UNIVERSITI PUTRA MALAYSIA

MOLECULAR CHARACTERIZATION OF BACTERIOCIN LOCI IN LACTOBACILLUS PLANTARUM I-UL4

TAI HUI FONG

FBSB 2013 45

MOLECULAR CHARACTERIZATION OF BACTERIOCIN LOCI IN *LACTOBACILLUS PLANTARUM* I-UL4

By

TAI HUI FONG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, In Fulfilment of the Requirements for the Degree of Master of Science

June 2013

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for degree of Master of Science

MOLECULAR CHARACTERIZATION OF BACTERIOCIN LOCI IN *LACTOBACILLUS PLANTARUM* I-UL4

By

TAI HUI FONG

June 2013

Chairman: Assoc. Prof. Foo Hooi Ling, PhD
Faculty: Biotechnology and Biomolecular Sciences

Bacteriocin is a group of proteinaceous antimicrobial peptides produced inhibiting the growth of closely related bacterial strains. Bacteriocin and bacteriocinogenic Lactic Acid Bacteria (LAB) have received special attention due to their potential applications as biopreservative, therapeutic agent and antibiotic-replacer in livestock animals. *Lactobacillus plantarum*, a member of LAB is found in various ecological niches with more than 10 types of bacteriocins have been reported for this species. *L. plantarum* I-UL4 isolated from the fermented tapioca exhibits a wide spectrum of bacteriocin activity against Gram-positive and Gram-negative bacteria as well as food-borne pathogens. It was reported to carry two bacteriocin structural genes, *plW* and *plnEF* encode for plantaricin W and plantaricin EF, respectively. However, the information regarding the bacteriocin biosynthetic genes for plantaricin W and plantaricin EF such as immunity, secretion and regulatory genes as well as the organisation of the respective bacteriocin loci are not available.

Hence, the bacteriocin loci of *L. plantarum* I-UL4 containing *plW* and *plnEF* structural genes were analysed in this study. The presence of 24 selected plantaricin (*pln*) biosynthetic genes (structural, immunity, secretion and regulatory genes) described for *plnS*, *pln423*, *plW* and *plnEF* loci were amplified and sequenced. The result revealed the presence of eight *pln* genes and two *pln* genes from *plnEF* and *plW* locus, respectively. On the contrary, the *pln* genes of *plnS* locus, *pln423* locus and nine *pln* genes of *plnEF* locus were absent from the studied strain as confirmed by gradient PCR.

The DNA sequence of the flanking region of these *pln* genes were amplified and sequenced. The results revealed two contigs of 2.7 kilobase (kb) (UL4-*plW* locus) and 17.5 kb (UL4-*plnEF* locus), respectively. The UL4-*plW* locus contains three open reading frames (ORFs) arranged in the same orientation which showed remarkable DNA (≥99.7%) and amino acid (≥99.3%) sequence identities to the *plW* locus of *L. plantarum* LMG2379. On the contrary, 21 ORFs were predicted on the UL4-*plnEF* locus. Each ORF has remarkable DNA and amino acid sequence identities to the reported ORFs of *plnEF* loci in *L. plantarum* C11, WCFS1, V90, J51, NC8, J23 and

JDM1 (reported *plnEF* loci). Five operons were deduced in the UL4-*plnEF* locus: *orf345*, *plnLR*, *plnUL4IF-UL4HK-plnD*, *plnEFI* and *plnGHSUVW*. The UL4-*plnEF* locus was demonstrated to contain different number of bacteriocin gene exhibiting different organisations from the reported *plnEF* loci. Specifically, *plnF* (bacteriocin structural gene encoding plantaricin EF) of the UL4-*plnEF* locus showed mutation which contributed to a longer plnF peptide with isoelectric point was 0.28 lower than the plnF of the reported *plnEF* loci. Interestingly, the UL4-*plnEF* locus was shown to be a hybrid of the *plnEF* locus of *L. plantarum* JDM1 and J51, where the left-half and right-half of UL4-*plnEF* locus resembled the *plnEF* locus of *L. plantarum* JDM1 and J51, respectively. Southern hybridisation with specific DNA probe showed that both UL4-*plW* and UL4-*plnEF* loci were chromosomally encoded. The UL4-*plW* locus encoded lantibiotic plantaricin W, while the UL4-*plnEF* locus encoded class IIb plantaricin EF and a putative two-peptide plantaricin orf34.

In conclusion, the concurrent presence of the UL4-*plW* and the mosaic UL4-*plnEF* loci suggested that the *L. plantarum* I-UL4 was a novel multi-bacteriocinogenic LAB.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENCIRIAN MOLEKULAR LOKUS PRODUKSI BAKTERIOSIN DARIPADA *LACTOBACILLUS PLANTARUM* I-UL4

Oleh

TAI HUI FONG

Jun 2013

Pengerusi: Prof. Madya. Foo Hooi Ling, PhD
Faculti: Bioteknologi dan Sains Biomolekul

Bakteriosin adalah sekumpulan peptida antimikrob yang dihasilkan untuk merencat pertumbuhan strain bakteria yang berkait rapat. Bakteriosin dan bakteria asid laktik (LAB) yang berbakteriosin telah menerima perhatian khas kerana aplikasi potensi mereka sebagai ejen biopreservative, terapeutik dan pengganti antibiotik pada haiwan ternakan. *Lactobacillus plantarum*, ahli LAB boleh didapati dalam pelbagai lapisan ekologi dengan lebih daripada 10 jenis bakteriosin telah dilaporkan untuk spesis ini. *L. plantarum* I-UL4 yang dipencilkan daripada ubi kayu tertapai menunjukkan spektrum aktiviti bakteriosin yang luas terhadap bakteria Gram-positif dan Gram-negatif serta patogen makanan. Ia telah dilaporkan mempunyai dua gen struktur bakteriosin, *plW* dan *plnEF* yang masing-masing mengekodkan plantaricin W dan plantaricin EF. Walau bagaimanapun, maklumat mengenai gen biosintesis bakteriosin untuk plantaricin W dan plantaricin EF seperti imuniti, rembesan dan gen kawalan serta organisasi lokus bakteriosin masih tidak diketahui.

Oleh itu, lokus bakteriosin *L. plantarum* I-UL4 yang mengandungi gen struktur *plW* dan *plnEF* dianalisiskan dalam kajian ini. Kehadiran 24 gen biosintesis plantaricin (*pln*) (gen struktur, imuniti, rembesan dan kawalan) yang diumumkan bagi lokus-lokus *plnS*, *pln423*, *plW* dan *plnEF* diamplifikasikan dan jujukannya ditentukan. Keputusan menunjukan kehadiran lapan dan dua gen *pln* masing-masing daripada lokus *plnEF* dan lokus *plW*. Sebaliknya, gen-gen *pln* daripada locus *plnS*, locus *pln423* dan sembilan gen-gen *pln* daripada locus *plnEF* didapati tidak hadir pada strain yang dikaji seperti yang disahkan oleh kecerunan PCR.

Jujukan DNA untuk DNA yang mengelilingi gen-gen *pln* ini dijujukkan. Keputusannya menunjukkan dua contig yang masing-masingnya mempunyai sebanyak 2.7 kilo pasangan bes (kb) (locus UL4-*plW*) dan 17.5 kb (locus UL4-*plnEF*). Lokus UL4-*plW* mengandungi tiga bingkai bacaan terbuka (ORF) yang disusunkan dalam orientasi yang sama di mana ia menunjukkan identiti jujukan DNA (≥ 99.7%) dan urutan asid amino (≥ 99.3%) yang tinggi dengan lokus *plW L. plantarum* LMG2379. Manakala, 21 ORF telah diramalkan pada lokus UL4-*plnEF*. Setiap ORF mempunyai identiti jujukan DNA

dan urutan asid amino yang tinggi dengan ORF yang dilaporkan untuk lokus *plnEF L. plantarum* C11, WCFS1, V90, J51, NC8, J23 dan JDM1 (lokus-lokus *plnEF y*ang diumumkan). Lima operon telah disimpulkan daripada lokus UL4-*plnEF*: *orf345*, *plnLR, plnUL4IF-UL4HK-plnD, plnEFI* dan *plnGHSUVW*. Lokus UL4-plnEF telah dibuktikan mengandungi jumlah gen bakteriosin yang berbeza dan mempamerkan organisasi yang berbeza daripada lokus-lokus *plnEF* yang dilaporkan. Khususnya, *plnF* (bakteriosin struktur gen yang mengekodkan plantaricin EF) daripada locus UL4-*plnEF* menunjukkan mutasi yang menyumbangkan kepada peptida plnF yang lebih panjang dengan titik isoelektriknya adalah 0.28 lebih rendah daripada *plnF* yang dilaporkan. Yang menariknya, lokus UL4-*plnEF* menyerupai cantuman lokus *plnEF* daripada *L. plantarum* JDM1 dan J51, di mana separuh kiri dan kanannya daripada UL4-*plnEF* locus masing-masing menyerupai separuh kiri dan separuh kanan lokus *plnEF L. plantarum* JDM1 dan J51. Hibridisasi Selatan dengan mengunakan probe DNA tertentu menunjukkan bahawa kedua-dua lokus UL4-*plW* dan lokus UL4-*plnEF* adalah dikodkan pada kromosom. Lokus UL4-*plW* mengekodkan lantibiotic plantaricin W, manakala lokus UL4-*plnEF* mengekodkan plantaricin EF yang berkelas IIB dan plantaricin putatif orf34 yang berpeptida dua.

Kesimpulannya, kehadiran serentak lokus UL4-*plW* dan lokus UL4-*plnEF* mencadangkan bahawa *L. plantarum* I-UL4 adalah satu LAB beraneka bakteriosin yang novel.

ACKNOWLEDGEMENTS

I would like to extend my heartfelt thanks and gratitude to my supervisor, Assoc. Prof. Foo Hooi Ling for her valuable guidance, advice and suggestions towards the completion of this project. Not forgetting my supervisory committee members, Prof. Dr. Raha Abdul Rahim and Assoc. Prof. Dr. Mohd. Puad Abdullah for their constructive comments and truthful helps during the on-going research works and the preparation of my thesis.

And finally, thanks to my family for their moral supports and love throughout the period of my study in UPM.

To all lab mates of the Laboratory of Industrial Biotechnology and Laboratory of Microbial Molecular Biology, I convey my gratefulness for their loves, supports, encouragements and the wonderful memory I shared with them. A million thanks for their assistance and suggestions and helped me for overcoming the problems I encountered. Needless to say, their friendships will be in my mind eternally.

The thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirements for the degree of Master of Science. The members of the Supervisory committee were as follow:

Foo Hooi Ling, PhD
Associate Professor
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Chairman)

Raha Abdul Rahim, PhD
Professor
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Menber)

Mohd. Puad Abdullah, PhD
Associate Professor
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: **TAI HUI FONG GS21649**

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of Chairman of
Supervisory Committee: **Foo Hooi Ling, PhD**

Signature: _____
Name of Member of
Supervisory Committee: **Raha Abdul Rahim, PhD**

Signature: _____
Name of Member of
Supervisory Committee: **Mohd. Puad Abdullah, PhD**

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

^{o}C	Degree Celsius
G	G-force
µL	Microlitre
µM	Micromolar
%	Percentage
≥	More than or equal to
<	Less than
>	More than
[name of the strain]-[ORF or peptide]	The ORF of peptide of a strain
ATP	Adenosine triphosphate
AviCys	2-aminovinyl-*D*-cysteine
AviMeCys	*S*-aminovinyl-methyl-*D*-cysteine
Bp	Basepair
Cm	Centimeter
Da	Dalton
dH_2O	Distilled water
Dha	dehydroalanine
Dhb	dehydrobutyrine
DNA	Deoxyribonucleic acid
dNTP	Deoxyribonucleotide triphosphate
EDTA	Ethylenediaminetetraacetic acid
G	Gram
HPK	Histidine protein kinase
HCl	Hydrochloric acid
Hr	Hour
IF	Induction factor
kDa	Kilodalton
LAB	Lactic acid bacteria
Lan	Lanthionine
M	Molar
MeLan	α-methyllanthionine
Mg	Milligram
$MgCl_2$	Magnesium chloride
Min	Minute
mL	Mililitre
Mm	Milimetre
mM	Milimolar
MRS	De Man, Rogasa and Sharpe medium

MRSA	Methicillin resistant *Staphylococcus aureus*
MW	Molecular mass
N	Normality
NaCl	Sodium chloride
Na_2HPO_4	Disodium hydrogen phosphate
NaH_2PO_4	Sodium dihydrogen phosphate
NaOAc	Sodium acetate
NaOH	Sodium hydroxide
NCBI	National Center for Biotechnology Information
ng	Nanogram
OD	Optical density
ORF	Open reading frame
PCR	Polymerase chain reaction
pI	Isoelectric point
pln	plantaricin
RBS	Ribosome binding site
reported *plnEF* loci	*plnEF* locus of *L. plantarum* JDM1, C11, WCFS1, V90, J51, NC8 and J23
rDNA	Ribosomal deoxyribonucleic acid
rRNA	Ribosomal ribonucleic acid
RNase	Ribonuclease
RR	Response regulator
RT	Room temperature
SDS	Sodium dodecyl sulphate
SSC	Saline-sodium citrate
TAE	Tris-Acetate-EDTA
TCR	Three component regulatory system
TE	Tris-EDTA
TS+3147	Teat seal formulated with lacticin 3147
U	Unclassified
UV	Ultraviolet
V	Volt
v/v	Volume per volume
w/v	Weight per volume
x	Times
Bacillus	*B.*
Carnobacterium	*C.*
Escherichia	*E.*
Enterococcus	*Ent.*
Lactobacillus	*L.*
Lactococcus	*Lc.*

Leuconostoc	*Leu.*
Listeria	*Ls.*
Pediococcus	*P.*
Pseudomonas	*Ps.*
Staphylococcus	*Stap.*
Streptococcus	*Strep.*
Salmonella	*S.*

CHAPTER 1

INTRODUCTION

During the past decade, many studies have focused on natural antimicrobial substances secreted by food-grade bacteria to inhibit undesirable microorganisms due to the general-consumer-demand of decreasing the use of chemical additives in food preservation. The antimicrobial effect of Lactic Acid Bacteria (LAB) is greatly appreciated by human being since 10,000 years ago and has been exploited to extend the shelf life of many foods through fermentation processes. It has been known for a long time that LAB are capable of producing antimicrobial compounds and among these, the ribosomally synthesised antimicrobial peptides generally termed as bacteriocins received special attention from both the scientific and food industries (Riley and Wertz, 2002). Both bacteriocins and bacteriocinogenic LAB can be used as natural biopreservatives in food industry, therapeutic agents and antibiotic-replacer in livestock animals (Lohans and Vederas, 2012; Joerger, 2003)

There are numerous factors that drive the researchers to carry out research on bacteriocin. Their relatively narrow and highly specific killing spectrum compared to antibiotic had raised the interest of using bacteriocin as antibiotic replacer in human and animal health. Several studies revealed the potential application of bacteriocin to replace the use of antibiotics in the prevention and/or treatment of various infectious disease such as peptic ulcer, mastitis infections (Fernandez *et al*., 2008; Mojgani *et al*., 2006), skin inflammation and acne (Oh *et al*., 2006) and dental caries (Bastos *et al*., 2009).

The works on bacteriocins are mainly focused on the genetic modifications of bacteriocins as to gain detailed insight of the amino acid residues that are responsible for their biological activities and mode of actions. The knowledge gained by studying genetically modified bacteriocin was used to improve engineered bacteriocin and designed drugs (Field *et al*., 2010; Papagianni and Anastasiadou, 2009; Gillor *et al*., 2005). In addition, there are interests in heterologous expression of bacteriocin in industrially important bacterial and yeast starter cultures (Rodriguez *et al*., 2003). However, it should be noted that in order to design a new and improved bacteriocin as well as bacteriocin expression system, a deeper understanding of the bacteriocin genetics, biosynthetic pathway and the mechanism underlying their mode of actions is required.

The DNA sequences of a large number of bacteriocin loci which are chromosomally encoded or plasmid-borne have been determined during the past decades by various workers (Dimov *et al*., 2005; Chen and Hoover, 2003; Cintas *et al*., 2001) to describe the genetic determinant of bacteriocin and the organisation of bacteriocin loci (Eijsink *et al*., 2002). Biosynthesis of LAB bacteriocins was reported to encompass several genes, namely structural gene, immunity gene, regulatory genes and genes encoding a dedicated ABC-transporter and its accessory proteins. To date, the available scientific information demonstrated that bacteriocin genes are in close proximity to each other,

organized into operon structures and controlled by a specific regulatory system (Dimov *et al*., 2005).

A number of bacteriocins produced by *Lactobacillus plantarum* (generally known as plantaricin) have been described (Smaoui *et al*., 2010; Todorov *et al*., 2007; Todorov and Dicks, 2005; Todorov and Dicks, 2004; Messi *et al*., 2001). However, only a few plantaricin (*pln*; with italic formatted is used to describe gene) loci have been characterized genetically. The structure and organisation of the *pln* loci may be simple or complex. The relatively simple *pln* loci are *plW* locus encoding Class I two-peptide plantaricin W (Holo *et al*., 2001), *plS* locus encoding Class IIb plantaricin S (Stephens *et al*., 1998) and *pln423* locus encoding Class IIa plantaricin 423 (van Reenen *et al*., 2003). The *plW*, *plS* and *pln423* loci are organised into one operon. Recently, many studies have been conducted for *plnEF* loci that were widely distributed among *L. plantarum* that could be isolated from various ecological niches. The well characterized *plnEF* locus have been reported for *L. plantarum* C11 (Diep *et al*., 1996), WCFS1 (Kleerebezem *et al*., 2003), JDM1 (Zhang *et al*., 2009), J23 (Rojo-Bezares *et al*., 2008), J51 (Navarro *et al*., 2008), NC8 (Maldonado *et al*., 2003) and V90 (Diep *et al*., 2009). For simplicity, the reported *plnEF* loci was designated for the *plnEF* locus of *L. plantarum* JDM1, C11, WCFS1, V90, J51, NC8 and J23. The size of the reported *plnEF* loci are between 18-19 kb, displaying mosaic like structure with 22 to 26 genes that are organised into five to six operons. Together, the reported *plnEF* loci encoded a total number of four class IIb plantaricins and three regulatory networks (Diep *et al*., 2009).

L. plantarum I-UL4 isolated from *tapai ubi* (fermented tapioca, a Malaysian traditional fermented food) exhibited a broad inhibitory spectrum against various Gram-positive (*Bacillus cereus*, *Staphylococcus aerues*, *Streptococcus pneumoniae*, *Enterococcus faecalis*, *Ent. faecium* and *Pediococcus acidilactici*) and Gram-negative bacteria (*Escherichia coli* and *Salmonella typhimurium*) (Lim, 2003). The probiotic effects of the bacteriocin-containing postbiotic metabolites produced by *L. plantarum* I-UL4 have been reported in rats and livestock animals (Loh *et al*., 2010, 2009, 2008a; Thanh *et al*., 2009; Foo *et al*., 2003).

According to Moghadam *et al*. (2010), *L. plantarum* I-UL4 is a multi-bacteriocin producer that harbours two *pln* structural genes of *plW* and *plnEF*. The simultaneous occurrence of both *plW* and *plnEF* encode for plantaricin W and plantaricin EF respectively has not been reported elsewhere. Furthermore, the genetic loci harbouring *plnEF* is of high plasticity and possesses many variable regions with respect to their mosaic genetic composition and regulatory network. Hence the characterization of the *pln* loci is important as variations in gene sequence, gene composition and organisation will lead to different antimicrobial spectrum. Besides, new open reading frame (ORF) can be discovered in close proximity to known bacteriocin genes. Therefore, the objectives of this study were:

a) To screen bacteriocin structural and biosynthetic genes in *L. plantarum* I-UL4.
b) To determine the organisation of bacteriocin gene loci of *L. plantarum* I-UL4.
c) To determine the genetic location of the bacteriocin gene loci.

REFERENCES

Adebayo, C.O., Aderiya, B.I. (2010). Antifungal activity of bacteriocins of lactic acid bacteria from some Nigerian fermented foods. *Research Journal of Microbiology* 5: 1070-1082.

Alemu, M., Laemkom, P., Doi, K., Ohmomo, S., Yajima, M., Nitisinprasert, S. (2006). Characterization of bacteriocin-producing Lactic acid bacteria strain N1-33 isolated from edible fermented bamboo shoot. *Kasetsart Journal: Natural Science* 40: 486-498.

Allgaier, H., Jung, G., Werner, R.G., Schneider, U., Zähner, H. (1986). Epidermin: sequencing of a heterodetic tetracyclic 21-peptide amide antibiotic. *European Journal of Biochemistry* 160: 9-22.

Allison, G.E., Ahn, C., Stiles, M.E., Klaenhammer, T.R. (1995). Utilization of the leucocin A export system in *Leuconostoc gelidum* for production of a Lactobacillus bacteriocin. *FEMS Microbiology Letter* 131: 87-93.

Altermann, E., Russell, W.M., Azcarate-Peril, M.A., Barrangou, R., Buck, B.L., McAuliffe, O., Souther, N., Dobson, A., Duong, T., Callanan, M., Lick, S., Hamrick, A., Cano, R., Klaenhammer, T.R. (2005). Complete genome sequence of the probiotic lactic acid bacterium *Lactobacillus acidophilus* NCFM. *Proceedings of the National Academy of Sciences of the United States of America* 102: 3906-3912.

Altena, K., Guder, A., Cramer, C., Bierbaum, G. (2000). Biosynthesis of the lantibiotic mersacidin: organization of a type B lantibiotic gene cluster. *Applied and Environmental Microbiology* 66: 2565-71.

Anastasiadou, S., Papagianni, M., Filiousis, G., Ambrosiadis, I., Koidis, P. (2008). Pediocin SA-1, an antimicrobial peptide from *Pediococcus acicilactici* NRRL B5627: Production conditions, purification and characterization. *Bioresource Technology* 99: 5384-5390.

Anderssen, E.L., Diep, D.B., Nes, I.F., Eijsink, V., Nissen-Meyer, J. (1998). Antagonistic activity from *Lactobacillus plantarum* C11: two new peptides bacteriocins, plantaricin E/F and J/K, and the induction factor, plantaricin A. *Applied and Environmental Microbiology* 64: 2269-2272.

Anstead, G.M., Quinones-Nazario, G., Lewis II, J.S. (2007). Treatments of infectious caused by resistant *Staphylococcus aureus*.In *Methods in molecular biology: Methicillin-resistant Staphylococcus aureus (MRSA) protocols*, volume 391, ed. Ji, Y., pp 227-258. Human Press: USA.

Aunpad, R., Na-Bangchang, K. (2007). Pumilicin 4, a novel bacteriocin with anti-MRSA and anti-VRE activity produced by newly isolated bacteria *Bacillus pumilus* strain WAPB4. *Current Microbiology* 55: 308-313.

Axelsson, L., Holck, A. (1995). The genes involved in production of and immunity to sakacin A, a bacteriocin from *Lactobacillus sake* Lb706. *Journal of Bacteriology* 177: 2125–2137.

Aymerich, T., Holo, H., Håvarstein, L.S., Hugas, M., Garriga, M., Nes I.F. (1996). Biochemical and genetic characterization of enterocin A from *Enterococcus faecium*, a new antilisterial bacteriocin in the pediocin family of bacteriocins. *Applied and Environmental Microbiology* 62: 1676-1682.

Barlow, S., Schlatter, J. (2010). Risk assessment of carcinogens in food. *Toxicology and Applied Pharmacology* 243: 180-190.

Bastos, M.C.F., Ceotto, H., Coelho, M.L.V., Nascimento, J.S. (2009). Staphylococcal antimicrobial peptides: relevant properties and potential biotechnological applications. *Current Pharmaceutical Biotechnology* 10: 38-61.

Bierbaum, G., Gotz, F., Peschel, A., Kupke, T., vandeKamp, M., and Sahl, H. G. (1996). The biosynthesis of the lantibiotics epidermin, gallidermin, Pep5 and epilancin K7. *International Journal of General and Molecular Microbiology* 69: 119-127.

Bolotin, A., Wincker, P., Mauger, S., Jaillon, O., Malarme, K., Weissenbach, J., Ehrlich, S.D., Sorokin, A. (2001). The complete genome sequence of the lactic acid bacterium *Lactococcus lactis* ssp. *lactis* IL1403. *Genome Research* 11: 731-753.

Bolotin, A., Quinquis, B., Renault, P., Sorokin, A., Ehrlich, S.D., Kulakauskas, S., Lapidus, A., Gotlsman, E., Mazur, M., Pusch, G.D., Fonstein, M., Overbeek, R., Kyprides, N., Purnelle, B., Prozzi, D., Ngui, K., Masuy, D., Hancy, F., Burteau, S., Boutry, M., Delcour, J., Goffeau, A., Hols, P. (2004). Complete sequence and comparative genome analysis of the dairy bacterium *Streptococcus thermophilus*. *Nature Biotechnology* 22: 1554-1558.

Bonelli, R.R., Wiedemann, I., Sahl, H.-G. (2006). Lantibiotics.In *Handbook of Biologically Active Peptides*, ed. Kastin, A.J.,pp 97-105.Burlington: Academic Press.

Booth, M.C., Bogie, C.P., Sahl, H-G., Siezen, R.J., Hatter, K.L., Gilmore, M.S. (1996). Structural analysis and proteolytic activation of *Enterococcus faecalis* cytolysin, a novel lantibiotic. *Molecular Microbiology* 21: 1175-1184.

Boziaris, I.S., Adams, M.R. (1999). Effects of chelators and nisin produced *in situ* on inhibition and inactivation of Gram-negatives. *International Journal of Food Microbiology* 53: 105-113.

Bergman, C.M., Quesneville, H. (2007). Discovering and detectingtransposable elements in genomesequences.*Briefings in Bioinformatics* 8: 382-392.

Breidt, F. McFeeters, R.F. Díaz-Muñiz, I. (2007) Fermented vegetables. In *Food Microbiology: Fundamentals and Frontiers3rd edition* ed. Doyle, M.P., Beuchat, L.R., Washington, D.C. pp. 783-793. ASM Press.

Brown, J.M., Valiere, A. (2004). Probiotics and medical nutrition theraphy. *Nutrition in Clinical Care* 7: 56-68.

Brown, T. (2004). Analysis of DNA sequences by blotting and hybridization: Southern blotting. *Current Protocols in Molecular Biology* 2.9.1-2.9.20.

Brurberg, M.B., Nes, I.F., Eijsink, V.G.H. (1997). Pheromone-induced production of antimicrobial peptides in *Lactobacillus*.*Molecular Microbiology* 26: 347-360.

Buyong, N., Kok, J., Luchansky, J.B. (1998). Use of a genetically enhanced, pediocin producing starter culture, *Lactococcus lactis* subsp. *lactis* MM217, to control Listeria monocytogenes in Cheddar cheese.*Applied and Environmental Microbiology* 64: 4842-4845.

Casaus, P., Nilsen, T., Cintas, L.M., Nes, I.F., Hernández, P.E., Holo, H. (1997). Enterocin B, a new bacteriocin from *E. faecium* T136 which can act synergistically with enterocin A. *Microbiology* 143: 2287-2294.

Carr, F.J., Hill, D., Maida, N. (2002). The lactic acid bacteria: A literature survey. *Critical Reviews in Microbiology* 28: 281-370.

Chagnaud, P., Machinis, K., Coutte, L.A., Marecat, A., Mercenier, A. (2001). Rapid PCR-based procedure to identify lactic acid bacteria: application to six common *Lactobacillus* species. *Journal of Microbiological Methods* 44: 139-148.

Chaillou, S., Champomier-Verges, M.C., Cornet, M., Crutz-Le Coq, A.M., Dudez, A.M., Martin, V., Beaufils, S., Darbon-Rongere, E., Bossy, R., Loux, V., Zagorec, M. (2005). The complete genome sequence of the meat-borne lactic acid bacterium *Lactobacillus sakei* 23K. *Nature Biotechnology* 23: 1527-1533.

Chatterjee, S., Chatterjee, D.K., Jani, R.H., Blumbach, J., Ganguli, B.N., Klesel, N., Limbert, M., Seibert, G. (1992). Mersacidin, a new antibiotic from *Bacillus*. *In vitro* and *in vivo* antibacterial activity.*The Journal of antibiotics* 45: 839-845.

Chikindas, M.L., Venema, K., Ledeboer, A.M., Venema, G., Kok, J. (1995). Expression of lactococcin A and pediocin PA-1 in heterologous hosts.*Letters in Applied Microbiology* 21: 183-189.

Cho, G-S., Huch, M., Hanak, A., Holzapfel, W.H., Franz, C.M.A.P. (2010). Genetic analysis of the plantaricin EFI locus of *Lactobacillus plantarum* PCS20 reveals an unusual plantaricin E gene sequence as a result of mutation. *International Journal of Food Microbiology* 141: 117-124.

Chen, H., Hoover, D.G. (2003). Bacteriocins and their food applications.*Comprehensive Reviews in Food Science and Food Safety* 2: 81-100.

Chen, C.M., Sebranek, J.G., Dickson, J.S., Mendonca., A.F. (2004). Combining pediocin (ALTA 2341) with post-packaging pasteurization for control of *Listeria monocytogenes* on frankfurters.*Journal of Food Protection* 67: 1855-1865.

Cheng, D.R., Zhu, S.Y., Yin, Z.H., Ding, W.W., Mu, Z.X., Su, Z.R., Sun, H.C. (2010). Prevalence of bacterial infection responsible for bovine mastitis. *African Journal of Microbiology Research* 4: 1110-1116.

Chermesh, I., Eliakim, R. (2006). Probiotics and the gastrointestinal track: Where are we in 2005? *World Journal of Gatroenterology* 12: 853-857.

Choe, D.W., Loh, T.C., Foo, H.L., Hair-Bejo, M., Awis, Q.S. (2012). Egg production, faecal pH andmicrobial population, small intestine morphology, and plasma and yolk cholesterol in laying hens given liquid metabolitesproduced by *Lactobacillus plantarum* strains. *British Poultry Science* 53(1): 106-115.

Cintas L.M., Casaus P., Håvarstein L.S., Hernández P.E., Nes I.F. (1997). Biochemical and genetic characterization of enterocin P, a novel sec-dependent bacteriocin from *Enterococcus faecium* P13 with a broad antimicrobial spectrum. *Applied and Environmental Microbiology* 63: 4321-4330.

Cintas, L.M., Casaus, P., Holo, H., Hernández, P.E., Nes, I.F., Håvarstein, L.S. (1998). Enterocins L50A and L50B, two novel bacteriocins from *Enterococcus faecium* L50, are related to staphylococcal hemolysins. *Journal of Bacteriology* 180: 1988-1994.

Cintas, L.M., Casaus, P., Herranz, C., Håvarstein, L.S., Holo, H., Hernández, P.E., Nes, I.F. (2000). Biochemical and genetic evidence that *Enterococcus faecium* L50 produces enterocins L50A and L50B, the sec-dependent enterocin P, and a novel bacteriocin secreted without an N-terminal extension termed enterocin Q. *Journal of Bacteriology* 182: 6806-6814.

Cintas, L.M., Casaus, M.P., Hettanz, C., Nes, I.F., Hernandez, P.E. (2001). Bacteriocins of lactic acid bacteria. *Food Science and Technology International* Review 7: 281-305.

Cintas, L.M., Rodriguez, J.M., Fernandez, M.F., Sletten, K., Nes, I.F., Hernandez, P.E., Holo, H. (1995). Isolation and characterization of pediocin L50, a new bacteriocin from *Pediococcus acidilactici* with broad inhibitory spectrum.*Applied and Environmental Microbiology* 61: 2643-2648.

Coburn, P.S., Pillar, C.M., Jett, B.D., Haas, W., Gilmore, M.S. (2004). *Enterococcus faecalis* senses target cells and in response expresses cytolysin. *Science* 306: 2270-2272.

Corvey, C., Stein, T., Dusterhus, S., Karas, M., Entian, K.D.,(2003). Activation of subtilin precursors by *Bacillus subtilis* extracellular serine proteases subtilisin (AprE), WprA, and Vpr. *Biochemical and Biophysical ResearchCommunications* 304:48-54.

Cotter, P.D., Hill, C., Ross,R.P. (2005). Bacteriocins: developing innate immunity for food. *Nature ReviewsMicrobiology* 3: 777-788.

Dalmau, M., Maier, E., Mulet, N., Viñas, M., Benz, R. (2002). Bacterial membraneinjuries inducedby lactacin F and nisin. *International Microbiology* 5: 73-80.

Datta, V., Myskowski, S.M., Kwinn, L.A., Chiem, D.N., Varki, N., Kansal, R.G. Kotb, M., Nizet, V. (2005). Mutational analysis of the group Astreptococcal operon encoding streptolysin S and its virulence role in invasiveinfection. *Molecular Microbiology* 56: 681-695.

Delcher, A.L., Bratke, K.A., Powers, E.C., Salzberg, S.L. (2007). Identifying bacterial genes and endosymbiont DNA with Glimmer. *Bioinformatics* 23: 673-679.

Delves-Broughton, J., Blackburn, P., Evans, J., Hugenholtz, J. (1996). Applications of the bacteriocin, nisin. *Antonie Leeuwenhoek* 69: 193-202.

de Jong, A., van Heel, A.J., Kok, J., Kuipers, O.P. (2010). BAGEL2: mining for bacteriocins in genomic data. *Nucleic Acids Research* 38: W647-651.

de los Reyes-Gavilan, C.G., Limsowtin, G.K., Tailliez, P., Sechaud, L., Accolas. J.P. (1992). *Lactobacillus helveticus*-specific DNA probe detects restriction fragment length polymorphisms in this species. *Applied and Environmental Microbiology* 58: 3429-3432.

de Man, J.C., Rogasa, M., Sharpe, M.E. (1960). A medium for the cultivation of *lactobacilli*. *Journal of Applied Bacteriology* 23: 130-135.

de Ruyter, P.G.G.A., Kuipers, O.P., Beerthuyzen, M.M., Van Alen-Boerrigter, I., de Vos, W.M. (1996). Functional analysis of promoters in the nisin gene cluster of *Lactococcus lactis*. *Journal of Bacteriology* 178: 3434-3439.

*de*Vuyst, L., Vandamme, E.J. (1994). Antimicrobial potential of lactic acid bacteria. In *Bacteriocins of Lactic Acid Bacteria* ed. de Vuyst, L., Vandamme, E.L. pp. 91-142. Glasgow, UK: Blackie Academic and Professional.

Dicks, L.M.T., Mellett, F.D., Hoffman, L.C. (2004). Use of bacteriocin producing starter cultures of *Lactobacillus plantarum* and *Lactobacillus curvatus* in production of ostrich meat salami. *Meat Science* 66: 703-708.

Dickson-Spillmann, M., Siegrist, M., Keller, C. (2011). Attitudes toward chemicals are associated with preference for natural food. *Food Quality and Preference* 22: 149-156.

Diep, D.B., Håvarstein, L.S., Nes, I.F. (1995). A bacteriocin-like peptide induces bacteriocin synthesis in *Lactobacillus plantarum* C11. *Molecular Microbiology* 18: 631-639.

Diep, D.B., Havarstein, L.S., Nes, I.F., (1996). Characterization of the locus responsible for the bacteriocin production in *Lactobacillus plantarum* C11. *Journal of Bacteriology* 178: 4472-4483.

Diep, D.B., Axelson, L., Grefsli, C., Nes, I.F. (2000). The synthesis of the bacteriocin sakacin A is a temperature-sensitive process regulated by a pheromone peptide through a three-component regulatory system. *Microbiology* 146: 2155-2160.

Diep, D.B., Godager, L., Brede, D., Nes, I.F. (2006). Data mining and characterization of a novel pediocin-like bacteriocin system from the genome of *Pediococcus pentosaceus* ATCC 25745. *Microbiology* 152: 1649-1659.

Diep, D.B., Straume, D., Kjos, M., Torres, C., Nes.I.F. (2009). An overview of the mosaic bacteriocin *pln* loci from *Lactobacillus plantarum*. *Peptides* 30:1562-1574.

Dimov, S., Ivanova, P., Harizanova, N., (2005). Genetics of bacteriocins biosynthesis by lactic acid bacteria. *Biotechnology and Biotechnological Equipment 19(3) Supplement: General & Applied Genetics*, 4-10.

Ehrmann, M.A., Remiger, A., Eijsink, V.G.H., Vogel, R.F. (2000). A gene cluster encoding plantaricin 1.25b and other bacteriocin-like peptides in *Lactobacillus plantarum* TMW1.25. *Biochimica et Biophysica Acta* 1490: 355-361.

Eijsink, V.G.H., Axelson, L., Diep, D.B., Havarstein, L.S., Holo, H., Nes, I.F. (2002). Production of Class II bacteriocins by lactic acid bacteria: an example of biological warfare and communication. *Antonie van Leewenhoek* 81: 639-654.

Eijsink, V.G.H., Brurberg, M.B., Middelhoven, P.H., Nes, I.F. (1996). Induction of bacteriocin production in *Lactobacillus sake* by a secreted peptide. *Journal of Bacteriology* 178: 2232-2237.

Ennahar, S., Sashihara, T., Sonomoto, K., Ishizaki, A. (2000). Class IIa bacteriocins: biosynthesis, structure and activity. *FEMS Microbiology* Review 24: 85-106.

Ennahar, S., Asou, Y., Zendo, T., Sonomoto, K., Ishizaki, A. (2001). Biochemical and genetic evidence for production of enterocins A and B by *Enterococcus faecium* WHE 81. *International Journal of Food Microbiology* 70: 291-301.

Fernandez, L., Delfado, S., Herrero, H., Maldonado, A., Rodriguez, J.M. (2008). The bacteriocin nisin, an effective agent for the treatment of *Staphylococcal mastitis* during lactation. *Journal of Human Lactation* 24: 311-316.

Field, D., Hill, C., Cotter, P.D., Ross, Ross, R.P. (2010). The dawning of a 'Golden era' in lantibiotic bioengineering. *Molecular Biology* 78: 1077-1087.

Foo, H.L., Loh, T.C., Law, F.L., Lim, Y.S., Kufli, C.N., Gulam Rusul, R.A. (2003). Effects of feeding *Lactobacillus plantarum* I-UL4 isolated from Malaysian Tempeh on growth performance, faecal flora and lactic acid bacteria and plasma cholesterol concentrations in postweaning rats. *Journal of Food Science and Biotechnology*12: 403-408.

Franz, C.M.A.P., Worobo, R.W., Quadri, L.E.N., Schillinger, U., Holzapfel, W.H., Vederas, J.C., Stiles, M.E. (1999). Atypicalgenetic locus associated with

constitutive production of enterocinB by *Enterococcus faecium* BFE 900. *Applied and Environmental Microbiology* 65: 2170-2178.

Franz, C.M.A.P., van Belkum, M.J., Worobo, R.W., Vederas, J.C., Stiles, M.E. (2000). Characterization of the genetic locus responsible for production and immunity carnobacteriocin A: the immunity gene confers cross-protection to enterocin B. *Microbiology* 146, 621-631.

Fremaux, C., Ahn, C., Klaenhammer,T.R. (1993). Molecular analysis of the lactacin F operon. *Applied and Environmental Microbiology* 59:3906-3915.

Fricourt, B.V., Barefoot, S.F., Testin, R.F., Hayasaka, S.S. (1994). Detection and activity of plantaricin F, an antibacterial substance from *Lactobacillus plantarum* BF001 isolatedfrom processed channel catfish. *Journal of Food Protection* 57: 698-702

Galvez, A., Abriouel, H., Lopez, R.L., Omar, B.O. (2007). Bacteriocin-based strategies for food biopreservation. *International Journal of Food Microbiology* 120: 51-70.

Galvin, M., Hill, C., Ross, R.P. (1999). Lacticin 3147 displays activity in buffer against Gram-positive bacterial pathogens which appear insensitive in standard plate assays. *Letters in Applied Microbiology* 28: 355-358.

Garneau, S., Martin, N.I., Vederas, J.C. (2002). Two-peptide bacteriocins produced by lactic acid bacteria. *Biochimie* 84: 577-592.

Geissler, S., Gotz, F., and Kupke, T. (1996). Serine protease EpiP from *Staphylococcus epidermidis* catalyzes the processing of the epidermin precursor peptide. *Journal of Bacteriology* 178: 284-288.

Ghrairi, T., Frere, J., Berjeaud, J.M., Manai, M. (2005). Lactococcin MMT24, a novel two-peptide bacteriocin produced by *Lactococcus lactis* isolated from *rigouta* cheese. *International Journal of Food Microbiology* 105: 389-398.

Gillor, O., Nigro, L.M., Riley, M.A. (2005).Genetically engineered bacteriocins and their potential as the next generation of antimicrobials. *Current Pharmaceutical Design* 11: 1065-1075

Gonzalez, B., Glaasker, E., Kunji, E.R.S., Driessen, A.J.M., Suarez, J.E., Konings, W.N. (1996). Bactericidal mode of action of plantaricin C. *Applied and Environmental Microbiology* 62: 2701-2709.

Gonzalez, B., Arca, P., Mayo, B., Suarez,J.E. (1994). Detection, purification, and partial characterization of plantaricin C, a bacteriocin produced by a *Lactobacillus plantarum* strain of dairy origin. *Applied and Environmental Microbiology* 60: 2158-2163.

Gould, G.W. (1995). Biodeterioration of foods and an overview of preservation in the food and dairy industries. *International Biodeterioration and Biodegradation* 36: 267-277.

Guder, A., Wiedeman, I., Sahl, H.G. (2000). Post translationally modified bacteriocins the lantibiotics. *Bioploymers* 55: 62-73.

Hall, T.A. (1999). BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series* 41: 95-98.

Hammami, R., Zouhir, A., Le Lay, C., Ben Hamida, J., Fliss, I. (2010). BACTIBASE second release: a database and tool platform for bacteriocin characterization. *BMC Microbiology* 10:22.

Havarstein, L.S., Holo, H., Nes, I.F. (1994). The leader peptide of colicin V shares consensus sequences with leader peptides that are common among peptide bacteriocins produced by Gram-positive bacteria. *Microbiology* 140: 2383-2389.

Havarstein, L.S., Diep, D.B., Nes, I.F. (1995). A family of bacteriocin ABC transporters carry out proteolytic processing of their substrates concomitant with export. *Molecular Microbiology* 16: 229–240.

Hechard, Y., Sahl, H.G. (2002). Mode of action of modified and unmodified bacteriocins from Gram-positive bacteria. *Biochemie* 84: 545-557.

Henderson, J.T., Chopko, A.L., van Wassenaar, P.D. (1992). Purification and primary structure of pediocin PA-1 produced by *Pediococcus acidilactici* PAC-1.0. *Archives in Biochemistry and Biophysics* 295: 5-12.

Heng, N.C.K., Wescombe, P.A., Berton, J.P., Jack, R.W., Tagg, J.R. (2007). The diversity of bacteriocins in Gram-positive bacteria. In *Bacteriocins ecology and evolution*, ed. Riley, M.A., Chavan, M.A., pp 45-92. Verlag Berlin: Springer.

Holck, A., Axelsson, L., Birkeland, S.E., Aukrust, T., Blom, H. (1992). Purification and amino acid sequence of sakacin A, a bacteriocin from *Lactobacillus sake* LB706. *Journal of GeneralMicrobiology* 138: 2715-2720.

Holo, H., Jeknic, Z., Daeschel, M., Stevanovic, S., Nes., I.F., (2001). Plantaricin W from *Lactobacillus plantarum* belongs to a new family of two-peptide lantibiotics. *Microbiology* 147: 643- 651.

Holzapfel, W.H., Haberer, P., Geisen, R., Björkroth, J., Schillinger, U. (2001). Taxonomy and important features of probiotic microorganisms in food nutrition. *The American Journal of Clinical Nutrition* 73: 365S-373S.

Hühne, K., Axelsson, L., Holck, A., Kröckel, L. (1996). Analysis of the sakacin P gene cluster from *Lactobacillus sake* Lb674 and its expression in sakacin-negative *Lb. sake* strains. *Microbiology* 142: 1437-1448.

Hugas, M., Garriga, M., Pascual, M., Aymerich, M.T., Monfort, J.M. (2002). Enhancement of sakacin K activity against *Listeria monocytogenes* infermented sausages with pepper or manganese as ingredients. *Food Microbiology 1*9: 519-528.

Hyatt, D., Chen, G.L., Locascio, P.F., Land, M.L., Larimer, F.W., Hauser, L.J. (2010). Prodigal: prokaryotic gene recognition and translation initiation site identification. *BMC Bioinformatics* 11: 119.

Izqueirdo, E., Bednarczyk, A., Schaeffer, C., Cai, Y.m, Marchioni, E., van Dorddelaer, A., Ennahar, S., (2008). Production of enterocins L50A, L50B, and IT, a new enterocin, by *Enterococcus faecium* IT62, a strain isolated from Italian Ryegrass in Japan. *Antimicrobial Agents and Chemotheraphy* 52: 1917-1923.

Jack, R.W., Tagg, J.R., Ray, B., (1995). Bacteriocins of Gram-positive bacteria. *Microbiological Reviews* 59: 171- 200.

Jasniewski, J., Cailliez-Grimal, C., Chevalot, I., Millière, J.B., Revol-Junelles, A.M. (2009). Interactions between two carnobacteriocins Cbn BM1 and Cbn B2 from *Carnobacterium maltaromaticum* CP5 on target bacteria and Caco-2 cells. *Food and Chemical Toxicology* 47: 893-897.

Jimenez-Diaz, R., Rios-Sanchez, R.M., Desmazeaud, M., Ruiz-Barba, J.L., Piard, J.-C., (1993). Plantaricins S and T, two new bacteriocins produced by *Lactobacillusplantarum* LPCO10 isolated from a green olive fermentation. *Applied and Environmental Microbiology* 59: 1416-1424.

Jimenez-Diaz, R., J. L. Ruiz-Barba, D. P. Cathcart, H. Holo, I. F. Nes, K. H. Sletten, P. J. Warner. (1995). Purification and partial amino acid sequence of plantaricin S, a bacteriocin produced by *Lactobacillus plantarum* LPCO10, the activity of which depends on the complementary action of two peptides. *Applied and Environmental Microbiology* 61:4459-4463.

Joerger, C., Klaenhammer, T.R. (1986). Characterization and purification of helveticin J and evidence for a chromosomally determined bacteriocin produced by *Lactobacillus helveticus* 481. *Journal of Bacteriology* 167: 439-446.

Joerger, R.D. (2003). Alternative to antibiotics: bacteriocins, antimicrobial peptides and bacteriophages. *Poutry Science* 82(4): 640-647.

John, R. (2004). Abundance of RNAs in bacteria.In Fundamental genetics. pp. 77-84. Cambridge University Press.

Kanatani K., Oshimura M. and Sano K. (1995). Isolation and characterization of acidocin A and cloning of the bacteriocin gene from *Lactobacillus acidophilus*. *Applied and EnvironmentalMicrobiology* 61: 1061-1067.

Katla, T., Moretro, T., Aasen, I.M., Holck, A., Axelsson, L., Naterstad,K. (2001). Inhibition of *Listeria monocytogenes* in cold smoked salmon by addition of sakacin P and/or live *Lactobacillus sakei* cultures. *Food Microbiology* 18: 431-439.

Katla, T., Moretro, T., Sveen, I., Aasen, I.M., Axelsson, L., Rorvik, L.M., Naterstad, K. (2002). Inhibition of *Listeria monocytogens* in chicken cold cuts by addition of sakacin P and sakacin P-producing *Lactobacillus sakei*. *Journal of Applied Microbiology* 93: 191-196.

Kawai,Y., Saito, T., Kitazawa, H., Itoh, T., (1998). Gassericin A: an uncommon cyclic bacteriocin produced by *Lactobacillus gasseri* LA39 linked at N- and C-terminal ends. *Bioscience, Biotechnology and Biochemistry* 62: 2438-2440.

Kawai, Y., Ishii, Y., Arakawa, K., Uemura, K., Saitoh, B., Nishimura, J., Kitazawa, H., Yamazaki, Y., Tateno,Y., Itoh, T., Saito, T. (2004). Structural and functional differences in two cyclic bacteriocins with the same sequences produced by lactobacilli. *Applied and Environmental Microbiology* 70: 2906-2911.

Kellner, R., Jung, G., Horner, T., Zahner, H., Schnell, N., Entian, K-D., Götz, F. (1988). Gallidermin: a new lanthionine-containing polypeptide antibiotic. *European Journal of Biochemistry* 177: 53-9.

Kjos, M., Snipen, L., Salehian, Z., Nes, I.F., Diep, D.B. (2010). The Abi proteins and their involvement in bacteriocin self-immunity. *Journal of Bacteriology* 192: 2068-2076.

Klaenhammer, T.R. (1993). Genetics of bacteriocins produced by lactic acid bacteria. *FEMS Microbiology Review* 12: 39-86.

Klaenhammer, T.R. (1988). Bacteriocins of lactic acid bacteria. *Biochemie* 70: 337-349.

Kleerebezem, M., Kuipers, O.P., de Vos, W.M., Stiles, M.E., Quadri, L.E.N. (2001). A two-component signal-transduction cascade in *Carnobacterium piscicola* LV17B: two signaling peptides and one sensor-transmitter. *Peptides* 22, 1597-1601.

Kleerebezem, M., Boekhorst, J., van Kranenburg, R., Molenaar, D., Kuipers, O.P., Leer, R., Tarchni, R., Peters, S.A., Sandbrink, H.M., Fiers, M.W., Stiekema, W., Lankhorst, R.M., Bron, P.A., Hoffer, S.M., Groot, M.N., Kerkhoven, R., de Vries, M., Ursing, B., de Vos, W.M., Siezen, R.J. (2003). Complete genome sequence of *Lactobacillus plantarum* WCFS1. *Proceedings of the National Academy of Sciences of the United States of America* 100: 1990-1995.

Knoll, C., Divol, B., du Toit, M. (2008). Genetic screening of lactic acid bacteria of oenological origin for bacteriocin encoding genes.*Food Microbiology* 25: 983-991.

Kouakou, P., Ghalfi, H., Dortu, C., Evrard, P., Thonart, P. (2010). Combined use of bacteriocin-producing strains to control *Listeria monocytogenes* regrowth in raw pork meat. *International Journal of Food Science and Technology* 45: 937-943.

Kuipers, O.P., Beerthuyzen, M.M., de Ruyter, P.G.G.A., Luesink, E.J., de Vos, W.M. (1995). Autoregulation of nisin biosynthesis in *Lactococcus lactis* by signal transduction. *Journal of Biological Chemistry* 270: 27299-27304.

Kuipers, O.P., Buist, G., Kok, J. (2000). Current strategies for improving food bacteria. *Research Microbiology* 151: 815-822.

Leer J.R., van der Vossen J.M.B.M., van Gieze M., van Noort J.M. and Pouwels P.H. (1995). Genetic analysis of acidocin B, a novel bacteriocin produced by *Lactobacillusacidophilus*. *Microbiology* 141: 1629-1635.

Lewus, C.B., Sun, S., Montville, T.J. (1992). Production of an amylase-sensitive bacteriocin by an atypical *Leuconostoc paramesenteroides* strain. *Applied and Environmental Microbiology* 58: 143–149.

Lim, Y.S., Foo, H.L., Mohd. Saleh, N., Gulam Rusul, R.A. (2003). The antagonistic interaction of bacteriocin UL4 produced by *Lactobacillus plantarum*I-UL4. *In:* 3rd Federation of Asia-Pacific Microbiology Societies Conference (15-18th Oct. 2003), Kuala Lumpur, Malaysia.

Lohans, C.T., Vederas, J.C.(2012). Development of Class II1 Bacteriocins as Therapeutic Agents.*International Jounal of Microbiology* 2012: 386410.

Loh, T.C., Chong, S.W., Foo, H.L., Law, F.L. (2009). Effects on growth performance, faecal microflora and plasma cholesterol after supplementation of spray-dried metabolite to postweaning rats. *Czech Journal Animal Science* 54: 10-16.

Loh, T.C., Harun, H.A., Foo, H.L., Law, F.L. (2008a). Effects of feeding spray-dried metabolites of *Lactococcus lactis* subsp. *lactis*–RW18 in post-weaning rats. *International Journal of Probiotics and Prebiotics* 3: 1-6.

Loh, T.C., Lee, T.M., Foo, H.L., Law, F.L., Rajion, M.A. (2008b). Growth Performance and Fecal Microflora of RatsOffered Metabolites from Lactic Acid Bacteria. *Journal of Applied Animal Research* 34: 61–64.

Loh, T.C., Thanh, N.T., Foo, H.L., Bejo, M.H., Kasim, A. (2010). Feeding of different levels of metabolite combinations produced by *Lactobacillus plantarum* on growth performance, fecal microflora, volatile fatty acids and villi height in broilers. *Animal Science Journal* 81: 205-214.

Loh, T.C., Thu, T.V., Foo, H.L., Bejo, M.H. (2013). Effects of different levels of metabolite combination produced by *Lactobacillus plantarum* on growth performance, diarrhoea, gut environment and digestibility of post weaning piglets. *Journal of Applied Animal Research* 41(2): 200-207.

Lowy, F.D. (1998). *Staphylococcus aureus* infections. *New England Journal of Medicine* 339: 520-532.

Lukashin, A., Borodovsky, M. (1998). Gene Mark.hmm: new solutions for gene finding. *Nucleic Acids Research* 26: 1107-1115.

Lux, T., Nuhn, M., Hakenbeck, R., Reichmann, P. (2007). Diversity of bacteriocins and activity spectrum in *Streptococcus pneumoniae*. *Journal of Bacteriology* 189: 7741-7751.

Makałowski, W., Pande, A., Gotea, V., Makałowska, I. (2012). Transposable elements and their identification. *Methods in Molecular Biology* 855:337-359.

Maldonado, A., Ruiz-Barba, J.L., Jimenez-Diaz, R. (2003).Purification and genetic characterization of plantaricin NC8, a novel coculture-inducible two-peptide bacteriocin from *Lactobacillus plantarum* NC8. *Applied and Environmental Microbiology* 69: 383-389.

Maldonado, A., Ruiz-Barba, J.L., Jimenez-Diaz, R. (2004a). Production of plantaricin NC8 by *Lactobacillus plantarum* NC8 is induced in the presence of different types of Gram-positive bacteria. *Archives of Microbiology* 181:8-16.

Maldonado, A., Jimenez-Diaz, R., Ruiz-Barba, J.L. (2004b). Induction of plantaricin production in *Lactobacillus plantarum* NC8 after coculture with specific Gram-positive bacteria is mediated by an autoinduction mechanism. *Journal of Bacteriology* 186:1556-1564.

Mannam, P., Jones, K.F., Geller, B.L. (2004). Mucosal vaccine made from live, recombinant *Lactococcus lactis*protects mice against pharyngeal infection with *Streptococcus pyogenes. Infection and Immunity* 72: 3444-3450.

Martínez, J.M., Kok, J., Sanders, J.W., Hernández, P.E. (2000). Heterologous coproduction of enterocin A and pediocin PA-1 by *Lactococcus lactis*: detection by specific peptide-directed antibodies.*Applied and Environmental Microbiology* 66: 3543-3549.

Martin, N.I., Sprules, T., Carpenter, M.R., Cotter, P.D., Hill, C., Ross, R.P., Vederas, J.C. (2004). Structural characterization of lacticin 3147, a two-peptide lantibiotic with synergistic activity. *Biochemistry* 43: 3049-56.

Martin-Visscher, L.A., van Belkum, M.J., Garneau-Tsodikova, S., Whittal., R.M., Zheng, J., McMullen, L.M., Vederas, J.C. (2008). Isolation and characterization of Carnocyclin A, a novel circular bacteriocin produced by Carnobacterium maltaromaticum UAL307. *Applied and environmental Microbiology* 74: 4756-4763.

Martin-Visscher, L.A., Yohanathan, S., Sit, C.S., Lohans, C.T., Vederas, J.C. (2011). The activity of bacteriocins from *Carnobacterium maltaromaticum* UAL307 against Gram-negative bacteria in combination with EDTA treatment. *FEMS Microbiology Letters* 317: 152-159.

Marugg, J.D., González, C.F., Kunka, B.S., Ledeboer, A.M., Pucci, M.J., Toonen, M.Y., Walker, S.A., Zoetmulder, L.C.M., Vandenbergh, P.A. (1992). Cloning, expression, and nucleotide sequence of genes involved in production of pediocin PA-1, a bacteriocin from *Pediococcus acidilactici* PAC1.0. *Applied and Environmental Microbiology* 58: 2360-2367.

Maqueda, M., Galvez, A., Bueno, M.M., Sanchez-Barrena, M.J., Gonzalez, C., Albert, A., Rico, M., Valdivia, E. (2004). Peptide AS-48: prototype of a new class of cyclic bacteriocins. *Current Protein and Peptide Science* 5: 399-416.

McAuliffe, O., Ross, R.P., Hill, C., (2001). Lantibiotics: structure, biosynthesis and mode of action. *FEMS Microbiology Review* 25: 285-308.

McCormick, J.K., Worobo, R.W., Stiles, M.E. (1996). Expression of the antimicrobial peptide carnobacteriocin B2 by a signal peptide- dependent general secretory pathway. *Applied and Environmental Microbiology* 62: 4095- 4099.

McCormick, J.K., Poon, A., Sailer, M., Gao, Y., Roy, K.L., McMullen, L.M., Vederas, J.C., Stiles, M.E., van Belkum, M.J. (1998). Genetic characterization and heterologous expression of brochocin-C, an antibotulinal, two-peptide bacteriocin produced by *Brochothrix campestris* ATCC 43754. *Applied and Environmental Microbiology* 64: 4757-4766.

Messens, W., de Vuyst, L. (2002). Inhibitory substances produced by Lactobacilli isolated from sourdoughs- A review. *International Journal of Food Microbiology* 30: 31-43.

Messi, P., Bondi, M., Sabia, C., Battini, R., Manicardi, G. (2001). Detection and preliminary characterization of a bacteriocin (plantaricin 35d) produced by *Lactobacillus plantarum* strain. *International Journal of Food Microbiology* 64: 193-198.

Meyer, C., Bierbaum, G., Heidrich, C., Reis, M., Suling, J., Iglesias-Wind, M.I., Kempter, G., Molitor, E., Sahl, H.G. (1995). Nucleotide sequence of the lantibiotic Pep5 biosynthetic gene cluster and functional analysis of PepP and PepC. Evidence for a role of PepC in thioether formation. *European Journal of Biochemistry* 232: 478-489.

Miller, K.W., Ray, P., Steinmetz, T., Janekamp, T., Ray, B. (2005). Gene organization and sequences of pediocin AcH/PA-1 production operons in *Pediococcus* and *Lactobacillus* plasmids.m*Letters in applied Microbiology* 40: 56-62.

Moghadam, M.S., Foo, H.L., Leow, T.C., Abdul Rahim, R., Loh, T.C. (2010). Novel bacteriocinogenic *Lactobacillus plantarum* strains and their differentiation by sequence analysis of 16S rDNA, 16S-23S and 23S-5S intergenic spacer regions and randomly amplified polymorphic DNA analysis.m*Food Technology and Biotechnology* 48: 476-483.

Mørtvedt, C.I., Nissen-Meyer, J., Sletten, K., Nes, I.F. (1991). *Purification and amino acid sequence of lactocin S, a bacteriocin produced by Lactobacillus sake L45. Applied and Environmental Microbiologym57:* 1829-*1834.*

Mojgani, N., Ashtiani, M.P. (2006). *In vitro* inhibition of mastitis pathogens by bacteriocin RN 86 produced by an indigenous *Lactobacillus casei* isolate. *Online Journal of Veterinary Research* 10: 61-67.

Mojgani, N., Sabiri, G., Ashtiani, M., Torshizi, M. (2009). Characterization of bacteriocins produced by *Lactobacillus brevis* NM 24 and *L. fermentum* NM 332 Isolated from Green Olives in Iran. *The Internet Journal of Microbiology* 6(2).

Moll, G.N., van den Akker, E., Hauge, H.H., Nissen-Meyer, J., Nes, I.F., Konings, W.N., Driessen, A.J.M. (1999).Complementary and overlapping selectivity of the

two-peptide bacteriocins plantaricin EF and JK. *Journal of Bacteriology* 181: 4848-4852.

Moretro, T., Naterstad, K., Wang, E., Aasen, I. M., Chaillou, S., Zagorec, M., Axelsson, L. (2005). Sakacin P non-producing *Lactobacillus sakei* strains contain homologues of the sakacin P gene cluster. *Research in Microbiology* 156: 949-960.

Mpountoukas, P., Vantarakis, A., Sivridis, E., Lialiaris, T. (2008). Cytogenetic study in cultured human lymphocytes treated with three commonly used preservatives. *Food and Chemical Toxicology* 46: 2390-2393.

Mulders, J.W., Boerrigter, I.J., Rollema, H.S., Siezen, R.J., de Vos,W.M. (1991). Identification and characterization of the lantibiotic nisin Z, a natural nisin variant. *European Journal of Biochemistry* 201: 581-584.

Nancy, J.T., Trempy, J.E. (2004). Gene expression and regulation. In *Fundamental bacterial genetics*. pp. 191-212. Blackwell Science Ltd.

Navaratna, M.A., Sahl, H.G., Tagg., J.R. (1998). Two-component anti-*Staphylococcus aureus* lantibiotic activity produced by *Staphylococcus aureus* C55. *Applied Environmental Microbiology*64:4803-4808.

Navaratna, M.A., Sahl, H.G., Tagg, J.R. (1999). Identification of genes encoding two-component lantibiotic production in *Staphylococcus aureus* C55 and other phage group II *S. aureus* strains and demonstration of an association with the exfoliative toxin B gene. *Infection and Immunity* 67: 4268-4271.

Navarro, L., Rojo-Bezares, B., Saenz, Y., Diez, L., Zarazaga, M., Ruiz-Larrea, F., Torres, C. (2008). Comparative study of the pln locus of the quorum-sensing regulated bacteriocinproducing *L. plantarum* J51 strain. *International Journal of Food Microbiology* 128: 390-394.

Nawaz, S.K., Riaz, S., Riaz, S., Hasnain, S. (2009). Screening for anti-methicillin resistant *Staphylococcusaureus* (MRSA) bacteriocin producing bacteria. *African Journal of Biotechnology* 8: 365-368.

Neutra, M.R., Kozlowski, P.A. (2006). Mucosal vaccines: The promise and the challenge. *Nature Reviews Immunology* 6: 148-158.

Nes, I.F., Diep, D.B., Havarstein, L.S., Brurberg, M.B., Eijsink, V., Holo, H., (1996). Biosynthesis of bacteriocins in lactic acid bacteria. *Antonie van Leeuwenhoek* 70: 113-128.

Nieto-Lozano, J.C., Nissen-Meyer, J., Sletten, K., Peláez, C., Nes, I.F. (1992). Purification and amino acid sequence of a bacteriocin produced by *Pediococcus acidilactici*. *Journal of General Microbiology*138:1985-1990.

Nilsen, T., Nes, I.F., Holo, H. (1998). An exported inducer peptide regulates bacteriocin production in *Enterococcus faecium* CTC492. *Journal of Bacteriology* 180: 1848-1854.

Nilsen, T., Nes, I.F., Holo, H. (2003). Enterolysin A, a cell wall-degrading bacteriocin from *Enterococcus faecalis* LMG 2333. *Applied and Environmental Microbiology* 69: 2975-2984.

Nissen-Meyer, J., Holo, H., Håvarstein, L.S., Sletten, K., Nes, I.F. (1992). A novel lactococcal bacteriocin whose activity depends on the complementary action of two peptides. *Journalof Bacteriology* 174: 5686-5692.

Nissen-Meyer, J., Oppegard, C., Rogne, P., Haugen, H.S., Kristiansen, P.E. (2010). Structure and mode-of-action of the two-peptide (Class-IIb) bacteriocins. *Probiotics and Antimicrobial Proteins* 2: 52-60.

Nouaille, S., Ribeiro, L.A., Miyoshi, A., Pontes, D., Le Loir, Y., Oliveira, S.C., Langella, P., Azevedo, V. (2003). Heterologous protein production and delivery systems for *Lactococcus lactis*. *Genetics and Molecular Research* 2: 102-111.

Oh, S., Kim, S.H., Ko, Y., Sim, J.H., Kim, K.S., Lee, S.H., Park, S., Kim, Y.J. (2006). Effect of bacteriocin produced by *Lactococcus* sp. HY 449 on skin-inflammatory bacteria. *Food and Chemical Toxicology* 44: 1184-1190.

Omar, N.B., Abriouel, H., Keleke, S., Sanchez Valenzuela, A., Martinez-Canamero, M., Lucas Lopez, R., Ortega, E., Galvez, A. (2008). Bacteriocin-producing Lactobacillus strains isolated from poto poto, a Congolese fermented maize product, and genetic fingerprinting of their plantaricin operons. *International Journal of Food Microbiology* 30: 18-25.

Omar, N.B., Abriouel, H., Lucas, R., Martinez-Canamero, M., Guyot, J.P., Galvez, A. (2006). Isolation of Bacteriocinogenic *Lactobacillus plantarum* strains from ben saalga, a traditional fermented gruel from Burkina Faso. *International Journal of Food Microbiology* 112: 44-50.

Orla-Jensen, S. (1919). The lactic acid bacteria.Andr. Fred. Host and Son, Copenhagen, pp. 1-196.

O'Keeffe, T., Hill, C., Ross, R.P. (1999). Characterization and heterologous expression of the genes encoding enterocin a production, immunity, and regulation in *Enterococcus faecium* DPC1146. *Applied and Environmental Microbiology* 65: 1506-1515.

O'Sullivan, L., Ross, R. P., Hill, C. (2002). Potential of bacteriocin-producing lactic acid bacteria for improvements in food safety and quality. *Biochimie* 84: 593-604.

Papagianni, M. (2003). Ribosomally synthesized peptides with antimicrobial properties: biosynthesis, structure, function, and applications. *Biotechnology Advances* 21: 465-499.

Papagianni, M., Anastasiadou, S., (2009). Pediocins: The bacteriocins of pediococci. sources, production, properties and applications. *Microbial Cell Factories* 8: 3.

Pei, J., Grishin. N.V. (2001). Type II CAAX prenyl endopeptidases belong to a novel superfamily of putative membrane-bound metalloproteases. *Trends in Biochemical Sciences* 26: 275-277.

Piard, J.C., Desmazeaud, M. (1991). Inhibiting factors produced by lactic acid bacteria: Oxygen metabolites and catabolism end products. *Le Lait* 71: 525-541.

Piard, J.C., Desmazeaud, M. (1992). Inhibiting factors produced by lactic acid bacteria: Bacteriocins and other antibacterial substances. *Le Lait* 72: 113-142.

Pouwels, P.H., Leer, R.J. (1993). Genetics of *lactobacilli*: plasmids and gene expression. *Antonie Van Leeuwenhoek* 64: 85-107.

Pouwels, P.H., Leer, R.J., Shaw, M., Heijne den Bak-Glashouwer, M.J., Tielen, F.D., Smit, E., Martinez, B., Jore, J., Conway, P.L. (1998). Lactic acid bacteria as antigen delivery vehicles for oral immunization purposes. *International Journal of Food Microbiology* 41: 155-167.

Pridmore, R. D., Berger, B., Desiere, F., Vilanova, D., Barretto, C., Pittet, A.C., Zwahlen, M.C., Rouvet, M., Altermann, E., Barrangou, R., Mollet, B., Mercenier, A., Klaenhammer, T., Arigoni, F., Schell, M.A. (2004). The genome sequence of the probiotic intestinal bacterium *Lactobacillus johnsonii* NCC 533. *Proceedings of the National Academy of Sciences of the United States of America* 24: 2512-2517.

Qi, F., Chen, P., Caufield, P.W. (2001). The group I strain of *Streptococcus mutans* UA140, produces both the lantibiotic mutacin I and a nonlantibiotic bacteriocin, mutacin IV. *Applied and Environmental Microbiology* 67:15-21.

Quadri, L.E.N., Saile,r M., Roy, K.L., Vederas, J.C., Stiles, M.E. (1994). Chemical and genetic characterization of bacteriocins produced by *Carnobacterium piscicola* LV17B. *Journal of Biological Chemistry* 269: 12204-12211.

Quadri, L.E.N., Kleerebezem, M., Kuipers, O.P., de Vos, W.M., Roy, K.L., Vederas, J.C., Stiles, M.E. (1997). Characterization of a locus from *Carnobacterium piscicola* LV17B involved in bacteriocin production and immunity: evidence for global inducer-mediated transcriptional regulation. *Journal of Bacteriology* 179: 6113-6171.

Rammelsberg, M., Muller, E., Radler, F. (1990). Caseicin 80: purification and characterization of a new bacteriocin from *Lactobacillus casei*. *Archives in Microbiology* 154: 249-252.

Revol-Junelles, A.M., Mathis, R., Krier, F., Fleury, Y., Delfour, A., Lefebvre, G. (1996). *Leuconostoc mesenteroides* subsp. *mesenteroides* FR52 synthesizes two distinct bacteriocins. *Letters in Applied Microbiology* 23: 120-124.

Rince, A., Dufour, A., Uguen, P., Le Pennec, J.P., Haras, D. (1997). Characterization of the lacticin 481 operon: the *Lactococcus lactis* genes *lctF*, *lctE*, and *lctG* encode a putative ABC transporter involved in bacteriocin immunity. *Applied and Environmental Microbiology* 63: 4252-4260.

Riley, M.A., Wertz, J.E. (2002). Bacteriocins: evolution, ecology, and application. *Annual Review of Microbiology* 56: 117-137.

Risoen, P.A., Havarstein, L.S., Diep, D.B., Nes, I.F. (1998). Identification of the DNA-binding sites for two response regulators involved in control of bacteriocin synthesis in *Lactobacillus plantarum* C11. *Molecular and General* Genetics 259: 224-232.

Risoen, P.A., Brurberg, M.B., Eijsink, V.G.H., Nes, I.F. (2000). Functional analysis of promoters involved in quorum sensing-based regulation of bacteriocin production in *Lactobacillus*. *Molecular Microbiology* 37: 619-628.

Risoen, P.A., Johnsborg, O., Diep, D.B., Hamoen, L., Venema, G., Nes, I.F. (2001). Regulation of bacteriocin production in *Lactobacillusplantarum* depends on a conserved promoter arrangement withconsensus binding sequence. *Molecular Genetics and Genomics* 265: 198-206.

Rodríguez, J.M., Martínez, M.I., Horn, N., Dodd, H.M. (2003). Heterologous production of bacteriocins by lactic acid bacteria. *International Journal of Food Microbiology* 80(2):101-116.

Rodrıguez, E., Calzada, J., Arques, J.L., Rodrıguez, J.M., Nunez, M., Medina., M. (2005). Antimicrobial activity of pediocin-producing *Lactococcuslactis* on *Listeria monocytogenes*, *Staphylococcus aureus* and *Escherichia coli* O157:H7 in cheese. *International Dairy Journal* 15: 51-57.

Rojo-Bezares, B., Sáenz, Y., Navarro, L., Jimenez-Diaz, R., Zarazaga, M., Ruiz- Larrea, F., Torres, C., (2008). Characterization of a new organization of the plantaricin locus in the inducible bacteriocin-producing *Lactobacillus plantarum* J23 of grape must origin. *Archives of Microbiology* 189: 491-499.

Rojo-Bezares, B., Sáenz, Y., Navarro, L., Zarazaga, M., Ruiz-Larrea, F., Torres, C. (2007). Coculture-inducible bacteriocin activity of *Lactobacillus plantarum* strain J23 isolated from grape must. *Food Microbiology* 24: 482-491.

Rollema, H.S., Kuipers, O.P., Both, P., de vos, W.M., Siezen, R.J., (1995). Improvement of solubility and stability of the antimicrobial peptide nisin by protein engineering. *Applied Environmental and Microbiology* 61: 2873-2878.

Ross, K.F., Ronson, C.W., Tagg, J.R. (1993). Isolation and characterization of the lantibiotic salivaricin A and its structural gene salA from *Streptococcus salivarius* 20P3. *Applied and Environmental Microbiology* 59: 2014-2021.

Rozen, S., Skaletsky, H.J. (2000). Primer3 on the WWW for general users and for biologist programmers.In: *Bioinformatics Methods and Protocols: Methods in Molecular Biology*, ed. Krawetz, S., Misener, S. Humana Press, Totowa, NJ, pp 365-386.

Ryan, M.P., Meaney, W.J., Hill, C. (1998). Evaluation of Lacticin 3147 and a teat seal containing this bacteriocin for inhibition of mastitis pathogens. *Applied and Environmental Microbiology* 64: 2287-2290.

Ryan, M.P., Flynn, J., Hill, C., Meaney, W.J. (1999). The natural food grade inhibitor, lacticin 3147, reduced the incidence of mastitis after experimental challenge with *Streptococcus dysgalactiae* in nonlactating dairy cows. *Journal of Dairy Science* 82: 2625-2631.

Ryan, M.P., Hill, C., Ross, R.P. (2005). Exploitation of lantibiotics peptides for food and medical uses. In *Peptide antibiotics: Discovery, modes of action, and applications*, ed. Dutton, C.J., Haxell, M.A., McArthur, H.A.I., Wax, R.G., pp. 145-179. Taylor and Francis: USA.

Sarika, A.R., Lipton, A.P., Aishwarya, M.S. (2010). Bacteriocin production by a new isolate of *Lactobacillus rhamnous* GP1 under different culture conditions. *Advance Journal of Food Science and Technology* 2: 291-297.

Sarikaya, R., Cakir, S. (2005). Genotoxicity testing of four food preservatives and their combinations in the *Drosophila* wing spot test. *Environmental Toxicology and Pharmacology* 20: 424-430.

Sasaki, F.Y., Kawaguchi, S., Kamaya, A., Ohshita, M., Kabasawa, K., Iwama, K., Taniguchi, K., Tsuda, S. (2002). The comet assay with 8 mouse organs: results with 39 currently used food additives. *Mutation Research* 519: 103-119.

Sawa, N., Zendo, T., Kiyofuji, J., Fujita, K., Himeno, K., Nakayama, J., Sonomoto, K. (2009). Identification and characterization of Lactocyclicin Q, a novel cyclic bacteriocin produced by *Lactococcus sp*. Strain QU 12. *Applied and Environmental Microbiology* 75: 1552-1558.

Sawa, N., Okamura, K., Zendo, T., Himeno, K., Nakayama, J., Sonomoto, K. (2010). Identification and characterization of novel multiple bacteriocins produced by *Leuconostoc pseudomesenteroides* QU 15. *Journal of Applied Microbiology* 109: 282-291.

Schillinger, U., Geisen, R., Holzapfel, W.H. (1996). Potential of antagonistic microorganisms and bacteriocins for the biological preservation of foods. *Trends in Food Science and Technology* 7: 158-164.

Sharma, M., Garg, A.P. (2005). Bacteriocins from lactic acid bacteria and their inductrial applications. In *Biotechnological applications of microbes*, ed. Varma, A., Podila, G.K., pp 281-310. New Delhi, India: I.K. International Pvt. Ltd.

Siezen, R.J. andvan Hylckama Vlieg, J.E. (2011). Genomic diversity and versatility of *Lactobacillus plantarum*, a natural metabolic engineer. *Microbial Cell Factory* 10(Suppl 1): S3.

Skaugen, M,, Nissen-Meyer, J,, Jung, G,, Stevanovic, S,, Sletten, K.,Abildgaard, C.I.M., Nes, I.F. (1994). *In vivo* conversion of L-serineto D-alanine in a ribosomally synthesized polypeptide. *The Journal of Biological Chemistry* 269: 27183-27185.

Skaugen, M., Cintas, L.M., Nes I.F. (2001). Genetics of bacteriocin production in lactic acid bacteria.In *Genetics of Lactic Acid Bacteria*, ed. Wood, B.J.B., Warner P., vol III. Gaithersburg, MD: Aspen Publishers, Inc.

Smaoui, S., Elleuch, L., Bejar, W., Karray-Rebai, I., Ayadi, I., Jaouadi, F., Chouayekh, H., Bejar, S., Mellouli, L. (2010). *Applied Biochemistry and Biotechnology* 162: 1132-1146.

Stevens, K.A., Sheldon, B.W., Klapes, N.A., Klaenhammer, T.R. (1991). Nisin treatment for inactivation of *Salmonella* species and other Gram-negative bacteria. *Applied and Environmental Microbiology* 57: 3613-3615.

Stiles, M.E., Hastings, J.W. (1991). Bacteriocin production by lactic acid bacteria: potential for use in meat preservation. *Trends in Food Science and Technology* 2: 247-251.

Steinkraus, K.H. (2002). Fermentations in World Food Processing.*Comprehensive Reviews in Food Science and Food Safety* 1: 23-32.

Stephens, S.K., Floriano, B., Cathcart, D.P., Bayley, S.A., Witt, V.F., Jiménez-Díaz, R., Warner, P.J., Ruiz-Barba,J.L. (1998). Molecular analysis of the locus responsible for production of plantaricin S, a two-peptide bacteriocin produced by *Lactobacillus plantarum*. *Applied and Environmental Microbiology* 64:1871-1877.

Stoyanova, L.G., Ustyugova, E.A., Sultimova, T.D., Bilanenko, E.N., Fedorova, G.B., Khatrukha, G.S., Netrusov, A.I. (2010). New antifungal bacteriocin-synthesizing strains of *Lactococcus lactis* ssp. *lactis* as the perspective biopreservation for protection of raw smoked sausages. *American Journal of Agriculture and Biological Sciences* 5: 477-485.

Survana, V.C., Boby, V.U. (2005). Probiotics in human health: A current assessment. *Current Science* 88: 1744-1748.

Tagg, J. R. (1992). Bacteriocins of gram-positive bacteria: an opinion regarding their nature, nomenclature and numbers. In *Bacteriocins, microcins and lantibiotics*, ed. James, R., Lazdunski, C., Pattus, F., pp. 33–35.Berlin: Springer Verlag.

Tagg, J.R., Dajani, A. S., Wannamaker, L. W. (1976). Bacteriocins of Gram-positive bacteria. *Bacteriological Reviews* 40: 722-756.

Thanh, N.T., Loh, T.C., Foo, H.L., Bejo, M.H., Azhar, B.K. (2009). Effects of feeding metabolite combinations produced by *Lactobacillus plantarum* on growth performance, faecal microbial population, small intestine villus height and faecal volatile fatty acids in broilers. *British Poultry Sciences* 50: 298-306.

Thu, T.V., Loh, T.C., Foo, H.L., Yaakub, H., Bejo, M.H. (2011a). Effects of liquid metabolite combinations produced by *Lactobacillus plantarum* on growthperformance, faeces characteristics, intestinal morphology and diarrhoea incidence in postweaning piglets. *Tropical Animal Health and Production* 43(1): 69-75.

Thu, T.V., Foo, H.L., Loh, T.C., Bejo, M.H. (2011b). Inhibitory activity and organic acid concentrations of metabolite combinations produced by various strains of *Lactobacillus plantarum*. *African Journal of Biotechnology* 10(8): 1359-1363.

Tichaczek, P.S., Nissen-Meyer, J., Nes, I.F., Vogel, R.F., Hammes, W.P. (1992). Characterization of the bacteriocins curvacin A from *Lactobacillus curvatus* LTH1174 and sakacin P from *Lactobacillus sake* LTH673. *Systematic and Applied Microbiology* 15: 460-468.

Todorov, S.D., Dicks, L.M.T. (2004). Influence of growth conditions on the production of a bacteriocin by *Lactococcus lactis* subsp. *lactis* ST34BR, a strain isolated from barley beer. *Journal of Basic Microbiology* 44: 305-316.

Todorov, S.D., Dicks, L.M.T. (2005). *Lactobacillus plantarum* isolated from molasses produces bacteriocins active against Gram-negative bacteria. *Enzyme and Microbial Technology* 36: 318-326.

Todorov, S.D., Nyati, H., Meinchen, M., Dicks, L.M.T. (2007). Partial characterization of bacteriocin AMA-K, produced by *Lactobacillus plantarum*AMA-K isolated from naturally fermented milk from Zimbabwe. *Food Control* 18: 656-664.

Todorov, S.D. 2008. Bacteriocin production by *Lactobacillus plantarum* AMA-K isolated from Amasi, a Zimbabwean fermented milk product and study of the adsorption of bacteriocin AMA-K to *Listeria sp*. *Brazilian Journal of Microbiology* 39: 178-187.

Tomita, H., Fujimoto, S., Tanimoto, K., Ike, Y. (1996). Cloning and genetic organization of the bacteriocin 31 determinant encoded on the *Enterococcus faecalis* pheromone-responsive conjugative plasmid pYI17. *Journal of Bacteriology* 178: 3583-3593.

Tsakalidou, E., Zoidou, E., Pot, B., Wassil, L., L., Ludwig, W., Devriese, L.A.,Kalantzopoulos, G., Schleifer, K.H., Kersters, K. (1998). Identification of *streptococci* from Greek Kasseri cheese and description of *Streptococcusmacedonicus* sp. nov. *International Journal of Systematic and Evolutionary Microbiology* 48:519-527.

Uguen, P., Hindre, T., Didelot, S., Marty, C., Haras, D., Le Pennec, J.P., Valee-Rehel, K., Dufour, A. (2005). Maturation by *lctT* is required for biosynthesis of full-length lantibiotic lacticin 481. *Applied and Environmental Microbiology* 71: 562-565.

van Belkum, M.J., Martin-Visscher, L.A., Vederas, J.C. (2011). Structure and genetics of circular bacteriocins. *Trends in Microbiology* 19: 411-418.

van Belkun, M.J., Hayema, B.J., Jeeninga, R.E., Kok, J., Venema, G. (1991). Organization and nucleotide sequence of two lactococcal bacteriocin operons. *Applied and Environmental Microbiology* 57: 492-498.

van den Hooven, H.W., Lagerwerf, F.M., Heerma, W., Haverkamp, J., Piard, J.C., Hilbers, C.W., Siezen, R.J., Kuipers, O.P., Rollema, H.S. (1996). The structure

of the lantibiotic lacticin 481 produced by *Lactococcus lactis*: location of the thioether bridges. *FEBS Letters* 391: 317-322.

van der Meer, J.R., Polman, J., Beerthuyzen, M.M., Siezen, R.J., Kuipers, O.P., de Vos, W.M. (1993). Characterization of the *Lactococcus lactis* nisin A operon genes nisP, encoding a subtilisin-like serine protease involved in precursor processing, and nisR, encoding a regulatory protein involved in nisin biosynthesis. *Journal of Bacteriology* 175: 2578-2588.

van Reenen, C.A., Dicks, L.M.T., Chikindas,M.L. (1998). Isolation, purification and partial characterization of plantaricin 423, a bacteriocin produced by *Lactobacillus plantarum*. *Journal of Applied Microbiology* 84:1131-1137.

van Reenen, C.A., Chikindas, M.L., van Zyl, W.H., Dicks,L.M.T. (2003). Characterization and heterologous expression of a class IIa bacteriocin, plantaricin 423 from *Lactobacillus plantarum* 423, in *Saccharomyces cerevisiae*. *International Journal of Food Microbiology* 81:29-40.

Vignolo, G., Palacios, J., Farías, M.E., Sesma, F., Schillinger, U., Holzapfel, W., Olliver, G. (2000). Combined effect of bacteriocins on the survival of various *Listeria* species in broth and meat system. *Current Microbiology* 41: 410-416.

Wang, H., Fewer, D.P., Sivonen, K. (2011). Genome mining demonstrates the widespread occurrence of gene clusters encoding bacteriocins in cyanobacteria. *Plos One* 6: e22384.

Welte, T., Pletz, M.W. (2010). Antimicrobial treatments of nosocomial meticilin-resistant Staphylococcus aureus (MRSA) pneumonia: current and future options. *International Journal of Antimicrobial Agents* 36: 391-400.

Wescombe, P.A., Tagg, J.R. (2003). Purification and characterization of streptin, a type A1 lantibiotic produced by *Streptococcus pyogenes*. *Applied and Environmental Microbiology* 69: 2737-2747.

Wescombe, P.A., Upton, M., Dierksen, K.P., Ragland, N.L., Sivabalan, S., Wirawan, R.E., Inglis, M.A., Moore, C.J., Walker, G.V., Chilcott, C.N., Jenkinson, H.F., Tagg, J.R. (2006). Production of the lantibiotic salivaricin A and its variants by oral streptococci and use of a specific induction assay to detect their presence in human saliva. *Applied and Environmental Microbiology* 72:1459-1466.

Wiedemann, I., Breukink, E., van Kraaij, C., Kuipers, O.P., Bierbaum, G., de Kruijff, B., Sahl, H.G. (2001). Specific binding of nisin to the peptidoglycan precursor lipid II combines pore formation and inhibition of cell wall biosynthesis for potent antibiotic activity. *Journal of Biological Chemistry* 276: 1772-1779.

Worobo R.W., Henkel T., Sailer M., Roy K.L., Vederas J.C., Stiles, M.E. (1994). Characteristics and genetic determinants of a hydrophobic peptide bacteriocin, carnobacteriocin A, produced by *Carnobacterium piscicola* LV17A. *Microbiology*140: 517-526.

Worobo, R.W., van Belkum, M.J., Sailer, M., Roy, K.L., Vederas, J.C., Stiles, M.E. (1995). A signal peptide secretion-dependent bacteriocin from *Carnobacterium divergens*. *Journal of Bacteriogy* 177:3143-3149.

Yuan, J., Zhang, Z.Z., Chen, X.Z., Yang, W., Huan, L.D. (2004). Site-directed mutagenesis of the hinge region of nisinZ and properties of nisinZ mutants. *Applied Microbiology and Biotechnology* 64: 806-815.

Zengin, N., Yuzbasioglu, D., Unal, F., Yilmaz, S., Aksoy, H. (2011). The evaluation of the genotoxicity of two food preservatives: Sodium benzoate and potassium benzoate. *Food and Chemical Toxicology* 49: 763-769.

Zhang, Z.Y., Liu, C., Zhu, Y.Z., Zhong, Y., Zhu, Y.Q., Zheng, H.J., Zhao, G.P., Wang, S.Y., Guo, X.K. (2009). *Complete genome sequence of Lactobacillus plantarum* JDM1. *Journal of Bacteriology* 191: 5020-5021.