

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

‘From boat to bowl’
An exploratory study of the implementation of the
Hazard Analysis Critical Control Point (HACCP)
system in tuna processing in the Solomon Islands



Ernest Kolly

A thesis submitted in partial fulfilment of the requirements for the degree
of **Master of Health Science in Environmental Health**,
Institute of Food, Nutrition and Human Health
Massey University, Wellington campus
New Zealand

May 2011

ABSTRACT

Fish and fish products are among the most internationally traded food commodities of which approximately fifty percent originate in developing countries. This raises concerns about seafood safety and quality for the food industry. The Solomon Islands currently export tuna loins to the European Union (EU), which requires accreditation. This lucrative market requires the Solomon Islands to meet stringent standards stipulated by the EU for fishery products.

The aim of the study was to explore and evaluate factors that influence the implementation of the Hazard Analysis Critical Control Point (HACCP) food safety system at National Fisheries Developments Company Ltd (NFD Ltd) and Soltai Fishing & Processing Company Ltd (Soltai Ltd) in the Solomon Islands, and its effectiveness at meeting stringent EU requirements. A mixed methods research and design was adopted in the study, which involved non-experimental research, survey research and qualitative research (one on one (*talanoa*) interviews).

The study revealed that NFD Ltd and Soltai Ltd are in general terms in compliance with the EU directives (EC 852/2004, EC 853/2004 and EC 854/2004) and the Solomon Islands Pure Food (*fishery products*) Regulation 2005. Furthermore, while NFD Ltd and Soltai Ltd do have a well documented HACCP system in place, the study showed that the majority of workers do not fully understand the HACCP system. The review of Good Manufacturing Practices (GMP) on board the fishing vessels revealed that the Chief Engineers, as far as histamine control and monitoring is concerned, are complying with EU Regulation EC 853/2004 and the Solomon Islands Pure Food (*fishery products*) Regulation 2005. The tests carried out to assess microbiological parameters revealed that, a large number of microorganisms were present at all four sites in the processing factory as indicated by Total Plate Counts, a good indicator of product/surface contamination from environmental sources. Furthermore, survey research revealed that a high proportion (43%) of participants indicated they only adhere to the HACCP system “sometimes” and for some “never” in the factory - which poses significant food safety risk. The qualitative (*talanoa*) interviews showed that culture and low literacy level were major factors that impede the effective implementation of the HACCP system in the processing factory. The study further indicated that, to control food safety hazards (physical, chemical, and biological), the tuna industry needs a collaborative approach among those involved throughout the food processing chain, from the fishing vessels during harvesting, through to the processing factory and product shipment.

Training programmes, including pre-requisite programmes, designed to increase staff awareness of HACCP principles should be comprehensive and ongoing, to ensure sustained implementation of HACCP principles in the workplace. These should be an integral component of the companies' HACCP food safety policies and systems.

ACKNOWLEDGEMENTS

I wish to acknowledge a number of people who have given invaluable support during this study:

I am indebted to my supervisors, Dr John Ruck and Dr Beatrice Dias-Wanigasekera for their expertise and systematic supervision, and the invaluable advice and critical evaluations provided. I would also like to acknowledge the assistance and support rendered by IFNHH staff especially to Associate Professor Rachel Page - Regional Director, College of Sciences, Wellington for allowing me to use the telephone for ease of communication to the Solomon Islands, Mrs Marilyn Mabon - Head Technician – IFNHH and Margaret Allison - Senior Science Technician – IFNHH for guidance with microbiology bench protocols and for assisting me with my order of laboratory reagents and equipment, and Ms Karen McKeeman - Secretary/Administrator - IFNHH for all logistical support rendered. Thanks also to Dr Steve Humphries – Senior Lecturer at the School of Psychology and Mr. Brian Caughley – Senior Lecturer at the IFNHH for helping me with my biostatistics data analysis. Special tribute to my friend the late Ivan John Heard retired teacher and former secondary school Principal in the Solomon Islands who offered much of his time critiquing my grammar prior to his sudden death just after I left for the Solomon Islands to collect data. Tarunāmu da mamatho kori Soleana (rest in peace) my friend.

I would also like to sincerely acknowledge and thank the former Chairman of Soltai Ltd, Mr Tony Hughes and the General Manager of Soltai Ltd, Mr Thomas Dorku, for their cooperation and support and granting me approval to conduct the research study in the Processing Plant, without which it would not have been possible.

My heartfelt appreciation also goes to the Line Managers and Factory Workers of Soltai Ltd for accepting my invitation to participate in the research study. Special thank you to Soltai Ltd laboratory personnel, especially Mr Charles Koli -Laboratory Supervisor for his expertise and assistance rendered in analysing my samples for histamine. I would also like to sincerely thank Miss Kim Irofufuli for her tireless effort and expertise in analysing my tuna loin samples for microbiological parameters. My sincere gratitude to Mr and Mrs Charles Koli, my hosts for the duration of my data collection phase at Noro.

I would also like to acknowledge and thank the staff of Massey University International Students Support Office and my sponsor, NZAID for providing the scholarship and funds to

cater for my home located research and my family's welfare during the duration of my course. I would not have attained my goals without their support and NZAID's generosity.

Last, but not least, I am thankful to my wife Lynnette and children, Elinda, Ernie, George, Lloyd, Lynter and Martin for their continuous support, patience and understanding during the course of my study.

I dedicate this thesis to my late dad, Ernest Hagore who had been inspirational in encouraging me to look to greater heights in search of knowledge and excellence. To those whom I have omitted to mention and acknowledge, nigua na dotho hutu puala itamiu igamu gougovu (Thank you very much).

SOLEANA (PEACE)

Ernest Kolly

TABLE OF CONTENTS

ABSTRACT	ii
ACKNOWLEDGEMENTS.....	iv
TABLE OF CONTENTS	vi
APPENDICES	viii
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF PHOTOS.....	x
LIST OF ABBREVIATIONS.....	x
CHAPTER 1 – INTRODUCTION	1
1.1 Background information of the tuna industry in the Solomon Islands	2
1.2 Overview of food safety in the Solomon Islands.....	4
1.3 Geographical and demographical features of the Solomon Islands	6
1.3.1 Location of the study site	7
1.4 Problem statement and rationale for the study	7
1.4.1 Overview	7
1.5 Aim and objectives	9
1.5.1 Aim of the study	9
1.5.2 Specific objectives	9
CHAPTER 2 – LITERATURE REVIEW	10
2.1 Introduction.....	10
2.1.1 Historical perspective of the Hazard Analysis Critical Control Point (HACCP) system	10
2.1.2 HACCP in practice (worldwide context)	11
2.1.3 HACCP in the context of the Solomon Islands	12
2.1.4 Application of the HACCP in the fishing industry	14
2.1.5 Application of HACCP in food industries, small to medium enterprises (SME), retail stores and homes.....	16
2.1.6 HACCP as compared to other quality management systems	17
2.1.7 Transition to HACCP.....	20
2.1.8 Different steps in HACCP.....	20
2.1.9 Criticisms of HACCP	21
2.2 Bacterial contamination	22
2.2.1 Role of bacteria in seafood spoilage	23
2.2.2 Chemical oxidation and enzymatic spoilage of food	23
2.2.3 Histamine fish poisoning.....	24
2.2.4 Indicator organisms.....	28
2.2.5 Total coliform as indicator bacteria	29
2.2.6 Enteric indicator bacteria (<i>Escherichia coli</i> and faecal coliforms).....	30
2.2.7 The TPC as an indicator of bacterial contamination.....	31
CHAPTER 3 - RESEARCH METHODS	33
3.1 Introduction.....	33
3.1.1 Research methodology	33
3.1.1.1 Definition of mixed methods methodology	33
3.1.1.2 Why mixed methods research?.....	34
3.1.1.3 Philosophical perspective.....	34
3.1.1.4 Application of mixed methods research in health research.....	36

3.2	Ethical, cultural and safety issues.....	36
3.3	Research framework and design.....	37
3.3.1	Overview	37
3.3.2	Summary explanation of what was involved in the different phases of the study	39
3.3.2.1	Phase One – Review of good manufacturing practices (GMP) on board fishing vessels and histamine monitoring during unloading	39
3.3.2.2	Phase Two – Process monitoring in the factory	39
3.3.2.3	Phase Three –Quantitative survey	39
3.3.2.4	Phase Four –Qualitative Interview	40
3.3.3	Detailed explanation of the data collection, analysis and result/findings of each research method.....	40
3.3.3.1	Phase one and phase two - non experimental research	40
3.3.3.1.1	Sources of data	40
3.3.3.1.2	Company document review & analysis	41
3.3.3.1.3	Histamine sampling	42
3.3.3.1.4	Required equipment for samples	43
3.3.3.1.5	Test procedure	43
3.3.3.1.6	Interpretation of histamine results	44
3.3.3.1.7	Microbiological test methods	44
3.3.3.1.8	Microbiological sampling.....	45
3.3.3.1.9	Sampling on food contact surfaces and food handlers.....	47
3.3.3.1.10	Interpretation of total coliform results	48
3.3.3.1.11	Calculation of results.....	50
3.3.3.1.12	Data analysis	51
3.3.3.1.13	Results	52
	a) Histamine monitoring records	52
	b) Compliance records	53
	c) Median temperatures of catching wells.....	54
	d) Brine salinity and temperature	55
	e) Histamine content.....	56
	f) Total microbial loads/TPC	56
3.3.3.1.14	Discussion.....	59
3.3.3.2	Phase three – survey research.....	68
3.3.3.2.1	Sample size and selection of participants.....	68
3.3.3.2.2	Framework used for development of the survey questionnaire.....	69
3.3.3.2.3	Piloting the questionnaire survey	70
3.3.3.2.4	Survey questionnaire data analysis (quantitative and qualitative)	71
3.3.3.2.5	Results.....	72
3.3.3.2.6	Discussion	87
3.3.3.3	Phase four – qualitative research.....	92
3.3.3.3.1	Sample size and selection of participants.....	92
3.3.3.3.2	Qualitative data collection.....	93
3.3.3.3.3	Qualitative data analysis	94
3.3.3.3.4	Qualitative (<i>Talanoa</i>) interview findings.....	94
	a) Conflict of local cultural practices versus organisational culture.....	95
	b) Culture and illiteracy impedes understanding of HACCP principles.....	100
	c) Women are involved a lot in food preparation	100
	d) HACCP principles can complement cultural practices.....	101
3.3.3.3.5	Discussion.....	102

CHAPTER 4 – SUMMARY DISCUSSION	108
CHAPTER 5 - CONCLUSION	112
5.1 Limitations of the study	113
5.2 Recommendations – company improvements.....	114
5.3 Recommendations- future areas of research	115
5.4 Personal reflection.....	115
CHAPTER 6 - REFERENCES	117

APPENDICES

Appendix I: MUHEC approval letter	126
Appendix II: Letter to Chairman of Soltai Ltd Board seeking permission to conduct the study.....	127
Appendix III: Letter to General Manager, NFD Ltd seeking permission to conduct the study	129
Appendix IV: Letter to Permanent Secretary Ministry of Education & Human Resources Development, Solomon Islands	131
Appendix V: Research Permit from the Ministry of Education, Solomon Islands.....	133
Appendix VI: Company (Soltai Ltd) Joint Agreement Form.....	134
Appendix VII: Participants’ Information Sheet	135
Appendix VIII: Participants’ Consent Form	138
Appendix IX: Survey questionnaire.....	140
Appendix X : Cue questions for the qualitative exploratory (one on one <i>talanoa</i>) interview.....	149
Appendix XI: Summary records of the review of GMPs on board fishing vessels	151
Appendix XII: Microbiological analysis results	152

LIST OF TABLES

Table 1: Summary value of Soltai Ltd Tuna products exports 2005-2009.....	4
Table 2: Summary of chemical (histamine) and microbiological parameters (total coliform, total microbial load/TPC and <i>E.coli</i>) samples collected and analysed	49
Table 3: Summary findings of the review of histamine monitoring on board fishing vessels	52
Table 4: Summary findings on review of the CA audit reports and interviews conducted with the CA auditors.....	53
Table 5: Shows the histamine content.....	56
Table 6: Mean, median, minimum and maximum total microbial load/TPC expressed as cfu/g, from frozen tuna using stomacher and homogenizer to macerate the samples	56
Table 7: Familiarity with term food hazard & food risk	73
Table 8: Reference definitions	74
Table 9: Attitude/perception checklist	86

LIST OF FIGURES

Figure 1:	Food Safety Administration and Control Organisational Structure in the Solomon Islands	6
Figure 2:	Map of the Solomon Islands and location of the study site	7
Figure 3:	Research framework and design	38
Figure 4:	Soltai Ltd plant layout and sampling sites	46
Figure 5:	Median Temperature (T°C) in different wells on different fishing dates on board Solomon Emerald.....	54
Figure 6:	Median Temperature (T°C) in different wells on different fishing dates on board Solomon Pearl.....	55
Figure 7:	Median of Total Microbial Loads (cfu/g) for 9 samples, by site.....	57
Figure 8:	Percentage frequency of sites vs colony count for all sites.....	57
Figure 9:	Distribution of Total Microbial Loads (cfu/g)	58
Figure 10:	Correlation of Total Microbial Loads (cfu/g) between sites 2 & 3	58
Figure 11:	Swab test on food handlers/food contact surfaces.....	59
Figure 12:	Flow diagram showing how to maintain GMP onboard fishing vessel (purse seiners) to control histamine formation.....	63
Figure 13:	Cognitive and behaviour barrier to HACCP guideline adherence model	70
Figure 14:	Years of work.....	72
Figure 15:	Educational level	73
Figure 16:	Familiar with the term HACCP.....	74
Figure 17:	Familiar with the seven principles of HACCP.....	75
Figure 18:	HACCP food safety & food hygiene training attended	76
Figure 19:	Awareness of HACCP	76
Figure 20:	Adequate information on HACCP	77
Figure 21:	Implementation of the HACCP system in the workplace	78
Figure 22:	Agreement with HACCP principles	79
Figure 23:	Compliance with HACCP systems.....	79
Figure 24:	Major barriers to implementation of HACCP	80
Figure 25:	Positive ways of implementing HACCP in the factory	81
Figure 26:	Behaviour towards work.....	82
Figure 27:	Adoption of HACCP in the work place	83
Figure 28:	Sustaining of the HACCP system	84
Figure 29:	Influence of local culture on HACCP system in the factory.....	85
Figure 30:	Influence of culture is overcome	85
Figure 31:	Modified cognitive and behaviour to HACCP principle adherence model in the context of the Solomon Islands	103

LIST OF PHOTOS

Photo 1:	Soltai Ltd cannery, Noro, Western Province. Loin cleaning in the processing lines	2
Photo 2:	Neogen alert test kits.Different reagents to be used in each step of histamine analysis	44
Photo 3:	Alert test kit sample interpretation. Sample shows a darker blue colour than the control which indicates sample contains less than 10 ppm of histamine..	44
Photo 4:	Swab sampling prior to and after washing of hands. This test is to determine total coliform presence on food handlers thumbs.....	48
Photo 5:	Swab reading after incubating at 35°C for 22-24 hours. Coliforms are blue in colour. Non coliforms are green, gray or cream colour	48

LIST OF ABBREVIATIONS

APC – Aerobic Plate Counts
BRC – British Retail Consortium
CA - Competent Authority
CARs - Corrective Action Requests
CCP – Critical Control Points
CCM – Couple Control Monitoring
CFU – Colony Forming Unit
EMS – Environmental Management System
EC – Enterococci
FAD - Fish Aggregating Device
FC – Faecal Coliform
GMP – Good Manufacturing Practices/Procedures
GOP – Good Operating Practices/Procedures
GDP – Gross Domestic Product
HACCP – Hazard Analysis Critical Control Points
HAZOP – Hazard and Operability Hazard Analysis
HFP – Histamine Fish Poisoning
IFNHH – Institute of Food, Nutrition and Human Health
ISO – International Standardization Organization
ICMSF – International Commission on Microbiological Specifications for Foods
m – Acceptable microbiological level in a sample unit
M – The level which, when exceeded in one or more samples, would cause the lot to be rejected
NFD Ltd – National Fisheries Developments Company Limited

NPHL – National Public Health Laboratory
QCO – Quality Control Officer
QA – Quality Assurance
QC- Quality Control
QRA – Quantitative Risk Assessment
RSW- Refrigerated Seawater
SPC – Standard Plate Counts
SSOP – Sanitation Standard Operation Practices/Procedures
SOP – Standard Operating Practices/Procedures
SOLTAI Ltd – Soltai Fishing & Processing Company Limited
SFIB – Sardine Fish Infusion Broth
TC – Total Coliform
TPC – Total Plate Counts
TVC – Total Viable Count
TQM – Total Quality Management
USFDA – United States Food and Drug Administration