NSW GOVERNMENT Food Authority

Follow up survey of cyanogenic glycosides in ready-to-eat cassava chips

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Executive summary

Cassava naturally contains cyanogenic glycosides, which can be broken down in the gut to form hydrogen cyanide. In 2008, the NSW Food Authority (the Authority) conducted a survey on levels of cyanogenic glycosides (measured as total hydrocyanic acid or HCN) in ready-to -eat (RTE) cassava chips.

The 2008 survey was in response to a notification from Japanese authorities that higher than expected levels of hydrogen cyanide were detected in Australian-manufactured RTE cassava-based fried cassava chips. Japanese authorities regarded the levels of hydrogen cyanide as unacceptable and rejected the entire batch. The Authority's 2008 survey detected HCN in 317 of 374 (84.7%) samples tested, with levels ranging from 13 to 165 mg HCN eq./kg.

A toxicological assessment performed at the time by Food Standards Australia New Zealand (FSANZ) concluded there was a potential public health risk associated with certain levels of HCN in these products and consequently a standard was introduced into the Food Standards Code in 2009. This standard specified a maximum level of 10 mg/kg HCN in RTE cassava chips. In addition, the Department of Agriculture, Fisheries and Forestry (DAFF) Biosecurity (formerly the Australian Quarantine and Inspection Service - AQIS) added cassava chips to the Imported Food Inspection Scheme as a risk category food, meaning that 100% of imports were inspected.

In 2011–12, the Authority undertook a follow-up survey to determine the level of total HCN in RTE cassava chips currently available in NSW (the Authority's 2011–12 survey). The aim was to compare the results with the 2008 survey to determine whether there has been a significant reduction in levels of total HCN in RTE cassava chips since the introduction of a limit in the Food Standards Code.

Results from the survey conducted during 2011–12 showed that there had been a significant increase in the number of samples compliant with the Food Standards Code limit.

However, there remained a proportion of RTE cassava chips that contained HCN, as it was detected in 94 of 325 (28.9%) samples tested, with levels ranging from 10 to 268 mg HCN eq./kg. In accordance with the compliance plan developed for the survey, compliance action included issuing advisory letters to the manufacturers and/or importers (as appropriate) for products that exceeded the maximum level specified in the Code and consumer level recalls of three product were also undertaken.

Introduction

Cassava (Manihot esculenta Crantz) is a woody shrub that is widely cultivated in many tropical countries for its edible, starchy and tuberous root. It is consumed in many developing countries as a major source of carbohydrates and forms the basis of many traditional foods such as lafun, fufu, gari, and tapioca flour. In terms of annual production, cassava is the sixth most important food crop globally and is a staple food for approximately 800 million people (Burns et al, 2011).

In its natural state, cassava contains compounds called cyanogenic glycosides (cyanogens), mainly composed of linamarin, acetone cyanohydrin, and hydrocyanic acid (HCN). If cassava is not adequately processed to reduce the level of cyanogens prior to consumption, these compounds can lead to the formation of HCN in the gut. Exposure to HCN can cause symptoms ranging from dizziness, vomiting and abdominal pain to coma and death.

In order to safely consume cassava, it is essential that the cyanogen content of raw cassava is reduced prior to consumption, and there are established processing methods to enable

this to occur. Processing techniques include soaking the cassava roots in water and then, crushing, cutting or heating them. These processes release the volatile HCN, ensuring it does not remain in the food. Failure to adequately process cassava to reduce the cyanogen content can result in human illness. While a proportion of the ingested cyanogens are absorbed and excreted unchanged in the urine, the remainder is enzymatically converted by bacteria in the human gut to form HCN as an end product.

While cassava-based products such as tapioca flour have been available to western consumers for many years, cassava-based snack foods such as fried crackers, chips, and crisps have become more popular in recent years, primarily being marketed as a healthier alternative to potato crisps. The chips may be made from either whole slices of cassava root or from tapioca flour dough, which is steamed to gelatinise the starch and cut into thin, circular-shaped slices. These slices are then dried to become semi-finished cassava crackers or chip 'pellets'. The pellets are then deep fried in hot oil or baked until brittle and may be further seasoned with herbs, spices, cheese, or artificial flavours to become RTE cassava chips.

Hydrocyanic acid survey of cassava chips in 2008 showed levels of concern

In 2008, the NSW Food Authority (the Authority) conducted a survey of RTE cassava-based chips to determine levels of cyanogens, measured as total hydrocyanic acid (mg HCN equivalents/kg) with a limit of detection of 10 mg HCN eq./kg.

This survey was undertaken in response to an alert of the detection of elevated levels of cyanogens in a RTE cassava-based snack food manufactured in NSW. Australian food regulatory authorities were informed by Japanese authorities that higher than expected levels of HCN were detected in RTE cassava-based fried cassava chips exported from Australia to Japan. The Japanese authorities regarded the levels of 52, 58, 59 mg/kg HCN as unacceptable and rejected the entire batch.

In the subsequent survey undertaken by the Authority, 374 samples of RTE cassava chips available in the NSW marketplace were analysed, covering 18 distinct brands. These products included both products manufactured in Australia from imported ingredients (cassava is not commercially grown in Australia) and products manufactured overseas and imported into Australia.

Significant variation in the levels of total HCN were observed in the 317/374 (84.7%) samples tested positive for HCN, with levels ranged ranging from 13 to 165 mg HCN eq./kg (mean value 64.2 mg HCN eq./kg for positive samples). The results from this survey were published in a peer reviewed journal (Miles et al, 2011).

The results of this survey served to highlight the importance for of food manufacturers to undertake a thorough hazard analysis to determine critical control points, particularly for those ingredients they may be unfamiliar with.

A maximum level for hydrocyanic acid established in the Food Standards Code

The notification from Japanese authorities, in addition to the results from the Authority's 2008 survey, prompted Food Standards Australia New Zealand (FSANZ) to assess the public health risks associated with HCN in RTE cassava chips. While the Code already established that the use of cassava tubers containing more than 50 mg/kg HCN ("bitter" cassava) was prohibited, there were no regulatory measures relating to cassava-based snack foods.

FSANZ initiated Proposal P1002 – Hydrocyanic Acid in Ready-to-Eat Cassava Chips and conducted a risk assessment on consumption of cassava chips containing HCN (FSANZ, 2008a). The main concern was that a small child may consume a significant amount of chips

in one sitting and, therefore, consumption levels to exceed the acute reference doses for 2 to 4 year olds were determined (outlined in Table 1). As an interim measure, FSANZ developed a guidance level of 25 mg/kg HCN which was considered appropriate to minimise the likelihood of acute toxicity in children arising from the consumption of RTE cassava chips (FSANZ, 2008a). This value was based on the existing maximum level of 25 mg/kg in the Food Standards Code for HCN in confectionery.

Table 1. Amount of cassava chip consumption required to exceed the acute reference dose (ARfD) for young children (2 to 4 year olds)

Scenario	Total HCN levels in chips			
	10 mg/kg (Code limit)	25 mg/kg (original guidance level proposed by FSANZ)	63 mg/kg (average value in initial samples of 2008 survey)	145 mg/kg (highest value in initial samples of 2008 survey)
Amount of chips consumed to exceed ARfD for 2–4 year olds	133 g	53 g	21 g	9g

Adapted from FSANZ (2008a, 2008b)

As a result of this assessment, FSANZ considered that additional regulatory measures in the Code were required to reduce levels of HCN in cassava chips in order to protect public health and safety. In accordance with these findings, a regulatory maximum level (ML) of 10 mg/kg HCN for RTE cassava chips was prescribed in Standard 1.4.1 of the Food Standards Code[1] . This limit aligned with the Codex Alimentarius Commission international standard for edible cassava flour (Codex Alimentarius Commission, 1989).

Inspection of imported products commenced in 2009

Once the ML was included in Standard 1.4.1 of the Code, DAFF Biosecurity (formerly Australian Quarantine and Inspection Service or AQIS) added cassava chips to the Imported Food Inspection Scheme as a risk category food[2]. As a result, inspections and testing of imported RTE cassava chips at the border commenced in August 2009. It should be noted that initially the testing did not extend to RTE tapioca chips as this was not included in the search term for foods to be referred.

The DAFF Biosecurity data from the imported food testing for cassava snack foods is shown in Table 2.

[1] Standard 1.4.1 – *Contaminants and natural toxicants* of the Australia New Zealand Food Standards Code defines ready to eat cassava chips as product containing sweet cassava that is represented as ready for immediate consumption with no further preparation required including crisps, crackers or 'Cassava' crackers.

[2] Foods that have been assessed by FSANZ as representing a medium to high potential risk to consumer health. Referred to DAFF Biosecurity by Customs for inspection at the rate of 100 % of imports.

Table 2. Testing of imported cassava snack foods

Total HCN content (mg HCN eq./kg)	2009[3]		2010		2011	
	Number (% of total)	Mean level (SD)	Number (% of total)	Mean level (SD)	Number (% of total)	Mean level (SD)
≤ 10	22 (100%)	—	20 (50%)		25 (69.4%)	—
11–25	—	—	17 (41.4%)		7 (19.4%)	15.5 (4.9)
26–50	—	—	3 (7.3%)		4 (11.1%)	34.8 (6.5)
51–100	—	—	1 (2.4%)	55.0	—	—
>100	—	—	—	—	—	—
Total	22	—	41	19.8 (10.7)	36	22.5 (11.0)

Adapted from AQIS failing food – Monthly Reports 2009, 2010, 2011 (DAFF Biosecurity, 2012)

The results from 2009 showed that all 22 samples tested were compliant with the limit. During 2010 however, 21/41 batches were rejected (with levels ranging from 11 to 55 mg HCN eq./kg) and in 2011 the number of batches rejected was 11/36 (with levels ranging from 10.3 to 41 mg HCN eq./kg).

Other published results

Burns et al (2011) published a small survey of the HCN content in RTE cassava chips available in grocery stores in Melbourne during February 2010 and over a six year period in Canberra. Three samples of each product were tested, except for chips from India where only two samples were available. The average cyanide content from products purchased in Melbourne was 91±106 ppm, including very high levels detected in product imported from India. Burns et al (2011) found the high level result of 262 ppm to be most alarming as a child of 20 kg body weight may only need to eat between 40–-270 g of these very high cyanide chips to reach a potential lethal dose.

The survey of products purchased in Canberra did show a significant improvement in levels of total cyanide after the introduction of the limit in the Food Standards Code, with samples taken in 2011 having an average value of 7±4 total cyanide (Table 3).

[3] Cassava snack foods were added to the imported food testing program in 2009.

Table 3. Published study of total cyanide content of cassava food products available in Melbourne and Canberra

Product purchased in Melbourne in 2010	Origin	Total cyanide (ppm) (SD)
Vegetable chips	Australia – with imported ingredients	26 (6)
Tapioca crisps (BBQ)	Singapore	42 (8)
Cassava chips	India	262 (34)
Product purchased in Canberra	**Year of purchase**	**Total cyanide (ppm) (SD)**
Vegetable chips	2005	68 (20)
Vegetable chips	2006	83 (5)
Vegetable chips	2007	84 (1)
Vegetable crackers	2008	51 (2)
Vegetable chips	2011	7 (4)

Adapted from Burns et al (2011)

Compliance plan for ready-to-eat cassava chips

In addition to the inclusion of a regulatory limit in the Food Standards Code, a compliance plan was developed by an Implementation Sub-Committee (ISC) working group on behalf of the Food Regulation Standing Committee (FRSC). For jurisdictions undertaking testing or responding to test results, the compliance plan required that samples were analysed using a published peer reviewed method and any risk management strategies were applied on the analysis of lots of five (5 five separate samples per batch). The average value of total HCN from the five samples for each batch was to be calculated and any compliance measures were based on that result (Table 4).

Table 4. Compliance action based on HCN levels in RTE cassava chips

Mean level of total hydrocyanic acid (mg HCN eq./kg)	Rationale	Compliance action	Action taken by
≤10	Product complies with the level in the *Food Standards Code*	No action required	N/A
11-25	Levels above regulated limit. However level is below the initial guidance level of 25 mg/kg proposed by FSANZ (2008a)	• Business (manufacturer or importer) contacted and informed of results. • Business asked to provide plan for reducing levels in products or evidence of addressing this issue. • Additional batches of product tested.	NSW Food Authority or interstate enforcement agency
>25	Levels are above the regulated limit and previous guidance level	Business may be requested to undertake a voluntary recall or withdrawal	NSW Food Authority or interstate enforcement agency

Adapted from ISC compliance plan

2011–12 Food Authority survey methodology

Sample range

As a follow -up to the 2008 survey, the Authority undertook another survey between October 2011 and November 2012 to determine whether there has been a reduction in the levels of total HCN in RTE cassava chips since the introduction of a limit in the Code for these products.

RTE cassava chips were purchased at the retail level by Authority officers. The product range selected for analysis included any RTE cassava chips or crisps available for sale, but did not include fresh, frozen or shredded cassava or raw crackers and chips required to be cooked prior to consumption. During the development of the survey plan, the Authority noted the testing being undertaken by DAFF Biosecurity at the border. As such, the aim was not to duplicate this work and, therefore, the sampling did not include imported RTE cassava chips that had been tested at the border and found to be compliant with the Code. The Authority's sampling focused on locally made RTE cassava chips and any imported product not assessed by DAFF Biosecurity.

Number of samples

The number of samples selected for analysis in the 2011–12 survey was based on product knowledge obtained from the 2008 survey. In 2008, there were 18 brands tested for the presence of HCN and, as far as possible, the same brands were analysed again to determine if there had been an improvement in compliance.

Five samples of each product with the same batch code were purchased and tested for total HCN.

Risk management strategy

In accordance with the ISC compliance plan, any compliance action was based on a mean value calculated from the five samples. The risk management strategy was based on the ISC compliance plan (Table 4).

Where product was manufactured or imported by an interstate business the relevant enforcement agency were informed and requested to provide feedback on action taken. The Authority issued advisory letters to manufacturers and/or importers (as appropriate) located in NSW and also worked with several companies to undertake consumer level recalls for products with high levels of HCN that were still available in the marketplace.

During the course of the survey, it was noted that imported RTE cassava chips labelled as tapioca chips were found to contain high levels of HCN. This was referred to DAFF Biosecurity for them to modify the imported food inspection scheme to ensure these products were also captured within the scope of testing occurring at the border.

Laboratory analysis

Upon purchase, samples were photographed and sample details recorded. The details recorded were:

- Product name, including flavour etc
- Manufacturer
- Importer, where relevant
- Country of origin
- Weight
- Batch code
- Best before
- Place of purchase

Samples were submitted to the General Chemistry laboratory at NSW Forensic Analytical and Science Service which has received NATA accreditation for a method based on that of Bradbury et al (1999).

This method was originally developed as a semi-quantitative test kit for field use in developing nations. For the purposes of analytical analysis, the method was modified by the use of laboratory equipment to accurately measure sample size and reagents and a spectrophotometer (Varian, Cary 3E UV-Vis spectrophotometer, Mulgrave, Victoria, Australia) used to assess the degree of colour change.

The entire contents of a bag (retail sizes varied from 40 to 275 g) of the RTE cassava chip samples were ground into a powder using a food processor (Blixer 3, Robot Coupe Australia Pty. Ltd., Northbridge, New South Wales), with a 100 mg subsample of the powder taken aside. To a flat-bottomed plastic bottle, a round paper disc containing the linamarase enzyme (Sigma-Aldrich Pty. Ltd., Sydney, New South Wales, Australia) and buffer at pH 6 was added. To this, the 100 mg of powder sample and 0.5 ml of distilled water were added, along with a piece of picrate paper to the side of the bottle. The picrate B2 paper containing the reagents was obtained from Dr J. Howard Bradbury (Australia National University, Canberra, Australian Capital Territory). The bottle was closed with a screw cap immediately.

A control was run with every sample containing all the reagents listed above, without the ground cassava powder. The bottles were allowed to stand for 16 to 24 hours at room temperature (25 to 30°C) or incubated in an oven for 16 hours (30°C). The picrate paper was removed from the bottle and placed in a test tube with 5 ml of water and placed on a shaker for 30 minutes with gentle shaking. The colour change in the picrate paper was determined by spectrophotometer at an absorbance of 510 nm. The total cyanide content was calculated by the equation: Total cyanide content (mg HCN eq./kg) ~ 396 absorbance at 510 nm. All samples were analysed in duplicate with the average results from duplicates reported. The limit of detection was reported as 10 mg of HCN eq./kg.

Statistical analysis

Product samples with the same brand, flavour and labelled with the same “best-before date” were assumed to be from the same batch for data analysis. While the mean value of five samples was used to direct compliance action, in the statistical analysis of the survey results each sample was analysed separately to provide consistency with that for the Authority’s 2008 survey. Mean values and standard deviations were calculated for positive samples only.

Results and discussion

The results of the survey are shown in Table 5 and were categorised in terms of:

- samples that complied with the regulatory limits in the Food Standards Code,
- samples that were within the original reference level proposed by FSANZ (2008a), and
- samples above this.

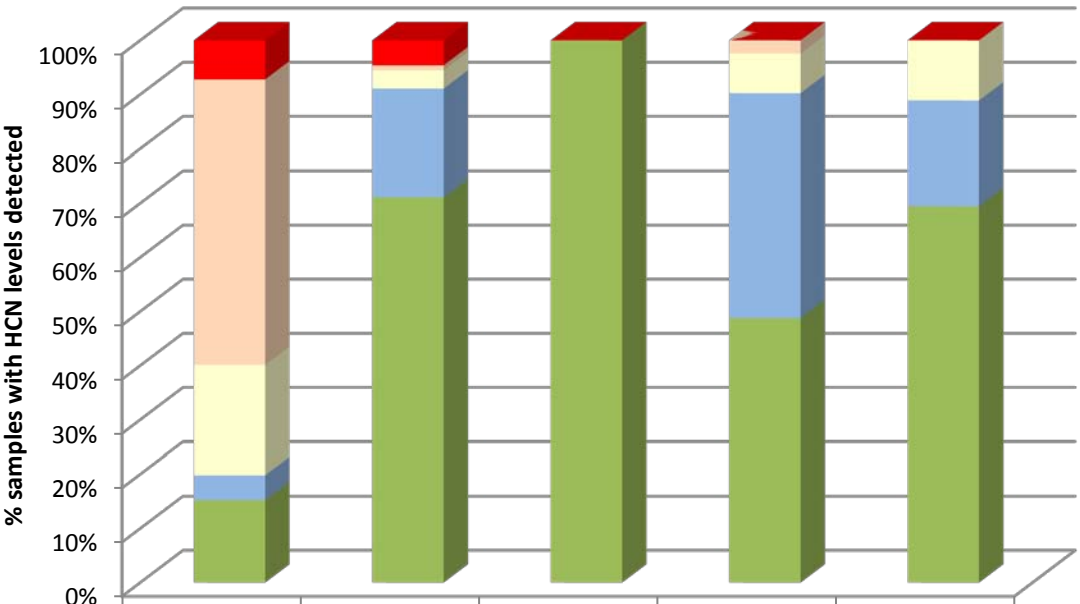
The results were compared with the 2008 survey to determine whether there has been a reduction in the levels of total HCN since the introduction of a limit in the Code for these products. Comparison was also undertaken with the imported product testing conducted by DAFF with testing undertaken by the Authority is shown in Figure 1.

The results from the Authority's 2011–12 survey show a significant improvement in compliance with the Food Standards Code limit of 10 mg HCN eq./kg total HCN in RTE cassava chips, when compared with the Authority's 2008 survey. The number of samples compliant with the Food Standards Code limit jumped from 15.2% in 2008 to 71.1% in 2011–12.

Table 5. Comparison of results between 2008 and 2011–12 surveys

Total hydrocyanic acid content (mg HCN eq./kg)	2008 survey		2011–12 survey	
	No. (% of total)	Mean level (SD) Positive results only	No. (% of total)	Mean level (SD) Positive results only
≤ 10	57 (15.2%)		231 (71.1%)	
11–25	17 (4.5%)	17.2 (4.6)	65 (20.0%)	15.0 (4.0)
26–50	76 (20.3%)	39.8 (7.5)	11 (3.4%)	35.9 (6.7)
51–100	197 (52.7%)	70.7 (13.2)	3 (0.9%)	74.3 (23.5)
>100	27 (7.2%)	123 (16.2)	15 (4.6%)	200.1 (42.9)
Total	**374**	**64.2 (27.5)**	**325**	**48.9 (69.5)**

Figure 1. Levels of HCN detected in RTE cassava chip samples



HCN levels	2008 survey (n=374)	2011 survey (n=325)	2009 DAFF results (n = 22)	2010 DAFF results (n=41)	2011 DAFF results (n=36)
>100	7.2%	4.6%	0%	0.0%	0.0%
51-100	52.7%	0.9%	0%	2.4%	0.0%
26-50	20.3%	3.4%	0%	7.3%	11.1%
11-25	4.5%	20.0%	0%	41.5%	19.4%
≤ 10	15.2%	71.1%	100%	48.8%	69.4%

In addition, in the current survey, of those samples that exceeded the 10 mg HCN eq./kg limit, almost half were at the lower end of the range, falling between 11–-25 mg HCN eq./kg. In essence, this meant that over 90% of samples were within the 25 mg/kg guidance level originally proposed by FSANZ (2008a), and similar in nature to the results from the DAFF Biosecurity testing during 2010 and 2011 (90.3% and 88.8% respectively samples containing total HCN less than 25 mg HCN eq./kg).

However, the current survey did find a similar proportion of samples to the Authority's 2008 with very high levels of total HCN >100 mg HCN eq./kg (7.2% in 2008 vs. 4.6% in 2011–12). It was noted that these samples belonged to 15 samples taken from three brands, all manufactured in India and labelled as tapioca chips. Testing by Burns et al (2011) also found cassava chips manufactured in India to contain very high HCN levels in excess of 200 ppm total HCN.

As noted previously, products labelled as tapioca chips may have allowed the product to escape DAFF testing at the border. However, the scope of the imported food inspection testing has been broadened to also capture RTE tapioca chip products which should ensure that compliance rates for product available for sale in NSW are improved.

For products that did not meet the Food Standards Code limit, compliance action was taken in accordance with the actions shown in Table 4. Advisory letters were issued to manufacturers and/or importers of product (as appropriate) for samples above the limit, but

within the 25 mg/kg guidance level originally proposed by FSANZ (2008a). In addition, there were consumer level recalls of three products containing high levels of HCN, where it could be determined that there was product available for sale in the marketplace.

It is proposed there may be a number of reasons for improvement in compliance levels with RTE cassava chips, namely:

- the introduction of a limit in the Food Standards Code (note this was not in place during the Authority's initial 2008 survey).
- since the survey in 2008, there may be more awareness by manufacturers of RTE cassava chips of the risk from HCN and risk management measures may have been introduced such as changing their source of cassava and/or changing product formulations and/or manufacturing methods in order to comply with the Food Standards Code limit. and
- testing of imported products by DAFF Biosecurity began in 2009 and batches not complying with the Food Standards Code limit were rejected at the border.

Conclusion

The results from the Authority's 2011–12 survey show a significant improvement in compliance with the Food Standards Code limit of 10 mg HCN eq./kg total HCN in RTE cassava chips, when compared with the Authority's 2008 survey.

The results from the Authority's survey show that greater more than 70% of samples were compliant with the maximum level specified in the Food Standards Code, and greater more than 90% of samples fall within the original guidance level proposed by FSANZ of 25 mg HCN eq./kg. These results are similar in nature to the results from the DAFF Biosecurity testing from 2009 through to 2011 where greater more than 85% of samples contained total HCN less than 25 mg HCN eq./kg.

However, the current survey did find a similar proportion of samples to the Authority's 2008 with very high levels of total HCN >100 mg HCN eq./kg (7.2% in 2008 vs 4.6% in 2011). These samples all belonged to product from India and may be captured by the extended scope of DAFF Biosecurity testing to also include tapioca chips in addition to cassava chips.

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Appendix 1. Cassava chip survey results

Product / flavour	**Country of origin**	**HCN level** (mg HCN eq./kg)	**HCN batch average** (mg HCN eq./kg)
Cassava chips – Natural	Australia	14	13.6
Cassava chips – Natural	Australia	12	
Cassava chips – Natural	Australia	14	
Cassava chips – Natural	Australia	12	
Cassava chips – Natural	Australia	16	
Cassava chips – Natural	Australia	ND	<10
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	<10
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	<10
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	<10
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	11	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	<10
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	10	
Cassava chips - Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	<10
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	ND	<10
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	11	

Product / flavour	Country of origin	HCN level (mg HCN eq./kg)	HCN batch average (mg HCN eq./kg)
Cassava chips – Natural	Australia	10	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	12	12.4
Cassava chips – Natural	Australia	15	
Cassava chips – Natural	Australia	12	
Cassava chips – Natural	Australia	ND	
Cassava chips – Natural	Australia	14	
Cassava chips – Natural	Australia	13	13
Cassava chips – Natural	Australia	14	
Cassava chips – Natural	Australia	13	
Cassava chips – Natural	Australia	14	
Cassava chips – Natural	Australia	11	
Cassava chips – Natural	Australia	16	-
Cassava crackers – Natural	Australia	ND	<10
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	<10
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	<10
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	<10
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava crackers – Natural	Australia	ND	
Cassava chips – BBQ	Australia	ND	<10
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	<10

Product / flavour	Country of origin	HCN level (mg HCN eq./kg)	HCN batch average (mg HCN eq./kg)
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	<10
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	26	23
Cassava chips – BBQ	Australia	22	
Cassava chips – BBQ	Australia	22	
Cassava chips – BBQ	Australia	21	
Cassava chips – BBQ	Australia	24	
Cassava chips – BBQ	Australia	ND	<10
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	<10
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	14	12.4
Cassava chips – BBQ	Australia	12	
Cassava chips – BBQ	Australia	12	
Cassava chips – BBQ	Australia	12	
Cassava chips – BBQ	Australia	12	
Cassava chips – BBQ	Australia	20	20.8
Cassava chips – BBQ	Australia	19	
Cassava chips – BBQ	Australia	23	
Cassava chips – BBQ	Australia	21	
Cassava chips – BBQ	Australia	21	
Cassava chips – BBQ	Australia	13	12.4
Cassava chips – BBQ	Australia	10	
Cassava chips – BBQ	Australia	14	
Cassava chips – BBQ	Australia	11	
Cassava chips – BBQ	Australia	14	

Product / flavour	Country of origin	HCN level (mg HCN eq./kg)	HCN batch average (mg HCN eq./kg)
Cassava chips – BBQ	Australia	ND	<10
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava chips – BBQ	Australia	ND	
Cassava crackers – BBQ	Australia	ND	<10
Cassava crackers – BBQ	Australia	ND	
Cassava crackers – BBQ	Australia	ND	
Cassava crackers – BBQ	Australia	ND	
Cassava crackers – BBQ	Australia	ND	
Cassava crackers – BBQ	Australia	ND	<10
Cassava crackers – BBQ	Australia	ND	
Cassava crackers – BBQ	Australia	ND	
Cassava crackers – BBQ	Australia	ND	
Cassava crackers – BBQ	Australia	ND	
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	-
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	<10
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	<10
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	
Cassava crackers – Balsamic vinegar and sea salt	Australia	ND	
Cassava crackers – Balsamic	Australia	ND	<10
Cassava crackers – Balsamic	Australia	ND	
Cassava crackers – Balsamic	Australia	ND	
Cassava crackers – Balsamic	Australia	ND	
Cassava crackers – Balsamic	Australia	ND	
Cassava chips – Sea salt and vinegar	Australia	37	39.4
Cassava chips – Sea salt and vinegar	Australia	39	
Cassava chips – Sea salt and vinegar	Australia	45	
Cassava chips – Sea salt and vinegar	Australia	36	
Cassava chips – Sea salt and vinegar	Australia	40	
Cassava chips – Sea salt and vinegar	Australia	11	10.8
Cassava chips – Sea salt and vinegar	Australia	12	
Cassava chips – Sea salt and vinegar	Australia	ND	

Product / flavour	Country of origin	HCN level (mg HCN eq./kg)	HCN batch average (mg HCN eq./kg)
Cassava chips – Sea salt and vinegar	Australia	10	
Cassava chips – Sea salt and vinegar	Australia	12	
Cassava chips – Sea salt and vinegar	Australia	18	18.8
Cassava chips – Sea salt and vinegar	Australia	19	
Cassava chips – Sea salt and vinegar	Australia	19	
Cassava chips – Sea salt and vinegar	Australia	18	
Cassava chips – Sea salt and vinegar	Australia	20	
Cassava chips – Salt and vinegar	Australia	ND	<10
Cassava chips – Salt and vinegar	Australia	ND	
Cassava chips – Salt and vinegar	Australia	ND	
Cassava chips – Salt and vinegar	Australia	ND	
Cassava chips – Salt and vinegar	Australia	ND	
Cassava chips – Salt and vinegar	Australia	ND	<10
Cassava chips – Salt and vinegar	Australia	ND	
Cassava chips – Salt and vinegar	Australia	ND	
Cassava chips – Salt and vinegar	Australia	ND	
Cassava chips – Salt and vinegar	Australia	ND	
Cassava chips – Salt and vinegar	Australia	13	15.0
Cassava chips – Salt and vinegar	Australia	19	
Cassava chips – Salt and vinegar	Australia	12	
Cassava chips – Salt and vinegar	Australia	15	
Cassava chips – Salt and vinegar	Australia	16	
Cassava chips – Salt and vinegar	Australia	12	10.8
Cassava chips – Salt and vinegar	Australia	11	
Cassava chips – Salt and vinegar	Australia	10	
Cassava chips – Salt and vinegar	Australia	11	
Cassava chips – Salt and vinegar	Australia	10	
Cassava chips – Sweet and sour	Australia	13	11.2
Cassava chips – Sweet and sour	Australia	13	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	12	
Cassava chips – Sweet and sour	Australia	ND	<10
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	10
Cassava chips – Sweet and sour	Australia	ND	

Product / flavour	Country of origin	HCN level (mg HCN eq./kg)	HCN batch average (mg HCN eq./kg)
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	11	
Cassava chips – Sweet and sour	Australia	12	
Cassava chips – Sweet and sour	Australia	ND	<10
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	33	27.4
Cassava chips – Sweet and sour	Australia	25	
Cassava chips – Sweet and sour	Australia	27	
Cassava chips – Sweet and sour	Australia	28	
Cassava chips – Sweet and sour	Australia	24	
Cassava chips – Sweet and sour	Australia	ND	10.8
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	10	
Cassava chips – Sweet and sour	Australia	12	
Cassava chips – Sweet and sour	Australia	14	
Cassava chips – Sweet and sour	Australia	ND	<10
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	ND	
Cassava chips – Sweet and sour	Australia	21	-
Cassava crackers – Sweet chilli and lime	Australia	ND	<10
Cassava crackers – Sweet chilli and lime	Australia	ND	
Cassava crackers – Sweet chilli and lime	Australia	ND	
Cassava crackers – Sweet chilli and lime	Australia	ND	
Cassava crackers – Sweet chilli and lime	Australia	ND	
Cassava crackers – Sweet chilli and lime	Australia	ND	<10
Cassava crackers – Sweet chilli and lime	Australia	ND	
Cassava crackers – Sweet chilli and lime	Australia	ND	
Cassava crackers – Sweet chilli and lime	Australia	ND	
Cassava crackers – Sweet chilli and lime	Australia	ND	
Cassava chips – Thai curry with lime	Australia	12	10.8
Cassava chips – Thai curry with lime	Australia	ND	
Cassava chips – Thai curry with lime	Australia	12	
Cassava chips – Thai curry with lime	Australia	ND	
Cassava chips – Thai curry with lime	Australia	12	

Product / flavour	**Country of origin**	**HCN level** (mg HCN eq./kg)	**HCN batch average** (mg HCN eq./kg)
Cassava chips – Tasty cheese	Australia	ND	<10
Cassava chips – Tasty cheese	Australia	ND	
Cassava chips – Tasty cheese	Australia	ND	
Cassava chips – Tasty cheese	Australia	ND	
Cassava chips – Tasty cheese	Australia	ND	
Cassava chips – Tasty cheese	Australia	ND	-
Cassava chips – Pizza flavour	Australia	ND	<10
Cassava chips – Pizza flavour	Australia	ND	
Cassava chips – Pizza flavour	Australia	ND	
Cassava chips – Pizza flavour	Australia	ND	
Cassava chips – Pizza flavour	Australia	ND	
Cassava chips – Herb and garlic	Australia	ND	<10
Cassava chips – Herb and garlic	Australia	ND	
Cassava chips – Herb and garlic	Australia	ND	
Cassava chips – Herb and garlic	Australia	ND	
Cassava chips – Herb and garlic	Australia	ND	
Cassava crackers – French onion	Australia	ND	<10
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	<10
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	<10
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	
Cassava crackers – French onion	Australia	ND	
Cassava chips – French onion	Australia	12	<10
Cassava chips – French onion	Australia	ND	
Cassava chips – French onion	Australia	ND	
Cassava chips – French onion	Australia	ND	
Cassava chips – French onion	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	<10
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	

Product / flavour	Country of origin	HCN level (mg HCN eq./kg)	HCN batch average (mg HCN eq./kg)
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	<10
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	<10
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Honey soy	Australia	ND	
Cassava crackers – Marinated fetta	Australia	ND	<10
Cassava crackers – Marinated fetta	Australia	ND	
Cassava crackers – Marinated fetta	Australia	ND	
Cassava crackers – Marinated fetta	Australia	ND	
Cassava crackers – Marinated fetta	Australia	ND	
Cassava crackers – Italian supreme	Australia	ND	-
Cassava chips	Indonesia	ND	<10
Cassava chips	Indonesia	ND	
Cassava chips	Indonesia	ND	
Cassava chips	Indonesia	ND	
Cassava chips	Indonesia	ND	
Vegetable snack	Malaysia	ND	<10
Vegetable snack	Malaysia	ND	
Vegetable snack	Malaysia	ND	
Vegetable snack	Malaysia	ND	
Vegetable snack	Malaysia	ND	
Tapioca stick	India	224	215.2
Tapioca stick	India	212	
Tapioca stick	India	196	
Tapioca stick	India	176	
Tapioca stick	India	268	
Tapioca chips	Malaysia	100	61.4
Tapioca chips	Malaysia	45	
Tapioca chips	Malaysia	69	
Tapioca chips	Malaysia	39	
Tapioca chips	Malaysia	54	
Tapioca chips	India	164	155.8

Product / flavour	Country of origin	HCN level (mg HCN eq./kg)	HCN batch average (mg HCN eq./kg)
Tapioca chips	India	174	
Tapioca chips	India	131	
Tapioca chips	India	144	
Tapioca chips	India	166	
Tapioca chips spicy	India	175	229.2
Tapioca chips spicy	India	226	
Tapioca chips spicy	India	262	
Tapioca chips spicy	India	253	
Tapioca chips spicy	India	230	
Tapioca crackers	Indonesia	ND	<10
Tapioca crackers	Indonesia	ND	
Tapioca crackers	Indonesia	ND	
Tapioca crackers	Indonesia	ND	
Tapioca crackers	Indonesia	ND	

Results grouped together come from a single batch (same flavour and best before date) and an average value was calculated to determine compliance actions.

Where the five samples included a mixture of values above and below the method's limit of detection (10 mg/kg), the average value was calculated by substituting a value of 9 mg/kg for the non-detect values.

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