



# Chemical Contaminants in Imported Dried Spices

Imported Foods Monitoring Programme

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# 1 Executive Summary

New Zealand imports more than 2 million kilograms of spices each year. Only a very small amount of spices is produced domestically. Spices are subjected to a range of processing steps including cultivation and harvesting, drying, winnowing, transport, finish drying, grinding, packing, fumigation and storage. Most of these steps have the potential to introduce chemical contaminants into the spices. Environmental pollution is also a major cause of contamination in the food chain.

Over the recent years, there have been numerous recalls overseas of dried spices due to chemical contamination. These include the presence of unauthorised colours/dyes and heavy metals. This survey has provided a snapshot to inform the Ministry for Primary Industries (MPI) on compliance of imported dried spices with regards to specific chemical hazards that have been assessed as being of high risk.

A total of 115 imported dried spice samples were collected from retailers and distributors from the Auckland and Wellington regions. The spices collected were pepper, paprika, cinnamon, curry powder, turmeric, garam masala and nutmeg. These samples were tested for heavy metals, pesticides and dyes/colours. The heavy metals tested for were cadmium, chromium and lead. The pesticides tested for are outlined in Appendix 1. The dyes tested for include Sudan Red, Mentanil Yellow, Butter Yellow, Orange II, Orange SS and Toluidine Red.

Standard 1.4.1 of the Food Standards Code sets out the maximum levels (MLs) of specified metal contaminants in various foods. The standard specifies that the levels of metal contaminants in all foods should be kept As Low As Reasonably Achievable (ALARA), regardless of whether or not an ML exists. For pesticides, the imported spices must comply with the Codex Alimentarius MRLs or with NZ default value of 0.1 mg/kg. The colours tested in this survey are prohibited in spices under Standard 1.3.1 of Food Standards Code.

All of the spices tested in this survey were found to contain detectable levels of heavy metals. Currently there are no standards for maximum limits (MLs) available for heavy metals in spices. The detected heavy metal results were compared with MLs for other commodities which are consumed more than other spices by the New Zealand population. It was observed

that the heavy metals detected in spices were below the MLs for other like commodities which are consumed more than the spices. Also given the minimal contribution that spices makes to the diet these heavy metal detections are unlikely to cause an immediate risk to health.

Around 50% of the paprika samples had detectable pesticide residues, while the other spices had detections in the range of 0 to 20%. It was difficult to interpret the pesticide residues detected in garam masala and curry powder since it is a blend of different spices. An acute dietary burden analysis was carried out for the pesticide detections which did not have relevant codex standards and were found to be above the New Zealand default MRL. It was observed from the generally low levels of consumption of spices and the acute dietary analysis study, the recorded levels would not cause a significant increase to the dietary burden to New Zealanders of these compounds.

Only one out of 115 samples of cinnamon quills had detectable levels of auramine O dye. It was concluded that the contamination is not widespread and the consumers will not have a consistent long-term exposure to this dye through cinnamon.

## 2 Background

The term spices, includes dried aromatic plants, which relates to natural dried components or mixtures thereof, used in foods for flavouring, seasoning and imparting aroma. As per the Code of Hygiene Practice for Spices and Dried Aromatic Plants (CAC/RCP 42-1995), spices should be protected from contamination by human, animal, domestic, industrial and agricultural waste, which may be present at levels likely to be a hazard to health. In recent years, there have been a number of overseas incidents involving chemical contaminants in spices. In 2005 United Kingdom authorities enforced numerous recalls<sup>1</sup> after detecting the presence of Sudan Red dyes in imported spices.

MPI currently has a prescribed food standard<sup>2</sup> for imported spices in which the focus is mainly on microbiological contaminants (*Salmonella* contamination in pepper, paprika and cinnamon), but not the presence of heavy metals, pesticides, other agricultural chemicals and colours.

A discussion document was commissioned by MPI in 2010 which identified chemical contaminants that may be present in spices available on the New Zealand market. This research document identified the information gaps which are the basis of the current survey. Since most spices available on the international market are sourced from the same countries, chemical contaminants that have been widely researched have been excluded from the focus of this survey. Mycotoxins have also been excluded as they were covered by MPI in a 2008-09 study.

## 3 Survey objectives

The objective of the survey was to determine if dried spices being imported into New Zealand pose a public health risk due to chemical contamination. This survey is not intended to monitor the performance of the Imported Food Requirements (IFR) for spices.

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<sup>1</sup> <http://www.foodnavigator.com/Financial-Industry/Illegal-yellow-prompts-spate-of-spice-recalls>

<sup>2</sup> Prescribed food standard for imported spices - [http://www.foodsafety.govt.nz/elibrary/industry/Imported\\_Food\\_Requirements\\_Spices-Sets\\_Clearance.pdf](http://www.foodsafety.govt.nz/elibrary/industry/Imported_Food_Requirements_Spices-Sets_Clearance.pdf)

## 4 Materials and Methods

### 4.1 SURVEY SCOPE

This survey focused on imported pepper, paprika, cinnamon, turmeric, nutmeg, garam masala and curry powder.

- **Pepper** included black and white pepper (*P. nigrum*), Sichuan pepper or Szechuan pepper (*Zanthoxylum piperitum*) and pink peppercorns (*Schinus terebinthifolius*)
- **Paprika** included chilli, cayenne, paprika (both the smoked and non-smoked varieties) (*Capsicum annuum*)
- **Cinnamon** included Cinnamomum verum, synonym *C.zeylanicum*, Cassia (*Cinnamomum aromaticum*), Saigon Cinnamon (*Cinnamomum loureiroi*), and Indonesian Cinnamon (*Cinnamomum burmannii*)
- **Turmeric** included *Curcuma longa*
- **Nutmeg** included *Myristica fragrans*
- **Garam masala** is a blend of ground spices. It typically includes peppercorns, cloves, cinnamon, cumin seeds and cardamom pods. Depending on the recipe additional ingredients may also be added.
- **Curry powder** is a mixture of spices and may typically include coriander, turmeric, cumin, fenugreek, pepper and may include other additional ingredients depending on the recipe.

All spices were dried and were either whole, crushed or ground. Garam masala that is blended in “New Zealand” was excluded from this survey.

The chemical contaminants that were investigated include:

- Heavy metals – (Cadmium, Chromium and Lead)
- Pesticides (refer to Appendix 1)
- Prohibited colours/dyes (Sudan Red, Mentanil Yellow, Auramine O, Butter Yellow, Orange II, Orange SS and Toluidine)

### 4.2 SAMPLE COLLECTION

A total of 115 samples were purchased from suppliers from Auckland and Wellington during June-July 2011 as given in Table 1 below. The suppliers included supermarkets, dairies,



specialist stores (i.e. ethnic stores and traders specialising in spices) and distributors (including wholesalers). These samples were collected by AgriChain Centre Limited staff and sample information sheets were completed for each sample.

**Table 1. Sample collection distribution**

Spice samples collected	No. of samples collected
Cinnamon	16
Curry powder	16
Garam Masala	17
Nutmeg	15
Paprika	19
Pepper	16
Turmeric	16
TOTAL	115

## 5 Methodology

### 5.1 CHEMICAL ANALYSIS AND ANALYTICAL TESTING

All samples were analysed for heavy metals and pesticides by R J Hill Laboratories Ltd. (Hamilton). Samples were analysed for heavy metals by Acid Digestion and for pesticides by Multiresidue GC/MS & LC/MS. Dye analysis was carried out by Environmental Science & Research (ESR) using LC/MS.

### 5.2 DATA ANALYSIS

Results for heavy metals, pesticides and dyes were interpreted against the limits as below -

Table 2. Standards for reference of heavy metal residues, pesticides and colours in dried spices:

Compound	Limit	Reference
Lead	ALARA <sup>3</sup>	Food Standards Code Australia New Zealand (FSANZ) - Standard 1.4.1 <sup>4</sup>
Cadmium		
Chromium		
Colours	Nil – Colours tested for are prohibited	Food Standards Code Australia New Zealand - Standard 1.3.1
Pesticides	Codex MRL or 0.1 mg/kg (NZ default MRL)	Imported spices must comply with the Codex MRL standards where they exist. In case there is no Codex MRL in place, NZ default MRL of 0.1 mg/kg would apply. Codex MRLs- <a href="http://www.codexalimentarius.net/mrls/pestdes/pest_ref/MRLs_Spices_e.pdf">http://www.codexalimentarius.net/mrls/pestdes/pest_ref/MRLs_Spices_e.pdf</a>

<sup>3</sup> ALARA – As a general principle, regardless of whether or not a ML exists, the levels of contaminants and natural toxicants in all foods should be kept As Low As Reasonably Achievable (the ALARA Principle)

<sup>4</sup> FSANZ Standard 1.4.1– The standard sets out the maximum levels (MLs) of specified metal and non-metal contaminants and natural toxicants in nominated foods.

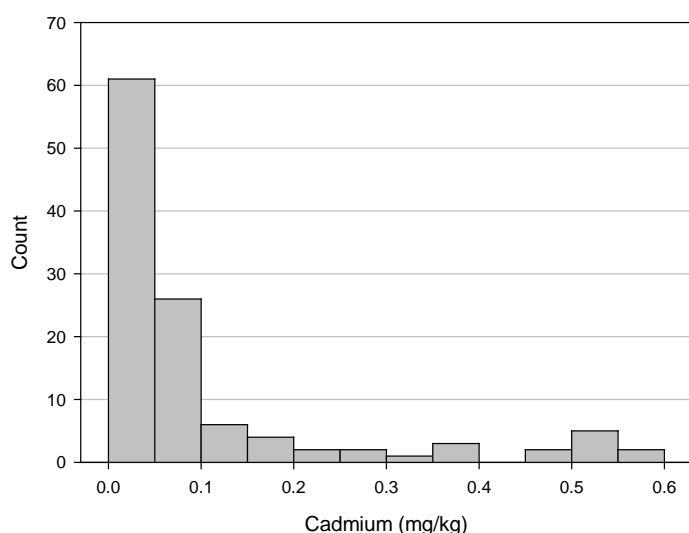
## 6 Results & Discussion

All spice samples were tested for heavy metals, pesticides and dyes. The results for each chemical contaminant group are discussed in the below sections.

### 6.1 HEAVY METALS

#### 6.1.1 Cadmium (Cd)

Out of the 115 samples tested, 114 samples had detectable levels of cadmium. The distribution of the data with detectable levels of Cadmium is profoundly right-skewed, i.e. it had relatively few high values (refer to Figure 1), with a minimum value of 0.0048 mg/kg and a maximum value of 0.590 mg/kg.

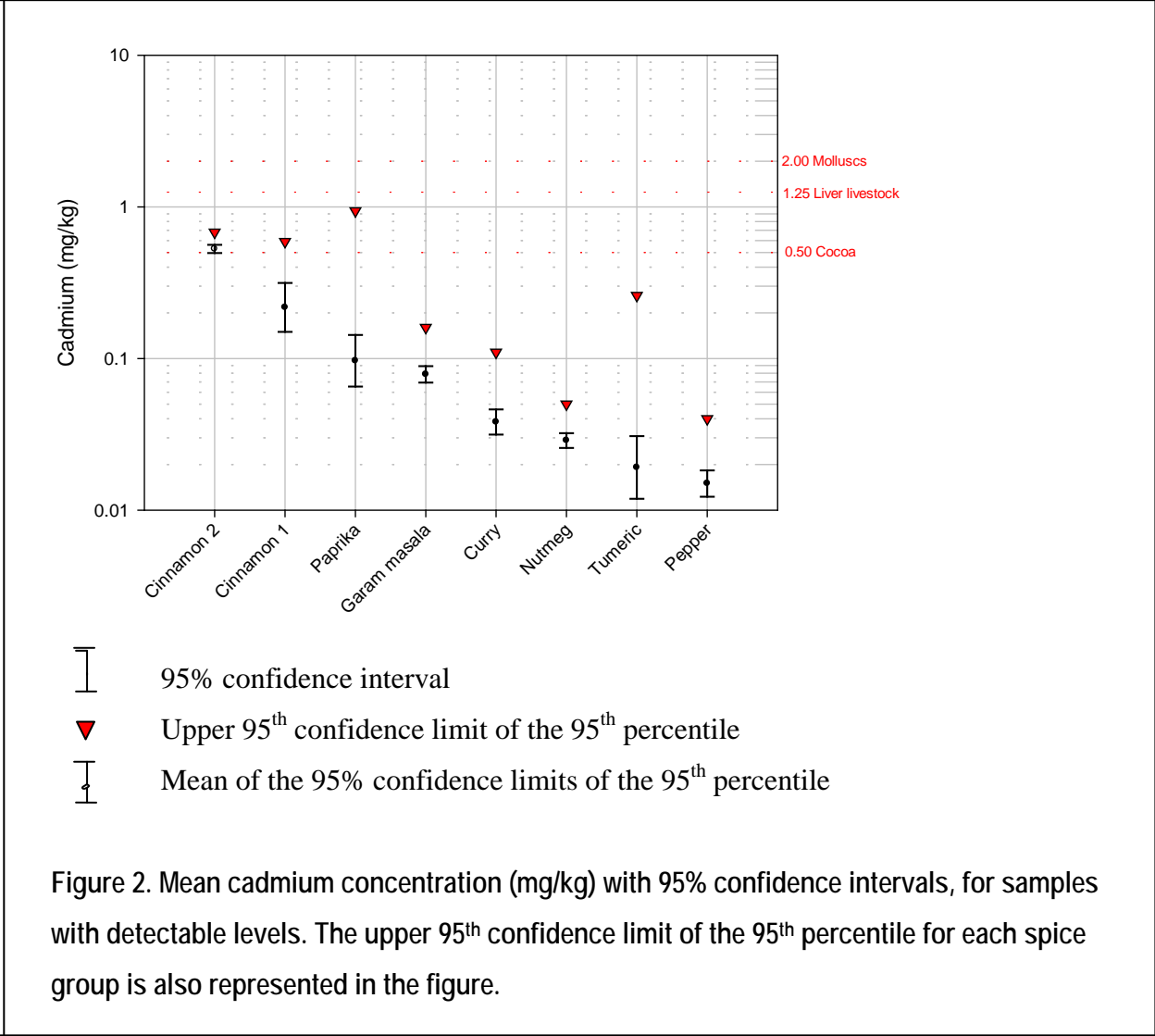


**Figure1. Histogram of cadmium concentration (mg/kg), for samples of spices which detected cadmium**

#### *Discussion*

There is no ML defined in the FSC therefore the discussion is based on the ALARA principle. For cadmium, we considered the acceptable levels which are set for other more highly consumed commodities from *Codex Standard 193-1995* (0.5 mg/kg for cocoa products; 1.25 mg/kg for liver of livestock and 2.00 mg/kg for molluscs).

The sample results have been used to infer values in the total population of imported dried spices. The statistics of the results (95% confidence interval, upper 95<sup>th</sup> confidence limit of the 95<sup>th</sup> percentile and mean of the 95% confidence limits of the 95<sup>th</sup> percentile) for each spice group in the population are summarized in the graph (Figure 2) below-



In the case of cinnamon, the distribution of the raw cinnamon data was found to be bimodal which suggests the possibility of two sub-populations (cinnamon 1 and cinnamon 2). As observed in Figure 2, for both the populations, the 95% confidence interval is close to the nominal acceptable level for cocoa, but is well below that of molluscs and liver of livestock. It is unclear as to why the distribution of the cinnamon data is bimodal. As observed for other spice groups, the 95% confidence interval is close to and/or lower than the Codex Alimentarius limits for the other highly consumed commodities (cocoa products, molluscs and liver live stock). Due to the minimal contribution that spices make to the diet, the levels

of cadmium detected in this survey are not considered to constitute an immediate risk to health.

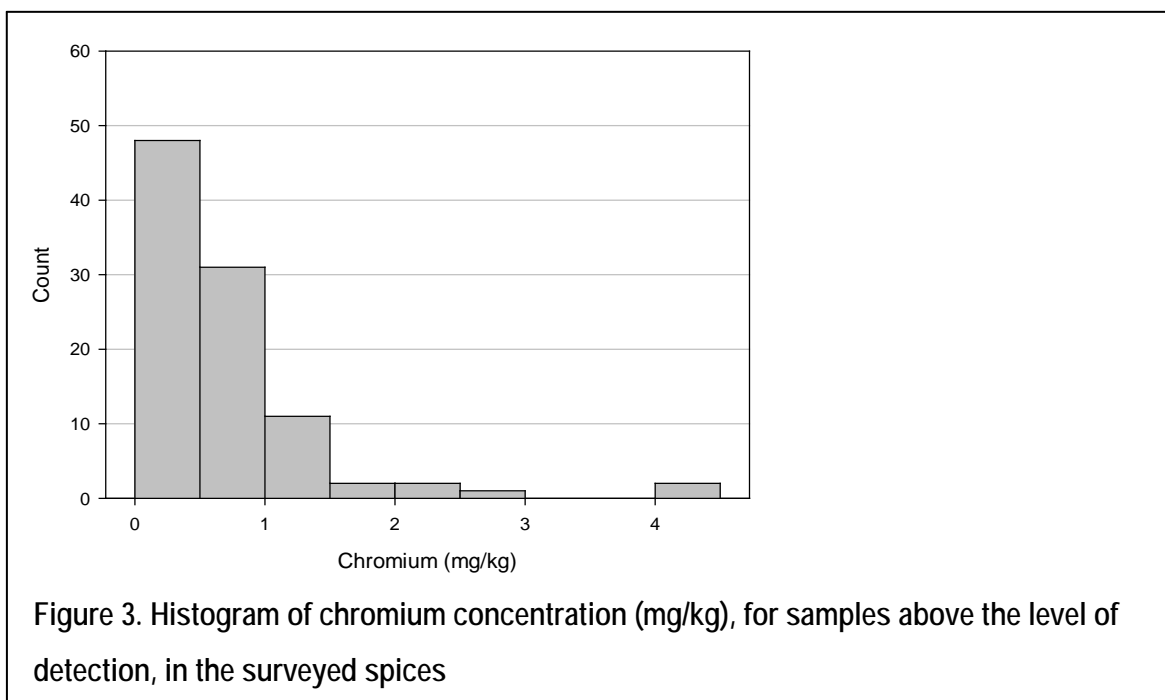
### 6.1.2 Chromium (Cr)

Out of the 115 samples tested, 18 samples were found to have no detectable values of chromium.

Within the spice types there were considerable differences in detected values, with the lowest result of 0.121 mg/kg and the highest result of 4.4342 mg/kg. The mean was 0.70mg/kg and the median was 0.50 mg/kg.

The distribution of the detected values for chromium was again right-skewed.

Refer to the Figure 3 below:



### Discussion

The sample results have been used to infer values in the total population of imported dried spices. The statistics of the results (95% confidence interval, upper 95<sup>th</sup> confidence limit of the 95<sup>th</sup> percentile and mean of the 95% confidence limits of the 95<sup>th</sup> percentile) for each spice group in the population are summarised in the graph (Figure 4) below:

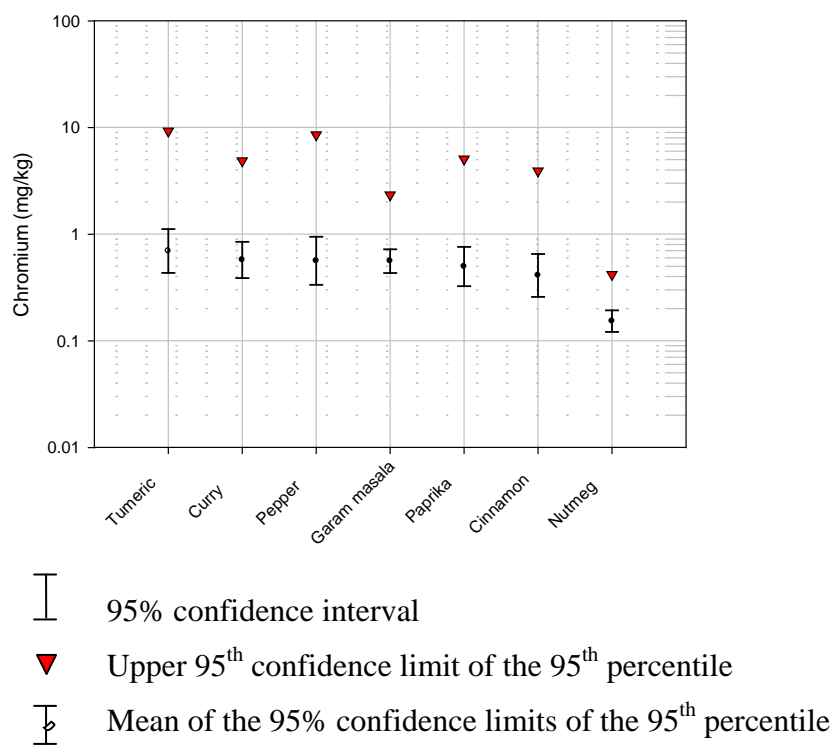


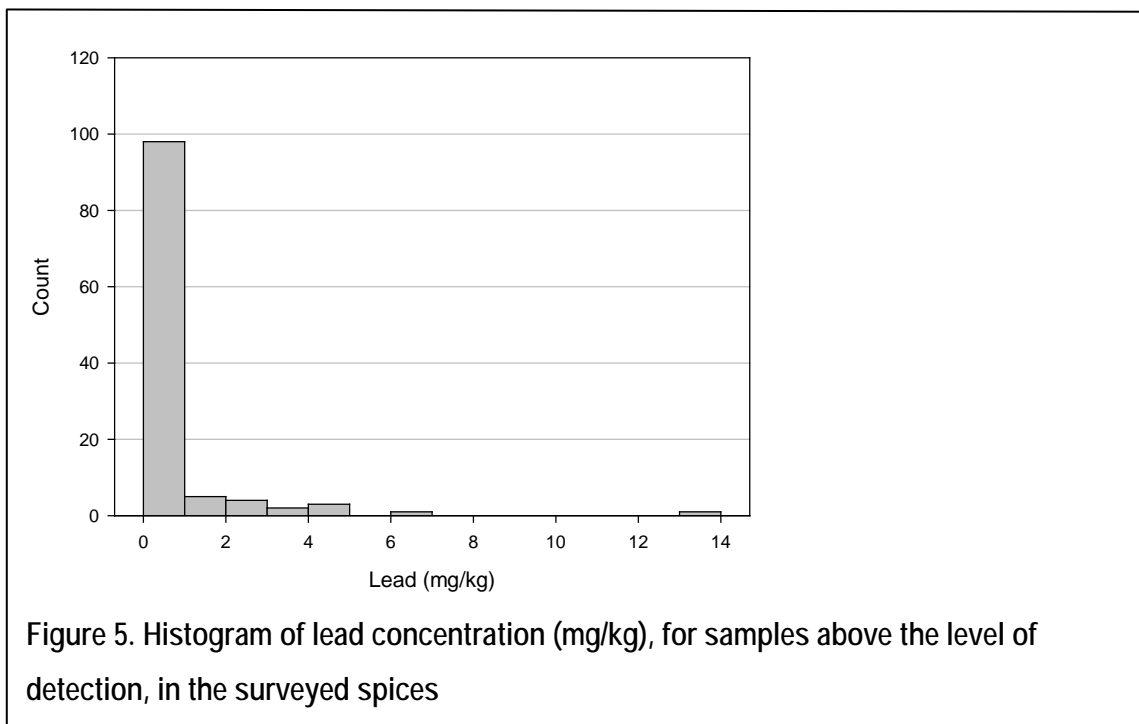
Figure 4. Mean chromium concentration (mg/kg), with 95% confidence limits, and the upper 95<sup>th</sup> confidence limit of the 95<sup>th</sup> percentile for each spice group.

From Figure 4, we can say that the 95% confidence intervals for all the spice groups are close to 1mg/kg which means that the likely range of the true values for chromium is close to 1mg/kg.

Chromium naturally occurs in foods as the trivalent form and it contributes to human nutrition as an essential element. Generally levels of trivalent chromium are not thought to exceed 1mg/kg in most food types. However, data on the natural level of chromium in foods is lacking so that the levels reported in this survey may fall within the naturally expected range. It is noted that spices are often recommended as being a dietary source rich in trivalent chromium. There is no established upper limit for trivalent chromium in New Zealand foods however the United Kingdom Food Standards Agency in 2008 issued a recommendation that levels of up to 10mg/day in foods was unlikely to be associated with adverse effects. From the generally low consumption rates of these spices it would not be expected that the contribution to the daily burden of trivalent chromium would represent a risk due to the levels of chromium detected.

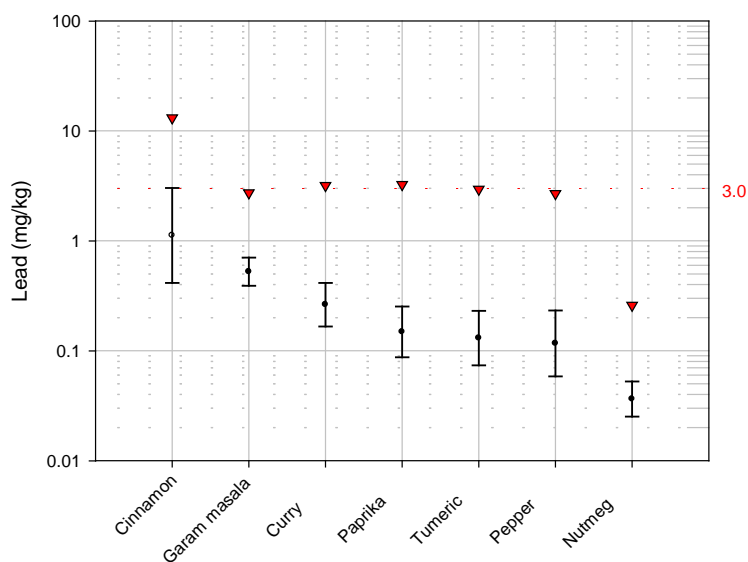
### 6.1.3 Lead (Pb)

Out of 115 samples tested, 114 samples had detectable levels of lead. As with cadmium and chromium, the distribution of the data for lead was profoundly right-skewed with a minimum detected value of 0.0147 mg/kg and a maximum detected value of 13.1936 mg/kg (as represented in Figure 5). The mean was 0.686 mg/kg and the median was 0.170 mg/kg.



#### *Discussion*

The sample results have been used to infer values in the total population of imported dried spices. The statistics of the results (95% confidence interval, upper 95<sup>th</sup> confidence limit of the 95<sup>th</sup> percentile and mean of the 95% confidence limits of the 95<sup>th</sup> percentile) for each spice group in the population are summarized in the graph (figure 6) below:






-  95% confidence interval
-  Upper 95<sup>th</sup> confidence limit of the 95<sup>th</sup> percentile
-  Mean of the 95% confidence limits of the 95<sup>th</sup> percentile

Figure 6. Mean lead concentration (mg/kg) with 95% confidence limits, for samples above the level of detection, and also the upper 95<sup>th</sup> confidence limit of the 95<sup>th</sup> percentile for each spice group

The World Health Organisation has stated that there is currently no known safe dose of lead. Considering other countries actions towards lead contamination of food, the European Food Safety Authority have a level of 3mg/kg for lead for food supplements.

From figure 6, we can say that the 95% confidence intervals for all the spice groups are close to 3mg/kg. This is the value used for population exposure risk estimates rather than extreme values which means that the likely range of the true values for lead is close to 3mg/kg. The high values observed in cinnamon substantially contributed for the high percentile value, however, given the minimal contribution that cinnamon makes to the diet it is unlikely to represent an immediate risk to health.

## 6.2 PESTICIDES

Out of 115 samples, 15 samples had detectable levels of pesticide residues. The observations for detections of pesticide residues in spice groups are given below in Table 3 and 4.

Currently there are no specific MRLs for spices, hence imported spices must comply with



either the Codex MRL standards or NZ default MRL of 0.1mg/kg. The NZ default MRL is applied where there are no Codex MRL standards for reference for the spices tested.

**Table 3: Summary of pesticide residue detections in spice samples**

Spice Group	Total number of samples taken	Number of samples with detectable pesticide residues
Cinnamon	16	0
Curry powder	16	3
Garam Masala	17	1
Nutmeg	15	0
Paprika	19	10
Pepper	16	1
Turmeric	16	0

**Table 4: Summary of results of detected pesticide residues in spice samples**

Note: Sample results exceeding the MRL are highlighted in the table below

Sample Number	Commodity	Pesticide	Result (mg/kg)	MRL
SY45	Garam Masala	Acetamiprid	0.264	0.1 mg/kg (NZ Default)
SY19	Paprika	Acetamiprid	0.226	0.1 mg/kg (NZ Default)
SY45	Garam Masala	Carbendazim	0.238	20 mg/kg <sup>5</sup>
SY15	Paprika	Carbendazim	0.796	20 mg/kg <sup>5</sup>
SY32	Paprika	Carbendazim	0.23	20 mg/kg <sup>5</sup>
SY49	Paprika	Carbendazim	0.279	20 mg/kg <sup>5</sup>
SY59	Paprika	Carbendazim	0.298	20 mg/kg <sup>5</sup>
SY13	Paprika	Chloromequat chloride	0.573	0.1 mg/kg (NZ Default)
SY63	Paprika	Chloromequat chloride	0.206	0.1 mg/kg (NZ Default)
SY80	Curry powder	Chlorpyrifos-methyl	1.076	10 mg/kg <sup>5</sup>
SY19	Paprika	Cypermethrin	0.705	5 mg/kg <sup>5</sup>
SY10	Curry powder	Ethion	0.985	0.1 mg/kg (NZ Default)
SY98	Curry powder	Ethion	0.315	0.1 mg/kg (NZ Default)
SY19	Paprika	Ethion	1.35	0.1 mg/kg (NZ Default)
SY30	Paprika	Ethion	0.423	0.1 mg/kg (NZ Default)
SY31	Paprika	Ethion	0.467	0.1 mg/kg (NZ Default)
SY32	Paprika	Ethion	0.26	0.1 mg/kg (NZ Default)
SY49	Paprika	Ethion	1.431	0.1 mg/kg (NZ Default)
SY56	Paprika	Ethion	0.291	0.1 mg/kg (NZ Default)
SY30	Paprika	Imidacloprid	0.434	10 mg/kg <sup>5</sup>

<sup>5</sup> Codex Alimentarius MRL for peppers chilli,dried: Carbendazim = 20mg/kg; Cypermethrin = 5mg/kg; Imidacloprid = 10mg/kg; Chlorpyrifos-methyl = 10mg/kg.

Sample Number	Commodity	Pesticide	Result (mg/kg)	MRL
SY59	Paprika	Imidacloprid	0.344	10 mg/kg <sup>5</sup>
SY110	Pepper	Piperonyl-butoxide	1.685	0.1 mg/kg (NZ Default)
SY30	Paprika	Pirimiphos-methyl	1.906	0.1 mg/kg (NZ Default)
SY31	Paprika	Triazophos	1.588	0.1 mg/kg (NZ Default)

**Table 5: Samples with >1 pesticide residue detection**

Sample Number	Commodity	Pesticides detected
SY19	Paprika	Acetamiprid Cypermethrin Ethion
SY30	Paprika	Ethion Imidacloprid Pirimiphos-methyl
SY31	Paprika	Ethion Triazophos
SY32	Paprika	Carbendazim Ethion
SY45	Garam Masala	Acetamiprid Carbendazim
SY49	Paprika	Carbendazim Ethion
SY59	Paprika	Carbendazim Imidacloprid

### *Discussion*

Currently there is a limited data set of Codex MRLs for spices. Since paprika is a spice made from the grinding of dried bell peppers or chilli peppers, we considered the Codex MRLs for Peppers Chilli, dried for carbendazim, cypermethrin and imidacloprid detections. The pesticide residue values detected for these pesticides in paprika were found to be below the MRLs of peppers chilli, dried.

In case of garam masala and curry powder, which are both blends of different ground spices, it is difficult to interpret as to which component/s contributed towards the pesticide residue value. Peppers chilli is considered to be the major component in garam masala and curry powder blends. If we assume that peppers chilli is the major source of the pesticide residues in garam masala and curry powder, the values detected for carbendazim in garam masala and chlorpyrifos-methyl in curry powder are below the Codex MRLs for dried chilli. However, if the residue resulted from two or more of the ingredients there would be various scenarios for whether or not the residue exceeded the relevant limits.

For the remainder of the pesticide residues detected i.e. pirimiphos-methyl, acetamiprid, ethion, chlormequat chloride, triazophos in paprika and piperonyl butoxide in pepper, there is no corresponding Codex MRL. Hence the New Zealand default MRL of 0.1 mg/kg is applied. As observed in Table 4, the results for these pesticide residues are above the default New Zealand MRL. Consequently, acute dietary burden analysis was done on the highest detected residue value. It was observed that the highest consumer intake was below the acute reference dose for these pesticide residues suggesting that the recorded levels would not cause any significant increase to the dietary burden to New Zealanders of these compounds. Also from the generally low consumption rates of these spices it would not be expected to be an immediate health risk to the population.

### 6.3 COLOURS/DYES

All 115 spice samples were analysed for the prohibited dyes. Out of 115 samples of spices only 1 sample of cinnamon quills had detectable levels of the dye Auramine O. The amount detected was 15 mg/kg.

#### *Discussion*

Pure Auramine O is a canary yellow colour, although it appears to also be retained in a more mustard/tan form. Commercial cinnamon is primarily graded on quill form, thickness and smell as opposed to colour. Adulteration is a likely rationale for the significant levels of Auramine O detected in cinnamon quills. However, there remains the potential that the level is due to cross contamination either from adulteration in the same processing facility of other spices with Auramine O, such as turmeric, or from surface contamination from legitimately dyed materials (leather, paper) used within the manufacturing process.

The dietary burden of cinnamon is low when considered on a per day basis and it will be heavily diluted in recipes. Since only one sample was positive for the dye Auramine O out of 115 samples, this shows that the contamination is not widespread. Also since toxicological concerns arise from long-term exposure, this detection in only 1 sample is unlikely to have a consistent long-term exposure to Auramine O.

## 7 Conclusion

This survey was conducted to inform MPI on general compliance with pesticides, heavy metals and dye residues in imported dried spices. Traces of heavy metals, pesticides and dyes were found in dried spices imported into New Zealand. A maximum level (ML) for heavy metals has been established in the Food Standards Code Australia New Zealand (FSC) only where it serves an effective risk management function and only for those foods which provide a significant contribution to the total dietary exposure. MLs have not been assigned to spices in the FSC because they present a low public health risk and also because they contain low levels of contaminants or natural toxicants. The pesticides residues detected in the spices were compared against the relevant Codex MRLs or the New Zealand default MRL. The results showed that the recorded levels in dried spices would not cause any significant increase to the dietary burden of these compounds to New Zealanders. Also the presence of Auramine O in the cinnamon quills does not cause an immediate risk to human health taking into consideration that only one sample was detected for the dye residue in the survey. Noting the very small contribution that spices make to the New Zealand diet, the detections of chemical contaminants observed in this survey are unlikely to be an immediate health risk for the New Zealand population.

MPI contacted all the importers of products included in this survey to notify them of the findings and remind them of their obligations under the Food Act 1981 to comply with Food Standards Code requirements.

## 8 References

1. Australia New Zealand Food Standards Code – Standard 1.4.1 – Contaminants and Natural Toxicants  
<http://www.comlaw.gov.au/Details/F2011C00542>
2. Australia New Zealand Food Standards Code – Standard 1.3.1 – Food Additives  
<http://www.comlaw.gov.au/Details/F2011C00892>
3. Codex general standard for contaminants and Toxins in Food and Feed. (Codex Stan 193-1995)  
<http://www.codexalimentarius.org/standards/list-of-standards/en/>
4. Pesticide Residues in Food and Feed  
<http://www.codexalimentarius.net/pestres/data/commodities/details.html?id=317>

## 9. Appendix

### APPENDIX 1: LIST OF PESTICIDES WHICH WERE TESTED IN THE SURVEY:

Pesticides tested by GC-MS method			
Compound	Compound	Compound	Compound
2,4' - DDD	2,4' - DDE	2,4' - DDT	4,4' - DDD
4,4' - DDE	4,4' - DDT	Acephate	Acetochlor
Acrinathrin	Alachlor	Aldrin	alpha-bHC
Atrazine	Atrazine - desethyl	Atrazine - desisopropyl	Azaconazole
Azinphos-methyl	Azoxystrobin	Benalaxyl	Bendiocarb
Benodanil	Benoxacor	Beta-BHC	Bifenox
Bifenthrin	Bioresmethrin	Bitertanol	Bromacil
Bromophos-ethyl	Bromopropylate	Bupirimate	Buprofezin
Butachlor	Butamifos	Cadusafos	Captafol
Captan	Carbaryl	Carbofenothion	Carbofuran
Carboxin	Chlorfenapyr	Chlorfenvinphos	Chlorfluazuron
Chlorobenzilate	Chlorothalonil	Chlorpropham	Chlorpyrifos
Chlorpyrifos-methyl	Chlorthal-dimethyl	Chlortoluron	Chlozolinate
cis-Chlordane	Clomazone	Coumaphos	Cyanazine
Cyanophos	Cyfluthrin	Cyhalothrin	Cypermethrin
Cyproconazole	Cyprodinil	delta-BHC	Deltamethrin
Demeton-S-methyl	Diazinon	Dichlobenil	Dichlofenthion
Dichlofluanid	Dichloran	Dichlorvos	Dicofol
Dicrotophos	Dieldrin	Difenoconazole	Diflufenican
Dimethenamid	Dimethoate	Dimethylvinphos	Dimthomorph
Dinocap	Dioxabenzofos	Diphenamid	Diphenylamine
Disulfoton	Diuron	Edifenphos	Endosulfan I
Endosulfan II	Endosulfan sulfate	Endrin	Endrin aldehyde
Endrin ketone	EPN	Epoxiconazole	EPTC
Esfenvalerate	Esprocarb	Ethion	Ethofumesate
Ethoprophos	Ethoxyquin	Etridiazole	Etrimfos
Famphur	Fenamiphos	Fenarimol	Fenchlorphos
Fenitrothion	Fenobucarb	Fenoxaprop-ethyl	Fenpiclonil
Fenpropathrin	Fenpropimorph	Fensulfothion	Fenthion
Fenvalerate	Flamprop-methyl	Fluazifop-butyl	Flucythrinate
Fludioxonil	Fluometuron	Flusilazole	Flutriafol
Fluvalinate	Folpet	Fonofos	Furalaxyl
Furathiocarb	gamma-BHC (Lindane)	Halfenprox	Haloxypop-methyl
Heptachlor	Heptachlor epoxide	Heptenophos	Hexachlorobenzene
Hexaconazole	Hexazinone	Imazalil	Indoxacarb
Iodofenphos	Iprobenfos	Iprodione	Isazophos
Isofenphos	Isoprocarb	Kresoxim-methyl	Leptophos
Linuron	Malathion	Mepronil	Metalaxyl
Methacrifos	Methamidophos	Methidathion	Methiocarb
Methoxychlor	Metolachlor	Metribuzin	Mevinphos
Molinate	Monocrotophos	Myclobutanil	Naled
Napropamide	Nitrofen	Nitrothal-isopropyl	Norflurazon
Omethoate	Oxadiazon	Oxadixyl	Oxychlordane
Oxyfluorfen	Paclobutrazol	Parathion-ethyl	Parathion - methyl
Penconazole	Pendimethalin	Permethrin	Phenthoate
Phorate	Phosalone	Phosmet	Phosphamidon
Piperonyl-butoxide	Pirimicarb	Pirimiphos-methyl	Prochloraz

Pesticides tested by GC-MS method			
Compound	Compound	Compound	Compound
Procymidone	Profenofos	Prometryn	Propachlor
Propanil	Propaphos	Propargite	Propazine
Propetamphos	Propham	Propiconazole	Propoxur
Propyzamide	Prothiofos	Pyraclufos	Pyrazophos
Pyrazoxyfen	Pyrethrin	Pyrifenox	Pyrimethanil
Quinalphos	Quintozene	Quizalofop-ethyl	Simazine
Simetryn	Sulfentrazone	Sulfotep	Tebuconazole
Tebufenpyrad	Tefluthrin	Terbacil	Terbufos
Terbumeton	Terbuthylazine	Terbuthylazine-desethyl	Terbutryn
Tetrachlorvinphos	Tetradifon	Thenylchlor	Thiobencarb
Thiometon	Tolclofos-methyl	Tolyfluanid	Trans-chlordane
Triadimefon	Tri-allate	Triazophos	Trifloxystrobin
Trifluralin			

Pesticides tested by LC-MS method			
Compound	Compound	Compound	Compound
Abamectin	Acetamiprid	Aldicarb	Aldicarb sulfone
Aldicarb sulfoxide	Ametryn	Anilazine	Anilofos
Azamethiphos	Azimsulfuron	Bensulide	Boscalid
Cafenstrole	Carbendazim	Carfentrazone-ethyl	Carpropamid
Chlorbufam	Chloridazon	Chlormequat chloride	Clethodim
Clodinafop	Clofentezine	Cumyluron	Cycloxydim
Cycluron	Cymoxanil	Desmedipham	Desmetryn
Diafenthuron	Dialifos	Diclobutrazol	Diclomezine
Diethofencarb	Difenzoquat methyl sulfate	Diflubenzuron	Dimethirimol
Dioxathion	Dodine	Dymron	Emamectin
Empenthrin	Ethametsulfuron-methyl	Ethoxysulfuron	Fenhexamid
Fenoxanil	Fenoxycarb	Fenpyroximate	Fentrazamide
Ferimzone	Fipronil	Flubenzimine	Flufenacet
Flufenoxuron	Flumioxazin	Fluthiacet-methyl	Flutolanil
Formentanate	Formothion	Fosthiazate	Hexaflumuron
Imazamethabenz-methyl	Imazamox	Imazosulfuron	Imidacloprid
Inabenfide	Isocarbofos	Isouron	Isoxaflutole
Isoxathion oxon	Lactofen	Lufenuron	Malaoxon
Mecarbam	Mefenacet	Metconazole	Methabenzthiazuron
Methabenzthiazuron	Methomyl	Methoxyfenozide	Metolcarb
Metosulam	Milbemectin	MPMC	Naptalam
Nitralin	Oryzalin	Oxamyl	Oxydemeton-ethyl
Paraoxon-ethyl	Paraoxon-methyl	Pencycuron	Phenmedipham
Phoxim	Pirimiphos- ethyl	Probenazole	Promecarb
Propaquizafop	Propargite	Pymetrozine	Pyraclostrobin
Pyrazolynate	Pyridalyl	Pyridaphenthion	Quinoclamine
Sethoxydim	Spinetoram	Spinosad	Sulfosulfuron
Tebufenozide	Tebuthiuron	Teflubenzuron	Tetraconazole
Thiacloprid	Thiamethoxam	Thidiazuron	Thifluzamide
Thiophanate-methyl	Tiadinil	Triadimenol	Trichlorfon
Tricyclazole	Trifloxysulfuron sodium	Triflumuron	Triflurosulfuron-methyl
Uniconazole	Zoxamide		

## APPENDIX 2: RAW DATA RESULTS FOR HEAVY METALS IN DRIED SPICE SAMPLES:

Method used: Standard Heavy Metal Acid Digestion

Sample number	Commodity	Result for Heavy Metal (mg/kg)			MRL (mg/kg)
		Cadmium	Chromium	Lead	
SY1	Curry powder	0.04	0.37	0.22	ALARA
SY2	Paprika	0.15	0.79	0.51	ALARA
SY3	Garam masala	0.10	0.56	0.50	ALARA
SY4	Turmeric	0.01	4.33	0.16	ALARA
SY5	Nutmeg	0.03	0.24	0.14	ALARA
SY6	Cinnamon	0.59	0.26	4.09	ALARA
SY7	Pepper	0.02	0.81	0.17	ALARA
SY8	Paprika	0.36	0.36	0.24	ALARA
SY9	Turmeric	0.01	0.35	0.05	ALARA
SY10	Curry powder	0.04	0.97	1.23	ALARA
SY11	Garam masala	0.06	0.74	0.76	ALARA
SY12	Pepper	0.01	0.73	0.09	ALARA
SY13	Paprika	0.10	0.92	0.59	ALARA
SY14	Garam masala	0.07	0.38	0.30	ALARA
SY15	Paprika	0.06	1.23	0.46	ALARA
SY16	Paprika	0.03	0.53	0.39	ALARA
SY17	Curry powder	0.03	0.62	0.41	ALARA
SY18	Garam masala	0.07	0.63	0.74	ALARA
SY19	Paprika	0.03	0.19	0.02	ALARA
SY20	Cinnamon	0.39	0.69	2.63	ALARA
SY21	Curry powder	0.03	1.03	0.67	ALARA
SY22	Pepper	0.02	1.54	0.05	ALARA
SY23	Paprika	0.19	0.76	0.16	ALARA
SY24	Cinnamon	0.28	0.28	0.73	ALARA
SY25	Nutmeg	0.04	No detects	0.05	ALARA
SY26	Turmeric	0.04	0.62	0.09	ALARA
SY27	Pepper	0.02	0.48	0.04	ALARA
SY28	Pepper	0.01	0.93	0.04	ALARA
SY29	Garam masala	0.09	1.16	0.54	ALARA
SY30	Paprika	0.08	0.15	0.02	ALARA
SY31	Paprika	0.04	0.37	0.10	ALARA
SY32	Paprika	0.10	0.46	0.16	ALARA
SY33	Cinnamon	0.11	0.57	0.03	ALARA
SY34	Cinnamon	0.54	0.31	3.37	ALARA
SY35	Garam masala	0.11	0.46	0.17	ALARA
SY36	Nutmeg	0.03	0.16	0.04	ALARA
SY37	Pepper	0.02	2.79	0.23	ALARA
SY38	Turmeric	0.03	0.37	0.12	ALARA
SY39	Turmeric	0.01	0.66	0.02	ALARA
SY40	Paprika	0.15	0.50	0.13	ALARA
SY41	Pepper	0.01	0.38	0.06	ALARA
SY42	Cinnamon	0.25	No detects	0.17	ALARA
SY43	Pepper	0.02	1.11	0.13	ALARA
SY44	Curry powder	0.03	1.08	0.34	ALARA
SY45	Garam masala	0.10	0.80	1.32	ALARA
SY46	Pepper	0.01	0.33	0.09	ALARA



Sample number	Commodity	Result for Heavy Metal (mg/kg)			MRL (mg/kg)
		Cadmium	Chromium	Lead	
SY47	Curry powder	0.06	2.21	0.60	ALARA
SY48	Turmeric	0.01	0.34	0.23	ALARA
SY49	Paprika	0.07	No detects	0.06	ALARA
SY50	Cinnamon	0.52	No detects	2.46	ALARA
SY51	Curry powder	0.05	0.21	0.17	ALARA
SY52	Cinnamon	0.53	No detects	2.35	ALARA
SY53	Garam masala	0.08	0.92	0.90	ALARA
SY54	Turmeric	0.01	0.23	0.08	ALARA
SY55	Pepper	0.01	0.18	0.07	ALARA
SY56	Paprika	0.04	No detects	0.11	ALARA
SY57	Garam masala	0.05	0.17	0.17	ALARA
SY58	Pepper	0.03	1.42	1.33	ALARA
SY59	Paprika	0.08	0.29	0.04	ALARA
SY60	Garam masala	0.07	0.74	0.83	ALARA
SY61	Turmeric	0.03	1.01	0.12	ALARA
SY62	Curry powder	0.02	0.20	0.10	ALARA
SY63	Paprika	0.05	2.11	0.39	ALARA
SY64	Curry powder	0.06	0.48	0.17	ALARA
SY65	Paprika	0.26	0.12	0.39	ALARA
SY66	Paprika	0.31	No detects	0.04	ALARA
SY67	Turmeric	0.01	0.29	0.07	ALARA
SY68	Pepper	0.01	0.22	0.05	ALARA
SY69	Paprika	0.37	1.36	0.23	ALARA
SY70	Nutmeg	0.03	No detects	0.04	ALARA
SY71	Garam masala	0.07	0.22	0.48	ALARA
SY72	Turmeric	0.02	0.92	0.11	ALARA
SY73	Curry powder	0.03	0.57	0.57	ALARA
SY74	Paprika	0.05	0.43	0.36	ALARA
SY75	Curry powder	0.06	1.13	0.19	ALARA
SY76	Nutmeg	0.02	0.12	0.04	ALARA
SY77	Nutmeg	0.03	0.18	0.02	ALARA
SY78	Cinnamon	0.46	0.99	4.50	ALARA
SY79	Turmeric	0.01	0.53	0.05	ALARA
SY80	Curry powder	0.02	0.37	0.04	ALARA
SY81	Garam masala	0.10	0.56	0.40	ALARA
SY82	Nutmeg	0.05	0.12	0.02	ALARA
SY83	Cinnamon	0.20	0.26	0.06	ALARA
SY84	Curry powder	0.05	1.30	0.24	ALARA
SY85	Turmeric	0.08	4.43	0.44	ALARA
SY86	Cinnamon	0.53	1.04	6.44	ALARA
SY87	Garam masala	0.08	0.83	0.41	ALARA
SY88	Pepper	0.01	0.14	No detects	ALARA
SY89	Turmeric	0.04	1.93	0.65	ALARA
SY90	Cinnamon	0.53	0.26	3.24	ALARA
SY91	Nutmeg	0.03	0.12	0.04	ALARA
SY92	Cinnamon	0.49	0.76	13.19	ALARA
SY93	Nutmeg	0.02	0.16	0.02	ALARA
SY94	Garam masala	0.07	0.48	0.47	ALARA
SY95	Curry powder	0.05	0.48	0.11	ALARA
SY96	Turmeric	0.04	0.54	0.09	ALARA
SY97	Cinnamon	0.20	0.12	0.14	ALARA
SY98	Curry powder	0.04	0.17	0.36	ALARA

Sample number	Commodity	Result for Heavy Metal (mg/kg)			MRL (mg/kg)
		Cadmium	Chromium	Lead	
SY99	Nutmeg	0.03	No detects	0.05	ALARA
SY100	Garam masala	0.12	0.69	1.08	ALARA
SY101	Pepper	No detects	0.27	2.70	ALARA
SY102	Turmeric	0.09	0.46	1.57	ALARA
SY103	Garam masala	0.08	0.81	0.75	ALARA
SY104	Nutmeg	0.02	No detects	0.03	ALARA
SY105	Nutmeg	0.03	No detects	0.05	ALARA
SY106	Nutmeg	0.03	No detects	0.12	ALARA
SY107	Cinnamon	0.59	No detects	4.33	ALARA
SY108	Curry powder	0.04	0.49	0.33	ALARA
SY109	Garam masala	0.05	0.38	0.46	ALARA
SY110	Pepper	0.01	No detects	0.07	ALARA
SY111	Pepper	0.02	No detects	0.09	ALARA
SY112	Nutmeg	0.04	No detects	0.02	ALARA
SY113	Cinnamon	0.21	No detects	0.21	ALARA
SY114	Turmeric	0.01	0.58	0.15	ALARA
SY115	Nutmeg	0.03	No detects	0.02	ALARA

### APPENDIX 3: RAW DATA RESULTS FOR PESTICIDES IN DRIED SPICE SAMPLES

Sample number	Commodity	Pesticide	Result (mg/kg)	MRL (mg/kg)	Codex MRLs reference (mg/kg)	Method used
SY1	Curry powder	No detects	No detects	N/A	N/A	GC
SY1	Curry powder	No detects	No detects	N/A	N/A	LC
SY2	Paprika	No detects	No detects	N/A	N/A	GC
SY2	Paprika	No detects	No detects	N/A	N/A	LC
SY3	Garam masala	No detects	No detects	N/A	N/A	GC
SY3	Garam masala	No detects	No detects	N/A	N/A	LC
SY4	Turmeric	No detects	No detects	N/A	N/A	GC
SY4	Turmeric	No detects	No detects	N/A	N/A	LC
SY5	Nutmeg	No detects	No detects	N/A	N/A	GC
SY5	Nutmeg	No detects	No detects	N/A	N/A	LC
SY6	Cinnamon	No detects	No detects	N/A	N/A	GC
SY6	Cinnamon	No detects	No detects	N/A	N/A	LC
SY7	Pepper	No detects	No detects	N/A	N/A	GC
SY7	Pepper	No detects	No detects	N/A	N/A	LC
SY8	Paprika	No detects	No detects	N/A	N/A	GC
SY8	Paprika	No detects	No detects	N/A	N/A	LC
SY9	Turmeric	No detects	No detects	N/A	N/A	GC
SY9	Turmeric	No detects	No detects	N/A	N/A	LC
SY10	Curry powder	Ethion	0.99	0.1	N/A	GC
SY10	Curry powder	No detects	No detects	N/A	N/A	LC
SY11	Garam masala	No detects	No detects	N/A	N/A	GC
SY11	Garam masala	No detects	No detects	N/A	N/A	LC
SY12	Pepper	No detects	No detects	N/A	N/A	GC
SY12	Pepper	No detects	No detects	N/A	N/A	LC
SY13	Paprika	Chlormequat chloride	0.57	0.1	N/A	LC
SY13	Paprika	No detects	No detects	N/A	N/A	GC
SY14	Garam masala	No detects	No detects	N/A	N/A	GC
SY14	Garam masala	No detects	No detects	N/A	N/A	LC
SY15	Paprika	Carbendazim	0.78	0.1	20	LC
SY15	Paprika	No detects	No detects	N/A	N/A	GC
SY16	Paprika	No detects	No detects	N/A	N/A	GC
SY16	Paprika	No detects	No detects	N/A	N/A	LC
SY17	Curry powder	No detects	No detects	N/A	N/A	GC
SY17	Curry powder	No detects	No detects	N/A	N/A	LC
SY18	Garam masala	No detects	No detects	N/A	N/A	GC
SY18	Garam masala	No detects	No detects	N/A	N/A	LC
SY19	Paprika	Cypermethrin	0.71	0.1	10	GC
SY19	Paprika	Acetamiprid	0.23	0.1	N/A	LC
SY19	Paprika	Ethion	1.35	0.1	N/A	GC
SY20	Cinnamon	No detects	No detects	N/A	N/A	GC
SY20	Cinnamon	No detects	No detects	N/A	N/A	LC
SY21	Curry powder	No detects	No detects	N/A	N/A	GC
SY21	Curry powder	No detects	No detects	N/A	N/A	LC
SY22	Pepper	No detects	No detects	N/A	N/A	GC
SY22	Pepper	No detects	No detects	N/A	N/A	LC
SY23	Paprika	No detects	No detects	N/A	N/A	GC
SY23	Paprika	No detects	No detects	N/A	N/A	LC

Sample number	Commodity	Pesticide	Result (mg/kg)	MRL (mg/kg)	Codex MRLs reference (mg/kg)	Method used
SY24	Cinnamon	No detects	No detects	N/A	N/A	GC
SY24	Cinnamon	No detects	No detects	N/A	N/A	LC
SY25	Nutmeg	No detects	No detects	N/A	N/A	GC
SY25	Nutmeg	No detects	No detects	N/A	N/A	LC
SY26	Turmeric	No detects	No detects	N/A	N/A	GC
SY26	Turmeric	No detects	No detects	N/A	N/A	LC
SY27	Pepper	No detects	No detects	N/A	N/A	GC
SY27	Pepper	No detects	No detects	N/A	N/A	LC
SY28	Pepper	No detects	No detects	N/A	N/A	GC
SY28	Pepper	No detects	No detects	N/A	N/A	LC
SY29	Garam masala	No detects	No detects	N/A	N/A	GC
SY29	Garam masala	No detects	No detects	N/A	N/A	LC
SY30	Paprika	Ethion	0.42	0.1	N/A	GC
SY30	Paprika	Imidacloprid	0.43	0.1	10	LC
SY30	Paprika	Pirimiphos-methyl	1.91	0.1	N/A	GC
SY31	Paprika	Ethion	0.47	0.1	N/A	GC
SY31	Paprika	Triazophos	1.59	0.1	N/A	GC
SY31	Paprika	No detects	No detects	N/A	N/A	LC
SY32	Paprika	Carbendazim	0.23	0.1	20	LC
SY32	Paprika	Ethion	0.26	0.1	N/A	GC
SY33	Cinnamon	No detects	No detects	N/A	N/A	GC
SY33	Cinnamon	No detects	No detects	N/A	N/A	LC
SY34	Cinnamon	No detects	No detects	N/A	N/A	GC
SY34	Cinnamon	No detects	No detects	N/A	N/A	LC
SY35	Garam masala	No detects	No detects	N/A	N/A	GC
SY35	Garam masala	No detects	No detects	N/A	N/A	LC
SY36	Nutmeg	No detects	No detects	N/A	N/A	GC
SY36	Nutmeg	No detects	No detects	N/A	N/A	LC
SY37	Pepper	No detects	No detects	N/A	N/A	GC
SY37	Pepper	No detects	No detects	N/A	N/A	LC
SY38	Turmeric	No detects	No detects	N/A	N/A	GC
SY38	Turmeric	No detects	No detects	N/A	N/A	LC
SY39	Turmeric	No detects	No detects	N/A	N/A	GC
SY39	Turmeric	No detects	No detects	N/A	N/A	LC
SY40	Paprika	No detects	No detects	N/A	N/A	GC
SY40	Paprika	No detects	No detects	N/A	N/A	LC
SY41	Pepper	No detects	No detects	N/A	N/A	GC
SY41	Pepper	No detects	No detects	N/A	N/A	LC
SY42	Cinnamon	No detects	No detects	N/A	N/A	GC
SY42	Cinnamon	No detects	No detects	N/A	N/A	LC
SY43	Pepper	No detects	No detects	N/A	N/A	GC
SY43	Pepper	No detects	No detects	N/A	N/A	LC
SY44	Curry powder	No detects	No detects	N/A	N/A	GC
SY44	Curry powder	No detects	No detects	N/A	N/A	LC
SY45	Garam Masala	Acetamiprid	0.26	0.1	N/A	LC
SY45	Garam Masala	Carbendazim	0.24	0.1	N/A	LC
SY45	Garam masala	No detects	No detects	N/A	N/A	GC
SY46	Pepper	No detects	No detects	N/A	N/A	LC
SY46	Pepper	No detects	No detects	N/A	N/A	GC
SY47	Curry powder	No detects	No detects	N/A	N/A	LC
SY47	Curry powder	No detects	No detects	N/A	N/A	GC

Sample number	Commodity	Pesticide	Result (mg/kg)	MRL (mg/kg)	Codex MRLs reference (mg/kg)	Method used
SY48	Turmeric	No detects	No detects	N/A	N/A	LC
SY48	Turmeric	No detects	No detects	N/A	N/A	GC
SY49	Paprika	Carbendazim	0.28	0.1	20	LC
SY49	Paprika	Ethion	1.43	0.1	N/A	GC
SY50	Cinnamon	No detects	No detects	N/A	N/A	GC
SY50	Cinnamon	No detects	No detects	N/A	N/A	LC
SY51	Curry powder	No detects	No detects	N/A	N/A	GC
SY51	Curry powder	No detects	No detects	N/A	N/A	LC
SY52	Cinnamon	No detects	No detects	N/A	N/A	GC
SY52	Cinnamon	No detects	No detects	N/A	N/A	LC
SY53	Garam masala	No detects	No detects	N/A	N/A	GC
SY53	Garam masala	No detects	No detects	N/A	N/A	LC
SY54	Turmeric	No detects	No detects	N/A	N/A	GC
SY54	Turmeric	No detects	No detects	N/A	N/A	LC
SY55	Pepper	No detects	No detects	N/A	N/A	GC
SY55	Pepper	No detects	No detects	N/A	N/A	LC
SY56	Paprika	Ethion	0.29	0.1	N/A	GC
SY56	Paprika	No detects	No detects	N/A	N/A	LC
SY57	Garam masala	No detects	No detects	N/A	N/A	GC
SY57	Garam masala	No detects	No detects	N/A	N/A	LC
SY58	Pepper	No detects	No detects	N/A	N/A	GC
SY58	Pepper	No detects	No detects	N/A	N/A	LC
SY59	Paprika	Carbendazim	0.30	0.1	20	LC
SY59	Paprika	Imidacloprid	0.34	0.1	10	LC
SY59	Paprika	No detects	No detects	N/A	N/A	GC
SY60	Garam masala	No detects	No detects	N/A	N/A	GC
SY60	Garam masala	No detects	No detects	N/A	N/A	LC
SY61	Turmeric	No detects	No detects	N/A	N/A	GC
SY61	Turmeric	No detects	No detects	N/A	N/A	LC
SY62	Curry powder	No detects	No detects	N/A	N/A	GC
SY62	Curry powder	No detects	No detects	N/A	N/A	LC
SY63	Paprika	Chlormequat chloride	0.21	0.1	N/A	LC
SY63	Paprika	No detects	No detects	N/A	N/A	GC
SY64	Curry powder	No detects	No detects	N/A	N/A	LC
SY64	Curry powder	No detects	No detects	N/A	N/A	GC
SY65	Paprika	No detects	No detects	N/A	N/A	LC
SY65	Paprika	No detects	No detects	N/A	N/A	GC
SY66	Paprika	No detects	No detects	N/A	N/A	LC
SY66	Paprika	No detects	No detects	N/A	N/A	GC
SY67	Turmeric	No detects	No detects	N/A	N/A	LC
SY67	Turmeric	No detects	No detects	N/A	N/A	GC
SY68	Pepper	No detects	No detects	N/A	N/A	LC
SY68	Pepper	No detects	No detects	N/A	N/A	GC
SY69	Paprika	No detects	No detects	N/A	N/A	LC
SY69	Paprika	No detects	No detects	N/A	N/A	GC
SY70	Nutmeg	No detects	No detects	N/A	N/A	LC
SY70	Nutmeg	No detects	No detects	N/A	N/A	GC
SY71	Garam masala	No detects	No detects	N/A	N/A	LC
SY71	Garam masala	No detects	No detects	N/A	N/A	GC
SY72	Turmeric	No detects	No detects	N/A	N/A	LC
SY72	Turmeric	No detects	No detects	N/A	N/A	GC

Sample number	Commodity	Pesticide	Result (mg/kg)	MRL (mg/kg)	Codex MRLs reference (mg/kg)	Method used
SY73	Curry powder	No detects	No detects	N/A	N/A	LC
SY73	Curry powder	No detects	No detects	N/A	N/A	GC
SY74	Paprika	No detects	No detects	N/A	N/A	LC
SY74	Paprika	No detects	No detects	N/A	N/A	GC
SY75	Curry powder	No detects	No detects	N/A	N/A	LC
SY75	Curry powder	No detects	No detects	N/A	N/A	GC
SY76	Nutmeg	No detects	No detects	N/A	N/A	LC
SY76	Nutmeg	No detects	No detects	N/A	N/A	GC
SY77	Nutmeg	No detects	No detects	N/A	N/A	LC
SY77	Nutmeg	No detects	No detects	N/A	N/A	GC
SY78	Cinnamon	No detects	No detects	N/A	N/A	LC
SY78	Cinnamon	No detects	No detects	N/A	N/A	GC
SY79	Turmeric	No detects	No detects	N/A	N/A	LC
SY79	Turmeric	No detects	No detects	N/A	N/A	GC
SY80	Curry powder	Chlorpyrifos-methyl	1.08	0.1	N/A	GC
SY80	Curry powder	No detects	No detects	N/A	N/A	LC
SY81	Garam masala	No detects	No detects	N/A	N/A	GC
SY81	Garam masala	No detects	No detects	N/A	N/A	LC
SY82	Nutmeg	No detects	No detects	N/A	N/A	GC
SY82	Nutmeg	No detects	No detects	N/A	N/A	LC
SY83	Cinnamon	No detects	No detects	N/A	N/A	GC
SY83	Cinnamon	No detects	No detects	N/A	N/A	LC
SY84	Curry powder	No detects	No detects	N/A	N/A	GC
SY84	Curry powder	No detects	No detects	N/A	N/A	LC
SY85	Turmeric	No detects	No detects	N/A	N/A	GC
SY85	Turmeric	No detects	No detects	N/A	N/A	LC
SY86	Cinnamon	No detects	No detects	N/A	N/A	GC
SY86	Cinnamon	No detects	No detects	N/A	N/A	LC
SY87	Garam masala	No detects	No detects	N/A	N/A	GC
SY87	Garam masala	No detects	No detects	N/A	N/A	LC
SY88	Pepper	No detects	No detects	N/A	N/A	GC
SY88	Pepper	No detects	No detects	N/A	N/A	LC
SY89	Turmeric	No detects	No detects	N/A	N/A	GC
SY89	Turmeric	No detects	No detects	N/A	N/A	LC
SY90	Cinnamon	No detects	No detects	N/A	N/A	GC
SY90	Cinnamon	No detects	No detects	N/A	N/A	LC
SY91	Nutmeg	No detects	No detects	N/A	N/A	GC
SY91	Nutmeg	No detects	No detects	N/A	N/A	LC
SY92	Cinnamon	No detects	No detects	N/A	N/A	GC
SY92	Cinnamon	No detects	No detects	N/A	N/A	LC
SY93	Nutmeg	No detects	No detects	N/A	N/A	GC
SY93	Nutmeg	No detects	No detects	N/A	N/A	LC
SY94	Garam masala	No detects	No detects	N/A	N/A	GC
SY94	Garam masala	No detects	No detects	N/A	N/A	LC
SY95	Curry powder	No detects	No detects	N/A	N/A	GC
SY95	Curry powder	No detects	No detects	N/A	N/A	LC
SY96	Turmeric	No detects	No detects	N/A	N/A	GC
SY96	Turmeric	No detects	No detects	N/A	N/A	LC
SY97	Cinnamon	No detects	No detects	N/A	N/A	GC
SY97	Cinnamon	No detects	No detects	N/A	N/A	LC
SY98	Curry powder	Ethion	0.32	0.1	N/A	GC

Sample number	Commodity	Pesticide	Result (mg/kg)	MRL (mg/kg)	Codex MRLs reference (mg/kg)	Method used
SY98	Curry powder	No detects	No detects	N/A	N/A	LC
SY99	Nutmeg	No detects	No detects	N/A	N/A	GC
SY99	Nutmeg	No detects	No detects	N/A	N/A	LC
SY100	Garam masala	No detects	No detects	N/A	N/A	GC
SY100	Garam masala	No detects	No detects	N/A	N/A	LC
SY101	Pepper	No detects	No detects	N/A	N/A	GC
SY101	Pepper	No detects	No detects	N/A	N/A	LC
SY102	Turmeric	No detects	No detects	N/A	N/A	GC
SY102	Turmeric	No detects	No detects	N/A	N/A	LC
SY103	Garam masala	No detects	No detects	N/A	N/A	GC
SY103	Garam masala	No detects	No detects	N/A	N/A	LC
SY104	Nutmeg	No detects	No detects	N/A	N/A	GC
SY104	Nutmeg	No detects	No detects	N/A	N/A	LC
SY105	Nutmeg	No detects	No detects	N/A	N/A	GC
SY105	Nutmeg	No detects	No detects	N/A	N/A	LC
SY106	Nutmeg	No detects	No detects	N/A	N/A	GC
SY106	Nutmeg	No detects	No detects	N/A	N/A	LC
SY107	Cinnamon	No detects	No detects	N/A	N/A	GC
SY107	Cinnamon	No detects	No detects	N/A	N/A	LC
SY108	Curry powder	No detects	No detects	N/A	N/A	GC
SY108	Curry powder	No detects	No detects	N/A	N/A	LC
SY109	Garam masala	No detects	No detects	N/A	N/A	GC
SY109	Garam masala	No detects	No detects	N/A	N/A	LC
SY110	Pepper	Piperonyl-butoxide	1.69	0.1	2	GC
SY110	Pepper	No detects	No detects	N/A	N/A	LC
SY111	Pepper	No detects	No detects	N/A	N/A	GC
SY111	Pepper	No detects	No detects	N/A	N/A	LC
SY112	Nutmeg	No detects	No detects	N/A	N/A	GC
SY112	Nutmeg	No detects	No detects	N/A	N/A	LC
SY113	Cinnamon	No detects	No detects	N/A	N/A	GC
SY113	Cinnamon	No detects	No detects	N/A	N/A	LC
SY114	Turmeric	No detects	No detects	N/A	N/A	GC
SY114	Turmeric	No detects	No detects	N/A	N/A	LC
SY115	Nutmeg	No detects	No detects	N/A	N/A	GC
SY115	Nutmeg	No detects	No detects	N/A	N/A	LC

## APPENDIX 4: RAW DATA RESULTS FOR COLOURS/DYES IN DRIED SPICE SAMPLES:

Method used: LCMS

Sample ID	Commodity	Result (mg/kg)	Colour Detected	MRL (mg/kg)
SY1	Curry powder	No detects	nil	nil
SY2	Paprika	No detects	nil	nil
SY3	Garam masala	No detects	nil	nil
SY4	Turmeric	No detects	nil	nil
SY5	Nutmeg	No detects	nil	nil
SY6	Cinnamon	No detects	nil	nil
SY7	Pepper	No detects	nil	nil
SY8	Paprika	No detects	nil	nil
SY9	Turmeric	No detects	nil	nil
SY10	Curry powder	No detects	nil	nil
SY11	Garam masala	No detects	nil	nil
SY12	Pepper	No detects	nil	nil
SY13	Paprika	No detects	nil	nil
SY14	Garam masala	No detects	nil	nil
SY15	Paprika	No detects	nil	nil
SY16	Paprika	No detects	nil	nil
SY17	Curry powder	No detects	nil	nil
SY18	Garam masala	No detects	nil	nil
SY19	Paprika	No detects	nil	nil
SY20	Cinnamon	15.00	Auramine O	nil
SY21	Curry powder	No detects	nil	nil
SY22	Pepper	No detects	nil	nil
SY23	Paprika	No detects	nil	nil
SY24	Cinnamon	No detects	nil	nil
SY25	Nutmeg	No detects	nil	nil
SY26	Turmeric	No detects	nil	nil
SY27	Pepper	No detects	nil	nil
SY28	Pepper	No detects	nil	nil
SY29	Garam masala	No detects	nil	nil
SY30	Paprika	No detects	nil	nil
SY31	Paprika	No detects	nil	nil
SY32	Paprika	No detects	nil	nil
SY33	Cinnamon	No detects	nil	nil
SY34	Cinnamon	No detects	nil	nil
SY35	Garam masala	No detects	nil	nil
SY36	Nutmeg	No detects	nil	nil
SY37	Pepper	No detects	nil	nil
SY38	Turmeric	No detects	nil	nil
SY39	Turmeric	No detects	nil	nil
SY40	Paprika	No detects	nil	nil
SY41	Pepper	No detects	nil	nil
SY42	Cinnamon	No detects	nil	nil
SY43	Pepper	No detects	nil	nil
SY44	Curry powder	No detects	nil	nil
SY45	Garam masala	No detects	nil	nil
SY46	Pepper	No detects	nil	nil



Sample ID	Commodity	Result (mg/kg)	Colour Detected	MRL (mg/kg)
SY47	Curry powder	No detects	nil	nil
SY48	Turmeric	No detects	nil	nil
SY49	Paprika	No detects	nil	nil
SY50	Cinnamon	No detects	nil	nil
SY51	Curry powder	No detects	nil	nil
SY52	Cinnamon	No detects	nil	nil
SY53	Garam masala	No detects	nil	nil
SY54	Turmeric	No detects	nil	nil
SY55	Pepper	No detects	nil	nil
SY56	Paprika	No detects	nil	nil
SY57	Garam masala	No detects	nil	nil
SY58	Pepper	No detects	nil	nil
SY59	Paprika	No detects	nil	nil
SY60	Garam masala	No detects	nil	nil
SY61	Turmeric	No detects	nil	nil
SY62	Curry powder	No detects	nil	nil
SY63	Paprika	No detects	nil	nil
SY64	Curry powder	No detects	nil	nil
SY65	Paprika	No detects	nil	nil
SY66	Paprika	No detects	nil	nil
SY67	Turmeric	No detects	nil	nil
SY68	Pepper	No detects	nil	nil
SY69	Paprika	No detects	nil	nil
SY70	Nutmeg	No detects	nil	nil
SY71	Garam masala	No detects	nil	nil
SY72	Turmeric	No detects	nil	nil
SY73	Curry powder	No detects	nil	nil
SY74	Paprika	No detects	nil	nil
SY75	Curry powder	No detects	nil	nil
SY76	Nutmeg	No detects	nil	nil
SY77	Nutmeg	No detects	nil	nil
SY78	Cinnamon	No detects	nil	nil
SY79	Turmeric	No detects	nil	nil
SY80	Curry powder	No detects	nil	nil
SY81	Garam masala	No detects	nil	nil
SY82	Nutmeg	No detects	nil	nil
SY83	Cinnamon	No detects	nil	nil
SY84	Curry powder	No detects	nil	nil
SY85	Turmeric	No detects	nil	nil
SY86	Cinnamon	No detects	nil	nil
SY87	Garam masala	No detects	nil	nil
SY88	Pepper	No detects	nil	nil
SY89	Turmeric	No detects	nil	nil
SY90	Cinnamon	No detects	nil	nil
SY91	Nutmeg	No detects	nil	nil
SY92	Cinnamon	No detects	nil	nil
SY93	Nutmeg	No detects	nil	nil
SY94	Garam masala	No detects	nil	nil
SY95	Curry powder	No detects	nil	nil
SY96	Turmeric	No detects	nil	nil
SY97	Cinnamon	No detects	nil	nil
SY98	Curry powder	No detects	nil	nil

Sample ID	Commodity	Result (mg/kg)	Colour Detected	MRL (mg/kg)
SY99	Nutmeg	No detects	nil	nil
SY100	Garam masala	No detects	nil	nil
SY101	Pepper	No detects	nil	nil
SY102	Turmeric	No detects	nil	nil
SY103	Garam masala	No detects	nil	nil
SY104	Nutmeg	No detects	nil	nil
SY105	Nutmeg	No detects	nil	nil
SY106	Nutmeg	No detects	nil	nil
SY107	Cinnamon	No detects	nil	nil
SY108	Curry powder	No detects	nil	nil
SY109	Garam masala	No detects	nil	nil
SY110	Pepper	No detects	nil	nil
SY111	Pepper	No detects	nil	nil
SY112	Nutmeg	No detects	nil	nil
SY113	Cinnamon	No detects	nil	nil
SY114	Turmeric	No detects	nil	nil
SY115	Nutmeg	No detects	nil	nil