

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.

# A STUDY OF THE MICROBIOLOGICAL QUALITY OF BOTTLED WATER SOLD IN NEW ZEALAND

A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF MASTER OF  
PHILOSOPHY



"Forget lemonade. The real money's in bottled water."

INSTITUTE OF FOOD, NUTRITION AND HUMAN HEALTH  
COLLEGE OF SCIENCES

MASSEY UNIVERSITY, WELLINGTON, NEW ZEALAND

TE KUNENGA KI PŪREHUROA

RUTA SVAGZDIENE

2010

## ABSTRACT

The aim of this study was to determine if retailed bottled water in New Zealand complied with the Australia and New Zealand Food Standards (ANZFS) Code (2002) and the New Zealand Microbiological Reference Criteria (1995).

The New Zealand Microbiological Reference Criteria for Packaged Waters include Total Coliforms, *Escherichia coli*, Enterococci (Group D streptococci) and *Pseudomonas aeruginosa*. Standard 1.6.1 of the ANZFS includes Total Coliforms, *Escherichia coli*, Enterococci (Group D streptococci), *Pseudomonas aeruginosa* and Total Viable Count (TVC).

In this study five samples of randomly selected 38 brands of different types of domestic and imported bottled waters were purchased from local retail stores in Wellington region. The samples were tested for Total Coliforms, *Escherichia coli*, Enterococci (Group D streptococci), *Pseudomonas aeruginosa*, TVC, Yeasts and Moulds and *Campylobacter spp.*

Three domestic brands did not comply with both of the above criteria for Total Coliforms.

Seventeen brands did not comply with TVC criteria of ANZFS Code (100 CFU/ml) with nine out of 17 being domestic New Zealand brands.

Twenty one brands displayed the growth of colonies on Sabouraud dextrose agar plates. Half of them displayed the growth of moulds.

Due to high incidence of campylobacteriosis in New Zealand composite samples of brands with TVC counts equal or higher than 100 CFU/ml were tested for *Campylobacter spp.* All samples were negative for *Campylobacter spp.*

A survey questionnaire was used to assess the impact of manufacturing procedures on bottled water quality. The aim of the survey was to investigate possible significant public health links between the source water quality, type of abstraction, pipework materials, bottling process, staff training, policies and procedures. All four manufacturers, which responded to the questionnaire and represented 11 bottled water brands, bottled at least one brand that did not comply with the ANZFS Code for TVC.

Ten years after the initial study was performed by Hasell and Capill in 1999 microbiological contamination in bottled waters in New Zealand was still being detected. We demonstrated that monitoring bottled water microbiological quality was essential and that the presence of manufacturers' procedures for ensuring satisfactory bottled water microbiological quality did not always guarantee it.

## **PREFACE**

“Everything comes from water!

And everything is kept alive by water!”

J.W. von Goethe, *Faust II*, 1833

## **ACKNOWLEDGEMENTS**

Assistance in statistical analysis of the data was provided by Ms Christine Roseveare, my previous colleague at the Regional Public Health, Hutt Valley District Health Board and Mr Brian Caughley, Senior Lecturer in Chemistry at Massey University in Wellington.

I would also like to thank Professor Philip Dickinson for his advice and guidance.

My thanks to the Wellington Massey University laboratory technicians Mrs Marilyn Mabon and Mrs Margaret Allison for their endless help.

Last, but not the least, I would like to thank my supervisors Associate Professor Rachel Page and Dr Robert Lau for their time, advice and guidance.

## **DEDICATION**

I dedicate my work to everyone who believed in me.

## TABLE OF CONTENTS

ABSTRACT .....	II
PREFACE .....	IV
ACKNOWLEDGEMENTS .....	IV
DEDICATION.....	IV
TABLE OF CONTENTS.....	V
LIST OF TABLES.....	VIII
LIST OF FIGURES .....	IIX
CHAPTER ONE- INTRODUCTION .....	1
1.1. BOTTLED WATER QUALITY .....	2
1.1.1. WORLDWIDE LITERATURE REVIEW .....	8
1.1.1.2. <i>United Kingdom Situation</i> .....	17
1.1.1.3. <i>New Zealand Context</i> .....	19
1.2. BOTTLED WATER QUALITY MONITORING- LEGISLATIVE RESPONSIBILITIES.....	21
1.2.1. Introduction .....	21
1.2.2. New Zealand Requirements for the Microbiological Compliance of Bottled Water (New Zealand Ministry of Health) .....	23
1.2.3. Australia and New Zealand Requirements for the Microbiological Compliance of Bottled Water under the Food Standards Code .....	27
1.3. Characteristics of Indicator Organisms and Rationale for Detecting and Enumerating Indicator Organisms .....	35
1.4. Objectives and Outline of my Research.....	36
CHAPTER TWO – MATERIALS AND METHODS.....	38
2.1. COLLECTION AND DESCRIPTION OF SAMPLES.....	38
2.2 ANALYSIS OF SAMPLES .....	38
2.2.1. <i>E. coli</i> Detection and Enumeration.....	38
2.2.2. Enterococci Detection and Enumeration.....	42



3.4.1. Yeast and Mould Testing Results .....	63
3.4.2. <i>Campylobacter spp.</i> Testing Results .....	64
CHAPTER FOUR. RESULTS AND DISCUSSION OF BOTTLING WATER PLANTS SURVEY .....	66
CHAPTER FIVE- CONCLUSIONS, RECOMMENDATIONS AND POSSIBLE FUTURE IMPLICATIONS .....	75
5.1. CONCLUSIONS.....	75
5.2. RECOMMENDATIONS .....	78
5.3. POSSIBLE FUTURE IMPLICATIONS .....	80
BIBLIOGRAPHY .....	81
APPENDICES.....	92
APPENDIX I. A COPY OF THE SURVEY QUESTIONNAIRE.....	92
APPENDIX II. CAMPYLOBACTERIOSIS TRENDS IN NEW ZEALAND. ....	97
APPENDIX III. CAMPYLOBACTER SPP. DETECTION METHODOLOGY (ELS LTD).....	101
APPENDIX IV. LIST OF BOTTLED WATER BRANDS TESTED. ....	108
APPENDIX V. SURVEY QUESTIONNAIRE COVERING LETTER.....	109
APPENDIX VI. COPY OF ETHIC'S COMMITTEE APPROVAL.....	110
APPENDIX VII. RESEARCHER QUALIFICATIONS. ....	111
APPENDIX VIII . RESEARCH OUTPUTS.....	112

## LIST OF TABLES

<b>Table No</b>	<b>Table Title</b>	<b>Page</b>
Table 1-1	Global Bottled Water Market - Leading Countries' Consumption and Compound Annual Growth Rates 2002 – 2007.	4
Table 1-2	Global Bottled Water Market - Per Capita Consumption by Leading Countries.	5
Table 1-3	Main Types of Bottled Water.	6
Table 1-4	<i>Microbiological Reference Criteria for Foods Packaged Waters</i> (Including Mineral Waters and Those Bottled from Natural Underground Sources).	26
Table 1-5	Australian/New Zealand Microbiological Standard for Mineral Water and Packaged Water and Ice.	31
Table 1-6	Guideline Levels for Determining the Microbiological Quality of Ready-To-Eat Foods.	34
Table 2-1	Reactions of Colilert and Enterolert <i>Quanti-Cult</i> Pack.	43
Table 3-1	Descriptive Characteristics of Tested Bottled Water Brands.	54
Table 3-2	Coliform counts of brands that did not comply with the New Zealand Ministry of Health Microbiological Reference Criteria for Food Guidelines.	56
Table 3-3	Average TVC Counts Obtained after Testing the 38 Bottled Water Brands.	60
Table 4-1	Survey Questionnaire Results.	68

## LIST OF FIGURES

<b>Figure No</b>	<b>Figure Title</b>	<b>Page</b>
Figure 2-1	Colilert Control Positive Reaction.	41
Figure 3-1	Categories of Bottled water Brands as Described on the Labels.	55
Figure 3-2	TVC colonies.	61