Addressing food safety and quality challenges through food science research

Prof FT Tabit

INAUGURAL LECTURE

24 May 2022

Define tomorrow.

UNISA

college of agriculture and environmental sciences

The academic journey

- FSLC-1989 (Primary)
- GCE O-Level-1994 (Secondary)
- GCE A-Level 1997 (High School)
- Bachelor of Science in Life sciences (Microbiology) 2000– University of Buea, Cameroon
- Masters in Bio-and Food Technology (Food Technology) 2004 – Lund University, Sweden
- PhD Food Science, University of Pretoria

PhD Experience

- Tukkies – University of Pretoria
- Metro rail experience
- My PhD Supervisor – Prof Buys

MSc Experience

- Lund Park Station – Lund University
- Extreme cold

Acknowledgements

My Lord Jesus Christ:

"When you shall eat of the fruit of your hands, you will be happy, and it will be well with you."

~ Psalm 128:2

Mother: Theresia Omah Tabit

Father: Peter Akwayi Tabit

Siblings: Comfort, Maxcel, Anthantius, Elvis, Macelus, Jude (Tabit)

Wife: Wendy Tabit

Children: Klein, Dumisani, Salome (Tabit)

Friends & other family members: …

Food Science Research Focus

- Microbial quality and safety of food.
- Food safety awareness and food safety implementation.
- Food product development.

Microbial quality of food

Incidence and survival of *Bacillus sporothermodurans* during processing of UHT milk

Frederick T. Tabit and Elna M. Buys
Department of Food Science, University of Pretoria, Pretoria, South Africa

Abstract

Purpose The presence of *Bacillus sporothermodurans* in retail UHT milk along with milk from different points of a processing line was determined. This paper aims to investigate the effect of chilling, pre-heating, UHT, reprocessing and H_2O_2 individually and in combination on the survival of *B. sporothermodurans* in broth.

Design/methodology/approach Standard plate counts were conducted for all milk samples and isolates from UHT milk were characterised using PCR. BS vegetative cells and spores in broth were subjected to various stresses encountered, during UHT processing of milk. Survival counts were conducted after all treatments.

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Milk sample	Treatment	SPC (log cfu/ml)	Spore count (spores/ml)
Fresh raw[a]	Chilled (4°C)	6.06 (± 0.17)	ND
24 h raw[b]		7.31 (± 0.22)	ND
Full cream	Pasteurised	6.73 (± 0.10)	ND
Cream		8.85 (± 0.08)	ND
2 per cent fat		7.80 (± 0.13)	ND
Skim		5.67 (± 0.14)	ND
UHT[c]	From defective packs	7.92 (± 0.08)	ND
Wash water (sterilizers)[d]		5.27 (± 0.50)	ND
Wash water (filters)		ND	ND
UHT	Directly after processing	2.67 (± 0.16)	1.0 (± 0.33)
UHT	Incubated (15d, 30°C)	3.01 (± 0.12)	20 (± 2.73)
UHT	Retail level	2.96 (± 0.21)	ND

Table I.
Bacterial quality of milk collected from retail and during processing of processor D

Notes: [a]Milk that has just been received from the farms. [b]fresh raw milk that had been in the storage tank for 24 hrs at 4°C. [c]UHT milk from defective packages removed from the processing line to be mixed with fresh milk to a 10 per cent v/v final concentration and subjected to another round of UHT treatment. [d]Water that had been used to rinse the filter or the sterilizers prior to another round of UHT processing, and spore count determination. ND = not detected for levels below 1 cfu/ml. Values = mean (± SD)

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UHT temp (°C)	Treatment	Strain	Survival (log cfu/ml)
120	Before UHT	DMS10599	6.86 (± 0.67)[b]
		UP20A	5.78 (± 0.92)[b]
	After UHT	DMS10599	2.11 (± 0.01)[c]
		UP20A	1.81 (± 0.27)[c]
	10 per cent reprocessing[a]	DMS10599	1.65 (± 0.45)[c]
		UP20A	1.31 (± 0.54)[cd]
140	Before UHT	DMS10599	6.43 (± 0.41)[b]
		UP20A	5.58 (± 0.84)[b]
	After UHT	DMS10599	ND
		UP20A	ND
	10 per cent reprocessing	DMS10599	ND
		UP20A	ND
p-values	$p = 0.68$[1]	$p = 0.53$[2]	$p = 0.89$[3]

Table II.
Effect of heating at 120 or 140°C for 4s, and repeat UHT with 10 per cent reprocessing on the survival of two strains of *Bacillus sporothermodurans*

Notes: [a] 10 per cent reprocessing = the addition of an overnight UHT treated cultures to fresh milk to a 10 per cent v/v final concentration and subjected to another round of UHT treatment. Superscripts: [b], [c] and [d] if similar denote statistical significant difference at $p \leq 0.05$, otherwise statistical similarity ($n = 3$). [1]treatment effect, [2] strain effect and [3] strain-treatment interaction effect. ND = not detected for levels below 1cfu/ml. Values = mean (± SD)

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5. Conclusions

B. sporothermodurans is present in UHT milk but the incidence is not extensive or widespread. Heat treatment at 140°C unlike 120°C eliminates *B. sporothermodurans* in broth whereas chilling renders *B. sporothermodurans* spores more susceptible to UHT treatment. The PCR detection protocol adopted for RT PCR is effective in confirming *B. sporothermodurans*.

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Design/methodology/approach Standard plate counts were conducted for all milk samples and isolates from UHT milk were characterised using PCR. BS vegetative cells and spores in broth were subjected to various stresses encountered, during UHT processing of milk. Survival counts were conducted after all treatments.

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Prevalence and growth characteristics of *Bacillus sporothermodurans* in UHT milk

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Abstract

Purpose The purpose of this paper is to evaluate the prevalence of *Bacillus sporothermodurans* in UHT milk brands in South Africa and to analyse the level of proteolysis in UHT milk due to the growth of *B. sporothermodurans* during short-term and long-term storage.

Design/methodology/approach Different brands and batches of commercially available retail UHT milk packages were bought from different supermarkets, during different seasons and tested for the presence of *B. sporothermodurans*. Sterile UHT milk was spiked with *B. sporothermodurans* vegetative cells and incubated at 37°C for up to 172 hours. Total plate counts, pH, spore counts, UHT milk proteolysis and the headspace volatiles dynamics were analysed at different intervals.

Findings The contamination of retail UHT milk packages by *B. sporothermodurans* was found to be prevalent. The growth of *B. sporothermodurans* in spiked UHT milk reached a maximum of 1.9×105 cfu/ml; however, the significant proteolytic activity in UHT milk due to *B. sporothermodurans* only occurred long after the exponential growth phase had been attained. Furthermore, the growth of *B. sporothermodurans* in UHT milk did not lead to significant changes in the headspace volatile profiles of spiked UHT milk samples. Proteolytic activity in retail UHT milk packages, contaminated with *B. sporothermodurans*, was significantly higher when the use-by dates were reached.

Practical implications Significant proteolysis in UHT milk means the assurance of high-quality UHT milk with extended storage stability for up to 10-12 months is compromised. Proteolysis of casein may lead to rapid sedimentation in UHT milk compared to UHT milk without sedimentation.

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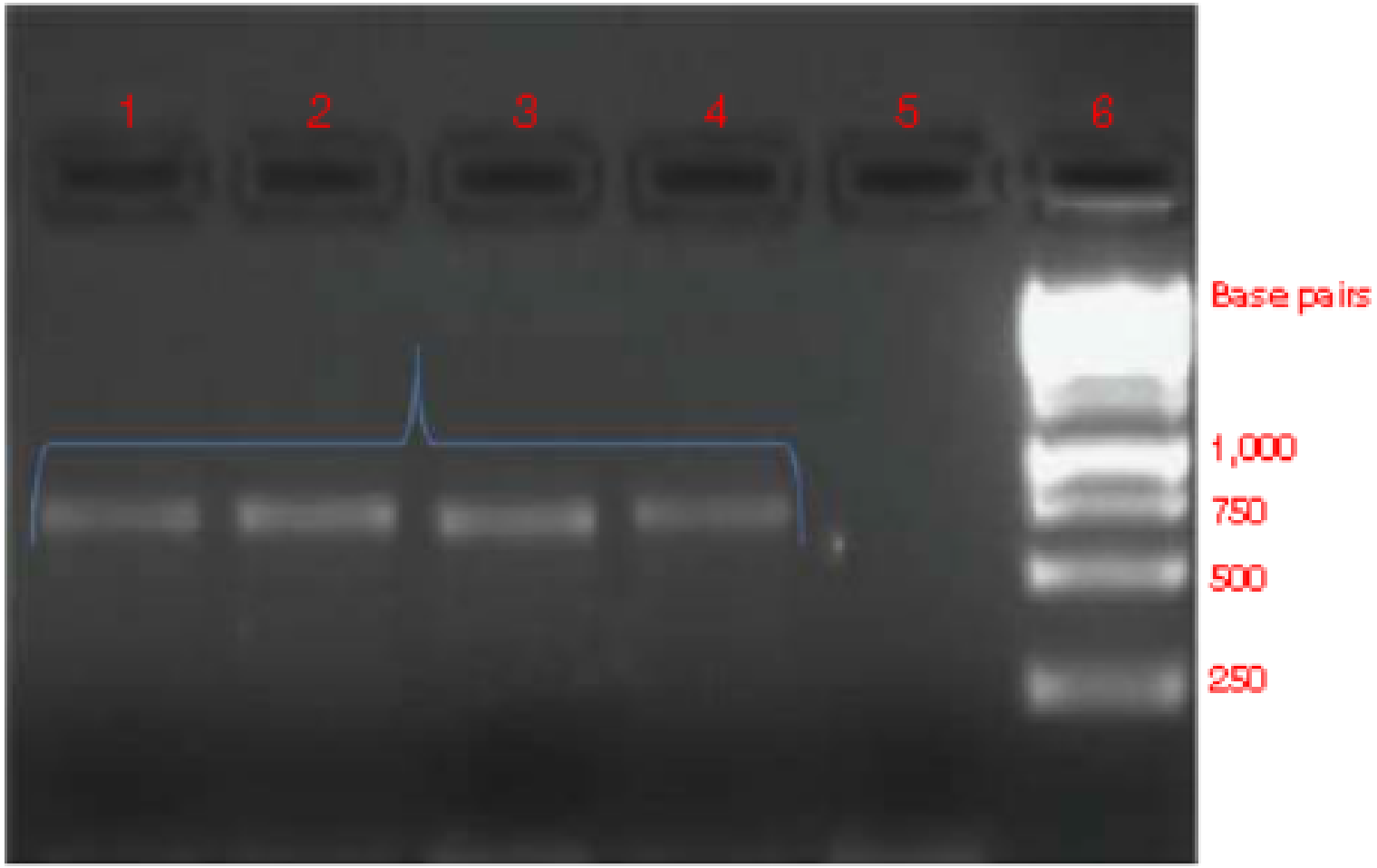

Figure 1. *Bacillus sporothermodurans* specific PCR gel photograph showing the band that confirms the identity of *Bacillus sporothermodurans* isolated from UHT

Notes: Lane 1, *Bacillus sporothermodurans* DMS 10599; lanes 2, 3 and 4, *Bacillus sporothermodurans* isolated from UHT; lane 5, *Geobacillus stereothermophilus* as negative control; lane 6, 1kb DNA ladder (Fermentas, South Africa)

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Table I.
Prevalence of *B. sporothermodurans* in commercial retail UHT across different seasons[c]

UHT milk brand contaminated with *B. sporothermodurans*	Mean counts (log cfu/g) of contaminated UHT milk packages less than three weeks after packaging per season[c] for four different batches of UHT milk packages per brand			
	Spring (September November)	Summer (December February)	Autumn (March May)	Winter (June August)
BRAND01 ($n = 16$)	2.67 ($\pm$0.46)^{ab}	3.97 ($\pm$0.35)^{c}	3.61 ($\pm$0.35)^{c}	3.50 ($\pm$0.35)^{bc}
BRAND04 ($n = 16$)	2.25 ($\pm$0.25)^{a}	2.78 ($\pm$0.26)^{ab}	2.50 ($\pm$0.26)^{ab}	2.51 ($\pm$0.26)^{ab}
BRAND05 ($n = 16$)	3.62 ($\pm$0.27)^{b}	4.11 ($\pm$0.37)^{c}	3.65 ($\pm$0.30)^{b}	3.50 ($\pm$0.37)^{b}
BRAND06 ($n = 16$)	3.50 ($\pm$0.37)^{bc}	3.73 ($\pm$0.31)^{bc}	3.30 ($\pm$0.31)^{b}	2.81 ($\pm$0.31)^{b}
BRAND09 ($n = 16$)	3.01 ($\pm$0.63)^{b}	4.10 ($\pm$0.51)^{c}	2.30 ($\pm$0.51)^{a}	3.60 ($\pm$0.51)^{bc}
BRAND10 ($n = 16$)	2.50 ($\pm$0.37)^{ab}	3.70 ($\pm$0.31)^{bc}	2.30 ($\pm$0.31)^{a}	3.20 ($\pm$0.31)^{b}

Notes: NB: 6 UHT milk brand were found not to be contaminated by *B. sporothermodurans*, mean values across rows with similar letters a, b, c and d are not significantly different at $p \leq 0.05$. Otherwise, they are significantly at $p > 0.05$. [c]Seasons in South Africa in the southern hemisphere

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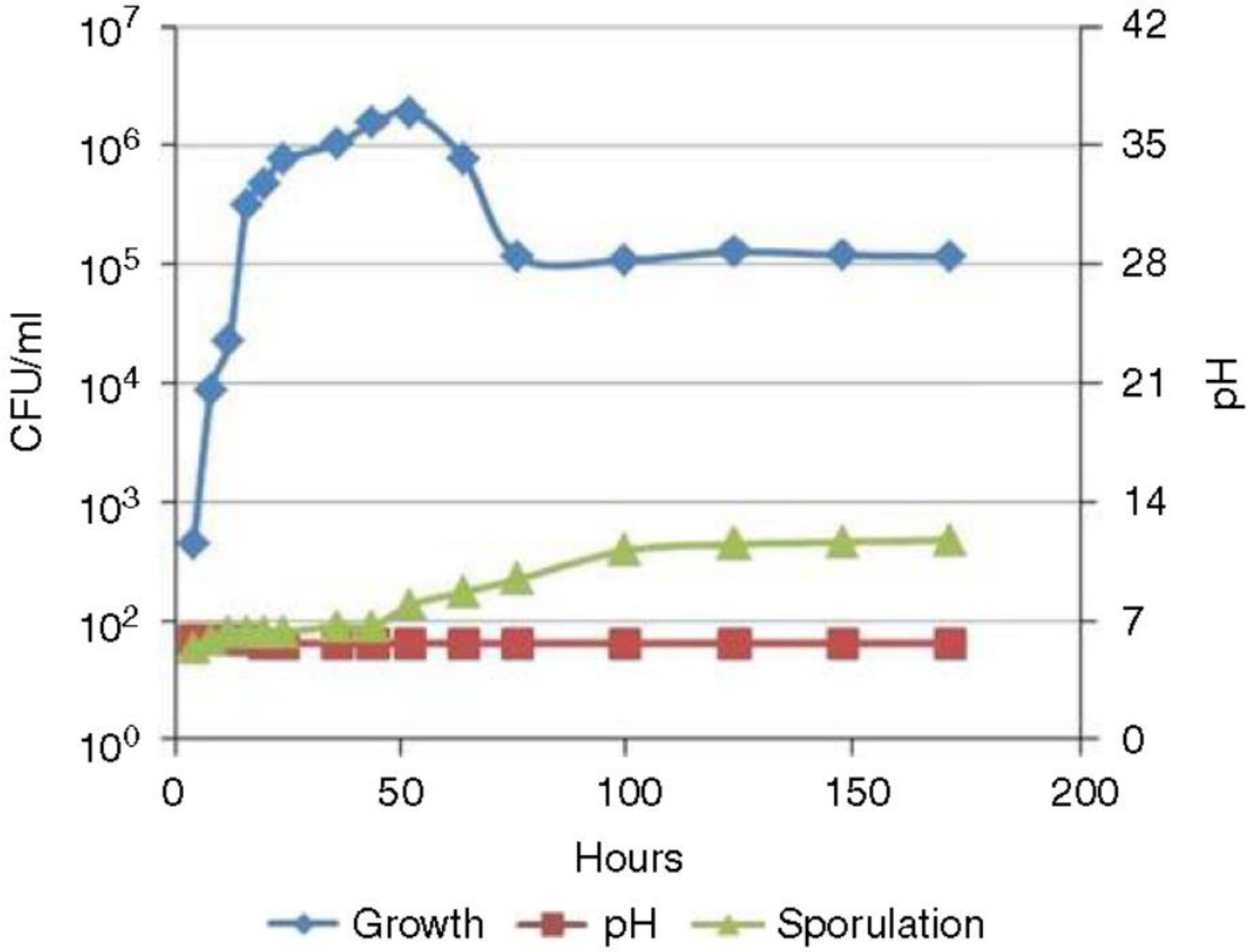

Figure 2.
Growth, sporulation and pH curve of *Bacillus sporothermodurans* in UHT milk over time

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5. Conclusion

This study inquired into some of the quality changes that can occur in UHT milk due to the growth of *B. sporothermodurans*. The contamination of retail UHT milk packages by *B. sporothermodurans* was found to be prevalent. The growth of *B. sporothermodurans* in spiked UHT milk reached a maximum of 1.9×10^5 cfu/ml, but significant proteolytic activity in UHT milk, due to *B. sporothermodurans*, only occurred long after the exponential growth phase had been attained. Furthermore, the growth of *B. sporothermodurans* in UHT milk did not lead to significant changes in the headspace volatiles profiles of spiked UHT milk samples. Proteolytic activity in retail UHT milk packages contaminated with *B. sporothermodurans* was significantly higher when the use-by dates had been reached. The findings of this study may be of interest to UHT processors because it raises the awareness that UHT milk contaminated with *B. sporothermodurans* may not have the same storage stability for extended duration when compared to those not contaminated with *B. sporothermodurans*. More studies need to be conducted to determine the effect of *B. sporothermodurans* induced proteolysis in milk on the structure and functional properties of casein micelle in milk after long-term storage.

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The effects of wet heat treatment on the structural and chemical components of *Bacillus sporothermodurans* spores

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ABSTRACT

The objective of this research was to study the rate of structural damage and survival of *Bacillus sporothermodurans* spores following treatment at high temperatures by determining the amount of Dipicolinic acid (DPA) and soluble protein leakage over time. A reference strain of *B. sporothermodurans* (DSM 10599) and a South African strain (UP20A) isolated from UHT milk were used. To determine the

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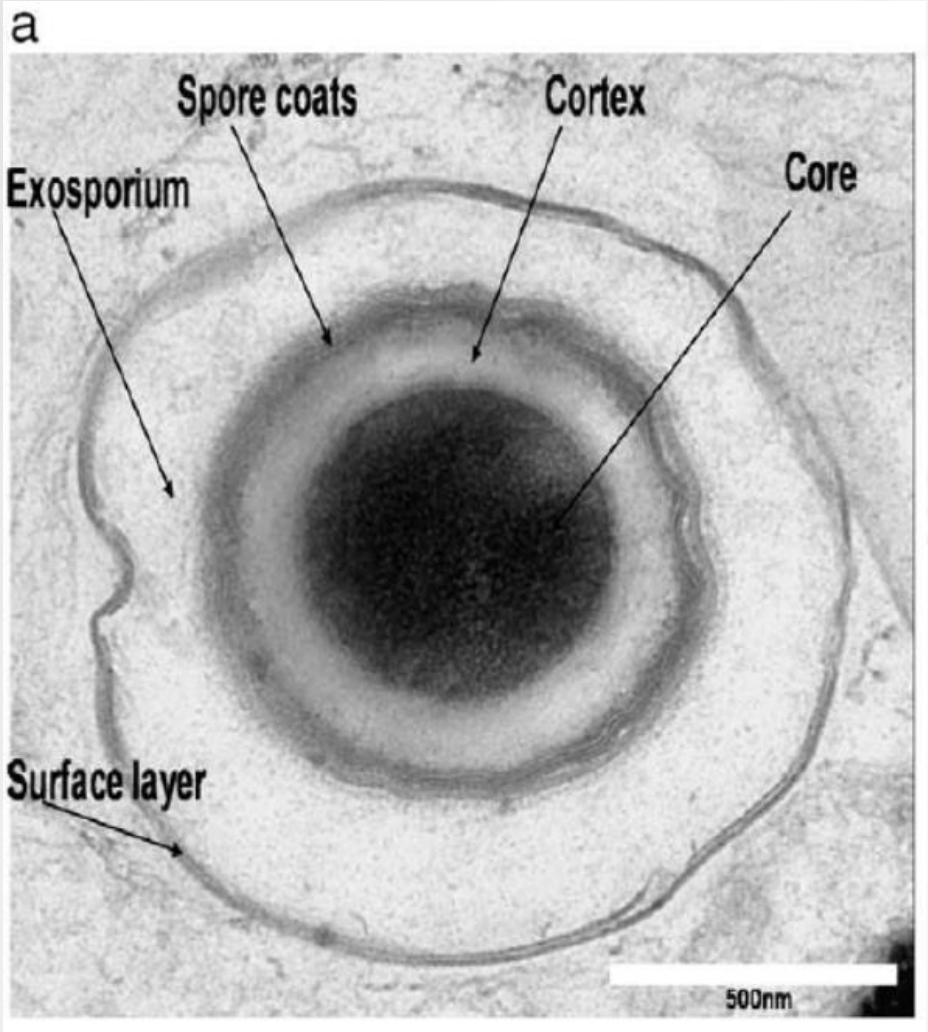

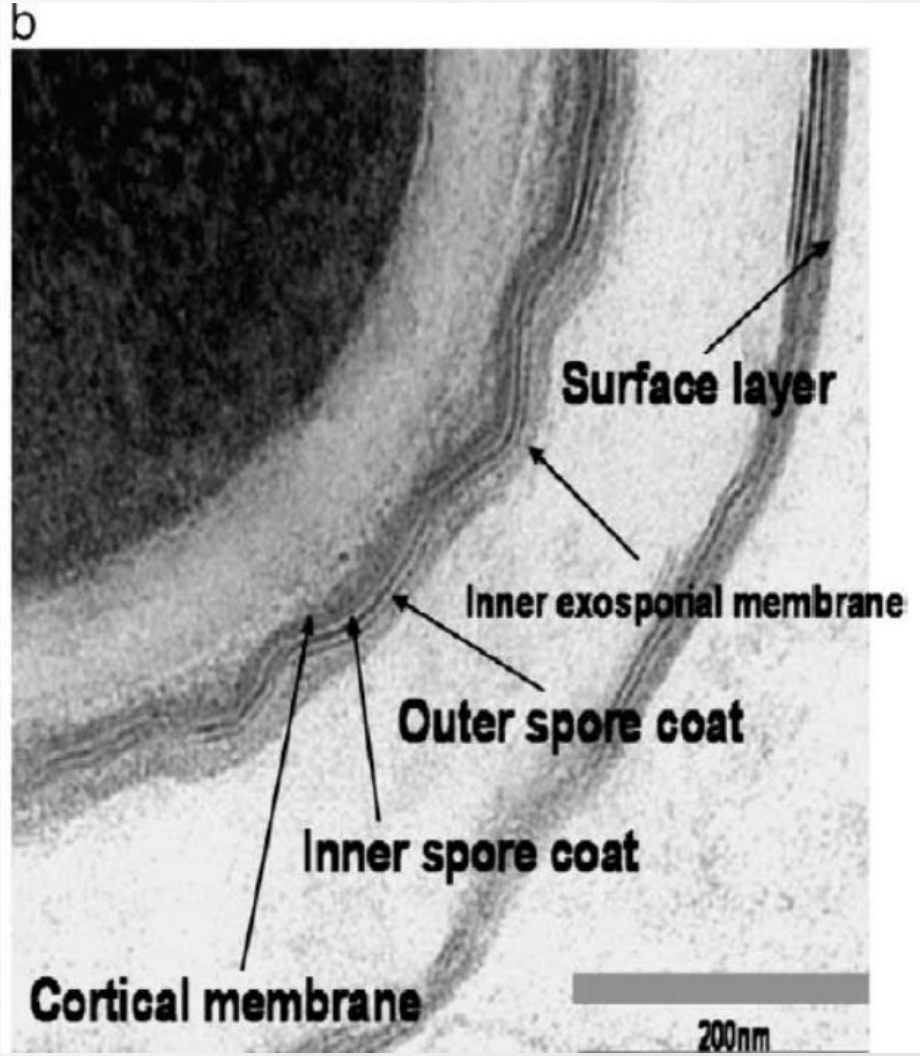

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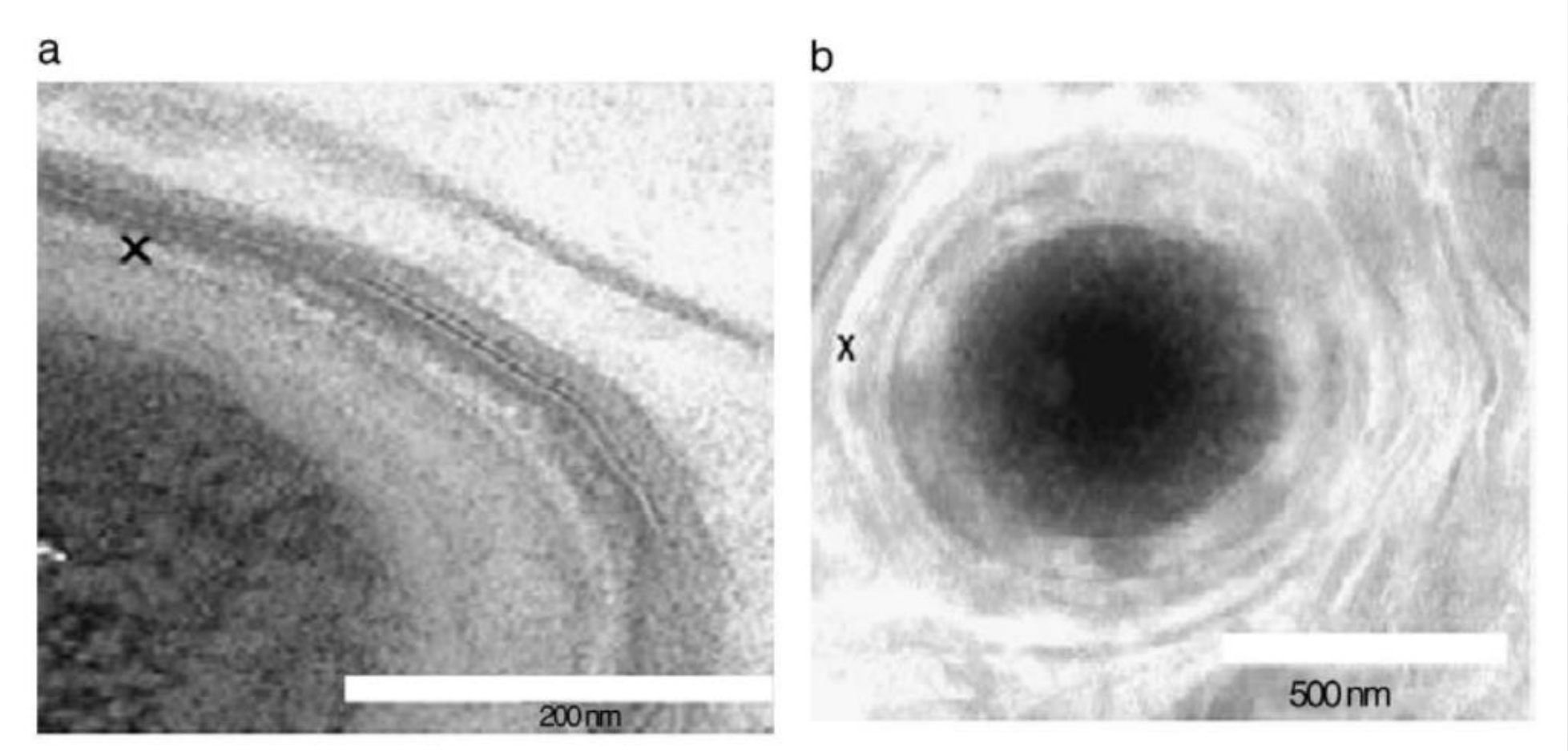

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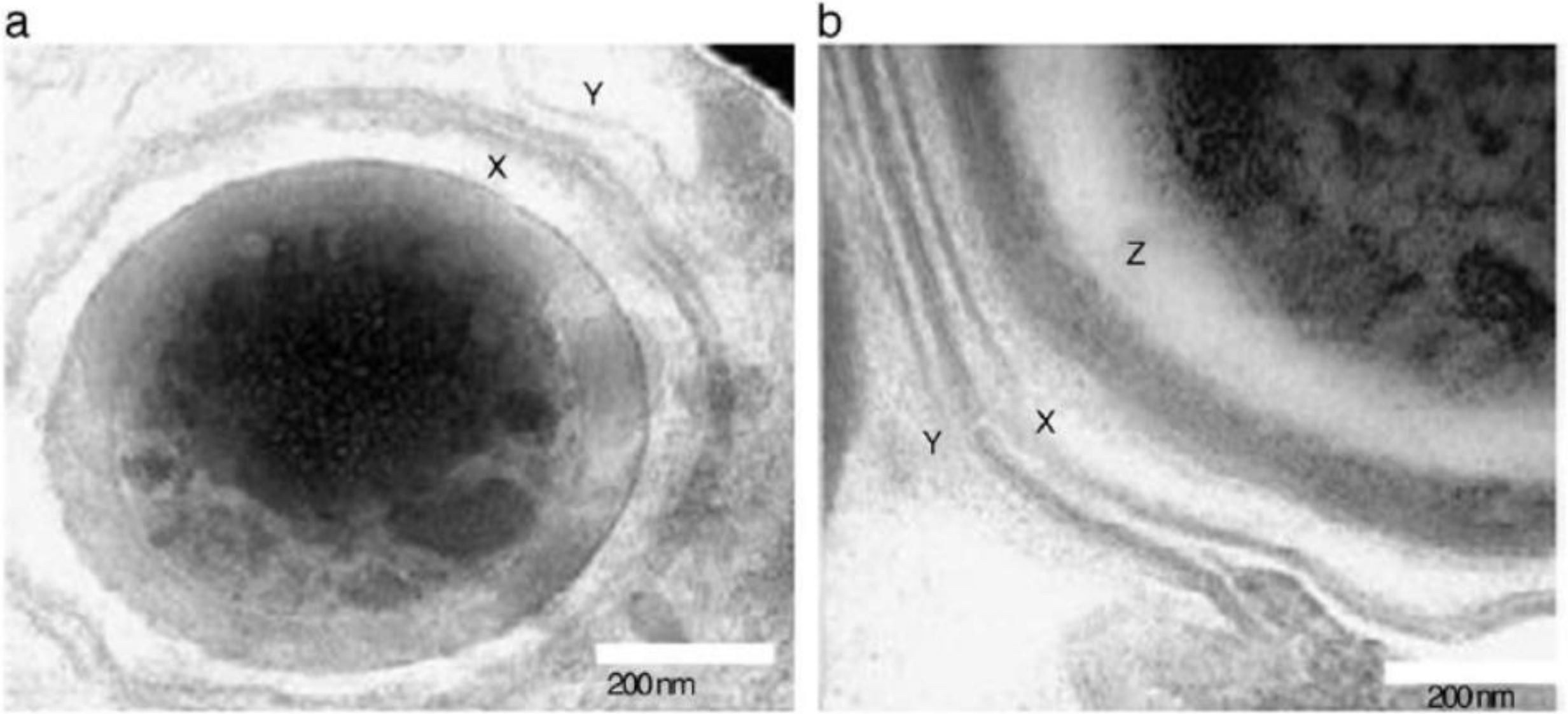

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5. Conclusion

The onset of DPA release during wet heat treatment coincides with visible signs of structural damage and significant inactivation of spores. Visible signs of spore structural damage emanate at different rates. The amount of protein release seems to be strain specific.

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JOURNAL OF FOOD QUALITY & HAZARDS CONTROL

SHAHID SADOUGHI UNIVERSITY OF MEDICAL SCIENCES & HEALTH SERVICES

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Microbial Quality of Ready-to-Eat Street Vended Food Groups Sold in the Johannesburg Metropolis, South Africa

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HIGHLIGHTS

- Out of 205 ready-to-eat Street-Vended Foods (SVFs) samples, 85.37% had aerobic growth.
- The dominant genus in ready to eat SVFs was *Pseudomonas* spp., followed by *Escherichia* spp. and *Bacillus* spp.
- Prevalence rates of *Listeria monocytogenes*, *Staphylococcus aureus*, *Salmonella* spp., and *Escherichia coli* O15:H7 were

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Table 6: The most predominant bacterial genera and their identified species in street-vended foods in Johannesburg, South Africa

Number of predominant bacteria genus (%)	Number of the most abundant species within genus (%)
Pseudomonas: 29 (10.66)	*P. aeruginosa*: 21 (72.41)
Escherichia: 25 (9.19)	*E. vulneris*: 19 (76)
Bacillus: 23 (8.46)	*B. pimulus*: 17 (73.91)
Stenotrophomonas: 21(7.72)	*S. maltophilia*: 13 (61.90)
Ralstonia: 19 (6.99)	*R. pickettii*: 15 (79.95)
Lactobacillus: 15 (5.51)	*L. brevis*: 9 (60)
Enterococcus: 13 (4.78)	*E. faecium*: 7 (53.85)
Pantoea: 10 (3.68)	*P. ananatis*: 4 (40)
Weissella:7 (2.57)	*W. cibaria*: 3 (42.86)
Citrobacter: 7 (2.57)	*C. freundii*: 4 (57.14)
Leuconostoc: 5 (1.84)	*L. mesenteroides*: 2 (40)
Serratia: 4 (1.47)	*S. proteamaculans*: 2 (50)
Others: 94 (34.56)	
Total: 272 (100)	

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Table 7: Prevalence of *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, and *Listeria monocytogenes* in ready-to-eat street-vended foods sold in the Johannesburg Metropolis, South Africa

Food groups	*E. coli* O15:H7 No. (%)	*Salmonella* spp. No. (%)	*S. aureus* No. (%)	*L. monocytogenes* No. (%)
Starch-based foods (n=20)	**0 (00)**	**3 (15)**	**8 (40)**	**12 (60)**
Boiled peanuts (n=5)	ND	1	2	5
Beans porridge (n=5)	ND	1	3	3
Grilled maize (n=5)	ND	1	3	4
Biscuits (n=5)	ND	ND	ND	ND
Beef-based foods (n=25)	**2 (8)**	**5 (20)**	**12 (48)**	**13 (52)**
Bologna sausage (polony) (n=5)	1	2	4	5
Beef broth (n=5)	1	2	3	4
Beef stew (n=5)	ND	1	4	2
Grilled beef (n=5)	ND	ND	1	1
Fried ox liver (n=5)	ND	ND	ND	ND
Poultry-based foods (n=20)	**0 (00)**	**7 (35)**	**5 (25)**	**8 (40)**
Boiled eggs (n=5)	ND	3	3	2
Fried chicken (n=5)	ND	2	1	3
Chicken stew (n=5)	ND	1	1	2
Grilled chicken (n=5)	ND	1	ND	1
Fish-based foods (n=10)	**0 (00)**	**1 (10)**	**1 (10)**	**3 (30)**
Fried hake (n=5)	ND	1	ND	2
Fried snoek (n=5)	ND	ND	1	1
Vegetable-based foods (n=10)	**0 (00)**	**1 (10)**	**1 (10)**	**3 (30)**
Vegetable relish (*chakalaka*) (n=5)	ND	ND	ND	2
Mixed vegetable salad (n=5)	ND	1	1	1
Sandwich-based foods (n=25)	**0 (00)**	**7 (28)**	**8 (32)**	**12 (48)**
Cheese burger (n=5)	ND	2	3	5
Cheese/egg burger (n=5)	ND	2	2	3
Samosa (n=5)	ND	1	2	2
Bread fillings (*kota*) (n=5)	ND	ND	ND	1
Hotdog sausage (n=5)	ND	2	1	1
Total (n=110)	**2 (1.8)**	**24 (21.8)**	**35 (31.8)**	**51 (46.36)**

ND: Not Detected

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Conclusion

Based on the findings of this study, the microbial quality and safety of ready-to-eat SVFs sold in the Johannesburg Metropolis remain a serious public health concern. Hence, it is necessary to educate street food vendors and enforce food safety legislation in the street food sector in the country.

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An assessment of the hygiene status and incidence of foodborne pathogens on food contact surfaces in the food preparation facilities of schools

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Food contact surfaces
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ABSTRACT

The microbial quality of food contact surfaces in the food preparation facilities is an indication of their hygiene status. The objective of this study was to assess the hygiene status and the incidence of pathogens of food contact surfaces in the food preparation facilities of schools offering school feeding programs in the Mpumalanga Province, South Africa. 192 swab samples were collected by swabbing 100 cm^2 areas of food contact surfaces in

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Table 2
Occurrence of foodborne pathogens; *Escherichia coli* O157:H7, *Salmonella* and *Shigella* species, *Staphylococcus aureus* and *Listeria monocytogenes* on food contact surfaces in the food preparation facilities of schools offering school feeding programmes.

Food contact surface	Incidence of foodborne pathogens per 100 cm^2 of food contact surfaces (%)				
	E. coli O157:H7	*Salmonella* species	*Shigella* species	*S. aureus*	*L. monocytogenes*
Benchtop (n = 32)	7 (21.9)	1 (3.1)	1 (3.1)	8 (25)	16 (50)
Cutting board (n = 32)	7 (21.9)	1 (3.1)	2 (6.3)	10 (31.3)	19 (59.4)
Refrigerator handle (n = 32)	3 (9.4)	0 (0)	1 (3.1)	8 (25)	13 (40.6)
Sink faucet (n = 32)	5 (15.6)	1 (3.1)	2 (6.3)	7 (21.9)	15 (46.9)
Dry storage shelf (n = 32)	5 (15.6)	0 (0)	1 (3.1)	12 (37.5)	22 (68.8)
Serving spoon (n = 32)	3 (9.4)	0 (0)	2 (6.3)	4 (12.5)	17 (53.1)
Total: 196	**30(15.6)**	**3(1.56)**	**9(4.69)**	**49(25.5)**	**102(53.1)**

dry storage shelf (37.5%) and cutting board (31.3%) surface samples. This was followed by benchtop (25%) and refrigerator handle (25%) samples. Serving spoon (12.5%) and sink faucet (21.9%) surfaces had the lowest percentage of samples in which *S. aureus* was detected (Table 2). *S. aureus,* which can cause gastroenteritis is prevalent in

with *Salmonella* species that have acquired antimicrobial-resistance (Yildirim, Gonulalan, Pamuk, & Ertas, 2011). The poor hygiene conditions of most these food contact surfaces in food preparation facilities at schools make them potential health hazards to the schoolchildren who regularly consume meals served at these schools, considering that these

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4. Conclusions

In conclusion, the vast majority of the food contact surfaces had unsatisfactory hygiene statuses with aerobic colony counts above the 2 log cfu/cm^2 maximum acceptable limit stipulated by South African Government Regulation 962. The benchtop and the dry storage surface areas had the worst hygiene status but the vast majority of the cutting board, sink faucet, serving spoon and refrigerator handle surfaces also had aerobic colony counts above the 2 log cfu/cm^2. *L. monocystogenes* and *S. aureus* were the pathogens with the most incidences on food contact surfaces. Most of the food contact surfaces in the food preparation facilities of schools offering school feeding programs were of unsatisfactory hygiene standard. We recommend that, the staff working in the food preparation and food service facilities of schools offering school feeding programs be trained in how to use cleaning materials and sanitisers adequately to clean and sanitise food contact surfaces to remove surface microorganisms effectively. Furthermore, the food preparation facilities should implement the HACCP program and schools should be equipped with adequate food preparation facilities as stipulated by South African Government Regulation 962.

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JOURNAL OF FOOD QUALITY & HAZARDS CONTROL

SHAHID SADOUGHI UNIVERSITY OF MEDICAL SCIENCES & HEALTH SERVICES

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Prevalence, Molecular Identification, Antimicrobial Resistance, and Disinfectant Susceptibility of *Listeria innocua* Isolated from Ready-to-Eat Foods Sold in Johannesburg, South Africa

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Table 1: Minimum Inhibitory Concentrations (MIC) of disinfectants against *Listeria innocua* isolated from ready-to-eat foods in Johannesburg, South Africa

Strain code	Source	MIC (mg/mL)			
		BX^{CHL} 0.1^{MRC}	HG^{QAC} 20^{MRC}	PF^{AB} 30^{MRC}	SC^{AB} 20^{MRC}
LI 101	Tomato salad 1	0.10	30.00	5.00	5.00
LI 102	Smoked Vienna	0.05	30.00	20.00	40.00
LI 103	Coleslaw 1	0.05	20.00	20.00	40.00
LI 104	Liver Spread	0.05	5.00	5.00	20.00
LI 105	Yoghurt	0.01	10.00	10.00	10.00
LI 106	Yoghurt	0.05	2.50	2.50	2.50
LI 107	Ham	0.10	10.00	10.00	10.00
LI 108	Tomato salad 2	0.05	10.00	10.00	10.00
LI 109	Beef Stew 1	0.02	10.00	10.00	10.00
LI 110	Pasteurized milk 1	0.10	20.00	10.00	10.00
LI 111	Beef Stew 2	0.00	10.00	5.00	5.00
LI 112	Pasteurized milk 2	0.05	0.50	15.00	15.00
LI 113	Tomato salad 3	0.10	0.38	15.00	15.00
LI 114	Coleslaw 2	0.10	0.50	0.25	0.25
LI 115	Beef Stew 3	0.00	0.75	0.15	0.15
LI 116	Pasteurized milk 3	0.05	1.90	0.50	2.50
LI 117	Pasteurized milk 4	0.01	0.38	0.25	0.25

LI: *Listeria innocua*; CHL: Chlorine based disinfect; QAC: Quaternary Ammonium Compounds; AB: Acid based; NI: Not inhibited; MIC: Minimum Inhibitory Concentration; MRC: Manufacturer Recommended Concentration

Manufacturer Recommended Concentration (BX: 0.1 mg/ml; PF: 20 mg/ml; HG: 30 mg/ml; SC: 20 mg/ml).

All experiments were conducted in triplicate.

Microbial safety of food

Table 3: Antibiotic susceptibility of *Listeria innocua* strain from ready-to-eat foods in Johannesburg, South Africa

Antibiotic	Susceptibility frequency (%)		
	Resistant	Intermediate	Susceptible
Ampicillin (10 µg)	100	0	0
Cephalothin (5 µg)	100	0	0
Colistin Sulphate (25 µg)	83	0	17
Gentamicin (10 µg)	21	6	73
Streptomycin (10 µg)	40	0	60
Sulphatriad (200 µg)	74	6	20
Tetracycline (30 µg)	49	0	51
Cotrimoxazole (25 µg)	31	0	69

The susceptibility *L. innocua* was determined using the guidelines of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) breakpoints for *Staphylococcus aureus* considering that the breakpoints for *Listeria* species for the antibiotic disks used is not available (EUCAST, 2021).

All experiments were conducted in triplicate.

Microbial safety of food

Conclusion

The overall prevalence of *L. innocua* was considerable in the RTE food samples sold in Johannesburg, South Africa. We found no significant differences between prevalence rates of *L. innocua* and various RTE food groups. Most *L. innocua* isolates were susceptible to the studied commercial disinfectants which could be useful for cleaning and sanitization in food processing facilities. The *L. innocua* isolates showed high antibiotic resistance against ampicillin, cephalothin, colistin sulphate, and sulphatriad.

Food safety awareness

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Food Control

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The food safety knowledge and microbial hazards awareness of consumers of ready-to-eat street-vended food

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ABSTRACT

Controlling and ensuring the safety of street-vended foods in many countries is a challenge considering that these foods are often less expensive and readily available. The objective of this study was to determine the food safety knowledge based on microbial hazard awareness of street food consumers in

Food safety awareness

Table 3
ANOVA of the responses of consumers' regarding their confidence in and reasons for purchasing and consuming street-vended foods within different groups (n – 402).

Descriptions	ANOVA between groups (p-value)				
	Gender	Age	Race	Level of education	Monthly income
Research question: how often do you buy ready-to-eat street-vended foods?	0.000¥	0.282	0.000¥	0.000¥	0.000¥
Research question: how confident are you in the safety of ready-to-eat street-vended foods?	0.002¥	0.334	0.000¥	0.000¥	0.001¥
Research question: which of the following is the main reason for purchasing ready-to-eat street-vended foods?	0.052	0.495	0.220	0.000¥	0.000¥

¥ – Significance at $p < 0.05$.

Table 9
ANOVA of the microbial food safety hazards awareness of street-vended food consumers within different groups (n – 402).

Descriptions of food safety hazards awareness	ANOVA between groups (p-value)				
	Gender	Age	Race	Level of education	Monthly income
Research question: which of the following in your opinion is the most important food safety issue of concern nowadays?	0.036	0.807	0.043	0.000¥	0.000¥
Research question: are you aware that certain food borne bacteria can cause diseases that may lead to death?	0.000¥	0.408	0.090	0.000¥	0.000¥
Research question: have you ever heard about any of the following food borne bacteria?					
Escherichia coli	0.005¥	0.101	0.000¥	0.000¥	0.000¥
Salmonella	0.124	0.575	0.001¥	0.000¥	0.000¥
Campylobacter jejuni	0.362	0.496	0.000¥	0.000¥	0.000¥
Listeria monocytogenes	0.093	0.098	0.000¥	0.000¥	0.000¥

¥ – Significance at $p < 0.05$.

Food safety awareness

5. Conclusions

This study investigated the level of food safety and microbial hazard awareness of street food consumers in the Johannesburg municipality. The results highlighted some gaps in consumers' food safety knowledge, attitudes and practices on purchase and consumption of street-vended foods. The consumption of street vended foods is popular among you black African male due to affordability, availability and convenience. The majority of the street vended food consumers were unmarried, literate and belong to the lower income group. The majority of the street vended food consumers do not have confidence in the safety of street vended foods and this does not affect their preference for street vended foods. Gender, race, level of education and monthly income affects the ways consumer of street vended foods perceived the safety of street vended foods and their desire to purchase them. Consumers are most worried when they buy ready to eat foods from shebbens and street food vendors compared to supermarkets and restaurants. The majority of consumers have very little knowledge about *Salmonella*, *E. coli*, *Listeria* and *Campylobacter*.

Food safety awareness

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BMC Public Health

RESEARCH ARTICLE Open Access

An assessment of the food safety knowledge and attitudes of food handlers in hospitals

Lesiba A. Teffo and Frederick T. Tabit*

Abstract

Background: The possession of inadequate food safety knowledge (FSK) by food handlers poses a serious threat to food safety in service establishments. The aim of this research was to investigate factors that influenced the FSK and food safety attitudes (FSA) of employees involved in the preparation and/or the serving of food from nine hospitals in the Capricorn District Municipality (CDM) in Limpopo Province, South Africa.

Food safety awareness

Table 4 ANOVA of hospital food handlers' response to knowledge questions based on temperature control

Knowledge questions	ANOVA between groups (*p* value)			
	Level of Education	Job position/ description	Experience in food handling practices	Food safety training course attendance
Which of the following is the correct temperature for receiving TCS food?	**0.039** ¥PCT 1	0.057	**0.006** ¥PCT 2	0.403
Which of the following is the maximum duration for which prepared ready to eat TCS food prepared in house is stored at 5 °C?	0.395	0.275	0.347	0.186
Which of the following is the best way to safely thaw frozen meat?	**0.000** ¥PCT 3	**0.001** ¥PCT 4	**0.000** ¥PCT 5	0.074

PCT 1: Below metric (CA = 83.3%, WA = 16.7%), Matric certificate (CA = 47.2%, WA = 52.8.6%), Certificate/Diploma (CA = 57.1%, WA = 42.9%), Higher Certificate/ Diploma (CA = 50%, WA = 50%), Bachelor degree and above (CA = 64.7%; WA = 35.3%)
PCT 2: Under 2 years (CA = 52.6%, WA = 47.4%), 2–4 years (CA = 41.1%; WA = 58.9%), 5–7 years (CA = 65.1%, WA = 34.9%), 8–10 years (CA = 71.4%, WA = 28.6%), Above 10 years (CA = 73.1%; WA = 26.9%)
PCT 3: Below metric (CA = 83.3%, WA = 16.7%), Matric certificate (CA = 26.4%, WA = 73.6%), Certificate/Diploma (CA = 21.4%, WA = 78.6%), Higher Certificate/ Diploma (CA = 8.3%, WA = 91.7%), Bachelor degree and above (CA = 33.3%; WA = 66.7%)
PCT 4: Food service managers (CA = 50%, WA = 50%), Food service supervisors (CA = 41.7%, WA = 58.3%), Chef (CA = 58.8%, WA = 41.2%), Support staff (CA = 50%, WA = 50%), Nurses (CA = 23%; WA = 77%)
PCT 5: Under 2 years (CA = 39.5%, WA = 60.5%), 2–4 years (CA = 17.9%; WA = 82.1%), 5–7 years (CA = 20.9%, WA = 79.1%), 8–10 years (CA = 23.8%, WA = 76.2%), Above 10 years (CA = 53.8%; WA = 46.2%)
¥: Significance at $p \leq 0.05$, *PCT* Partial Cross Tabulation, *CA* Correct Answer, *WA* Wrong Answer

Food safety awareness

Table 9 ANOVA of hospital food handlers answers to knowledge questions on food-borne pathogens and diseases ($N = 210$)

Knowledge questions	ANOVA between groups (*p* value)			
	Level of Education	Employment position	Experience in food handling practices	Food safety training course attendance
Food-borne pathogens				
Which of the following is the main foodborne bacteria pathogens mostly associated with poultry products?	**0.000¥PCT 1**	**0.002¥PCT 2**	0.097	0.119
Which of the following best explains what will happen to food borne bacteria in food at a temperature of 37 °C?	**0.000¥PCT 3**	**0.010¥PCT 4**	0.257	0.330
Food-borne diseases				
Which of the following is the most common symptom for food poisoning?	0.077	0.127	0.160	0.073
Which of the following best explains why are preschool age children at a higher risk for foodborne illnesses?	**0.030¥PCT 5**	0.317	0.220	**0.043¥PCT 6**
Which of the following groups of people are more vulnerable to foodborne diseases?	0.113	0.769	0.320	0.104

PCT 1: Below metric (CA = 75%, WA = 25%), Matric certificate (CA = 34%, WA = 66%), Certificate/Diploma (CA = 32.9%, WA = 67.1%), Higher Certificate/Diploma (CA = 58.3%, WA = 41.7%), Bachelor degree and above (CA = 64.7%; WA = 35.3%)

PCT 2: Food service managers (CA = 70%, WA = 30%), Food service supervisors (CA = 33.3%; WA = 66.7%), Chef (CA = 85.3%, WA = 14.7%), Support staff (CA = 33.3%, WA = 66.7%), Nurses (CA = 41.7%; WA = 58.3%)

PCT 3: Below metric (CA = 4.2%, WA = 95.8%), Matric certificate (CA = 32.1%, WA = 67.9%), Certificate/Diploma (CA = 40%, WA = 60%), Higher Certificate/Diploma (CA = 33.3%, WA = 66.7%), Bachelor degree and above (CA = 58.8%; WA = 41.2%)

PCT 4: Food service managers (CA = 90%, WA = 10%), Food service supervisors (CA = 50%, WA = 50%), Chef (CA = 67.6%, WA = 32.4%), Support staff (CA = 33.3%, WA = 66.7%), Nurses (CA = 39.9%; WA = 60.1%)

PCT 5: Below metric (CA = 91.7%, WA = 8.3%), Matric certificate (CA = 56.6%, WA = 43.4%), Certificate/Diploma (CA = 61.4%, WA = 38.6%), Higher Certificate/

Food safety awareness

Conclusion

The majority of respondents were knowledgeable on the symptoms of foodborne diseases as well as the vulnerable groups to foodborne diseases. The majority of respondents possessed a Satisfactory FSK outcome and good FSA outcome. Food handlers with higher levels of education, years of experience and job position did not necessarily possess better FSK outcomes. There was a weak positive but significant correlation between FSK and FSA outcomes. It is recommended that the hospital management ensures that that all hospital food handlers, irrespective of their level of education, years of food handling experience or job description, be subjected to continuous food safety training especially on handing and minimum internal cooking temperatures of TCS foods.

Food safety awareness

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Research article

The food safety knowledge of street food vendors and the sanitary conditions of their street food vending environment in the Zululand District, South Africa

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HIGHLIGHTS

- Most of the street food vendors had not attended any food safety-training.

Food safety awareness

Table 5. The microbial hygiene knowledge of street food vendors (N – 399).

Variables	Answer options	Number of respondents (%)
S3.6. Which of the following best describe correct qualities of a display container, where prepared foods should be stored prior to selling?	Clean display container, dust free	126 (31.6)
	Clean display container, rust free	58 (14.5)
	Clean display container in direct contact with the floor	29 (7.3)
	All of the above	86 (21.6)
	Only 1 and 2 are correct	**100 (25.1)**
S3.7. Which of the following is the correct thing to do if protein-rich foods made from milk, and meat and fish are exposed to non-refrigeration temperatures (below 5 °C) for more than 2 h?	Quickly put perishable food back into the refrigerator	162 (40.6)
	Discard perishable food	**16 (4)**
	Quickly cook the perishable food	83 (20.8)
	Both 1 and 2 are correct	79 (19. 8)
	All of them are correct	59 (14.8)
S3.9. Which of the following is the safest way to thaw perishable foods such as meat, fish, dairy and poultry products?	Allow perishable foods to thaw on a table	72 (18)
	Allow perishable foods to thaw in hot water	130 (32.6)
	Allow to thaw on the upper shelve of the refrigerator	**68 (17)**
	Both 2 and 3 are correct	128 (32.1)
	None of the above is safe	1 (0.3)
S3.10. Which of the following is the safest way to use cutting boards to avoid cross-contamination?	**Use separate cutting boards for meat and salad and wash them in between usage**	**172 (43.1)**
	Use any cutting boards for meat and salad, but wash them between use	68 (17)
	Use the same cutting board for meat and salad, but wash them between use	66 (16.5)
	All of the above ways are correct	90 (22.6)

The correct response under answer options is in bold

Food safety awareness

Table 9. Sanitary requirements for which there was compliance by less than 50 % of street food vending sites (n = 200).

Sanitary requirements		Compliance with requirements (%)	
1	There is electricity power supply at the vending facility (Q30)	48	(24)
2	There sufficient illumination for all food handling areas (Q26)	50	(25)
3	There is a tap water supply in the facility (Q31)	55	(27,5)
4	The windows and doors are cleaned and free from dirt or damage (Q29)	59	(29,5)
5	Storage rooms are separated from food service area (Q27)	66	(33)
6	Displayed foods not in direct contact with floor or ground surface (Q12).	71	(35,5)
7	Food storage containers not damaged or prone to rust (Q15).	73	(36,5)
8	There is a dedicated garbage disposal bins with lid at the vending site (Q21)	83	(41,5)
9	There is sufficient space for hygienic storage of food, utensils and separate area for storage of refuse (Q24).	83	(41,5)
10	Food handlers washing their hands in clean water each time before the handling, preparation and serving of food (Q2).	86	(43)
11	Food preparation site is effectively cross-ventilated (Q25)	89	(44,5)

Food safety awareness

4. Conclusions

This research investigated the food safety knowledge of street food vendors and the sanitary conditions of their street food vending environment in the Zululand District, South Africa. The study demonstrates that street food vending activities constitute a food safety risk to the consumers and the public at large in communities where there is rapid urbanisation. This primarily due to the possession of inadequate food safety knowledge of street food vendors, non-compliant street food vending infrastructure, and inadequate monitoring and controls by competent authorities. In order to remedy the situation, it is recommended that, authorities should implement the food stalls/food caravans equipped with adequate food preparation and sanitation resources and use the licensing and permit tool to ensure control and adherence to food safety regulations. Thereafter, street food vendors and health inspectors should be trained on safe food handling principles and practice. More research needs to be conducted to understand the response of street food vendors to food safety training.

Food safety awareness

ORIGINAL ARTICLE

Journal of Food Safety

WILEY

The food safety knowledge of street food vendors and the sanitary compliance of their vending facilities, Johannesburg, South Africa

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Abstract

The inadequate food safety knowledge of street food vendors has proved to be an obstacle in ensuring the safety of street food. The aim of this study was to assess the food safety knowledge of street food vendors in Johannesburg, South Africa, and to evaluate both the compliance of their street food vending facilities with food safety

Food safety awareness

TABLE 3 Location and characteristics of street food vending facilities of respondents ($N = 315$)

Variables		Frequency (%)
Location of street food vending facility	Braamfontein	28 (8.9)
	Johannesburg CBD	58 (18.4)
	Parktown	35 (11.1)
	Hillbrow	37 (11.7)
	Berea	31 (9.8)
	Joubert Park	64 (20.3)
	Newtown	32 (10.2)
	Marshalltown	30 (9.5)
Type of street food vending facility	Roadside with no shelter/ premises	67 (21.3)
	Roadside with makeshift shelter	96 (30.5)
	In a permanent facility/ premises	152 (48.3)
Where are the foods prepared?	Food prepared at home	32 (10.2)
	Food prepared onsite, in this vending facility	283 (89.8)
Food service types provided	Takeaway foods	75 (23.8)
	Both takeaway and onsite consumption	240 (76.2)

TABLE 8 The monitoring and enforcement of food hygiene regulations at the food service sites of street food vendors ($N = 315$)

Variables		Frequency (%)
Has this street food vending facility been authorized or issued with a license to sell foods?	No	178 (56.5)
	Yes	137 (43.5)
Has this street food vending business been registered with the companies and intellectual property commission (CIPC) of South Africa?	No	241 (76.5)
	Yes	74 (23.5)
Has this street food vending facility been inspected by a health inspector as of now?	No	100 (31.7)
	Yes	215 (68.3)
If your facility has been inspected before, how often is your facility being inspected?	Monthly	68 (31.6)
	Quarterly	105 (48.8)
	Yearly	42 (19.5)
If your facility has been inspected before, have you ever received a penalty/warning for noncompliance?	No	154 (71.6)
	Yes	61 (28.4)

Food safety awareness

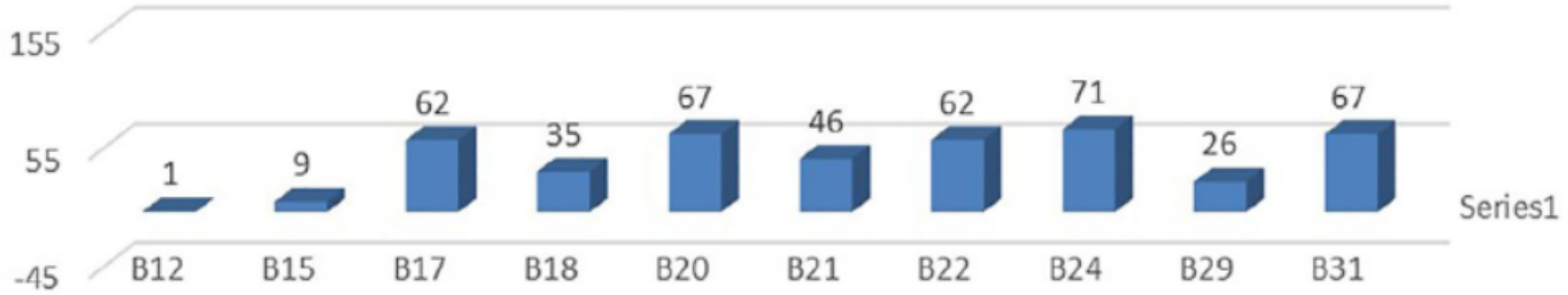

FIGURE 4 Bottom 10 food safety sanitary criteria in terms of compliance by street food vending facilities. **B12:** Are displayed foods in direct contact with floor or ground surface? **B15:** Are food storage containers damaged or rusted? **B17:** Is there any cooling and freezing storage equipment at the vending site? **B18:** Is there any ready-to-eat hot holding equipment at the vending site? **B20:** Is there a proper wastewater removal mechanism on the vending site? **B21:** Are there dedicated garbage disposal bins with lids at the vending site? **B22:** Are there toilet facilities around vending sites? **B24:** Is there sufficient space for hygienic storage of food, utensils, and separate area for storage of refuse?, **B29:** Are the windows and doors clean and free from dirt or damage? and **B31:** Is there a tap water supply in the facility?

Food safety awareness

4 | CONCLUSIONS

In this research study, the food safety knowledge of street food vendors in the Johannesburg metropole and the compliance and monitoring of their street food vending facilities in accordance with the regulations governing the general hygiene requirements for food premises and the transport of food in South Africa were investigated. Most respondents demonstrated moderate food safety knowledge but possessed inadequate knowledge areas of food safety some such as food hygiene, internal cooking temperatures, as well as hot and cold storage temperatures. Most street food vendors were aware that microorganisms could lead to foodborne diseases and possibly death and the majority were aware of the existence of food-borne pathogens. Most street food vending sites had been inspected by health officials and the majority demonstrated moderate to high levels of compliance with regulations governing the general hygiene requirements for food premises and the transport of food in South Africa. It is recommended that street food vendors receive training with regard to food hygiene practices, internal cooking temperatures, hot and cold storage temperatures for ready-to-eat foods and food pathogens such as *Salmonella*, *Campylobacter*, *Listeria*, *Clostridium*, and *Staphylococcus*. This will enhance street food vendors' knowledge in terms of these critical aspects of food safety.

Food product development

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Journal homepage: http://www.myfoodresearch.com

FOOD RESEARCH

Development of composite biscuits made from amadumbe (*Colocasia esculenta* L. Schott) and soybean (*Glycine max* L. Merrill) and investigation of their nutritional and organoleptic properties

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Abstract

The development of more popular and nutritious amadumbe based food products such as biscuits from amadumbe may be necessary to improve its utilisation and commercialization. The aim of this study was to investigate the nutritional and

Food product development

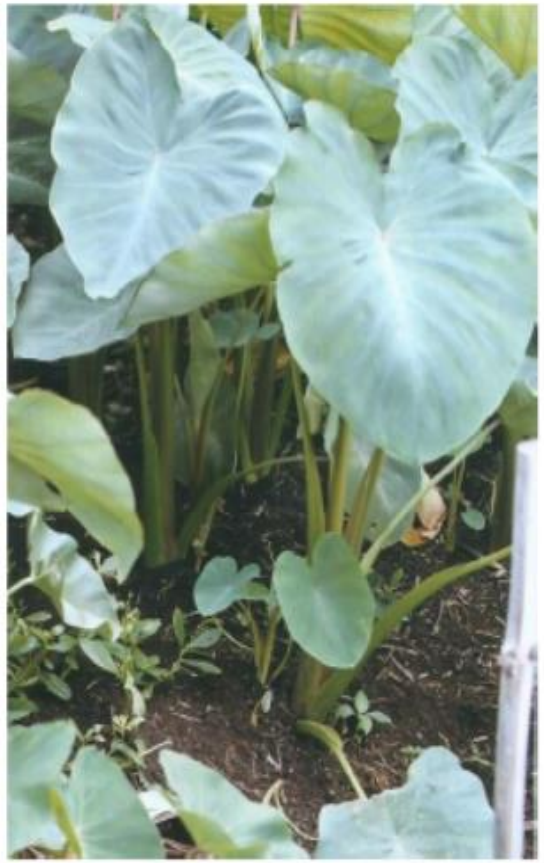

Figure 1. Amadumbe (*Colocasia esculenta* (L.) Schott) plants

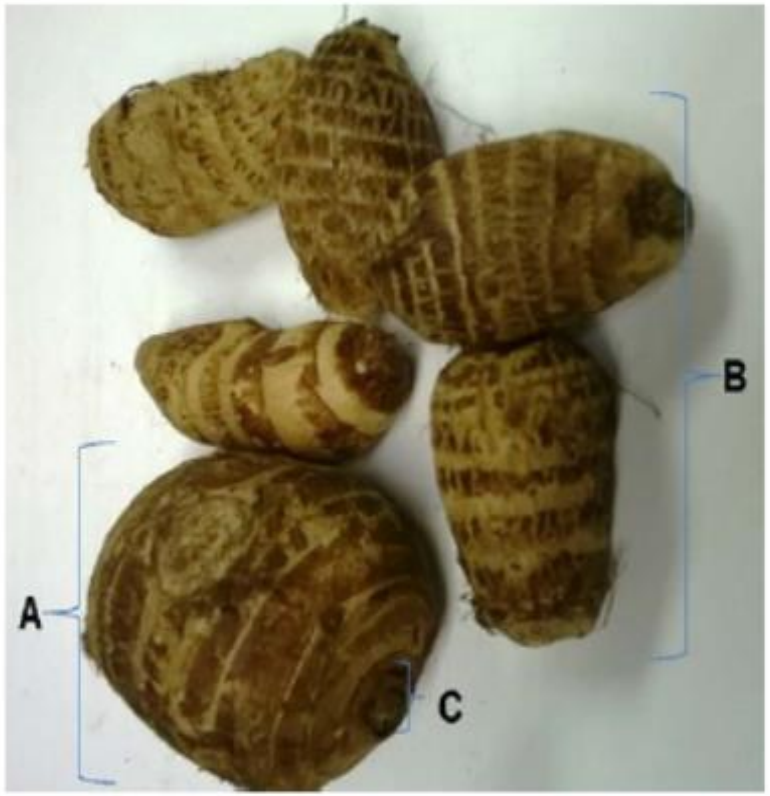

Figure 2. Amadumbe (*Colocasia esculenta* (L.) Sc

Food product development

Table 2. Proximate composition of amadumbe-soya composite biscuits (g/100 g)

Variables	Flour blends (amadumbe: soya) *biscuits*				
	Amadumbe (100%)	Soya - 100%	Amadumbe-soya (90:10)	Amadumbe-soya (70:30)	Amadumbe-soya (50:50)
Moisture	7.44 ± 0.08^{bc}	6.07 ± 0.24^{d}	8.42 ± 0.03^{a}	8.22 ± 0.08^{a}	6.76 ± 0.16^{cd}
Ash	3.45 ± 0.01^{a}	2.62 ± 0.23^{c}	3.35 ± 0.08^{a}	3.13 ± 0.05^{b}	3.03 ± 0.01^{b}
Fat	19.59 ± 0.41^{e}	37.3 ± 0.17^{a}	21.2 ± 0.18^{d}	24.78 ± 0.05^{c}	28.8 ± 0.35^{b}
Dietary fibre	8.28 ± 0.28^{e}	15.75 ± 0.74^{a}	10.04 ± 0.82^{d}	11.13 ± 0.39^{c}	13.38 ± 0.03^{b}
Crude protein	4.59 ± 0.00^{f}	32.3 ± 0.08^{a}	7.0 ± 0.04^{e}	13.2 ± 0.14^{c}	19.2 ± 0.18^{b}
Total Carbohydrates	64.93 ± 0.73^{a}	30.65 ± 0.26^{f}	59.86 ± 0.19^{c}	50.72 ± 0.16^{d}	42.24 ± 0.04^{e}
Energy value (Kcal)	600.7	501.07	449.9	437.34	414.73

Values expressed as Mean ± SD and Mean within rows with the same superscript letters are not significantly different ($p \geq 0.05$), otherwise significantly different at ($p \leq 0.05$).

Food product development

Table 4. Amino acid (chemical) scores of amadumbe-soya composite biscuit

Essential amino acids	Amadumbe (100%)	Soya (100%)	Amadumbe-soya (90:10)	Amadumbe-soya (70:30)	Amadumbe-soya (50:50)
Histidine	1.23 ± 0.01^{e}	1.47 ± 0.01^{e}	1.34 ± 0.01^{d}	1.37 ± 0.01^{c}	1.40 ± 0.01^{b}
Threonine	1.57 ± 0.01^{a}	1.46 ± 0.01^{d}	1.52 ± 0.01^{b}	1.48 ± 0.01^{c}	1.48 ± 0.01^{c}
Valine	1.20 ± 0.01^{a}	1.03 ± 0.01^{d}	1.19 ± 0.01^{a}	1.16 ± 0.01^{b}	1.11 ± 0.01^{c}
Isoleucine	1.02 ± 0.01^{d}	1.30 ± 0.01^{a}	1.05 ± 0.01^{c}	1.15 ± 0.01^{b}	1.16 ± 0.01^{b}
Leucine	1.29 ± 0.01^{a}	1.16 ± 0.01^{d}	1.27 ± 0.01^{b}	1.23 ± 0.01^{c}	1.23 ± 0.01^{c}
Phenylalanine	1.30 ± 0.01^{a}	1.15 ± 0.01^{d}	1.29 ± 0.01^{a}	1.26 ± 0.01^{b}	1.20 ± 0.01^{c}
Lysine	0.64 ± 0.01^{e}	1.08 ± 0.01^{a}	0.68 ± 0.01^{d}	0.94 ± 0.01^{c}	1.04 ± 0.01^{b}

Values expressed as Mean ± SD and Mean within rows with the same superscript letters are not significantly different ($p \geq 0.05$), otherwise significantly different at ($p \leq 0.05$).

Food product development

Table 6. Mineral composition of amadumbe-soya composite biscuits

Mineral	Amadumbe (100%)	Soya (100%)	Amadumbe-soya (90:10)	Amadumbe-soya (70:30)	Amadumbe-soya (50:50)
Ca (g/100 g)	0.08 ± 0.00^{d}	0.15 ± 0.00^{a}	0.09 ± 0.00^{c}	0.10 ± 0.00^{a}	0.11 ± 0.01^{a}
Mg (g/100 g)	0.05 ± 0.00^{e}	0.13 ± 0.01^{a}	0.06 ± 0.00^{d}	0.08 ± 0.00^{c}	0.09 ± 0.01^{b}
K (g/100 g)	1.20 ± 0.03^{a}	0.54 ± 0.01^{d}	1.13 ± 0.01^{a}	0.99 ± 0.13^{b}	0.79 ± 0.13^{c}
Na (g/100 g)	0.14 ± 0.01^{a}	0.09 ± 0.01^{d}	0.12 ± 0.00^{b}	0.11 ± 0.01^{bc}	0.11 ± 0.00^{bc}
$K/Ca^{+}Mg$ (g/100 g)	3.74 ± 0.11^{a}	0.78 ± 0.01^{f}	3.07 ± 0.03^{b}	2.19 ± 0.04^{c}	1.60 ± 0.16^{d}
P (g/100 g)	0.17 ± 0.00^{e}	0.44 ± 0.00^{a}	0.19 ± 0.00^{d}	0.25 ± 0.01^{c}	0.30 ± 0.01^{b}
Zn (mg/kg)	4.00 ± 0.00^{f}	30.0 ± 0.00^{a}	9.00 ± 0.00^{e}	13.0 ± 0.00^{d}	17.00 ± 0.00^{c}
Cu (mg/kg)	1.00 ± 1.41^{c}	6.50 ± 0.71^{a}	0.75 ± 0.36^{c}	2.00 ± 0.00^{bc}	4.00 ± 1.41^{b}
Mn (mg/kg)	2.00 ± 0.00^{e}	23.0 ± 0.00^{a}	4.75 ± 1.06^{d}	11.0 ± 0.00^{c}	14.00 ± 1.41^{b}
Fe (mg/kg)	24.0 ± 2.83^{c}	38.0 ± 0.00^{b}	26.0 ± 0.00^{c}	32.0 ± 1.41^{b}	38.00 ± 2.83^{bc}

Values expressed as Mean ± SD and Mean within rows with the same superscript letters are not significantly different ($p \geq 0.05$), otherwise significantly different at ($p \leq 0.05$).

Food product development

4. Conclusion

An increase in the percentage of soya in the formulation produced biscuits with a significant decrease in moisture, ash content, carbohydrate content and energy of amadumbe-soya composite biscuits. Conversely, an increase in the percentage of soya in the formulation produced composite biscuits with an increase in crude protein and lysine content of amadumbe-soya composite biscuits. The addition of soya flour to amadumbe flour resulted in composite biscuits with an overall improved amino acid profile, especially in those amino acids whose content was low in either amadumbe flour or soya flour. The addition of soya to amadumbe improved the protein digestibility and the PDCAAS of the composite biscuits. The addition of soya flour to amadumbe flour resulted in composite biscuits with improved amounts of individual minerals, especially those that were low in either amadumbe flour or soya flour. There was no significant difference in consumer response to the colour, aroma, taste, texture and overall acceptability of the different formulations of composite biscuits. The 50% amadumbe-50% soya composite biscuit was identified as having the optimum quality parameters. We recommend the usage of the 50% amadumbe-50% soya formulation to produce amadumbe biscuits with optimal nutritional and organoleptic properties.

Community engagement project

Name of the project:	**Food safety system implementation in small formal and informal food production and vending outlets**				
Project Description (Provide a succinct description):	**To evaluate and the food safety knowledge and food handling practices of stake holders involve in food processing and vending in small formal and informal establishments in various areas and regions in South Africa. Provide training on food safety system design and implementation.**				
College Name:					
College of Accounting Sciences	☐				
College of Agriculture and Environmental Sciences	☒				
College of Economic and Management Sciences	☐				
College of Education	☐				
College of Graduate Studies	☐				
College of Human Sciences	☐				
College of Law	☐				
College of Science Engineering and Technology	☐				
Graduate School of Business Leadership	☐				
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Project Leader					Date: 27 February 2021

THANKS