VALUE ADDED WHEAT CRC
FINAL REPORT

Project 2.1.7 – Microbiological safety and stability of noodles, breadcrumbs and steamed breads made from Australian flour

Part: 1

Market place survey of the microbiological status of noodles sold in Australia

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EXECUTIVE SUMMARY

A market place survey was conducted on 89 samples of high moisture, packaged wheat flour noodles purchased from supermarkets and Asian grocery stores in three Australian states. Some were shelf stable, but most were refrigerated. Twelve samples of uncooked, refrigerated Asian pastry were also included in the survey.

The pathogens salmonellae, *Listeria monocytogenes, Staphylococcus aureus* and *Escherichia coli* were not detected in any noodle sample, however very low numbers of *Bacillus cereus* (< 5 MPN/g) were detected in 17 refrigerated noodle samples (30%) and in three shelf stable samples (9%).

Total aerobic counts, coliforms, lactic acid bacteria, yeasts and moulds were high in some samples of refrigerated noodles (10^6 - > 10^8 total counts cfu/g). Of the shelf stable noodles, all except two samples had very low microbial counts ($\leq 10^2$ cfu/g), and most were pH < 4.6. The survey indicated the risk from the consumption of high moisture noodles was low.

Many of the pastry samples had high total and other counts, reflecting their raw status. Two had high *E. coli* and *B. cereus* counts. Pastry should be thoroughly cooked prior to consumption and so it is difficult to assess the significance of these results.

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INTRODUCTION

Noodles are strips or strands cut from sheets of dough made from wheat or rice flour, salt(s) and water. Both rice and wheat noodles are staple foods in Southeast and East Asia, and consumption is now rising in Australia, as noodles are convenient to store and quick for the consumer to prepare. More than 75% (approximately 16 million tonnes) of Australian wheat is exported. About one-third of this is milled into flour in Asia and used in noodle manufacture. Of the flour milled domestically in Australia, only about 10% (approximately 200,000 tonnes) is exported and a small proportion used to make high quality noodles. Most of the noodles manufactured in Asia are consumed locally, but some, such as shelf-stable and instant noodles are traded internationally. Australian wheat is suited for Asian noodle manufacture because of its white bran coat and high yield of clean, white flour. Noodles manufactured from flours milled from white wheats also have a lower number of residual bran specks which can reduce noodle whiteness and lower rates of darkening than those made from red wheat flours such as those commonly grown in North America and other wheat exporting countries.

Noodles can be divided into a number of types – dried, instant, frozen, chilled and shelf stable. Dried and instant noodles are hard, low moisture products, similar to pasta, (but manufactured by a different process from different raw materials). The other three types are soft, high moisture products, and thus their safety and stability will be governed by their microbiology. Frozen noodles are used in food service operations, and are not generally sold through retail outlets.

There are many different types of chilled noodles made from wheat flour (Miskelly 1998, Corke & Bhattacharya 1999) but the distinctions between each category may sometimes be blurred. Many are uncooked (often termed 'fresh') and include groups such as Shanghai and Chinese noodles. Some are processed, for example Hokkien noodles are generally lightly boiled for around 1 min, Udon noodles are boiled for 10-20 min depending on their thickness, and yellow steamed noodles are generally steamed for around 15 min. Some chilled noodles contain egg, and many are alkaline, containing various carbonates and/or phosphates, along with flour, water and salt. Alkaline environments modify the dough characteristics and enhance the development of yellow colour from the flavones in the flour. The chilled noodles sold in Australia are generally manufactured locally and have shelf lives of up to 6 weeks, although in Asia, the shelf life may be only a few days.

Shelf stable noodles are a relatively recent addition to supermarket shelves in Australia, first making their appearance here in the late 1990s. In Australia, these noodles have shelf lives of up to 12 months. Shelf stable noodles are raw noodles that are cooked, packaged, and subjected to a thermal process. They can be sub-divided into acidified ($pH \leq 4.5$) and non-acidified ($pH > 4.5$) products (Wu & others 1998). Acidified noodles are acid washed, which should result in noodles of $pH < 4.6$, and undergo in-pack pasteurisation at 90-100°C. Non-acidified products would be subjected to a full thermal process for non acid foods. Many are packaged in medium-high barrier films that prevent moisture loss and gas exchange.

Whilst the incidence of food borne disease from noodle products is not high, and deaths or severe illness have not been reported, noodles have been the subject of four recalls in Australia between 1997 and 2000 (two for microbiological hazards, two for foreign matter, ANZFA 2001). In addition, there may be some potential risks associated with noodles and their manufacture. Many of the manufacturers (of chilled noodles) in Australia are small businesses, often with a limited

understanding of food safety and hygiene. It is likely that some chilled noodle products will have high counts, particularly if not cooked adequately. For the shelf stable products, there may be microbiological risks if pH > 4.6 and viable microorganisms are present which could grow during the lengthy shelf life of the product. In addition, heating by the consumer may be brief and not adequate to inactivate microorganisms or toxins. When this work commenced in early 2000, there was little published data of the microbiology of these products in Australia. Unknown to us, ANZFA (now FSANZ) also shared our concern in the microbiology of these products and commissioned a survey that was published in 2001 (ANZFA 2001).

The ANZFA survey was conducted on 25 brands of refrigerated noodles in Australia and New Zealand, sampling each of them 4 times, from July to September 2000. Samples were examined for salmonellae, *Listeria monocytogenes, Escherichia coli, Bacillus cereus*, Enterobacteriaceae, staphylococcal enterotoxin and borate. Our survey was conducted as part of an assessment of the microbiological quality of products manufactured from Australian flour, and included raw pastry sheets, chilled and shelf stable noodles. Samples were examined for pathogens and a wide range of spoilage organisms. The survey was conducted between January 2000 and March 2001.

PROJECT AIM

To assess the microbiological safety and stability of chilled and shelf stable noodles and Asian pasty sheets sold in Australian supermarkets and Asian grocery stores.

MATERIALS AND METHODS

Samples were purchased from supermarkets and Asian grocery stores in Sydney, Brisbane, and Adelaide. In addition, some Korean samples destined for the Australian market, were provided by the commercial partners of the CRC. Overall, brand duplication was avoided and all samples were tested within the shelf life stated on the pack. Samples showing mould growth in the packs were excluded. Samples were placed in cooler boxes at purchase and then transported to the laboratory where they were stored at 1^{o}C until tested. Where possible, test procedures were based on Australian Standards 1766 Methods for the microbiological examination of food (Standards Australia, see references). Testing was conducted for *B. cereus*, *E. coli*, *L. monocytogenes,* salmonellae, coagulase-positive staphylococci, standard plate count, lactic acid bacteria, coliforms, mesophilic aerobic spores, clostridia, yeasts and moulds. Sample pH and water activity (a_w) were also determined. All microbiological media were purchased from Oxoid Australia Pty Ltd and prepared as per the supplier's instructions. All reference cultures were obtained from the CSIRO culture collection, North Ryde NSW, Australia.

An initial dilution was prepared from each sample using 25 g sample and 225mL 0.1% aqueous peptone solution. Serial tenfold dilutions were prepared using the peptone solution. Standard plate counts were performed using AS1766.2.1, plate count agar and the pour plate technique. Plates were incubated at 30°C for 72 h and colonies counted. Coliform and *E. coli* testing was conducted in accordance with AS1766.2.3 using the three tube most probable number (MPN) technique in lauryl tryptose broth, with the initial incubation at 37$\pm$1^{o}C for up to 48 h.

Examination for *L. monocytogenes* was conducted in accordance with AS 1766.2.16.1, using 25 g samples enriched in half Fraser followed by Fraser broths and subculturing onto Oxford and palcam agars. Examination for salmonellae was conducted in accordance with AS 1766.2.5, using

25 g samples pre-enriched in buffered peptone water followed by enrichment in Rappaport-Vassiliadis medium and mannitol selenite cysteine broth, and subculturing onto xylose lysine decarboxylase and bismuth sulphite agars. Examination for coagulase-positive staphylococci was in accordance with AS 1766.2.4 using Baird Parker medium. Examination for *B. cereus* was in accordance with AS 1766.2.6 using polymyxin pyruvate egg-yolk mannitol bromothymol blue agar. Examination for lactic acid bacteria was conducted using spread plates of MRS (de Man, Rogosa and Sharpe) agar. Plates were incubated at 30^{o}C for up to 5 d. Colonies were examined for Gram and catalase reactions and for the presence of spores. Gram positive, non-spore forming, catalase negative bacteria were counted as lactic acid bacteria.

Examination for clostridia was conducted by inoculating approximately 10 g sample into 90 mL cooked meat medium (CMM). The CMM was incubated at 30^{o}C and after 7 d streaked onto reinforced clostridial agar (RCA). RCA was incubated anaerobically at 30^{o}C for up to 7 d and plates examined for growth. Colonies were examined for Gram and catalase reactions, for their ability to grow aerobically, and for spore production. Colonies of Gram positive, anaerobic, spore-forming bacteria that were catalase negative were counted as clostridia. Additional tests were conducted on presumptive clostridia including API Rapid ID 32A (bioMérieux, France) and gelatine hydrolysis in an attempt to speciate the isolates. Spores (obtained by heating shocking at 80^{o}C for 10 mins) were inoculated into reinforced clostridial medium (RCM) and incubated at 37^{o}C for 7 d and 10^{o}C for 2 months.

Examination for mesophilic aerobic spores was adapted from Stevenson and Segner (1992). Approximately 10 mL of the initial homogenate was placed into a 250 mL flask containing 100 mL of dextrose tryptone agar. Each flask was heated at 80ºC for 30 minutes, cooled and poured into 5 sterile plates. Plates were incubated aerobically at 37^{o}C for 48 h and examined for colonies typical of spore formers. Colonies were examined microscopically prior to counting to confirm the presence of spores.

Examination for yeasts and moulds was conducted in accordance with AS1766.2.2 using spread plates of dichloran rose bengal chloramphenicol agar and dichloran 18% glycerol agar. Presumptive yeast colonies were examined microscopically for confirmation. Mould genera were identified according to methods described by Pitt & Hocking (1997). The water activity of all samples was measured using an Aqualab CX-3 dew point instrument (Decagon Devices, Washington, USA). The pH was measured without dilution, using a surface electrode attached to a Sentron 1001 pH meter (Sentron Europe BV, Roden, The Netherlands).

RESULTS

In total, 57 samples of refrigerated noodles, 32 samples of shelf stable noodles and 12 (raw) pastry samples were examined. No salmonellae, *L. monocytogenes* or coagulase-positive staphylococci were detected in any sample. Limit of detection was 1 *Salmonella* spp. or *L. monocytogenes* colony forming unit (cfu)/25 g sample and 10^2 coagulase-positive staphylococci cfu/g sample. *B. cereus* was detected in 17 refrigerated noodle samples at 0.3-10MPN/g and at 0.3-0.4 MPN/g in three shelf stable samples. *B. cereus* was detected at 0.3-5 MPN/g in five pastry samples and at > 10^2 MPN/g (upper limit of the test) in two other pastry samples. *E. coli* was detected in two samples only (both pastry samples) at 240 and >10^3 MPN/g. Limit of detection (for all samples) was 10 cfu/g for the standard plate counts, 3 MPN/g for coliforms and *E. coli*, 0.3 MPN/g for *B.*

cereus, 1 cfu/g for mesophilic aerobic spores, 1cfu/10 g for clostridia and 10^2 cfu/g for aerobic lactic acid bacteria, yeasts and moulds.

Microbiological results from the noodles tested are shown in Appendix 1; those from the pastry samples are shown in Appendix 2. Compositional data for all samples are shown in Appendix 3. The results for the average counts for the different noodle categories and for the pastry samples are shown in Figure 1. The results for the average counts for the different noodle categories and pastry samples are shown in Figure 1 and Table 1. The results for pH and a_w are shown in Table 2. For all categories except the shelf stable noodles, the average standard plate count was around 10^6 cfu/g or higher, with some individual counts > 10^8 cfu/g. Udon and Hokkien noodles had the highest counts averaging 4 x 10^8 and 1 x 10^8 cfu/g for the 3 and 20 samples tested, respectively. All pastry samples had counts >10^3 cfu/g, and averaged 3 x 10^7 cfu/g. Two were >10^8 cfu/g.

No microorganisms were detected in the majority of samples of shelf stable noodles (24 of 32 samples). Three had very low total counts (< 50 cfu/g) and one had a count of 7 x 10^3 cfu/g. Another sample had a lactic acid bacteria count of 2 x 10^4 cfu/g and total count of 10^2 cfu/g. No coliforms, mesophilic spores, yeasts, or moulds were detected in the shelf stable samples, however very low numbers of *B. cereus*, presumably present as spores, were detected in three samples at 0.3 and 0.4 MPN/g. These samples would have been at room temperature for several months prior to testing, so presumably the spores had been unable to germinate and grow. For one sample it is likely that the pH was too low to support germination and outgrowth of *B. cereus* spores (pH 4.1), however for the other samples the result is unclear (pH 5.1, and not tested).

Coliforms were detected in 27 noodle samples (30%) at numbers ranging from 3 MPN/g to >10^3 MPN/g, the lower and upper limits of the test. Fourteen of these samples were ≥10^3 MPN/g, two were between 100 and 500 MPN/g, and the others were < 10 MPN/g. Coliforms were detected in six of the pasty samples, two of which were >10^3 MPN/g.

Lactic acid bacteria were detected in 12 noodle samples (13.5%). Of these, seven were >10^5 cfu/g and were generally associated with total counts >10^6 cfu/g. The MRS plates were not incubated anaerobically, so not all of the lactic acid bacteria present in the samples may have been detected. It is likely that the dominant microorganisms in samples with high total counts were actually lactic acid bacteria, which was not always reflected by the results. Lactic acid bacteria were detected in 50% of the pastry samples, with the highest being around 10^4 cfu/g in three samples.

Numbers of mesophilic spores detected were very low, averaging <20 spores/g for most categories, including shelf stable noodles. Counts from the pastry samples averaged 40 spores/g. The detection procedure, requiring heating at 80°C for 30 mins, was devised for raw materials and may have been too severe to detect injured spores, particularly those from acidic environments such as the shelf stable noodles.

Of the 42 refrigerated and shelf stable samples tested for clostridia, one pastry and five refrigerated noodle samples were shown to be positive. The isolates could not be identified using the tests stated in the methods and the spores failed to germinate and grow in RCM incubated at 10°C for 2 months, but grew at 37°C in 7 d. As the isolates were not able to grow at refrigeration temperatures they were regarded to be of little significance in the products.

Yeasts were present in a number of samples of refrigerated noodles and pastry. Generally counts were moderate, around 10^3 – 10^4 cfu/g but four samples of refrigerated noodles were around 10^6 cfu/g. Many yeasts are capable of growth at refrigeration temperatures, so would have the potential to grow in these products during their shelf life. The results indicate that these four samples may have been close to spoilage at the time of analysis. In the pastry samples, the highest yeast counts were 10^3 –10^4 cfu/g in two samples.

Moulds were not detected as frequently as yeasts but visibly spoiled packs were excluded from the analyses. Many moulds are also capable of growth at refrigeration temperatures and would have the potential to spoil the products, depending on their storage temperature. Two noodle samples had counts around 10^6 cfu/g, indicating them to be close to spoilage. One sample contained *Penicillium* spp. the other contained a mixture of *Cladosporium* and *Aspergillus* spp. Moulds were detected in four pastry samples at 100-500 cfu/g.

The pH and a_w of seven refrigerated and three shelf stable noodle samples were not recorded. Most shelf stable samples were pH 4.1-4.2, but five were pH>4.6. The refrigerated noodles varied greatly (pH 4.1-11.1) reflecting the addition of alkali to many of these products, and the presence of lactic acid bacteria and/or yeasts in some of the products with low pH values. The samples ranged from a_w 0.902-0.999, most being a_w>0.980. The pastry samples were all pH < 6.6 and a_w 0.945-0.988.

Table 1. Range and average results for standard plate, coliform, yeast and mould counts, and the number of samples tested in each category

Sample type	No. tested	Standard plate count cfu[a]/g		Coliform count MPN[b]/g		Yeast/mould count cfu/g	
		Average	Range	Average	Range	Average	Range
Fresh white	13	5.9×10^5	5×10^2- 5×10^6	7.2	ND[c]-4	150	ND[d]-1×10^3
Fresh yellow alkaline	4	4×10^7	6×10^4-1×10^8	0.3	ND-0.9	3×10^5	ND-1×10^6
Fresh yellow alkaline egg	13	1×10^7	ND[e]-1×10^8	19	ND-240	3×10^3	ND-4×10^4
Udon	3	4×10^8	5×10^4->3×10^8	>10^3	ND->10^3	3×10^3	ND-1×10^4
Hokkien	20	1×10^8	ND->3×10^8	9×10^2	ND->10^3	2×10^5	ND-8×10^6-
Yellow steamed	4	1×10^6	ND-6×10^6	5×10^2	ND->10^3	1×10^3	ND-4×10^3
Shelf-stable	32	2×10^2	ND-7×10^3	ND	ND	ND	ND
Pastry	12	3×10^7	6×10^3-2×10^8	4×10^2	ND->10^3	6×10^2	ND-7×10^3

[a] Colony forming units

[b] Most probable number

[c] Not detected. Limit of detection 3 MPN/g sample.

[d] Not detected. Limit of detection 100 cfu/g sample.

[e] Not detected. Limit of detection 10 cfu/g sample.

Table 2. Range and average results for pH and a_w analyses and the number of samples tested in each category

Sample type	No. tested	Average pH	pH range	Average a_w	a_w range
Fresh white	13	6.5	4.1-8.2	0.958	0.928-0.978
Fresh yellow alkaline	2	6.9	6.3-7.4	0.969	0.963-0.974
Fresh yellow alkaline egg	12	9.6	6.1-11.1	0.959	0.935-0.977
Udon	2	5.3	4.9-5.7	0.997	0.995-0.999
Hokkien	17	7.2	4.8-10.9	0.990	0.979-0.999
Yellow steamed	4	7. 7	4.9-9.0	0.964	0.935-0.999
Shelf-stable	29	4.4	3.7-5.3	0.991	0.902-0.999
Pastry	12	5.9	5.2-6.6	0.968	0.945-0.988

DISCUSSION

The total counts across most refrigerated noodle samples were generally high which is not unexpected, as few samples had been adequately heat processed. In addition, some contamination may have occurred after processing and microbial growth would have occurred in most samples during refrigerated storage. However, the only pathogen detected in the noodle samples was *B. cereus*, which was detected in low numbers.

The ANZFA survey reported higher standard plate counts: 28% were between 10^6-10^8 cfu/g and 50.5% were > 10^8 cfu/g, compared to our survey of 20% and 11%, respectively. The ANZFA survey also showed high Enterobacteriaceae counts with 36% of samples containing > 10^6 cfu/g. Although not directly comparable, 16% of our samples had coliform counts > 10^3 MPN/g. No *E. coli* or *L. monocytogenes* or staphylococcal enterotoxin were detected in the ANZFA survey, which is similar to the results obtained in our survey. The ANZFA survey did not include counts for lactic acid bacteria, clostridia, yeasts, moulds, pH or a_w.

In our survey, we detected *B. cereus* in 30% of the refrigerated noodles. Although many strains of *B. cereus* are psychrotrophic, the numbers detected were very low indicating the organisms were not actively growing in the product. This result is not unexpected as previous studies of the microbiology of flour showed a high proportion contained very low numbers of *B. cereus* spores (Berghofer & others in press). No other pathogens were detected in the refrigerated noodle samples, which indicates that the microflora is comprised mainly of spoilage organisms. In the ANFZFA survey, *B. cereus* was detected in one sample only at 2.2 x 10^4 cfu/g. The procedure used in our survey was more sensitive than that used in the ANZFA survey (0.3 MPN/g compared with 100 cfu/g, respectively), hence the higher detection rate.

For refrigerated noodles, the combined hurdles of pH (either high or low), a_w and low temperature storage seem to combine effectively to prevent the growth of pathogens including *B. cereus*, over the relatively short shelf life of the product. Of these, refrigeration is probably the most important. However, some products had high counts of coliforms and other bacteria, yeasts and moulds. Improvements to production hygiene, control of storage temperature and shorter shelf life are likely to reduce these counts.

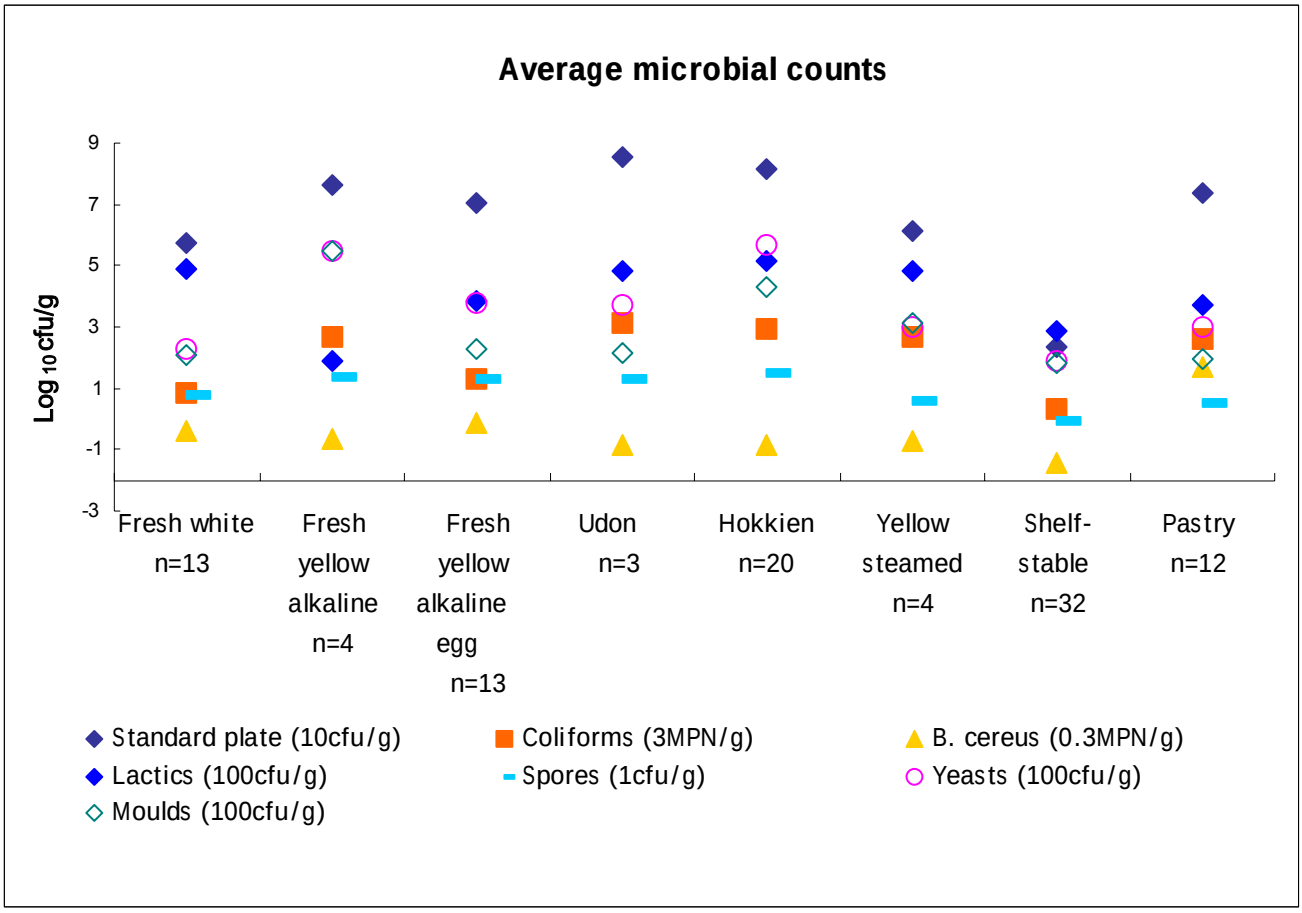

Figure 1. Average counts of the noodle and pastry samples. The lower limit of detection of each test is shown in parenthesis in the key

Shelf stable noodles appear to be low risk, provided that their pH is maintained below 4.6, but not all samples were in this category. It is not possible to determine if a thermal process designed for non-acid foods was given to these products, however a number of samples similar to those tested originally have been re-tested, and all values were pH $\leq$ 4.6. Provided there is sufficient acid to maintain acid-pasteurised noodles at pH <4.6, the major pathogens should not grow. However there is concern that acid tolerant, spore forming spoilage organisms may survive the process, and their spores germinate and grow, which may then impact on product safety as well as stability. Certainly this study detected low numbers of *B. cereus* spores that had survived the process.

It is difficult to evaluate the significance of the results from the pastry samples. All had total counts exceeding 10^3 cfu/g, but this should not be unexpected as the products are raw and would be cooked substantially before consumption. Two had counts around 10^8 cfu/g which may impact on the quality of the product, particularly as these samples also contained high levels of coliforms and *E. coli*. *B. cereus* was also detected in these samples at levels exceeding the detection limit of the test. The presence of > 10^2 *B. cereus* MPN/g in these samples is significantly greater than would be expected from the flour (Berghofer & others, in press), which indicates possible growth in the raw pastry. This may be of concern if toxins are produced, however the diarrhoeal enterotoxin generally produced by psychrotrophic strains of *B. cereus* is not as heat resistant as the emetic

toxin produced by mesophilic strains (Jenson & Moir, 1997) and should be inactivated during cooking of the pastry.

CONCLUSIONS AND RECOMMENDATIONS

Overall the results indicate that refrigerated and unrefrigerated noodles are probably low risk products, however the following actions are required:

1. The microbiology of shelf stable noodles needs to be investigated further to determine if there is potential for growth of acid tolerant spore forming bacteria that survive the thermal process. This should be evaluated in current formulations and in formulations with a marginally increased pH. Growth under these conditions could impact not only on the product's stability, but also on its safety, if conditions are created which could support the growth of pathogens.

2. Guidelines should be prepared for manufacturers of chilled noodles, to assist them to identify problem areas, and to improve production hygiene and temperature control. This should result in improvements in product quality. In addition, guidance should be provided for setting product shelf lives.

3. Seminars and workshops should be held to inform manufacturers of the guidelines and assist them in implementing process improvements and controls.

OUTCOMES

Data has been generated and knowledge gained of the microbiology of these products, allowing assessments of potential risks associated with them. It is anticipated that the market place survey data will be published in Food Australia, to allow dissemination of the information to the Australian food industry and to consumers. The paper has been prepared and will be submitted to Food Australia by December 2002.

ACKNOWLEDGEMENT

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REFERENCES

Australian New Zealand Food Authority. 2001. How safe are soft, chilled noodles? Food Surveillance Australia New Zealand Special Edition – Spring 2001. Downloaded from http://www.anzfa.gov.au/mediareleasespublications/foodsurveillancenewsletter/specialeditionspring1059.cfm on 5/8/2002.

Berghofer, LK, Hocking, AD, Miskelly, D & Jansson, EJ. In press. Microbiology of wheat and flour milling in Australia. Submitted to Int J of Food Microbiol.

Corke, H & Bhattacharya, M. 1999. Wheat products: 1. Noodles. In Ang, CYW & others (eds). Asian Foods Science & Technology. Technomic Publishing Co. Inc, Basel: 43-70.

Jenson, I & Moir, CJ. 1997. *Bacillus cereus* and other *Bacillus* species. In Hocking AD & others (eds). Food-borne microorganisms of public health significance. AIFST (NSW Branch) Food Microbiol Group, North Sydney: 370-406.

Miskelly, D. 1998. Modern noodle based foods – raw material needs. In Blakeney, AB & O'Brien, L (eds). Pacific people and their food. AACC, St Paul MN:123-142.

Pitt, JI & Hocking, AD. 1997. Fungi and Food Spoilage. 2nd ed. Blackie Academic & Professional, London.

Standards Australia. 1991. AS 1766 Methods for the microbiological examination of food. Method 2.1: Examination for specific organisms - Standard plate count. Standards Australia: 1-4.

Standards Australia. 1997. AS 1766 Methods for the microbiological examination of food. Method 2.2: Examination for specific organisms - Colony counts of yeasts and moulds. Standards Australia:1-8.

Standards Australia. 1992. AS 1766 Methods for the microbiological examination of food. Method 2.3: Examination for specific organisms – Coliforms and *Escherichia coli*. Standards Australia:1-7.

Standards Australia. 1994. AS 1766 Methods for the microbiological examination of food. Method 2.4: Examination for specific organisms – Coagulase positive staphylococci. Standards Australia:1-8.

Standards Australia. 1991. AS 1766 Methods for the microbiological examination of food. Method 2.5: Examination for specific organisms – Salmonellae. Standards Australia:1-12.

Standards Australia. 1991. AS 1766 Methods for the microbiological examination of food. Method 2.6: Examination for specific organisms – *Bacillus cereus*. Standards Australia:1-8.

Standards Australia. 1998. AS 1766 Methods for the microbiological examination of food. Method 2.16.1: Examination for specific organisms – Food and animal feeding stuffs – Horizontal method for the detection and enumeration of *Listeria monocytogenes* – Detection method. Standards Australia:1-18.

Stevenson, KE and Segner, WP. 1992. Mesophilic aerobic sporeformers. In Vanderzant, C & Splittstoesser, DF (eds). The Compendium of Methods for the microbiological examination of foods. APHA, Washington, DC, USA: 265-289.

Wu, TP, Kuo, WY & Cheng, MC. 1998. Modern noodle based foods – Product range and production methods. In Blakeney, AB & O'Brien, L (eds). Pacific people and their food. AACC, St Paul MN:37-90.

APPENDIX 1 – RESULTS OF MICROBIOLOGICAL TESTS OF NOODLE SAMPLES

Sample type	No.	SPC	Coliforms	*E. coli*	*B. cereus*	*Salmo-nella*	*S. aureus*	*L. mono*	Spores	Lactics	Yeasts	Moulds	pH	a_w
Fresh white	11	5..2 x 10^4	3	<3	<0.3	nd[a]	<100	nd	3	<100	<100	<100	7.66	0.963
	12	3.1 x 10^3	<3	<3	1.1	nd	<100	nd	4	<100	<100	2 x 10^2	7.28	0.928
	14	7.1 x 10^4	3	<3	<0.3	nd	<100	nd	9	4.5 x 10^5	<100	<100	7.81	0.961
	18	2 x 10^4	<3	<3	<0.3	nd	<100	nd	7	<100	<100	5 x 10^2	5.51	0.967
	20	1.0 x 10^6	75	<3	<0.3	nd	<100	nd	9	<100	9 x 10^2	<100	6.50	0.964
	21	1.1 x 10^6	<3	<3	<0.3	nd	<100	nd	4	3 x 10^2	2 x 10^2	<100	5.98	0.949
	22	5.2 x 10^6	3	<3	<0.3	nd	<100	nd	3	4.2 x 10^5	1.3 x 10^3	<100	8.15	0.969
	24	7.1 x 10^4	3	<3	<0.3	nd	<100	nd	7	<100	<100	<100	5.90	0.957
	42	4.7 x 10^4	<3	<3	<0.3	nd	<100	nd	2	1.3 x 10^5	<100	<100	6.16	0.968
	43	5.4 x 10^2	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.08	0.943
	5	1.6 x 10^4	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	2 x 10^2	7.93	0.953
	70	1.2 x 10^4	3	<3	4.3	nd	<100	nd	31	<100	<100	4 x 10^2	6.08	0.955
	65	1.0 x 10^3	4	<3	<0.3	nd	<100	nd	<1	<100	<100	2 x 10^2	5.90	0.978
Hokkien	25	>3x 10^6	>1.1 x 10^3	<3	<0.3	nd	<100	nd	<1	<100	1.6 x 10^5	8 x 10^2	6.51	0.994
	30	4.4 x 10^6	<3	<3	<0.3	nd	<100	nd	1.4 x 10^2	<100	<100	<100	6.70	0.984
	15	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	9.71	0.982
	17	7.4 x 10^5	<3	<3	0.4	nd	<100	nd	1.9 x 10^2	<100	<100	<100	10.39	0.986
	8	2.7 x 10^6	>1.1 x 10^3	<3	0.4	nd	<100	nd	3	<100	4.5 x 10^3	6.4 x 10^2	7.89	0.979
	32	3.5 x 10^6	>1.1 x 10^3	<3	<0.3	nd	<100	nd	<1	<100	5.6 x 10^5	<100	7.73	0.991
	33	1.3 x 10^8	<3	<3	0.4	nd	<100	nd	<1	<100	<100	<100	7.51	0.999
	34	8 x 10^8	>1.1 x 10^3	<3	<0.3	nd	<100	nd	<1	2.4 x 10^6	2 x 10^3	<100	6.66	0.995
	35	3.2 x 10^8	>1.1 x 10^3	<3	<0.3	nd	<100	nd	12	4.0 x 10^5	2.7 x 10^4	<100	4.80	0.989
	38	>3 x 10^6	>1.1 x 10^3	<3	<0.3	nd	<100	nd	<1	<100	6.7x 10^4	4 x 10^2	6.87	0.993

Sample type	No.	SPC	Coliforms	*E. coli*	*B. cereus*	*Salmo*	*S. aureus*	*L. mono*	Spores	Lactics	Yeasts	Moulds	pH	a_w
	39	9.4×10^4	<3	<3	0.3	nd	<100	nd	<1	<100	<100	<100	7.09	0.993
	40	1.7×10^7	<3	<3	<0.3	nd	<100	nd	<1	<100	9×10^2	<100	6.20	0.990
	41	7.7×10^5	<3	<3	0.9	nd	<100	nd	<1	<100	2.2×10^4	1.7×10^4	5.12	0.983
	60	4.0×10^6	93	<3	<0.3	nd	<100	nd	<1	<100	7.7×10^6	1.5×10^2	6.46	0.992
	67	$>1 \times 10^7$	$>1.1 \times 10^3$	<3	<0.3	nd	<100	nd	<1	<100	1.0×10^5	6.1×10^3	4.77	0.999
	16	8.1×10^8	<3	<3	0.4	nd	<100	nd	2.0×10^2	<100	<100	<100	7.78	0.989
	89	$>3 \times 10^8$	$>1.1 \times 10^3$	<3	<0.3	nd	<100	nd	<1	<100	4.2×10^4	1.2×10^4	NT	NT
	87	8×10^7	$>1.1 \times 10^3$	<3	<0.3	nd	<100	nd	1.2×10^2	<100	6.8×10^4	5.1×10^4	NT	NT
	92	1.8×10^8	64	<3	<0.3	nd	<100	nd	10	<100	$>3 \times 10^5$	$>3 \times 10^5$	NT	NT
	3	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	10.88	0.985
Fresh yellow alkaline	6	6.3×10^4	<3	<3	0.9	nd	<100	nd	2	<100	<100	<100	7.41	0.963
	27	3.3×10^6	<3	<3	<0.3	nd	<100	nd	<1	<100	1.1×10^6	1.2×10^6	6.31	0.974
	90	4.8×10^7	$>1.1 \times 10^3$	<3	<0.3	nd	<100	nd	59	<100	9.9×10^4	<100	NT	NT
	91	1.2×10^8	$>1.1 \times 10^3$	<3	<0.3	nd	<100	nd	28	<100	1.9×10^4	8.1×10^4	NT	NT
Fresh yellow alkaline egg	26	1.0×10^8	<3	<3	<0.3	nd	<100	nd	<1	<100	2.5×10^4	2.3×10^3	6.11	0.969
	29	1.4×10^2	<3	<3	<0.3	nd	<100	nd	2	<100	<100	<100	9.10	0.948
	2	<10	<3	<3	2.3	nd	<100	nd	5	<100	<100	<100	11.04	0.954
	1	1.3×10^6	3	<3	4.3	nd	<100	nd	14	<100	<100	<100	10.70	0.935
	4	5.6×10^3	<3	<3	0.9	nd	<100	nd	15	<100	<100	<100	10.78	0.951
	7	3.4×10^5	<3	<3	0.4	nd	<100	nd	9	<100	<100	<100	10.15	0.962

Sample type	No.	SPC	Coliforms	*E. coli*	*B. cereus*	*Salmo*	*S. aureus*	*L. mono*	Spores	Lactics	Yeasts	Moulds	pH	a_w
	9	4.0×10^4	<3	<3	<0.3	nd	<100	nd	5	2.9×10^3	<100	<100	11.07	0.966
	66	3.0×10^7	<3	<3	0.9	nd	<100	nd	7	<100	3.4×10^3	<100	9.37	0.962
	68	1.1×10^3	4	<3	<0.3	nd	<100	nd	25	<100	<100	1×10^2	8.56	0.977
	69	3.0×10^6	3	<3	0.7	nd	<100	nd	12	<100	1.2×10^3	2×10^2	9.58	0.954
	44	1.0×10^4	2.4×10^2	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	8.34	0.962
	88	5.7×10^2	<3	<3	0.3	nd		nd	1.6×10^2	<100	4.7×10^4	<100	NT	NT
	13	2.2×10^5	<3	<3	<0.3	nd	<100	nd	2	9.3×10^4	<100	<100	10.65	0.964
Yellow steamed	19	1.4×10^5	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	4.9×10^3	9.02	0.940
	23	<10	<3	<3	<0.3	nd	<100	nd	4	<100	<100	<100	8.05	0.981
	28	8.7×10^2	<3	<3	<0.3	nd	<100	nd	12	<100	4×10^2	3×10^2	8.66	0.935
	37	5.5×10^6	$>1.1 \times 10^3$	<3	<0.3	nd	<100	nd	<1	2.8×10^5	3.2×10^3	<100	4.94	0.999
Udon	31	5.1×10^4	<3	<3	0.4	nd	<100	nd	52	<100	<100	<100	5.65	0.995
	93	$>3 \times 10^8$	$>1.1. \times 10^3$	<3	<0.3	nd	<100	nd	7	<100	3.7×10^3	<100	NT	NT
	36	8×10^8	$>1.1. \times 10^3$	<3	<0.3	nd	<100	nd	<1	2.0×10^5	1.3×10^4	4×10^2	4.94	0.999
Shelf stable	45	1.3×10^2	<3	<3	<0.3	nd	<100	nd	<1	2.2×10^4	<100	<100	4.94	0.999
	47	<10	<3	<3	0.4	nd	<100	nd	<1	<100	<100	<100	5.08	0.929
	49	<10	<3	<3	0.4	nd	<100	nd	<1	<100	<100	<100	4.08	0.999
	50	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.32	0.993
	71	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.08	0.999
	74	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	3.96	0.999
	75	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.8	0.999
	77	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.44	0.999
	78	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.21	0.999

Sample type	No.	SPC	Coliforms	*E. coli*	*B. cereus*	*Salmo*	*S. aureus*	*L. mono*	Spores	Lactics	Yeasts	Moulds	pH	a_w
	79	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.26	0.999
	80	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	3.98	0.999
	81	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.44	0.999
	84	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.07	0.999
	85	<10	<3	<3	0.3	nd	<100	nd	<1	<100	<100	<100	NT	NT
	86	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	NT	NT
	94	7.2×10^3	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	NT	NT
	96	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	5.2	0.994
	99	20	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.3	0.992
	72	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.14	0.999
	73	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4	0.999
	76	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.12	0.999
	82	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.24	0.999
	83	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.26	0.999
	46	<10	<3	<3	<0.3	nd	<100	nd	1	<100	<100	<100	4.41	0.999
	97	30	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.2	0.988
	98	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.2	0.993
	100	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.8	0.988
	101	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	3.7	0.996
	102	20	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.6	0.994
	103	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.4	0.989
	48	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	5.29	0.993
	51	<10	<3	<3	<0.3	nd	<100	nd	<1	<100	<100	<100	4.39	0.902

[a] Not detected in 25 g sample

APPENDIX 2 – RESULTS OF MICROBIOLOGICAL TESTS OF PASTRY SAMPLES

No.	SPC	Coliforms	*E. coli*	*B. cereus*	*Salmo*	*S. aureus*	*L. mono*	Spores	Lactics	Yeasts	Moulds	pH	a_w
52	4.9×10^3	<3	<3	4.3	nd[a]	<100	nd	3	<100	<100	<100	5.19	0.956
53	1.6×10^4	<3	<3	<0.3	nd	<100	nd	<1	3.8×10^3	<100	<100	5.87	0.954
54	3.4×10^4	1.5×10^2	<3	<0.3	nd	<100	nd	8	<100	<100	<100	6.59	0.960
55	2.5×10^5	4.6×10^2	<3	<0.3	nd	<100	nd	8	1.0×10^4	2×10^2	1×10^2	6.55	0.962
56	9.1×10^4	9	<3	<0.3	nd	<100	nd	2	2.4×10^4	<100	<100	6.55	0.962
57	6.2×10^3	<3	<3	0.4	nd	<100	nd	<1	1.8×10^4	2×10^2	<100	5.84	0.979
58	1.7×10^4	<3	<3	0.3	nd	<100	nd	10	4.0×10^3	2×10^2	2×10^2	5.48	0.945
59	6.7×10^3	<3	<3	<0.3	nd	<100	nd	<1	1.7×10^3	<100	<100	5.59	0.961
61	2.0×10^4	3	<3	0.3	nd	<100	nd	<1	<100	<100	<100	5.87	0.983
62	$>10^8$	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^2$	nd	<100	nd	<1	<100	4.8×10^3	3×10^2	5.88	0.985
63	$>10^8$	$>1.1 \times 10^3$	2.4×10^2	1.1×10^2	nd	<100	nd	3	<100	7.0×10^3	4×10^2	5.63	0.982
64	6.5×10^4	3	<3	0.4	nd	<100	nd	7	<100	<100	<100	6.04	0.988

[a] Not detected in 25 g sample

APPENDIX 3: COMPOSITIONAL INFORMATION OF NOODLE SAMPLES

Sample type	No.	Manufacturer	Egg	Oil	Preservative	Salt type	Colour	Other
Fresh white	11	1	no	no	202	salt	none stated	
	12	2	no	no	202	salt	none stated	
	14	1	no	no	202	salt	none stated	
	18	2	no	no	202	salt	none stated	
	20	1	no	no	202	salt	none stated	
	21	3	no	no	202, 621	salt	none stated	
	22	4	no	no	none stated	salt	none stated	
	24	3	no	yes	202	salt	none stated	
	42	1	no	no	202	salt	none stated	
	43	5	yes	yes	none stated	potassium carbonate, salt	none stated	
	5	3	no	no	potassium sorbate	salt	none stated	
	70	6	yes	no	202	mineral salt 501	102	
	65	1	no	no	202	none stated	none stated	
Hokkien	25	7	none stated	none stated	none stated	none stated	none stated	
	30	8	yes	no	none stated	salt, alkali water	102, 122	
	15	2	no	yes	none stated	salt, sodium bicarbonate	none stated	
	17	8	yes	yes	none stated	salt	none stated	
	8	9	no	no	potassium sorbate	salt	none stated	
	32	10	no	yes	none stated	sea salt, baking soda	none stated	
	33	11	no	yes	none stated	salt	none stated	
	34	12	no	yes	none stated	sea salt, baking soda	none stated	
	35	13	no	yes	none stated	salt	none stated	
	38	14	no	yes	none stated	sea salt, baking soda	none stated	
	39	15	no	yes	none stated	salt, lye water	none stated	
	40	16	yes	yes	none stated	sea salt, baking powder	none stated	
	41	17	no	yes	202	salt	none stated	

Sample type	No.	Manufacturer	Egg	Oil	Preservative	Salt type	Colour	Other
	60	1	no	yes	none stated	none stated	none stated	
	67	18	yes	yes	none stated	none stated	102, 110	
	16	8	no	no	none stated	none stated	none stated	
	89	19	no	none stated	none stated	none stated	none stated	
	87	20	none stated	none stated	none stated	none stated	No artificial colouring	
	92	21	no	yes	states no preservative	salt	102, 122	
	3	8	no	yes	none stated	salt	none stated	
Fresh yellow alkaline	6	2	no	no	potassium sorbate	salt	none stated	
	27	8	no	no	none stated	lye water	none stated	
	90	19	no	none stated	states no preservative	none stated	none stated	
	91	22	no	yes	none stated	salt	102, 110	
Fresh yellow alkaline egg	26	1	yes	no	none stated	salt, sodium bicarbonate	none stated	
	29	3	yes	no	282	salt, lyewater	not stated	
	2	8	yes	no	none stated	lyewater, salt	none stated	
	1	23	yes	yes	potassium sorbate	baking powder, potassium carbonate	none stated	
	4	23	yes	yes	potassium sorbate	baking powder, potassium carbonate	none stated	
	7	24	yes	yes	sorbic acid	salt	none stated	carbonated water
	9	1	yes	no	none stated	salt, lye water	none stated	
	66	25	yes	no	none stated	none stated	110	
	68	1	yes	no	none stated	salt, lye water	102, 110 155	
	69	18	yes	no	none stated	salt	102, 110	

Sample type	No.	Manufacturer	Egg	Oil	Preservative	Salt type	Colour	Other
	44	1	yes	no	none stated	salt, lye water	none stated	
	88	22	yes	none stated	none stated	none stated	102, 110	
	13	26	yes	yes	200	salt, potassium carbonate	none stated	
Yellow steamed	19	7	no	yes	none stated	salt	none stated	
	23	2	no	no	none stated	lye	none stated	
	28	7	yes	no	202	salt	none stated	
	37	27	no	yes	none stated	sea salt, baking soda	none stated	
Udon	31	15	no	yes	none stated	salt	none stated	
	93	21	no	none stated	none stated	salt	none stated	
	36	14	no	yes	none stated	sea salt, baking soda	none stated	
Shelf stable	45	28	no	no	none stated	none stated	none stated	citric acid
	47	29	no	no	none stated	salt	none stated	citric acid
	49	30	no	no	none stated	salt	none stated	citric acid
	50	31	no	no	none stated	salt	none stated	
	71		no	none stated	none stated	salt	none stated	
	74	33	no	no	states no preservatives	salt	none stated	
	75	34	no	no	none stated	salt	none stated	
	77	35	no	no	none stated	salt	none stated	
	78	36	no	no	none stated	salt	none stated	
	79	37	no	no	none stated	salt	none stated	
	80	38	no	no	none stated		none stated	
	81	39	no	no	states no preservative	Salt, mineral salts 339, 340; emulsifying salt 451	states no artificial colour	
	84	40	no	no	none stated	salt	none stated	

Sample type	No.	Manufacturer	Egg	Oil	Preservative	Salt type	Colour	Other
	85	41	no	none stated	none stated	salt	none stated	
	86	42	no	none stated	none stated	salt	none stated	
	94	43	no	none stated	none stated	salt	none stated	
	96	44	no	none stated	acid	salt	none stated	acid for preservative
	99	45	no	yes	states no preservative	salt	none stated	
	72	33	yes	yes	states no preservative	salt	none stated	egg flavouring, food acid
	73	46	no	yes	none stated	salt	none stated	
	76	33	no	yes	states no preservative	salt	none stated	
	82	33	no	yes	states no preservative	salt	none stated	
	83	32	no	no	none stated	salt	none stated	
	46	29	no	yes	none stated	salt	none stated	
	97	47	no	yes	states no preservative	salt	none stated	
	98	48	no	yes	states no preservative	salt	none stated	
	100	49	no	no	none stated	salt	none stated	
	101	50	no	no	states no preservative	no	states no added colouring	‘acid’
	102	51	no	no	states no preservative	salt	none stated	
	103	44	no	no	states no preservative	salt	none stated	
	48	33	no	no	none stated	salt	none stated	‘pH formulated powder’
	51	52	yes	no	alcohol (<1%)	salt, sodium and potassium carbonate	none stated	egg white

APPENDIX 4: COMPOSITIONAL INFORMATION OF PASTRY SAMPLES

Pastry type	No.	Manufacturer	Egg	Oil	Preservative	Salt type	Colour
Gow Gee	52	2	no	no	202	salt	none stated
Egg	53	2	yes	no	202	salt	110
Egg	54	1	no	no	none stated	salt	1955
Shanghai Wonton	55	1	no	no	none stated	salt	none stated
Gow Gee	56	1	no	no	none stated	salt	none stated
Shoei Jeau	57	4	no	no	none stated	salt	none stated
Hun Tun	58	4	no	no	none stated	salt	none stated
Egg	59	2	yes	no	202	salt	110
Dumpling crust	61	6	egg white	no	none stated	none stated	none stated
Wan ton	62	25	yes	no	none stated	none stated	102, 110
Dumpling	63	25	no	no	none stated	salt	none stated
Dumpling	64	6	yes	no	202	none stated	none stated