazaars in the major cities of each of the 10 administrative regions somewhat proportional to spice sales/production and population. Because this is exploratory, I do not think we need a random nationally representative sample.

Table 1 shows the list of 23 cities to visit and sample from their large bazaar(s). I've listed them here. In each city visit the major wholesale or retail spice bazaar (1 for most cities but more for the larger cities like Tblisi, Batumi, and Kutaisi). 1 Kutaisi wholesale bazaar, 1 in Batumi and 3 in Tblisi: Samgori, Gldani, and Vagzal. I have included the unique 2 letter code for each city below. See how 4 cities text have slightly different 2 letter codes to keep them unique.

1. Batumi (2)* (BA)
2. Kobuleti (15) (KO)
3. Khulo (KH)
4. Ozurgeti (16)* (OZ)

5. Chokhatauri (CH)
6. Zugdidi (6)* (ZU)
7. Poti (7) (PO)
8. Senaki (11) (SE)
9. Abasha (ag trading point) (AB)
10. Kutaisi (3)* (KU)
11. Samtredia (9) (SA)
12. Zestafoni (12) (ZE)
13. Chiatura (18) (CI)
14. Akhaltsikhe (14)* (AK)
15. Tblisi (1)* (TB)
16. (3 wholesale markets)
17. Telavi (13)* (TE)
18. Sighnaghi (SI)
19. Gori (5)* (GO)
20. Khashuri (8) (KA)
21. Mtskheta (28)*(MT)
22. Rustavi (4)* (RU)
23. Marneuli (13) (MA)

Table 1. Administrative regions of Georgia and major cities for spice bazaar sampling. (Cities in grey are those where sampling is complete).

Region	**% children with elev. BLL** (2018, MICS)	**Market with elevated lead levels** (2019, Pure Earth)	**Proposed sampling cities** (rank in population) *=regional capital	**Population of region** (2015, wikipedia)	**Percent of population**
Adjara	85	Y (Batumi and Kobuleti)	Batumi (2)* Kobuleti (15) Khulo	336,077	9.03
Guria	73	-	Ozurgeti (16)* Chokhatauri	113,000	3.04
Samegrelo-Zemo Svaneti	71	-	Zugdidi (6)* Poti (7) Senaki (11) Abasha (included because it is an agricultural trading point)	331,145	8.90
Imereti/Kvemo Svaneti/Racha-lechkhumi	61	N (Kutaisi bazaar ND)	~~Kutaisi (3)*~~ Samtredia (9) Zestafoni (12) Chiatura (18)	518,927	13.95
Samtshke-Javakheti	32	-	Akhaltsikhe (14)*	160,262	4.31
Tblisi	30	N (Deserter's bazaar ND)	Tblisi (1)* (3 wholesale markets)	1,158,700	31.15

Khaketi	25	-	Telavi (13)* Sighnaghi	319,144	8.58
Shida Kartli	21	-	~~Gori (5)*~~ ~~Khashuri (8)~~	264,633	7.11
Mtskheta-Mtianeti	20	-	Mtskheta (28)*	94,370	2.54
Kvemo Kartli	18	-	Rustavi (4)* Marneuli (13)	423,986	11.4

Table 2. Market chain sampling

Market chain name	**City**	**Sampling strategy**
Spar	Tblisi	Only purchase 1 package of each brand of: marigold/zaprana, khmeli suneli, and svanuri marili. No need for duplicates from the same brand. (e.g., 1 package of "SUNELI brand" marigold. Purchase spices in loose form if available.
Carrefour	Tblisi	
Nikora	Tblisi	

4.2 Vendor selection within each bazaar

Within each bazaar, I propose selecting 1 spice vendor to sample from for every 5 spice vendors at the bazaar. Select the vendor by first walking through the bazaar to get an understanding of the overall size of the bazaar and the number of spice vendors. Then sketch a map of the bazaar and number each spice vendor. Randomly select a proportional number of vendors from this list. Keep the map drawing of each bazaar in a notebook. Take a picture of vendor setup and spices for sale.

4.3 Sample collection

- Sample 50 or 100 grams of each type of spice available: loose powder, packaged spices, branded spices, including spice mixes, ground marigold powder and dried marigold petals. If there are multiple buckets of the same spices only sample duplicates if they are marigold or marigold-containing spices. If there are branded packaged spices, only sample 1 of each lot number.
- For each bazaar, keep a sketch of i) number of vendors and their position, ii) type of goods sold by vendors (vegetables, fruits, spices, grains, other).
- Record the following for each spice (see Appendix B for an example):
    - Sample ID – 14 digit code consisting of the following in order:
        - 2 letter abbreviation for city (first two letters of the city name) + 2 letter abbreviation for bazaar name + 2 letter abbreviation for bazaar type (wholesale (WH) or retail (RE)) + 2 numbers for vendor position (e.g., 01) + 2 letter abbreviation for spice type + 4 numbers for date (DDMMYY)
        - The 2 first letters of all but 4 cities are unique. For the following four cities let's modify so each 2 letter code is unique: Khulo keep as "KH", but Khashuri will be "KA." Chokhatauri can be "CH" but Chiatura will be "CI."
        - For the 2 letter abbreviation for spice names, I suggest: (bold are highest priority/necessary, unbolded not necessary)
            - **Marigold/kviteli kvavili/zaprana = MA**
            - **Khmeli suneli = KH**
            - **Svanuri marili = SV**

- **Khatchos suneli = KA**
- **Saffron = SA**
- **Utsko suneli = UT**
- Coriander = CO
- Red pepper = RE
- Curcuma = CU
- Ajika = AJ

- Sample # - start with #1 then 2, 3, 4, etc. for additional samples on the spreadsheet so there is a detailed sample 14 digit sample ID plus a simple number for each sample.
- Date
- Region
- Bazaar name
- Bazaar address
- Vendor number
- Vendor name and/or contact information if willing to be contacted (not necessary)
- Name of spice
- Price per 100 grams (or price per 1 kg, whichever is stated)
- Package type
  - loose
  - packaged but unbranded
  - packaged branded
- Take a picture of the receipt from the vendor (if applicable)
- Take a picture of each sample (to show color if loose spice or label and color if a packaged spice)
- For pure marigold and marigold-containing spice mixes, include the following information
  - True marigold or curcuma
  - Production place
    - Country
    - District (if produced in Georgia)
  - Supplier/packager distributer information
    - Name of person from whom the vendor purchases the product
    - Name of city where supplier is from
    - Form that spice is supplied in – ground or whole spice
  - Grinder information (only for marigold and marigold-containing spices)
    - grinder name
    - city from where grinder is located (if applicable). Collect additional names of spice producers and packagers.

Estimate sampling from ~30 bazaars, ~2 vendors per bazaar on average, and 10 types of spices per vendor for a total of ~600 samples.

4.4 Measurement

- First screen samples for lead levels using XRF
- Arrange for samples with detectable lead to be measured next with AAS
- Retain marigold and marigold-containing samples for possible lead speciation measurement, isotope, and/or curcumin measurement

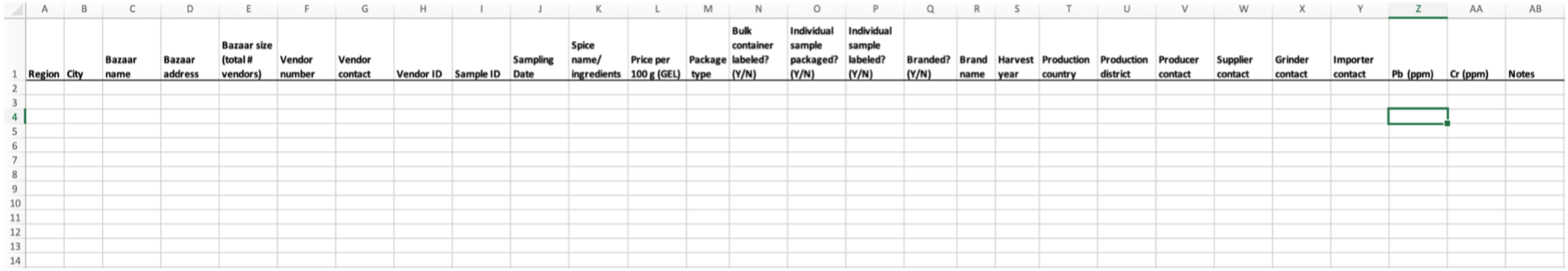
4.5 Analysis

- Analyze descriptive statistics: median, interquartile range of lead concentrations based on region of sale, spice type, production region, etc.

5. Supplies

- Small polyethylene plastic baggies for sample collection (2 per sample)
- Labeling table and permanent marker for marking samples
- Small slips of paper that the sample-related information can be written on. I suggest double bagging each spice sample and put the slip of paper with that spice sample's information inside in the short-term until a longer-term label can be made.
- Large bag to hold samples
- Notebook per data collector to jot down sample information and draw a sketch of the bazaar layout and number of vendors.

APPENDIX B: Example spreadsheet for filling out sample-related information



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1	Region	City	Bazaar name	Bazaar address	Bazaar size (total # vendors)	Vendor number	Vendor contact	Vendor ID	Sample ID	Sampling Date	Spice name/ ingredients	Price per 100 g (GEL)	Package type	Bulk container labeled? (Y/N)	Individual sample packaged? (Y/N)	Individual sample labeled? (Y/N)	Branded? (Y/N)	Brand name	Harvest year	Production country	Production district	Producer contact	Supplier contact	Grinder contact	Importer contact	Pb (ppm)	Cr (ppm)	Notes
2																												
3																												
4																												
5																												
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14																												

APPENDIX C: Example of interview guides developed for Georgia

1. Key informant interview guide
    - Basic information about respondent: name, age, occupation, years of experience, knowledge area
    - What do you know about the sale of lead chromate pigment powders in Georgia?
    - Is lead chromate called something different locally? What is the name?
    - Where are lead chromate pigments sold? What other commodities are these sold with?
    - When (what year) did lead chromate pigments become available in Georgia? Why?
    - Are there other types of yellow pigment powders available? Are there any food-grade yellow pigments? Do each of these have unique names?
    - How much do they sell for per kg (retail vs. wholesale)?
    - Are there hubs of sale or distribution (e.g., where the pigments are sold in bulk to business people)?
    - Are the pigments produced locally or imported? If imported, from where?
    - What are they primary uses for these pigments (e.g., what do people buy them for?)
    - What is the size of the lead chromate market in Georgia (e.g., kg sold per year)?
    - Who are the dominant sellers and who do they sell to?

2. Spice seller/distributor interview guide
    - Basic information about respondent: name, age, occupation, years of experience
    - What is the process of setting up a spice packing and sales business? What is required?
    - What are the associated fees for registering your business? What are the benefits and drawbacks of registering your business?
    - How many registered and unregistered businesses do you own and what are the business names? What products do you sell for each? What spices do you sell?
    - When did you start your spice business(es)? How and why did you get involved in the spice business?
    - How do you make your spices most attractive for sale?
    - Where are your spices available throughout the country of Georgia?
    - What have your biggest challenges in your spice business been over the years? How have you overcome them?
    - What are your biggest concerns about quality when it comes to spices you sell? How do you ensure quality?
    - Where do you get your spices and in what form?
    - How many different spice suppliers do you purchase from? Who are your primary suppliers?
    - Do you mix your own spice blends or do you buy them pre-mixed? If the latter, who do you buy from?
    - Who produces your spices and where are they produced?
    - What regulations or restrictions have there been on spice vendors at bazaars – when were they established, how are they enforced, what do they intend to do?
    - We are aware that some spice sellers like to add non-spice substances to spices, especially those containing marigold. Do you know anything about this practice? How common is it? What is added to them? Why is it done? When (what year) did the practice start (and why)? How has the frequency of this practice changed over the years?

3. Lead chromate seller/distributor interview guidelines

- Basic information about respondent: name, age, occupation, years of experience
- What do you sell? Who do you sell your products to?
- What pigments do you sell? How many types of yellow pigments do you sell and what are their names?
- For lead chromate…
- How long have you sold it?
- Where do you get it from?
- Is it locally produced or imported (if imported, from where)?
- What do people buy it for?
- How does it rank in terms of popularity compared to other types of yellow pigments?
- How much does it cost per kg?
- In what form is it sold (e.g., loose, packaged, mixed as paint, or all three)?
- Who are your primary customers (what do they do)?
- How many kg do you sell per month/year?
- Have there been any changes to your business this year compared to last year? Increased/decreased demand, why?
- What regulations or restrictions have there been on lead chromate – when were they established, how are they enforced, what do they intend to do?