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Frontispiece



Rihaakuru

Control of Histamine in *Rihaakuru*: Emerging Approaches

A thesis presented in partial fulfilment of the requirements for the degree of
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2. Naila, A., Flint, S., Fletcher, G. C., Bremer, P. J., & Meerdink, G. (2011a). Chemistry and microbiology of traditional *Rihaakuru* (fish paste) from the Maldives. *International Journal of Food Sciences and Nutrition*, 62(2), 139-147.
3. Naila, A., Flint, S., Fletcher, G. C., Bremer, P. J., & Meerdink, G. (2011b). Biogenic amines and potential histamine - Forming bacteria in *Rihaakuru* (a cooked fish paste). *Food Chemistry*, 128(2), 479-484.
4. Naila, A., Flint, S., Fletcher, G. C., Bremer, P. J., Meerdink, G., & Morton, R. H. (2011c). Degradation of histamine in tuna soup by diamine oxidase (DAO). In: *Food and Environment*, vol. 152 (p. 103-112). England, UK: WIT press.
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4. Naila, A., Flint, S., Fletcher, G. C., Bremer, P. J., Meerdink, G. (2011). Degrading histamine in *Rihaakuru*: An emerging approach. NZMS Annual Conference, 23-25 November, Palmerston North, New Zealand.

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Other publications

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Abstract

Rihaakuru is a cooked fish paste from the Maldives, consumed as a condiment with rice and other food. The product is unique to the Maldives and there is no information on the composition, characteristics and safety of this product. Histamine contamination has been suspected due to symptoms sometimes seen following consumption. This research established that *Rihaakuru* is a nutritious and shelf-stable product. *Rihaakuru* is generally produced from poor quality fish therefore presence of biogenic amines was suspected. This study confirmed that *Rihaakuru* contained up to ten different biogenic amines, with histamine in excess of 500 ppm. This may cause histamine poisoning with symptoms such as skin rashes, vomiting and fever. The product examined in this study contained a few weak histamine forming bacteria. Most of the histamine is likely to be produced by bacteria in the raw fish. These bacteria are likely to die during the manufacture of *Rihaakuru*. Histamine in *Rihaakuru* decreased by 30-70% during storage at -80°C, 4°C and 30°C for 10 months. This showed that the histamine hazard in *Rihaakuru* is unlikely to increase and may decrease during long term storage. Traditional control of histamine in food is through refrigeration of raw material. In the case of the fish used to manufacture *Rihaakuru*, refrigeration is not available or limited. Histamine oxidizing bacteria and enzymes were identified as emerging approaches to degrade pre-formed histamine. Histamine oxidizing bacteria (*Lactobacillus sakei* [AGR 37, AGR 46, Lb 706] and *Vergibacillus halodonitrificans* Nai18) tested in this study degraded histamine by 30-50%. The histamine oxidizing enzyme, diamine oxidase (DAO) completely degraded 500 mg/L of histamine at pH 6 and salt 1% in buffer and in the tuna soup used to manufacture *Rihaakuru*. A regression model was developed that predicted the rate and amount of histamine removal by DAO under varied pH and salt concentration. This model may be used to determine conditions that will reduce histamine in other foods that have similar characteristics to the tuna soup used to manufacture *Rihaakuru*.

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Table of Contents

Control of Histamine in <i>Rihaakuru</i>: Emerging Approaches.....	i
Chapter 1 Introduction.....	1
1.1 Background.....	2
1.2 Thesis hypothesis and objectives	2
1.3 Preface.....	3
Chapter 2 Literature Review	5
2.1 Abstract.....	6
2.2 Introduction	7
2.3 Existing methods for biogenic amine control in food.....	9
2.4 Emerging methods for biogenic amine control.....	10
2.5 Methods for delaying biogenic amines accumulation	12
2.5.1 Application of food additives and preservatives	12
2.5.2 High hydrostatic pressure.....	17
2.5.3 Irradiation	18
2.5.4 Packaging	24
2.5.5 Microbial modelling.....	29
2.5.6 Starter cultures	31
2.6 Methods for oxidizing/degrading formed biogenic amines	33
2.7 Conclusion.....	35
2.8 Nomenclature.....	36
2.9 References.....	37
2.10 Additions and Updates to Literature Review:.....	49
2.10.1 Control of biogenic amines in food - Existing and emerging approaches.....	49
2.10.2 Histamine in food.....	53
2.10.3 Histamine stability during storage.....	55
2.10.4 References	56
Chapter 3 <i>Rihaakuru</i>: Process, Composition and Microflora	61
3.1 Abstract.....	62
3.2 Introduction	63
3.3 Materials and Methods.....	65
3.3.1 Sampling	65
3.3.2 Physicochemical analysis.....	65

3.3.3 Amino acid, fatty acid, minerals and composition analysis.....	65
3.3.4 Total aerobic and anaerobic count.....	66
3.3.5 Natural microflora isolation and identification.....	67
3.4 <i>Results and Discussion</i>	68
3.4.1 Physicochemical analysis	68
3.4.2 Amino acid, composition analysis, minerals and fatty acid of <i>Rihaakuru</i>	69
3.4.3 Compositional analysis of <i>Rihaakuru</i>	69
3.4.4 Amino acid profile.....	71
3.4.5 Mineral profile.....	73
3.4.6 Fatty acid profile.....	75
3.4.7 Omega fatty acids	77
3.4.8 Total aerobic and anaerobic count.....	78
3.4.9 Natural microflora isolation and identification.....	78
3.5 <i>Conclusion</i>	80
3.6 <i>Acknowledgement</i>	80
3.7 <i>References</i>	81
Chapter 4 Biogenic Amines in <i>Rihaakuru</i>	87
4.1 <i>Abstract</i>	88
4.2 <i>Introduction</i>	89
4.3 <i>Materials and Methods</i>	90
4.3.1 Sampling.....	90
4.3.2 Standards and reagents.....	91
4.3.3 Biogenic amines standards preparation	91
4.3.4 Sample extraction	91
4.3.5 Derivatization reaction.....	92
4.3.6 HPLC analysis	92
4.3.7 Histamine production by bacteria	92
4.4 <i>Results and Discussion</i>	95
4.4.1 Analysis of biogenic amines	95
4.4.2 Bacteria isolated from <i>Rihaakuru</i>	98
4.5 <i>Conclusions</i>	101
4.6 <i>Acknowledgement</i>	101
4.7 <i>References</i>	102
Chapter 5 Histamine Stability in <i>Rihaakuru</i> at -80°C, 4°C and 30°C	107
5.1 <i>Abstract</i>	108
5.2 <i>Introduction</i>	109

5.3 <i>Materials and Methods</i>	110
5.3.1 Rihaakuru	110
5.3.2 Chemical and microbial and analysis.....	110
5.3.3 Statistical analysis	111
5.4 <i>Results and Discussion</i>	111
5.5 <i>Conclusion</i>	115
5.6 <i>Acknowledgement</i>	116
5.7 <i>References</i>	117
Chapter 6 Histamine Degradation by Diamine Oxidase, <i>Lactobacillus</i> and <i>Vergibacillus</i>	
<i>halodonitrificans</i> Nai18	121
6.1 <i>Abstract</i>	122
6.2 <i>Introduction</i>	123
6.3 <i>Materials and Methods</i>	124
6.3.1 <i>Materials</i>	124
6.3.2 <i>Histamine degradation by bacteria</i>	124
6.3.3 <i>Histamine degradation by DAO</i>	125
6.3.4 <i>Histamine analysis</i>	126
6.4 <i>Results and Discussion</i>	127
6.4.1 <i>Histamine degradation by bacteria</i>	127
6.4.2 <i>Histamine degradation by DAO</i>	131
6.5 <i>Conclusion</i>	132
6.6 <i>Acknowledgement</i>	133
6.7 <i>References</i>	134
Chapter 7 Prediction of the Amount and Rate of Histamine Degradation by Diamine	
<i>Oxidase (DAO)</i>	137
7.1 <i>Abstract</i>	138
7.2 <i>Introduction</i>	139
7.3 <i>Materials and Methods</i>	143
7.3.1 <i>Materials</i>	143
7.3.2 <i>Experimental design</i>	144
7.3.3 <i>Preparation of phosphate buffer</i>	144
7.3.4 <i>Preparation of tuna soup</i>	144
7.3.5 <i>DAO Experimental procedure</i>	145
7.3.6 <i>Analysis</i>	146
7.3.7 <i>Statistical analysis</i>	146
7.4 <i>Results and Discussion</i>	147

7.4.1 Exponential decline model.....	147
7.4.2 Response surface model.....	151
7.4.3 Comparison of buffer and tuna soup models	161
7.4.4 Conclusion	162
7.5 Future work.....	162
7.6 Acknowledgement.....	163
7.7 References	164
Chapter 8 General Discussion and Conclusion.....	167
8.1 Reminder of thesis hypothesis and objectives	168
8.2 Major contributions and findings of this thesis.....	168
8.3 Recommendations and future directions	172
8.3.1 <i>Rihaakuru</i> : manufacturing process, physiochemical analysis, nutritional composition and bacterial microflora.....	172
8.3.2 Biogenic amines in <i>Rihaakuru</i>	173
8.3.3 Long-term histamine stability in <i>Rihaakuru</i>	173
8.3.4 Histamine degradation by bacteria and DAO	173
8.3.5 Histamine degradation using DAO in a model system	173
8.3.6 Histamine degradation by DAO in tuna soup	174
8.4 References	176
Appendix I: Supplementary Data Relevant to Chapters 3 and 7.....	177
Aerobic and Anaerobic Count in <i>Rihaakuru</i>	177
Mean Aerobic and Anaerobic Count in <i>Rihaakuru</i>	177
Histamine peak	180
Calibration curve used to quantify histamine	180
Experimental data of buffer (bf) and tuna soup (sp) fitted into Exponential decline model (primary model)	181
Appendix II: Publications.....	191
Bibliography.....	197

List of Abbreviations

ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
CCD	central composite design
CHD	coronary heart disease
CHO	carbohydrates
DAO	diamine oxidase
DHA	docosaheptaenoic acid
DNA	deoxyribonucleic acid
DPA	docosapentaenoic acid
DSMZ	Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH
EDTA	ethylene diamine tetra acetic acid
EPA	eicosapentaenoic acid
ETE	eicosatrienoic acid
FDA	Food and Drug Administration
FID	Flame Ionization Detector
GAM	Gifu Anaerobic Medium broth
GC	gas chromatography
GDL	glucono-delta-lactone
GE	Gross Energy
HDC	Histidine Decarboxylase
HHP	high hydrostatic pressure
HPLC	high performance liquid chromatography
ICMSF	International Commission on Microbiological Specification for Foods
MAOI	monoamine oxidase inhibitors
MAP	modified atmosphere packaging
MPN	most probable number
MRS	deMan, Rogosa and Sharpe broth
MS	mass-spectroscopy
NOAEL	no observed adverse effect level
NZAID	New Zealand Agency for International Development
NZDS	New Zealand Development Scholarship

NZIFST	New Zealand Institute of Food Science and Technology
NZMS	New Zealand Microbiological Society
PCR	polymerase chain reaction
PUFA	polyunsaturated fatty acids
RDI	recommended daily intake
rDNA	Ribosomal DNA
RSM	response surface model
SBMB	New Zealand Society for Biochemistry and Molecular Biology
sfam	Society for Applied Microbiology
TCA	trichloroacetic acid
TDF	Total Dietary Fibre
TLC	thin layer chromatography
TMAH	tetramethylammonium hydroxide
TSA	trypticase soy agar
TSB	trypticase soy broth
TSBH	histidine tripticase soy broth
UHT	ultra high temperature
USA	United States of America
USDA	United States Department of Agriculture
UV	ultra-violet
WHO	World Health Organization

List of Tables

Table 1: Biogenic amines reduction through food preservatives.....	14
Table 2: Biogenic amines reduction through high hydrostatic pressure	20
Table 3: Biogenic amines reduction through irradiation.....	21
Table 4: Biogenic amines reduction through packaging.....	26
Table 5: Composition analysis of <i>Rihaakuru</i> (n=2).....	70
Table 6: Amino acid profile of <i>Rihaakuru</i> (n=2)	72
Table 7: Essential amino acids of <i>Rihaakuru</i> (n=2) in comparison to recommended level	73
Table 8: Mineral content of <i>Rihaakuru</i> (n=2)	74
Table 9: Fatty acid profile of <i>Rihaakuru</i> (n=2)	76
Table 10: Identified bacteria isolated from <i>Rihaakuru</i> by 16S rDNA, using internet blast server (http://bioinfo.unice.fr/blast/)	93
Table 11: Contents of biogenic amines in tested <i>Rihaakuru</i> samples (n=28)	96
Table 12: Histamine production by selective bacterial strains isolated from <i>Rihaakuru</i>	99
Table 13: Identified potential histamine forming bacterial species from <i>Rihaakuru</i> basing on other researches	100
Table 14: Amino acid and protein content in <i>Rihaakuru</i> AN-1 before and after storage at 30°C	111
Table 15: Histamine stability in <i>Rihaakuru</i> stored for 10 months	114
Table 16: Comparison of primary and secondary model values for r and L in the 2- factor 15-run central composite design and validated experiments	148
Table 17: Significance of the models coefficients	152
Table 18: ANOVA results of buffer and soup models.....	152
Table 19: Model summary of buffer and tuna soup.....	153

List of Figures

Figure 1: Overview of the thesis chapters and their relationship to knowledge gaps	4
Figure 2: <i>Lactobacillus</i> species degradation of histamine in TSB containing 500 ppm of histamine. Error bars representing mean standard deviation of n = 3.....	128
Figure 3: <i>Vergibacillus halodonitrificans</i> Nai18 degradation of histamine in TSB containing 500 ppm histamine. Error bars represent mean standard deviation of n = 3.....	129
Figure 4: <i>Arthrobacter crystallopoietes</i> DSM 20117 degradation histamine in TSB containing 500ppm histamine. Error bars represent mean standard deviation of n = 3.....	130
Figure 5: Histamine degradation (500 ppm) by DAO (2534 units/L) in 0.5 M phosphate buffer and tuna soup under pH 6 and salt 1% incubated at 37°C and agitated at 100 rpm for 10 h. Error bars represent mean standard deviation of n = 3.....	132
Figure 6: <i>Rihaakuru</i> manufacturing steps, including the tuna soup step where DAO can be added after which the soup is further boiled until it becomes <i>Rihaakuru</i> . The boiling will kill all the pathogenic microorganisms that may have grown during DAO treatment.	142
Figure 7: Summary of experimental procedure for DAO activity in buffer and tuna soup.	146
Figure 8: Experiment 11 run at pH 7.0 and salt 3% in 0.5 M phosphate buffer containing 500 mg/L histamine dihydrochloride, and 2534 units/L DAO, shows that the observed and predicted values are in strong agreement ($R^2 = 0.998$).	149
Figure 9: Experiment run at pH 7.0 and salt 3% (exp 11) in tuna soup containing 500 mg/L histamine dihydrochloride, and 2534 units/L DAO, shows that the observed and predicted values are in strong agreement ($R^2 = 0.985$).	150
Figure 10: pH (x) and salt (y) as a function of the L-fit- amount of histamine remained in buffer (mg/L) [see key] after degradation by DAO. Salt was not significant at the 5% level.....	155
Figure 11: pH (x) and salt (y) as a function of the predicted exponential rate constant (r-fit) of histamine degradation in buffer, by DAO. Salt was not significant at the 5% level.	156
Figure 12: pH (x) and salt concentration (%) (y) as a function of L-fit- predicted amount of histamine remained (mg/L) [see key] in tuna soup after degradation by DAO. ...	159
Figure 13: pH (x) and salt concentration (%) (y) as a function of the r-fit- predicted exponential rate constant of histamine degradation in tuna soup, by DAO.....	160