UNIVERSITI PUTRA MALAYSIA

BIOMANUFACTURING OF BACTERIOCIN-LIKE INHIBITORY SUBSTANCE PRODUCER, *lactococcus lactis* Gh1, WITH HIGH STABILITY IN FREEZE-DRIED FORM

ROSLINA BINTI JAWAN

FBSB 2021 17

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By

ROSLINA BINTI JAWAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

June 2021

DEDICATION

Dedicated to my mother, my father, my family, and to my beloved husband, who have been a source of inspiration which contributed immensely to the success of this thesis.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman : Arbakariya B. Ariff, PhD
Faculty : Biotechnology and Biomolecular Sciences

Globally, foodborne illness is still uncontrolled, and outbreaks can result in both health and economic losses. In conjunction with community awareness of the link between lifestyle, diet, and good health, explains the growing demand for functional food products that can improve health beyond the provision of essential nutrition. This scenario encouraged researchers to look for a unique lactic acid bacterium (LAB) with antimicrobial as well as health-promoting traits. In the biomanufacturing of LAB, all the influencing factors are often strain-specific. Therefore, it is important to establish the upstream and downstream processes for mass production of any newly isolated LAB strain. The environment and media compositions strongly influence the growth of LAB and the accumulation of their metabolites such as bacteriocin. In retrieval of the bacteriocin from the culture media, most of the recovery and purification methods are expensive and required several steps in partitioning the final products, which can lead to a decrease in yield. The probiotic application remains a challenge facing the food industry due to the substantial loss of cell viability during the manufacturing, transportation, and prolonged storage of the formulated products.

This study was designed to develop a biomanufacturing process started from upstream up to downstream and product development for the production of bacteriocins-like-inhibitory substance (BLIS) from *Lactococcus lactis* Gh1, a newly isolated LAB from a traditional flavour enhancer. This BLIS- producing LAB was first assessed *in vitro*, to evaluate its potential applications in the food industry. Subsequently, optimisation of culture conditions and medium composition for improvement of growth and ability of the *L. lactis* Gh1 to secrete BLIS were conducted in shake flask culture and then transferred into the large scale using stirred tank bioreactor to maximise the product yield. Response surface methodology (RSM) and artificial neural network (ANN) models were employed for medium optimisation. Concurrently, the purification of BLIS for large scale process was carried out to optimise the parameters affecting partitioning

of a BLIS in extractive fermentation using aqueous two-phase system (ATPS). In the end, the stability of the freeze-dried cells in the optimal combination of drying medium was examined under different conditions of storage.

Results from this study have demonstrated that *L. lactis* Gh1 was a good candidate as a probiotic bacterium with the ability to coagulate milk, tolerant to NaCl (0.1 - 4.0%, w/v), phenol (0.1 - 0.4%, w/v), bile salt, pH 3 and produced few important enzymes. The absence of haemolytic activity and susceptibility towards ten types of antibiotics ensured the safety of *L. lactis* Gh1 for human consumption. The antimicrobial activity of BLIS had significant stability at 4 °C in up to 6 months, displayed firmness in four freeze-thaw cycles, did not affected by pH 4 - 8, sensitive to proteinase k, and tolerant to numbers of important food additives. In the cultivation of *L. lactis* Gh1, the replacement of nitrogen and carbon sources to soytone and fructose, respectively with mid-exponential age of inoculum at 1% (v/v) grown in media with pH 7 increased BLIS production up to 34.94% compared to commercial BHI medium. Subsequently, in medium optimisation, ANN methodology provided better estimation point and data fitting with higher value of R^2 and lower value of MAE and RMSE as compared to RSM. BLIS production in optimal medium (717.13±0.76 AU/mL) was about 1.40-fold higher than that obtained in non-optimised (520.56±3.37 AU/mL) medium. BLIS production was further improved by about 1.18 times higher in 2 L stirred tank bioreactor (787.40±1.30 AU/mL) as compared to that obtained in 250 mL shake flask (665.28±14.22 AU/mL) using the optimised medium. The suitable purification of BLIS using extractive ATPS fermentation through RSM modeling was successfully proposed. The scaled up in a 2 L stirred tank bioreactor shows that the maximum recovery rate of BLIS (68.34%), *K* (0.93) and *PF* (1.93) were achieved under the conditions of PEG 2000 (10%, w/w)/dextran T500 (8%, w/w) at suitable impeller speed (200 rpm) and pH (pH 7). Sustainable growth of the cells and repeated fermentation up to 8 times (7.35×10^8 CFU/mL) were observed in this study. In final product preparation, the combination of 10% (w/v) galactose with 10% (w/v) trehalose exhibited the highest survivability rate (91.86±1.54%) and cell viability (7.95×10^8 CFU/mL) of freeze-dried cells during storage at -30 °C up to day-60.

In conclusion, the results of this study demonstrated the potential of *L. lactis* Gh1 to be used in the food industry. This bacteriogenic LAB has a favourable probiotic property that allows it to be integrated into compatible food matrices. The formulated culture medium and determined influencing fermentation parameters in a 2 L stirred tank bioreactor could be used in larger scale mass production of this probiotic strain. The response of BLIS on extractive ATPS has uncovered the rarely practiced approach in BLIS recovery directly from the fermentation culture which provides a simple yet effective purification procedure. The formulated non-dairy-based protection agents could be utilised to diversify the functional food products, which are useful to vegans, vegetarians, and lactose-intolerant people. The data and information generated from this study could be used to propose a suitable biomanufacturing design for commercial BLIS production by *L. lactis* Gh1.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

BIOPENGHASILAN PENGELUAR BAHAN INHIBITORI SEPERTI BAKTERIOSIN, *Lactococcus lactis* Gh1, DENGAN KESTABILAN YANG TINGGI DALAM BENTUK KERING-BEKU

Oleh

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Di peringkat global, penyakit bawaan makanan masih tidak terkawal, dan wabak boleh mengakibatkan kerugian kesihatan dan ekonomi. Selari dengan kesedaran masyarakat mengenai hubungan antara gaya hidup, diet, dan kesihatan yang baik, menjelaskan permintaan yang semakin meningkat untuk produk makanan berfungsi yang dapat meningkatkan kesihatan melebihi penyediaan nutrien penting. Senario ini mendorong para penyelidik untuk mencari bakteria asid laktik yang unik dengan sifat antimikrobial dan menggalakkan kesihatan. Dalam pembuatan bio LAB, semua faktor yang mempengaruhi selalunya adalah strain-khusus. Oleh itu, adalah mustahak untuk menetapkan proses hulu dan hilir untuk pengeluaran besar-besaran bagi setiap strain LAB yang baru diasingkan. Keadaan persekitaran dan komposisi medium sangat mempengaruhi pertumbuhan LAB dan pengumpulan metabolitnya seperti bakteriosin. Dalam pengambilan bakteriosin dari medium kultur, kebanyakan kaedah pemulihan dan pemurnian itu mahal dan memerlukan beberapa langkah dalam pemisahan produk akhir, yang boleh menyebabkan penurunan hasil. Aplikasi probiotik tetap menjadi cabaran yang dihadapi oleh industri makanan kerana kehilangan daya hidup sel yang besar semasa pembuatan, pengangkutan, dan penyimpanan produk yang diformulasikan secara berpanjangan.

Kajian ini dirancang untuk mengembangkan proses pembuatan bio yang bermula dari hulu ke hilir serta pengembangan produk untuk penghasilan bahan inhibitori seperti bakteriosin (BLIS) dari *Lactococcus lactis* Gh1, LAB yang baru diasingkan dari penambah rasa tradisional. Pertama, LAB penghasil BLIS ini dinilai secara *in vitro*, untuk menilai potensi penggunaannya dalam industri makanan. Selepas itu, pengoptimuman keadaan pengkulturan dan komposisi medium untuk peningkatan pertumbuhan dan kemampuan *L. lactis* Gh1 untuk mengeluarkan BLIS dilakukan dalam kultur kelalang goncang dan kemudian dipindahkan ke skala besar menggunakan bioreaktor tangki berpengaduk untuk memaksimumkan penghasilan produk. Metodologi

permukaan respons (RSM) dan model rangkaian neural buatan (ANN) digunakan untuk pengoptimuman medium. Bersamaan dengan itu, pemurnian BLIS untuk proses skala besar dilakukan untuk mengoptimumkan parameter yang mempengaruhi pembahagian BLIS dalam fermentasi ekstraktif menggunakan sistem dua fasa berair (ATPS). Pada akhirnya, kestabilan sel kering beku dalam kombinasi medium pengering yang optimum diperiksa dalam keadaan penyimpanan yang berbeza.

Hasil kajian ini menunjukkan bahawa *L. lactis* Gh1 adalah calon yang baik sebagai bakteria probiotik dengan kemampuan membekukan susu, toleran terhadap NaCl (0.1 - 4.0%, b/i), fenol (0.1 - 0.4%, b/i), garam hempedu, pH 3 dan menghasilkan beberapa enzim penting. Ketiadaan aktiviti hemolitik dan kerentanan terhadap sepuluh jenis antibiotik memastikan keselamatan *L. lactis* Gh1 untuk penggunaan manusia. Aktiviti antimikrobial BLIS mempunyai kestabilan yang ketara pada suhu 4 °C sehingga 6 bulan, menunjukkan ketahanan dalam empat kitaran pembekuan-pencairan, tidak dipengaruhi oleh pH 4 - 8, sensitif terhadap proteinase k, dan toleran terhadap sejumlah bahan tambahan makanan yang penting. Dalam pengkulturan *L. lactis* Gh1, penggantian sumber nitrogen dan karbon masing-masing kepada soytone dan fruktosa, dengan usia inokulum pertengahan eksponen pada 1% (i/i) dikultur di dalam media dengan pH 7 meningkatkan pengeluaran BLIS hingga 34.94% berbanding medium BHI komersial. Seterusnya, dalam pengoptimuman medium, metodologi ANN memberikan titik anggaran dan data yang lebih baik dengan nilai R^2 yang lebih tinggi dan nilai MAE dan RMSE yang lebih rendah berbanding dengan RSM. Penghasilan BLIS dalam medium optimum (717.13±0.76 AU/mL) adalah sekitar 1.40-kali lebih tinggi daripada yang diperoleh dalam medium yang tidak dioptimumkan (520.56±3.37 AU/mL). Pengeluaran BLIS terus ditingkatkan dengan kira-kira 1.18-kali lebih tinggi dalam bioreaktor tangki berpengaduk 2 L (787.40±1.30 AU/mL) berbanding dengan yang diperoleh dalam kelalang goncang 250 mL (665.28±14.22 AU/mL) menggunakan medium yang dioptimumkan. Pemurnian BLIS yang sesuai menggunakan fermentasi ATPS ekstraktif melalui pemodelan RSM berjaya dicadangkan. Peningkatan skala dalam tangki berpengaduk 2 L menunjukkan bahawa kadar pemulihan maksimum BLIS (68.34%), K (0.93) dan PF (1.93) dicapai dalam keadaan PEG 2000 (10%, b/b)/dextran T500 (8%, b/b) pada kelajuan pengaduk (200 rpm) dan pH (pH 7) yang sesuai. Pertumbuhan sel yang berterusan dan penapaian berulang hingga 8 kali (7.35×10^8 CFU/mL) diperhatikan dalam kajian ini. Dalam penyediaan produk akhir, gabungan galaktosa 10% (b/i) dengan trehalose 10% (b/i) menunjukkan kadar kelangsungan hidup (91.86±1.54%) dan daya maju sel (7.95×10^8 CFU/mL) yang tertinggi pada sel kering-beku semasa penyimpanan pada suhu -30 ° C hingga hari ke-60.

Kesimpulannya, hasil kajian ini menunjukkan potensi *L. lactis* Gh1 untuk digunakan dalam industri makanan. LAB bakteriogenik ini mempunyai sifat probiotik yang baik yang membolehkannya disatukan ke dalam matriks makanan yang serasi. Medium kultur yang diformulasikan dan parameter fermentasi mempengaruhi yang ditentukan dalam bioreaktor tangki berpengaduk 2 L dapat digunakan dalam pengeluaran besar-besaran strain ini. Tindak balas BLIS terhadap ATPS ekstraktif telah menemui pendekatan yang jarang dipraktikkan dalam pemulihan BLIS secara langsung dari kaldu fermentasi yang menyediakan prosedur pemurnian yang mudah tetapi berkesan. Agen perlindungan berasaskan susu yang diformulasikan dapat digunakan untuk mempelbagaikan produk makanan yang berfungsi dan membantu vegan, vegetarian, dan orang yang tidak toleran laktosa. Data dan maklumat yang dihasilkan dari kajian ini dapat digunakan untuk mengusulkan reka bentuk pembuatan bio yang sesuai untuk pengeluaran BLIS komersial oleh *L. lactis* Gh1.

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful. All praises to Allah and His blessing for the completion of the thesis. I thank God for all the opportunities, trials and strength that have been showered on me in completing the thesis. My humblest gratitude to the Holy Prophet Muhammad (Peace be upon him) whose way of life has been continuous guidance for me.

Firstly, I would like to express my greatest gratitude to my supervisor Professor Dr. Arbakariya B. Ariff, for the continuous support to my PhD study, for his patience, motivation, and immense knowledge. He has been an idol that I would like to become in the future. He always taught me to evaluate things in research and life from a different perspectives. His guidance helped me a lot in the study, research and finishing the thesis. I could not have imagined having a better supervisor and mentor for my PhD study. Further, I would like to extend my gratitude to my co-supervisors: Professor Dr. Suhaimi Mustafa and Associate Professor Dr. Murni Halim, for their insightful comments and encouragement throughout my study. I also would like to express my sincere gratitude to the Ministry of Higher Education, Malaysia for the financial support under Skim Latihan Akademik Bumiputera (SLAB) scholarship programme.

My deepest appreciation goes to my dear friend Dr. Sahar Abbasiliasi, who always made me believe in myself to continue my struggle. She continuously encouraged and was always willing and enthusiastic to assist in any way she could throughout the research project. She always put me on the right path whenever I faced difficulties along my PhD journey.

My sincere thanks also go to the fellow staffs of Biomanufacturing and Bioprocess Research Centre (BBRC), Universiti Putra Malaysia (UPM): Mdm. Liyana Ithnin, Mr. Mohd. Rizal Kapri, Mr. Sobri Mohd. Akhir, and Mdm. Zainon Sidik who had helped me in handling and accessing the laboratory and research facilities. Lecturers of Department of Bioprocess, Faculty of Biotechnology and Science Biomolecules, UPM: Dr. Mohd Shamzi Mohamed and Dr. Fadzlie Wong Faizal Wong, thank you very much for the kind assistance and guidance throughout my research.

I would sincerely like to thank all my beloved friends who were with me and support me through thick and thin. Most importantly I would like to thank Wani, Atun, Bai, Miza, Amal, Asma, Rai, Mai, Mun, Nadzmie, and Puva for the great discussions, for the sleepless nights we spent working together, and for all the fun we have had along the journey. May this friendship last forever. Indeed, being away from my beloved family was not an easy thing during my PhD journey. But, the presence of my thoughtful friends at the BBRC had been amazing, and we were as one family had always made feel like at home with their love and friendship. Alhamdulillah, Allah blessed me with good people to facilitate my PhD study.

I owe thanks to an exceptional person, my husband, Ahmad Ismail, for his continued and unfailing love, support and understanding during my pursuit of PhD degree that made the completion of thesis possible. You were always around at times I thought that it is impossible to continue and helped me to keep things in perspective. I am indebted to my beloved parents for their continuous support and bless during my PhD career. My heartfelt regard also goes to my mother-in-law, my family members, and in-laws for their love and moral support. Finally, I would like to thank all whose directly and indirectly had successfully helped me in completing my study.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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Date: 14 October 2021

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ANN	Artificial neural network
ANOVA	Analysis of variance
ATCC	American type culture collection
ATP	Adenosine triphosphate
ATPS	Aqueous two-phase system
AU	Arbitrary unit/Activity unit
AU/mL	Arbitrary unit per millilitre
BHI	Brain heart infusion
BLIS	Bacteriocin like inhibitory substances
BSA	Bovine serum albumin
BSH	Bile salt hydrolase
BW	Box-Wilson
C_B	Ratio of volume in the bottom phase
CCD	Central composite design
CCD	Central composite design
CFS	Cell free supernatant
CFU/g	Colony forming unit per gram
CFU/mL	Colony forming unit per millilitre
C_T	Ratio of volume in the top phase
°C	Degree centigrade
DCW	Dry cell weight
DMSO	Dimethyl sulfoxide
DO	Dissolved oxygen

DOT	Dissolved oxygen tension
EDTA	Ethylenediaminetetraacetic acid
EFSA	European Food Safety Authority
ELISA	Enzyme-linked immunosorbent assay
FAO	Food and Agriculture Organisation
FDA	Food and Drug Administration
g	Gram
GA	Genetic algorithm
GIT	Gastrointestinal tract
GRAS	Generally recognised as safe
h	Hour
HCl	Hydrochloric acid
HPLC	High performance liquid chromatography
IPTG	Isopropyl β-D-1-thiogalactopyranoside
K	Partition coefficient
kDa	Kilodalton
k_e	Partition coefficient
k_p	Protein partition coefficient
L	Litre
LAB	Lactic acid bacteria
LB	Luria Bertani
MAE	Mean absolute error
$MgSO_4.7H_2O$	Magnesium sulphate
Min	Minute

mM	Millimolar
MRS	De Man, Rogosa and Sharpe
MW	Molecular weights
N	Nitrogen
$(NH_4)_2SO_4$	Ammonium sulphate
Na_2HPO_4	Disodium hydrogen phosphate
Na_2SO_4	Sodium sulphate
NaCl	Sodium chloride
NaOH	Sodium hydroxide
NH_4Cl	Ammonium chloride
NH_4NO_3	Ammonium nitrate
NH_6PO_4	Ammonium dihydrogen phosphate
NM	Nelder-Mead
OD	Optical density
OFAT	One-factor-at-a-time
%	Percentage
PBS	Phosphate-buffered saline
PCR	Polymerase chain reaction
PEG	Polyethylene glycol
PF	Purification factor
PMF	Proton motive force
P_{mX}	Maximum product formed
PTM	Posttranslational modification
q_p	Volumetric product production

QPS	Qualified presumption of safety
q_s	Volumetric substrate uptake rate
R^2	Correlation determination
R^2_{adj}	Adjusted coefficients of determination
RMSE	Root mean square error
rpm	Revolutions per minute
RSM	Response surface method
S	Selectivity
SA	Specific activity
SD	Standard deviation
SDS	Sodium dodecyl sulphate
SEM	Scanning electron microscope
SPSS	Statistical package for the social sciences
TDC	Taurodeoxycholic acid
TFTC	Too few to count
T_g	Transition temperature
TSBYE	Trypticase soy broth yeast extract
UV/VIS	Ultraviolet/Visible
V	Volume
v/v	Volume per volume
V_R	Volume ratio of the top phase to the bottom phase
V_R	Volume ratio
V_T	Volume in the top phase
w/v	Weight per volume

w/w	Weight per weight
WHO	World health organization
X	Cell concentration
X-gal	5-bromo-4-chloro-3-indoyl β-D-galactopyranoside
X_{Max}	Maximum cell concentration
Y	Yield
$Y_{P/X}$	Cell productivity
Y_T	Yield
$Y_{X/S}$	Cell yield
β	Beta
μg	Microgram
μL	Microlitre
μ_{max}	Maximum specific growth rate

CHAPTER 1

INTRODUCTION

In recent decades, demands on foods that promote health and prevent disease have led to the development of functional foods containing probiotic bacteria. Furthermore, concern over possible health effects due to the existence of chemical additives in foods and consequently, the consumer has often drawn natural or "fresher" foods without additional chemicals. These perceptions and the increasing demand for minimally processed foods with a long shelf life and comfort combined with recurrent Listeria problems in food have stimulated the interest of research to find natural, but efficient, protective products (Vijayakumar and Muriana, 2015).

Listeria monocytogenes is one of the deadliest foodborne pathogens found in food-related infections implicated in sporadic cases, outbreaks, and food recall worldwide. *L. monocytogenes* can cause fatal disease (30 - 40%) in foetuses, infants, pregnant women, elderly subjects and immunocompromised individuals with cancer, kidney disease, heart disease or AIDS; subject to organ transplants; and/or treated with immunosuppressants (Iacumin *et al.*, 2020). The outbreak in South Africa has been the largest in Listeria to date, with over 1000 laboratory-confirmed cases and over 200 deaths (NICD, 2019). Concerns associated with this pathogen survives and replicates over a wide range of temperature (4 to 42 ^{o}C), pH, salt, and oxygen concentration (Roberts *et al.*, 2020).

Lactic acid bacteria (LAB) are a group of Gram-positive, non-spore-forming, cocci or rods, catalase-negative, and fastidious organisms, with a high tolerance for low pH (De Vuyst and Leroy, 2007; Mokoena, 2017). Since their discovery, LAB have been gained much interest in various applications, as starter cultures in food and feed fermentations, pharmaceuticals, probiotics and as biological control agents. In the food industry, LAB are widely used as starters to achieve favourable changes in texture, aroma, flavour and acidity (Leory and De Vuyst, 2004). LAB are generally-recognized-as-safe (GRAS) by the Food and Drug Administration (FDA) and the bacteria themselves, or their cultured by-products, can be freely used in foods as food ingredients, and also been granted the Qualified Presumption of Safety (QPS) status by the European Food Safety Authority (EFSA) (EFSA, 2007). Some strains of LAB are known for the production of growth inhibition substances such as bacteriocins, hydrogen peroxide, diacyls, which prevent the proliferation of food spoilage bacteria and pathogens (Alakomi *et al.*, 2000; De Vuyst and Leroy, 2007).

Globally, the market for probiotic foods is rapidly growing due to increased consumer awareness of the health effects of food. Among emerging functional foods in the market, probiotics-based foods and beverages are considered as one of the future foods that are more prominent with wider acceptability among consumers (Shi *et al.*, 2016). This has expanded its global market value of US$ 42.55 billion in 2017 and is expected to reach US$ 94.48 billion by 2024 (Fortune Business Insights, 2020). Asia-Pacific is the major market in the worldwide probiotics industry, accounting for 43% of the market in 2019, and is expected to grow at the fastest compound annual growth rate (CAGR) of around 9%, reaching US$ 35.8 billion by 2026 (Research and Markets, 2020). Vast health benefits of probiotics in human wellbeing are long known mostly in providing living microorganisms with nutrient absorption and keeping a healthy balance in the gastrointestinal tract at minimum viable counts from 10^6 to 10^7 CFU/mL to exhibit pronounced probiotic effect (Gandhi and Shah, 2015).

Bacteriocins are heat-stable ribosomally synthesized antimicrobial peptides produced by various bacteria, including food-grade LAB. Bacteriocins can be considered as safe since they can be easily degraded by proteolytic enzymes of the mammalian gastrointestinal tract (Silva *et al.,* 2018). These antimicrobial peptides have enormous potential as food preservatives as well as antibiotics of the next generation for multi-drug resistant pathogens. The increasing amount of new bacteriocins with unique properties shows that this family of peptide antibiotics still has to be learned (Perez *et al.,* 2014). The global food additives market is estimated at US$ 86660 million in 2020 and is predicted to increase at a CAGR of 6% between 2021 and 2026, reaching US$ 131040 million by the end of 2026 (Market Study Report, 2020).

In the development of any bioproducts from microbial sources for human consumption, a careful *in vitro* and *in vivo* assessment is required to evaluate the safety and appropriateness to be incorporated in the food product. In the human digestive system, probiotic properties and biological barrier resistance different between species and even the same species. Although a fair number of well-characterized probiotic strains are available commercially around the world, screening for new strains is still of great industrial interest (Ayeni *et al.*, 2011). *In vitro* evaluations are vital steps in searching of new potential LAB strains to be applied in the food industry as the *in vitro* tests provide significant information concerning species and strain differences and are extremely helpful and strong instruments particularly for the rapid and efficient screening of bacterial probiotic activity (Zielińska *et al.*, 2015).

Industrially, the main hurdles concerning the application of bacteriocins in the food industry is their low yield in food-grade medium (Garsa *et al.*, 2014). The properties of the growth medium including amino acid composition, carbon/ nitrogen ratio, pH and lactose levels have a significant influence on the change in biomass of the culture and the corresponding change in the level of bacteriocin production (Guerra and Pastrana, 2001). Furthermore, the optimal design of the culture medium is a crucial aspect to be considered when developing a fermentation process. The formulation of medium containing complex nutrients is generally preferred for large-scale fermentations since it leads to the development of cost-effective processes that support maximum product yield (Dinarvand *et al.,* 2013).

In industrial production of bacteriocins, the cost of culture media and subsequent purification is indispensable. The purification process is difficult and expensive, which are sometimes suitable at laboratory scale but not at industrial scale. Extraction and purification of bio-molecules such as protein need to be economically viable and industrially proficient. The currently in vogue practices for this purpose, unfortunately, are both expensive and labour- and time-intensive (Muhammad Khan *et al.*, 2019). Extractive fermentation in an aqueous two-phase system (ATPS) incorporates both product formation and purification into a single-phase process that allows the desired bio-molecules in the form to be recovered spontaneously (Banik and Santhiagu, 2002). In bacteriocin recovery from LAB culture, limited literature been reported on extractive fermentation for using ATPS except study conducted by Li *et al.* (2001) and Li *et al.* (2000), who exploited the cultivation of *L. lactis* in PEG/Na_2SO_4 and PEG/$MgSO_4.7H_2O$ aqueous two-phase medium, respectively. Therefore, there is an extensive need to investigate these methods for large scale purification of bacteriocin for industrial use.

The storage of probiotic microorganisms in the dairy and food industries generally requires for a long period of time and before use in food production and, therefore, the drying procedure is necessary (De Giulio *et al*., 2005). Freeze-drying is one of the most commonly adopted methods in microbial culture collections. This method offers the convenience of storing and transportation, as well as keeping the microorganisms viable for extended periods (Hennebert, 1991; Berner and Viernstein 2006; Berny and Miyamoto-Shinohara *et al.* 2006). Alongside the type of protectant use in freeze-drying and powder residual moisture, the level of oxygen, relative humidity and temperature of the atmosphere are essential factors for the storage of freeze-dried probiotics (Broeckx *et al.*, 2016).

Statistical methods have been applied for developing reliable culture system. Recently, response surface methodology (RSM) coupled with central composite design (CCD) and artificial neural network (ANN) have been a popular tool to model the probable curvature of the measured responses in bacteriogenic LAB medium formulation (Guo *et al.*, 2010; Suganthi and Mohanasrinivasan, 2015), also for optimisation of the purification protocol of bacteriocin (Li *et al*. 2001) and other bacterial products (Zhi *et al*. 2005; Alhelli *et al*., 2016; Liu *et al*. 2019). Through this method, high accuracy in predicting the bioproduction was achieved and represented an established useful tool for the control of LAB kinetics in bioreactors in terms of its statistical consistency.

This study was focused on developing the upstream and downstream bioprocessing of newly lactic acid bacterium, *Lactococcus lactis* Gh1, and its bacteriocin-like inhibitory substances (BLIS) to be used in the food industry. The new LAB strain might possess potential special features that can overcome various food processing challenges. *L. lactis* Gh1 was chosen in this study because of its ability to produce antimicrobial substances, that exhibited antagonistic effect against *Listeria monocytogenes* ATCC 15313. Therefore, this study was designed to establish the biomanufacturing procedures for the production of BLIS by *L. lactis* Gh1. The specific objectives of this study were:

1) To assess the characteristics of *L. lactis* Gh1 and its BLIS for potential use in the food industry.

2) To evaluate the physiological (pH value, inoculum age, and size) and nutritional (medium compositions) factors for improving the growth and ability of *L. lactis* Gh1 to produce BLIS.

3) To optimise the fermentation medium for improvement of BLIS production by *L. lactis* Gh1 in shake flask and also in 2 L stirred tank bioreactor.

4) To establish an *in situ* continuous production and extraction approaches of BLIS by *L. lactis* Gh1.

5) To evaluate the influence of type and concentration of lyoprotectants, storage temperature and storage duration on cell viability and antibacterial activity of *L. lactis* Gh1.

REFERENCES

Aasen, I.M., Mørentrø, T., Katla, T., Axelsson, L., and Storrø, I. 2000. Influence of complex nutrients, temperature, and pH on bacteriocin production by *Lactobacillus sakei* CCUG 42687. *Appl. Microbiol. Biotechnol*, 53: 159-166.

Abadias, M., Benabarre, A., Teixidó, N., Usall, J., and Viñas, I. 2001a. Effect of freeze-drying and protectants on viability of the biocontrol yeast *Candida sake*. *Int. J. Food Microbiol.*, 65: 173-182.

Abadias, M., Teixidó, N., Usall, J., Benabarre, A., and Viñas, I. 2001b. Viability, efficacy, and storage of freeze-dried biocontrol agent *Candida sake* using different protective and rehydration media. *J Food Prot*, 64(6): 856–861.

Abbas, K.A., Lasekan, O., and Khalil, S.K. 2010. The significance of glass transition temperature in processing of selected fried food products: A Review. *Mod. Appl. Sci.*, 4(5): 3-21.

Abbasiliasi, S., Ramanan, R. N., Ibrahim, T. A. T., Mustafa, S., Mohamad, R., Daud, H.H.M., and Ariff, A.B. 2011. Effect of medium composition and culture condition on the production of bacteriocin-like inhibitory substances (BLIS) by *Lactobacillus paracasei* LA07, a strain isolated from budu. *Biotechnol. Biotechnol. Equip.*, 25(4): 2652–2657.

Abbasiliasi, S., Ramanan, R.N., Tengku Azmi, T.I., Shuhaimi, M., Mohammad, R., and Ariff, A.B. 2010. Partial characterization of antimicrobial compound produced by *Lactobacillus paracasei* LA 07, a strain isolated from Budu. *Minerva Biotecnol*, 22(3): 75-82.

Abbasiliasi, S., Tan, J., Bashokouh, F., Azmi, T., Ibrahim, T., Mustafa, S., Vakhshiteh, F., Sivasamboo, S., and Ariff, A.B. 2017a. *In vitro* assessment of *Pediococcus acidilactici* Kp10 for its potential use in the food industry. *BMC Microbiol*, 17: 1–11.

Abbasiliasi, S., Tan, J.S., Ibrahim, T.A.T., Kadkhodaei, S., Ng, H.S., Vakhshiteh, F., Ajdari, Z., Mustafa, S., Ling, T.C., Abdul Rahim, R., and Ariff, A.B. 2014. Primary recovery of a bacteriocin-like inhibitory substance derived from *Pediococcus acidilactici* Kp10 by an aqueous two-phase system. *Food Chem.*, 151: 93–100.

Abbasiliasi, S., Tan, J.S., Ibrahim, T.A.T., Ramanan, R. N., Kadkhodaei, S., Mustafa, S., and Ariff, A.B. 2018. Kinetic modeling of bacteriocin-like inhibitory substance secretion by *Pediococcus acidilactici* Kp10 and its stability in food manufacturing conditions. *J Food Sci Technol*, 55(4): 1270-1284.

Abbasiliasi, S., Tan, J.S., Ibrahim, T.A.T., Ramanan, R. N., Vakhshiteh, F., Mustafa, S., and Ariff, A.B. 2012. Isolation of *Pediococcus acidilactici* Kp10 with ability to secrete bacteriocin-like inhibitory substance from milk products for applications in food industry. *BMC Microbiol*., 12(1): 260.

Abbasiliasi, S., Tan, J.S., Kadkhodaei, S., Nelofer, R., Tengku Ibrahim, T.A., Mustafa, S., and Ariff, A.B. 2016. Enhancement of BLIS production by *Pediococcus acidilactici* Kp10 in optimized fermentation conditions using an artificial neural network. *RSC Adv*., 6(8): 6342–6349.

Abbasiliasi, S., Tan, J.S., Tengku Ibrahim, T.A., Bashokouh, F., Ramakrishnan, N. R., Mustafa, S., and Ariff, A.B. 2017b. Fermentation factors influencing the production of bacteriocins by lactic acid bacteria: a review. *RSC Adv*., 7(47): 29395–29420.

Abdel-Rahman, M.A., Hassan, S.E.D., El-Din, M.N., Azab, M.S., El-Belely, E.F., Alrefaey, H.M.A., and Elsakhawy, T. 2020. One-factor-at-a-time and response surface statistical designs for improved lactic acid production from beet molasses by *Enterococcus hirae* DS10. *SN Applied Sciences*, 2(4): 1–14.

Abdul Aziz, N.F.H., Abbasiliasi, S., Ng, Z.J., Abu Zarin, M., Oslan, S.N., Tan, J.S., and Ariff, A.B. 2020. Recovery of a bacteriocin-like inhibitory substance from *Lactobacillus bulgaricus* FTDC 1211 using polyethylene-glycol impregnated Amberlite XAD-4 resins system. *Molecules*, 25: 5332.

Abriouel, H., Valdivia, E., Mart nez-Bueno, M., Maqueda, M., and Gallvez, A. 2003. A simple method for semi-preparative-scale production and recovery of enterocin AS-48 derived from *Enterococcus faecalis* subsp. *liquefaciens* A-48-32. *J Microbiol Methods*, 55(3): 599-605.

Adinarayana, K., Ellaiah, P., Srinivasulu, B., Devi, R.B., and Adinarayana, G. 2003. Response surface methodological approach to optimize the nutritional parameters for neomycin production by *Streptomyces marinensis* under solid-state fermentation. *Process Biochem.* 38: 1565-1572.

Aguilar, O., and M. Rito-Palomares. 2010. Aqueous two-phase systems strategies for the recovery and characterization of biological products from plants. *J Sci Food Agric*, 90: 1385–1392.

Aguilar-Galvez, A., Guillermo, S., Dubois-Dauphin, R., Campos, D., and Thonart, P. 2011. The influence of growth conditions on enterocin-like production by *Enterococcus faecium* CWBI-B1430 and *Enterococcus mundtii* CWBI-B1431 isolates from artisanal Peruvian cheeses. *Ann. Microbiol.*, 61(4): 955–964.

Ahmed, T., Kanwal, R., and Najma Ayub, N. 2006. Influence of temperature on growth pattern of Lactococcus lactis, *Streptococcus cremoris* and *Lactobacillus acidophilus* isolated from camel milk. *Biotechnol Adv.*, 5: 481-488.

Alakomi, H.L., Skyttä, E., Saarela, M., Mattila-Sandholm, T., Latva-Kala, K., and Helander, I.M. 2000. Lactic acid permeabilizes Gram-negative bacteria by disrupting the outer membrane. *Appl. Environ. Microbiol.,* 66: 2001–2005.

Albertsson, P.-Å. 1986. *Partition of cell particles and macromolecules*. 3rd ed. New York: Wiley.

Alegbeleye, O.O., Singleton, I., and Sant'Ana, A.S. 2018. Sources and contamination routes of microbial pathogens to fresh produce during field cultivation: A review. *Food Microbiol,* 73: 177–208.

Alhelli, A.M., Manap, M.Y.A., Mohammed, A.S., Mirhosseini, H., Suliman, E., Shad, Z., Mohammed, N.K., and Hussin, A.S.M. 2016. Response surface methodology modelling of an aqueous two-phase system for purification of protease from *Penicillium candidum* (PCA 1/TT031) under solid state fermentation and its biochemical characterization. *Int. J. Mol. Sci.*, 17(11): 1–23.

Aljeboury, G.H., and Mahmoud, S.N. 2020. Evaluation of antagonistic potential of *Lactobacillus* isolates against phytopathogenic fungi and pathogenic bacteria *in vitro*. *Sys Rev Pharm.*, 11(12): 1699-1703.

Allam, M., Tau, N., Smouse, S.L., Mtshali, P.S., Mnyameni, G., and Khumalo, Z.T.H. 2018. Whole-genome sequences of *Listeria monocytogenes* sequence type 6 isolates associated with a large foodborne outbreak in South Africa, 2017–2018. *Genome Announc.,* 6(25): e00538-18.

Aller, K., Adamberg, K., Timarova, V., Seiman, A., Feštšenko, D., and Vilu, R. 2014. Nutritional requirements and media development for *Lactococcus lactis* IL1403. *Appl. Microbiol. Biotechnol,* 98(13): 5871–5881.

Allison, S.D., Chtang, B., and Randolph, T. 1999. Hydrogen bonding between sugar and protein is responsible for inhibition of dehydration-induced protein unfolding. Arch. *Biochem. Biophys.* 365: 289–298.

Alvarez-Sieiro, P., Montalbán-López, M., Mu, D., and Kuipers, O.P. 2016. Bacteriocins of lactic acid bacteria: Extending the family. *Appl Microbiol Biotechnol,* 100: 2939–2951.

Al-Zahrani, S.H. and Al-Zahrani, F.S. 2006. Production of bacteriocin (s) by four lactic acid bacteria isolated from raw milk on organic waste. *World Appl. Sci. J.,* 1: 135–143.

Ambros, S., Hofer, F., and Kulozik, U. 2019. Protective effect of sugars on storage stability of microwave freeze- dried and freeze- dried *Lactobacillus paracasei* F19. *J Appl Microbiol*, 125(4): 1128-1136.

Amiali, M.N., Lacroix, C., and Simard, R.E. 1998. High nisin Z production by *Lactococcus lactis* UL719 in whey permeate with aeration. *World J Microbiol Biotechnol,* 14: 887–94.

Amine, K.M., Champagne, C. P., Salmieri, S., Britten, M., St-Gelais, D., and Fustier, P. 2014. Effect of palmitoylated alginate microencapsulation on viability of Bifidobacterium longum, during freeze-drying. *LWT - Food Sci Technol*, 56(1): 111–117.

Ammor, M. S., and Mayo, B. 2007. Selection criteria for lactic acid bacteria to be used as functional starter cultures in dry sausage production: An update. *Meat Sci.*, 76(1): 138-146.

An, Y., Wang, Y., Liang, X. Yi, H., Zuo, Z., Xu, X., Zhang, D., Yu, C., and Han, X. 2017. Purification and partial characterization of M1-UVs300, a novel bacteriocin produced by *Lactobacillus plantarum* isolated from fermented sausage. *Food Control*, 81: 211-217.

Anacarso, I., Bondi, M., Mura, C., Niederhäusern, S., Iseppi, R., Messi, P., Sabia, C., and Condò, C. 2014. Culture compounds which are able to increase the growth and the production of bacteriocins by two different LABs. *J Plant Pathol Microb*, 5: 234.

Anadón, A., Martínez-Larrañaga, M.R., Ares, I., and Martínez, M.A. 2016. Probiotics: Safety and toxicity considerations. In Gupta, R.C. (Ed.), *Nutraceuticals efficacy, safety and toxicity* (pp. 777-798). London: Academic Press.

Ananou, S., Maqueda, M., Martínéz-Bueno, M., Gálvéz, A., and Valdivia, E. 2005. Control of *Staphylococcus aureus* in sausages by enterocin AS-48. *Meat Sci.*, 71: 549-556.

Anastasiadou, S., Papagianni, M., Filiousis, G., Ambrosiadis, I., and Koidis, P. 2008. Pediocin SA-1, an antimicrobial peptide from *Pediococcus acidilactici* NRRL B5627: production conditions, purification and characterization. *Bioresour. Technol.*, 99: 5384-5390.

Anders, R.F., Hogg, D.M., and Jago, G.R. 1970. Formation of hydrogen peroxide by group N streptococci and its effect on their growth and metabolism. *Appl Microbiol.*, 19: 608–612

Anderson, R.K.I., and Jayaraman, K. 2003. Influence of carbon and nitrogen sources on the growth and sporulation of *Bacillus thuringiensis* var Galleriae for biopesticide production. *Chem. Biochem. Eng. Q.*, 17: 225–232.

Andersson, H., Asp, N-G, Bruce, A., Roos, S., Wadstrom, T., and Wold, A.E. 2001. Health effects of probiotics and prebiotics: A literature review on human studies. *Scand J Nutr*, 45: 58-75.

Angmo, K., Kumari, A., Savitri, and Bhalla, T.C. 2015. Probiotic characterization of lactic acid bacteria isolated from fermented foods and beverage of Ladakh. *LWT - Food Sci. Technol.*, 66: 428-435.

Ansari, A., Zohra, R.R., Tarar, O. M., Ul Qader, S.A., and Aman, A. 2018. Screening, purification and characterization of thermostable, protease resistant bacteriocin active against methicillin resistant *Staphylococcus aureus* (MRSA). *BMC Microbiol*, 18: 1-10.

AOAC. 1995. *Official methods of analysis*, 16th Ed. Washington DC, USA: Association of official analytical chemists.

Arakawa, K., Kawai, Y., Fujitani, K., Nishimura, J., Kitizawa, H., Komine, K., Kai, K., and Saito, T. 2008. Bacteriocin production of probiotic *Lactobacillus gasseri* LA39 isolated from human feces in milk-based media. *Anim. Sci. J.*, 79: 634–640.

Archacka, M., Białas, W., Dembczyński, R., Olejnik, A., Sip, A., Szymanowska, D., Celińska, E., Jankowski, T., Olejnik, A., and Rogodzińska, M. 2019. Method of preservation and type of protective agent strongly influence probiotic properties of *Lactococcus lactis:* a complete process of probiotic preparation manufacture and use. *Food Chem.*, 274: 733-742.

Argyri, A.A., Zoumpopoulou, G., Karatzas, K.-A.G., Tsakalidou, E., Nychas, G.-J.E., Panagou, E.Z., and Tassou, C.C. 2013. Selection of potential probiotic lactic acid bacteria from fermented olives by *in vitro* tests. *Food Microbiol.*, 33: 282-291.

Aspri, M., Papademas, P., and Tsaltas, D. 2020. Review on non-dairy probiotics and their use in non-dairy based products. *Fermentation*, 6: 30.

Atlas, R.M. 2004. *Handbook of microbiology media*, 3rd Ed. New York: CRC Press.

Axelsson, L.T. 1993. Lactic acid bacteria: classification and physiology. In Salminen, S., and von Wright, A. (Eds). *Lactic Acid Bacteria*, (pp. 1–63). New York: Marcel Dekker, Inc.

Ayeni, F.A., Sánchez, B., Adeniyi, B.A., de Los Reyes-Gavilán, C.G., Margolles, A., and and Ruas-Madiedo, P. 2011. Evaluation of the functional potential of *Weissella* and *Lactobacillus* isolates obtained from Nigerian traditional fermented foods and cow's intestine. *Int J Food Microbiol*, 147: 97–104.

Azevedo, A.M., Rosa, P.A.J., Ferreira, I.F., and Aires-Barros, M.R. 2008. Integrated process for the purification of antibodies combining aqueous two-phase extraction, hydrophobic interaction chromatography and size-exclusion chromatography. *J Chromatogr A.*1213:154–61.

Aziz, G., Fakhar, H., ur Rahman, S., Tariq, M., and Zaidi, A. 2019. An assessment of the aggregation and probiotic characteristics of *Lactobacillus* species isolated from native (desi) chicken gut. *J Appl Poul Res*, 28(4): 846-857.

Badhwar, P., Kumar, P., and Dubey, K.K. 2019. Extractive fermentation for process integration and amplified pullulan production by *A. pullulans* in aqueous two-phase systems. *Sci. Rep.*, 9: 32.

Bagad, M., Pande, R., Dubey, V., and Ghosh, A.R. 2017. Survivability of freeze-dried probiotic *Pediococcus pentosaceus* strains GS4, GS17 and *Lactobacillus gasseri* (ATCC 19992) during storage with commonly used pharmaceutical excipients within a period of 120 days. *Asian Pac. J. Trop. Biomed.*, 7(10): 921–929.

Baindara, P., Gautam, A., Raghava, G., and Korple, S. 2017. Anticancer properties of a defensin like class IId bacteriocin Laterosporulin10. *Sci. Rep.*, 7: 46541

Bakde, C., and Poddar, A. 2011. Effect of steel plant effluent on acid and alkaline phosphatases of gills, liver and gonads of *Cyprinus carpio* Linn. *Int J Environ Sci*, 1(6): 1305-1316.

Baker, R.C., Winkowski, K., and Montville, T.J. 1996. pH - controlled fermentors to increase production of leuconocin S by *Leuconostoc paramesenteroides*. *Proc Biochem,* 31: 225–228.

Balciunas, E.M., Castillo Martinez, F.A., Todorov, S.D., de Melo Franco, B.D.G., Converti, A., and de Souza Oliveira, R.P. 2013. Novel biotechnological applications of bacteriocins: A review. *Food Control*, 32: 134-142.

Banik, R., Santhiagu, A., Kanari, B., Sabarinath, C., and Upadhyay, S. 2003. Technological aspects of extractive fermentation using aqueous two-phase systems. *World J Microb Biot*. 19: 337–48.

Banik, R.M. and Santhiagu, A. 2002. Extractive fermentation for enhanced gellan-hydrolysing enzyme production by Bacillus thuringiensis H14. *World J Microbiol Biotechnol*, 18: 715–720.

Barbosa, A.A.T., Mantovani, H.C., and Jain, S. 2017. Bacteriocins from lactic acid bacteria and their potential in the preservation of fruit products. *Crit Rev Biotechnol*., 37(7): 852–64.

Barbosa, M.S., Todorov, S.D., Ivanova, I., Chobert, J.-M., Thomas Haertlé, T., and de Melo Franco, B.D.G. 2015. Improving safety of salami by application of bacteriocins produced by an autochthonous *Lactobacillus curvatus* isolate. *Food Microbiol.*, 46: 254–262.

Bari, M.L., Ukuku, D.O., Kawasaki, T., Inatsu, Y., Isshiki, K., and Kawamoto, S. 2005. Combined efficacy of nisin and pediocin with sodium lactate, citric acid, phytic acid, and potassium sorbate and EDTA in reducing the *Listeria monocytogenes* population of inoculated fresh-cut produce. *J. Food Prot.*, 68: 1381–1387.

Barman, S., Ghosh, R., and Mandal, D.C. 2018. Production optimization of broad spectrum bacteriocin of three strains of *Lactococcus lactis* isolated from homemade buttermilk. *Ann. Agrar. Sci.*, 16: 286–296.

Baş, D., and Boyaci, I.H. 2007. Modeling and optimization II: Comparison of estimation capabilities of response surface methodology with artificial neural networks in a biochemical reaction. *J. Food Eng.*, 78(3): 846-854.

Bauer, A.W., Kirby, W.M., Sherris, J. C., and Turck, M. 1966. Antibiotic susceptibility testing by standardized single disc method. *Am J Clinl Pathol.*, 45: 493–496.

Bayraktar, E. 2001. Response surface optimization of the separation of DL-tryptophan using an emulsion liquid membrane. *Process Biochem.* 37: 169–175.

BD biosciences. 2015. BD bionutrients™ Technical Manual. Available via DIALOG. http://www.bd.com/ds/technicalCenter/misc/lcn01558-bionutrients-manual.pdf. Retrived 19 July 2020.

Beasley, D.E., Koltz, A.M., Lambert, J.E., Fierer, N., and Dunn, R.R. 2015. The evolution of stomach acidity and its relevance to the human microbiome. *PLoS ONE*, 10(7): 1-12.

Begde, D., Bundale, S., Mashitha, P., Rudra, J., Nashikkar, N., and Upadhyay, A. 2011. Immunomodulatory efficacy of nisin—A bacterial lantibiotic peptide. *J. Pept. Sci.*, 17: 438–444.

Behboudi-Jobbehdar, S., Soukoulis, C., Yonekura, L., and Fisk, I. 2013. Optimization of spray-drying process conditions for the production of maximally viable microencapsulated *L. acidophilus* NCIMB 701748. *Dry. Technol.*, 31: 1274-1283.

Bello, E.F.T., Martínez, G.G., Ceberio, B.F.K., Rodrigo, D., and López, A.M. 2014. High pressure treatment in foods. *Foods*. 3: 476–490.

Ben Braïek, O., Smaoui, S., Ennouri, K., Ben Ayed, R., Hani, K., Mastouri, M., and Ghrairi, T. 2020. *In situ Listeria monocytogenes* biocontrol and sensory attributes enhancement in raw beef meat by *Enterococcus lactis*. *J. Food Process. Preserv.*, 1-8.

Benabbou, R., Subirade, M., Desbiens, M., and Fliss, I. 2018. The impact of chitosan-divergicin film on growth of *Listeria monocytogenes* in cold-smoked salmon. *Front Microbiol.*, 9: 2824.

Bendjeddou, K., Fons, M., Strocker, P., and Sadoun, D. 2012. Characterization and purification of a bacteriocin from *Lactobacillus paracasei* subsp paracasei BMK2005, an intestinal isolate active against multidrug-resistant pathogens. *World J Microb Biot*, 8: 1543-1552.

Berner, D., and Viernstein, H. 2006. Effect of protective agents on the viability of *Lactococcus lactis* subjected to freeze-thawing and freeze-drying. *Sci. Pharm.*, 74(3): 137-150.

Berny, J.F. and Hennebert, G.L. 1991. Viability and stability of yeast cells and filamentous fungus spores during freeze-drying: Effects of protectants and cooling rates. *Mycologia*. 83, 805–815.

Bevilacqua, A., Petruzzi, L., Perricone, M., Speranza, B., Campaniello, D., Sinigaglia, M., and Corbo, M.R. 2018. Nonthermal technologies for fruit and vegetable juices and beverages: overview and advances. *Compr. Rev. Food Sci. Food Saf.* 17: 2–62.

Bhatta, S., Janezic, T.S., and Ratti, C. 2020. Freeze-drying of plant-based foods. *Foods*, 9: 87.

Bhattacharjee, M.K. 2016. *Antimetabolites: Antibiotics that inhibit nucleotide synthesis Chemistry of antibiotics and related drugs*. Switzerland: Springer International Publishing.

Bhavani, A.L., and Nisha, J. 2010. Dextran - the polysaccharide with versatile uses. *Int J Pharma. Bio. Sci.,* 1(4): 569-573.

Bi, P.Y., Dong, H.R. and Dong, J. 2010. The recent progress of solvent sublation, *J. Chromatogr. A,* 1217(16): 2716-2725.

Bibal, B., Goma, G., Vayssier, Y., and Pareilleux, A. 1988. Influence of pH, lactose and lactic acid on the growth of *Streptococcus cremoris*: a kinetic study. *Appl. Microbiol. Biotechnol,* 23: 340–344.

Bilski J, M.-B., A, Wojcik, D., Zahradnik-Bilska, J., Brzozowski, B., Magierowski, M., Mach, T., Magierowska, K., and Brzozowski, T. 2017. The role of intestinal alkaline phosphatase in inflammatory disorders of gastrointestinal tract. *Mediators Inflamm*, 1-9.

Bintis, T. 2018. Lactic acid bacteria: their applications in foods. *J Bacteriol Mycol.*, 6(2): 89–94.

Bircher, L., Geirnaert, A., Hammes, F., Lacroix, C., and Schwab, C. 2018. Effect of cryopreservation and lyophilization on viability and growth of strict anaerobic human gut microbes. *Microb. Biotechnol.*, 11(4): 721–733.

Biscola, V., Todorov, S.D., Capuano, V.S.C., Abriouel, H., Galvez, A., and Franco, B.D.G.M. 2013. Isolation and characterization of a nisin-like bacteriocin produced by a *Lactococcus lactis* strain isolated from charqui, a Brazilian fermented, salted and dried meat product. *Meat Sci.*, 93: 607-613

Biswas, S.R., Ray, P., Johnson, M. C., and Ray, B. 1991. Influence of growth conditions on the production of a bacteriocin, pediocin AcH, by *Pediococcus acidilactici* H. *Appl. Environ. Microbiol.*, 57: 1265–1267

Blandino, A., Al-Aseeri, M.E., Pandiella, S.S., Cantero. D., and Webb, C. 2003. Cereal-based fermented foods and beverages. *Food Res Int*, 36: 527 – 543.

Bogovic-Matijasic, B., and Rogeli, I. 1998. Bacteriocin complex of *Lactobacillus acidophilus* LF221—production studies in MRS-media at different pH-values and effect against *Lactobacillus heleticus* ATCC 15009. *Process Biochem*. 33: 345–352.

Boland, M. 2016. Human digestion – a processing perspective. *J. Sci. Food Agric.*, 2275-2283.

Boneca, I. G., and Chiosis, G. 2003. Vancomycin resistance: Occurrence, mechanisms and strategies to combat it. *Expert Opin Ther Targets*, 7(3): 311-328.

Borzenkov, V., Surovtsev, V. and Dyatlov, I. 2014. Obtaining bacteriocins by chromatographic methods. *Adv. Biosci. Biotechnol*. 5: 446–451.

Bouksaim, M., Lacroix, C., Bazin, R., and Simard, R.E. 1999. Production and utilization of polyclonal antibodies against nisin in an ELISA and for immunolocation of nisin in producing and sensitive bacterial strains. *J Appl Microbiol.*, 87: 500-510.

Boylston, T.D., Vinderola, C.G., Ghoddusi, H.B., and Reinheimer, J.A. 2004. Incor poration of Bifidobacteria into cheeses: challenges and rewards. *Int. Dairy J.*, 14: 375-387.

Boziaris, I.S., and Adams, M.R. 2001. Temperature shock, injury and transient sensitivity to nisin in Gram negatives. *J Appl Microbiol,* 91: 715-724.

Bradford, M.M. 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal. Biochem.,* 72(1–2): 248-254.

Bramsiepe, C., Sieversa, S., Seiferta, T., Stefanidisb, G.D., Vlachosc, D.G., Schnitzerd, H., Mustere, B., Brunnere, C., Sandersf, J.P.M., Bruinsf M.E. and Schembeckera, G. 2012. Low-cost small-scale processing technologies for production applications in various environments—Mass produced factories. *Chem. Eng. Process,* 51: 32–52.

Brand, A.M., Smith, C., and Dicks, L.M.T. 2013. The effects of continuous *in vivo* administration of nisin on *Staphylococcus aureus* infection and immune response in mice. *Probiotics Antimicro Prot*. 5: 279–286.

Bremer, E., and Kramer, R. 2000. Coping with osmotic challenges: Osmoregulation through accumulation and release of compatible solutes. In Storz, G. and Hengge-Aronis, R. (Eds.), *Bacterial stress responses* (pp. 79–97). Washington: ASM Press.

Brennan, M., Wanismail, B., Johnson, M.C., and Ray, B. 1986. Cellular Damage in Dried Lactobacillus acidophilus. *J. Food Protect*. 49: 47–53.

Briggiler-Marco, M., Capra, M., Quiberoni, A., Vinderola, G., Reinheimer, J., and Hynes, E. 2007. Nonstarter *Lactobacillus* strains as adjunct cultures for cheese making: *In vitro* characterization and performance in two model cheeses. *J Dairy Sci*, 90: 4532–4542.

Broeckx, G., Vandenheuvel, D., Claes, I.J.J., Lebeer, S., and Kiekens, F. 2016. Drying techniques of probiotic bacteria as an important step towards the development of novel pharmabiotics. *Int. J. Pharm.*, 505: 303–318.

Broeckx, G., Vandenheuvel, D., Claes, I.J., Lebeer, S. and Kiekens, F. 2016. Drying techniques of probiotic bacteria as an important step towards the development of novel pharmabiotics. *Int. J. Pharmacol*., 505: 303–318.

Cabo, M.L., Murado, M.A., Gonzàlez, M.P., and Pastoriza, L. 2001. Effects of aeration and pH gradient on nisin production. A mathematical model. *Enzyme Microb. Technol.*, 29: 264–273.

Callewaert, R., and De Vuyst, L. 2000. Bacteriocin production with *Lactobacillus amylovorus* DCE 471 is improved and stabilized by fed-batch fermentation. *Appl. Environ. Microbiol.*, 66(2): 606-613.

Callewaert, R., Holo, H., Devreese, B., Van Beeumen, J., Nes, I., and De Vuyst, L. 1999. Characterization and production of amylovorin L471, a bacteriocin purified from *Lactobacillus amylovorus* DCE 471 by a novel three-step method. *Microbiology*, 145: 2559-2568.

Cao, S., Du, R., Zhao, F., Xiao, H., Han, Y., and Zhou, Z. 2019. The mode of action of bacteriocin CHQS, a high antibacterial activity bacteriocin produced by *Enterococcus faecalis* TG2. *Food Control*, 96, 470–478.

Carolissen-Mackay, V., Arendse, G., and Hastings, J.W. 1997. Purification of bacteriocins of lactic acid bacteria: problems and pointers. Int. *J. Food Microbiol*., 34(1): 1–16.

Carvalho, A.S., Silva, J., Ho, P., Teixeira, P., Malcata, F.X., and Gibbs, P. 2004a. Relevant factors for the preparation of freeze-dried lactic acid bacteria. *Int. Dairy J*, 14: 835 –847.

Carvalho, A.S., Silva, J., Ho, P., Teixeira, P., Malcata, F.X., and Gibbs, P. 2004b. Effects of various sugars added to growth and drying media upon thermotolerance and survival throughout storage of freeze-dried *Lactobacillus delbruekii* ssp. bulgaricus. *Biotechnol. Prog.*, 20: 248-254.

Casey, P.G., Casey, G.D., Gardiner, G.E., Tangney, M., Stanton, C., and Ross, R.P. 2004. Isolation and characterization of anti-Salmonella lactic acid bacteria from the porcine gastrointestinal tract. *Lett. Appl. Microbiol.* 39: 431–438.

Castelani, L., Arcaro, J.R.P., Braga, J.E.P., Bosso, A.S., Moura, Q., Esposito, F., Sauter, I.P., Cortez, M., and Lincopan, N. 2019. Short communication: Activity of nisin, lipid bilayer fragments and cationic nisin-lipid nanoparticles against multidrug-resistant *Staphylococcus* spp. isolated from bovine mastitis. *J Dairy Sci*., 102(1): 678-683.

Castro, H.P., Teixeira, P.M., and Kirby, R. 1995. Storage of lyophilized cultures of *Lactobacillus bulgaricus* under different relative humidities and atmospheres. *Appl. Microbiol. Biotechnol*. 44: 172–176.

Castro, M.P., Palavecino, N.Z., Herman, C., Garro, O.A., and Campos, C.A. 2010. Lactic acid bacteria isolated from artisanal dry sausages: characterization of antibacterial compounds and study of the factors affecting bacteriocin production. *Meat Sci.*, 87: 321-329.

Cavera, V.L., Arthur, T.D., Kashtanov, D., and Chikindas, M.L. 2015. Bacteriocins and their position in the next wave of conventional antibiotics. *Int J Antimicrob Agents,* 46(5): 494-501.

Cazetta, M.L., Celligoi, M.A.P.C., Buzato, J.B., and Scarmino, I.S. 2007. Fermentation of molasses by *Zymomonas mobilis*: Effects of temperature and sugar concentration on ethanol production. *Biores Technol* 98: 2824–2828.

Celik, O.F. and O'Sullivan, D.J. 2013. Factors influencing the stability of freeze-dried stress-resilient and stress-sensitive strains of bifidobacterial. *J. Dairy Sci.*, 96(6): 3506-3516.

Chakchouk-Mtibaa, A., Smaoui, S., Ktari, N., Sellem, I., Najah, S., Karray-Rebai, I., and Mellouli, L. 2017. Biopreservative efficacy of bacteriocin BacFL31 in raw ground Turkey meat in terms of microbiological, physicochemical, and sensory qualities. *Biocontrol Sci.*, 22(2): 67–77.

Chandrakasan, G., Rodríguez-Hernández, A., del Rocío López-Cuellar, M., Palma-Rodríguez, H. and Chavarría-Hernández, N. 2019. Bacteriocin encapsulation for food and pharmaceutical applications: advances in the past 20 years. *Biotechnol Lett.*, 41: 453–469.

Charlebois, D.A., and Balázsi, G. 2019. Modeling cell population dynamics. *In Silico Biology*, 13(1-2): 21-39.

Chatterjee, M., Jana, S.C., and Raychaudhuri, U. 2019. Optimization of media and culture conditions for improved production of bacteriocin by using conventional one-factor-at-a-time (OFAT) method. *EC Microbiology,* 15.4: 251-258.

Chavez-Santoscoy, A., Benavides, J., Vermaas, W., and Rito-Palomares, M. 2010. Application of aqueous two-phase systems for the potential extractive fermentation of cyanobacterial products. *Chem Eng Technol*. 33: 177–82.

Cheigh, C.I., Choi, H.J., Park, H., Kim, S.B., Kook, M.C., Kim, T.S., Hwang J.K., and Pyun, Y.R. 2002. Influence of growth conditions on the production of a nisin-like bacteriocin by *Lactococcus lactis* subsp. *lactis* A164 isolated from kimchi. *J Biotechnol*, 95: 225– 235.

Chen, H., and Hoover, D. 2003. Bacteriocins and their food applications. *Compr. Rev. Food Sci. Food Saf.* 2, 82–100.

Chen, H., Tian, M., Chen, L., Cui, X., Meng, J., and Shu, G. 2019. Optimization of composite cryoprotectant for freeze-drying *Bifidobacterium bifidum* BB01 by response surface methodology. *Artif Cells Nanomed Biotechnol.*, 47(1): 1559–1569.

Chen, H.C., Lin, C.W., and Chen, M.J. 2006. The effects of freeze drying and rehydration on survival of microorganisms in kefir. *Asian Australas J Anim Sci.*, 19(1): 126-130.

Chen, J., Shen, J., Hellgren, L.I., Jensen, P.R., and Solem, C. 2015. Adaptation of *Lactococcus lactis* to high growth temperature leads to a dramatic increase in acidification rate. *Sci Rep.*, 5: 1-15.

Chen, J., Shen, J., Solem, C., and Jensen, P.R. 2013. Oxidative stress at high temperatures in *Lactococcus lactis* due to an insufficient supply of riboflavin. *Appl Environ Microbiol*, 79(19): 6140 – 6147.

Chen, M.C., Sebranek, J.G., Dickson, J.S., and Mendonca, A.F. 2004. Use of pediocin (ALTA 2341™) for control of *Listeria monocytogenes* on frankfurters. *J. Muscle Foods.*, 15(1): 35–56.

Chen, W., and Hang, F. 2019. *Lactic acid bacteria: Bioengineering and industrial applications*. Singapore: Springer Nature Singapore Pte Ltd. and Science Press.

Chettri, R., and Tamang, J.P. 2014. Functional properties of Tungrymbai and Bekang, naturally fermented soybean foods of North East India. *Int J Ferment Foods*, 3: 87–103.

Chikindas, M.L., and Montville, T.J. 2002. Perspectives for application of bacteriocins as food preservatives. In Juneja V.K., and Sofos, J.N. (Eds), *Control of Food-Borne Microorganisms* (pp. 303-321). New York: Marcel Dekker.

Chinachoti, N., Matsusaki, H., Sonomoto, K. and Ishizaki, A. 1997. Utilisation of xylose as an alternative carbon source for nisin Z production by *Lactococcus lactis* IO-1. *J. Fac. Agric., Hokkaido Univ.*, 42: 171–181

Choi, H.J., Cheigh, C.I., Kim, S.B., and Pyun, Y.R. 2000. Production of a nisin like bacteriocin by *Lactococcus lactis* subsp. *lactis* A164 isolated from Kimchi. *J Appl Microbiol.*, 88(4): 563–571.

Choi, H.Y., Kim, J.S., and Kim, W.J. 2011. Optimization of conditions for the maximum bacteriocin production of *Enterococcus faecium* DB1 using response surface methodology. *Korean J. Food Sci. Ani. Resource.*, 31(2): 176-182.

Choi, M.H., and Park, Y.H., 2000. Selective control of lactobacilli in kimchi with nisin. *Lett. Appl. Microbiol.*, 30: 173–177.

Chong, E.S.L. 2014. A potential role of probiotics in colorectal cancer prevention: review of possible mechanisms of action. *World J. Microbiol. Biotechnol.*, 30: 351–374.

Chugh, P., Dutt, R., Sharma, A., Bhagat, N., and Dhar, M.S. 2020. A critical appraisal of the effects of probiotics on oral health. *J. Funct. Foods.*, 70: 103985.

Cintas, L.M., Casaus, M.P., Herranz, C., Nes, I.F., and Hernández, P.E. 2001. Review: Bacteriocins of lactic acid bacteria. *Food Sci Technol Int.*, 7(4): 281–305.

Cleveland, J., Montville, T.J., Nes, I.F., and Chikindas, M.L. 2001. Bacteriocins: Safe, natural antimicrobials for food preservation. *Int J Food Microbiol*, 71(1): 1-20.

CLSI. 2014. Performance standards for antimicrobial susceptibility testing; twenty-fourth informational supplement. CLSI document M100-S24. Clinical and Laboratory Standards Institute, Wayne.

Coetzee, J.C.J. 2007. Increased production of bacST4SA by *Enterococcus mundtii* in an industrial-based medium with pH-control. University of Stellenbosch, Stellenbosch

Coico, R. (2005). *Gram Staining. Current Protocols in Microbiology*. A.3C.1-A.3C.2. New York: John Wiley & Sons, Inc.

Collins, B., Cotter, P.D., Hill, C., and Ross, R.P. 2010. Applications of lactic acid bacteria-produced bacteriocins. In Mozzi, F., Raya, R.R. and Vignolo, G.M. (Eds.), *Biotechnology of lactic acid bacteria: Novel applications* (pp. 89-109). New Jersey: Blackwell, Hoboken.

Colombo, M., Castilho, N.P.A., Todorov, S.D., and Nero, L.A. 2018. Beneficial properties of lactic acid bacteria naturally present in dairy production. *BMC Microbiol*, 18: 219.

Condon, S. 1987. Responses of lactic acid bacteria to oxygen. *FEMS Microbiol Rev.*, 46: 269–280.

Corcoran, B.M., Stanton, C., Fitzgerald, G.F., and Ross, R.P. 2005. Survival of probiotic lactobacilli in acidic environments is enhanced in the presence of metabolizable sugars. *Appl Environ Microbiol.*, 71: 3060–3067.

Cosentino, S., Fadda, M.E., Deplano, M., Melis, R., Pomata, R., and Pisano, M.B. 2012. Antilisterial activity of nisin-like bacteriocin-producing *Lactococcus lactis* subsp. lactis isolated from traditional Sardinian dairy products. *J Biomed Biotechnol.*, 376428

Coskun, O. 2016. Separation techniques: Chromatography. *North Clin Istanbul*, 3(2): 156–60.

Cotter, P.D., Hill, C., and Ross, R.P. 2005. Bacteriocins: developing innate immunity for food. *Nat. Rev. Microbiol*. 3: 777–788.

Coulibaly, I., Kouassi, E. K., N'guessan, E., Destain, J., Béra, F., and Thonart, P. 2018. Lyophilization (drying method) cause serious damages to the cell viability of lactic acid bacteria. *Annu. Res. Rev. Biol.*, 24(24): 1-15.

Da Costa, R. J., Voloski, F.L.S., Mondadori, R.G., Duval, E.H., and Fiorentini, Â.M. 2019. Preservation of meat products with bacteriocins produced by lactic acid bacteria isolated from meat. *J. Food Qual.*, 4726510.

da Silva Malheiros, P., Daroit, D.J., and Brandelli, A. 2010. Food applications of liposome-encapsulated antimicrobial peptides. *Trends Food Sci. Technol*. 21: 284–292.

da Silva Sabo S., Vitolo M., González J.M.D., and de Souza Oliveira R.P. 2014. Overview of *Lactobacillus plantarum* as a promising bacteriocin producer among lactic acid bacteria. *Int. Food Res. J.*, 64: 527–536.

Daba, G.M., El-Dien, A.N., Saleh, S.A.A., Elkhateeb, W.A., Awad, G., Nomiyama, T., Yamashiro, K., and Zendo, T. 2021. Evaluation of *Enterococcus* strains newly isolated from Egyptian sources for bacteriocin production and probiotic potential. *Biocatal. Agric. Biotechnol.*, 35: 102058.

Damania, P., Patel, R., Shaw, R., Kataria, R.P., and Wadia, A. 2016. Development of antimicrobial packaging materials for food preservation using bacteriocin from *Lactobacillus casei*. *Microbiol Res.*, 7: 6622.

Daranas, N., Roselló, G., Cabrefiga, J., Donati, I., Francés, J., Badosa, E., Spinelli, F., Montesinos, E., and Bonaterra, A. 2019. Biological control of bacterial plant diseases with *Lactobacillus plantarum* strains selected for their broad-spectrum activity. *Ann. Appl. Biol.,* 174(1): 92–105.

Daw M.A, and Falkiner F.R. 1996. Bacteriocins: nature, function and structure. *Micron Journal,* 27: 467-479.

De Arauz, L.J., Jozala, A.F., Baruque-Ramos, J., Mazzola, P.G., Júnior, A.P., and Penna, T.C.V. 2012. Culture medium of diluted skimmed milk for the production of nisin in batch cultivations. *Ann. Microbiol*. 62: 419–426.

De Giani, A., Bovio, F., Forcella, M., Fusi, P., Sello, G., and Di Gennaro, P. 2019. Identification of a bacteriocin-like compound from *Lactobacillus plantarum* with antimicrobial activity and effects on normal and cancerogenic human intestinal cells. *AMB Express*, 9(1): 88.

De Giulio, B., Orlando, P., Barba, G., Coppola, R., De Rosa, M., Sada, A. 2005. Use of alginate and cryoprotective sugars to improve the viability of lactic acid bacteria after freezing and freeze-drying. *World J. Microbiol. Biotechnol.*, 21(5): 739-746.

De Kwaadsteniet, M., Doeschate, K.T., and Dicks, L.M. 2009. Nisin F in the treatment of respiratory tract infections caused by *Staphylococcus aureus*. *Lett Appl Microbiol.*, 48:65–70.

De Kwaadsteniet, M., Todorov, S.D., Knoetze, H., and Diks, L.M. 2005. Characterization of a 3944 Da bacteriocin produced by *Enterococcus mundtii* ST15, with activity against gram positive and Gram-negative bacteria. *Int J Food Microbiol,* 105(3): 433–444.

De Simone, N., Capozzi, V., de Chiara, M.L.V., Amodio, M.L., Brahimi, S., Colelli, G., Drider, D., Spano, G., and Russo, P. 2021. Screening of lactic acid bacteria for the bio-control of *Botrytis cinerea* and the potential of *Lactiplantibacillus plantarum* for eco-friendly preservation of fresh-cut kiwifruit. *Microorganisms*, 9: 773.

De Vos, W.M. 1996. Metabolic engineering of sugar catabolism in lactic acid bacteria. *Antonie Van Leeuwenhoek,* 70: 223–42.

De Vuyst L., Foulquie Moreno, M.R., and Revets, H. 2003. Screening for enterocins and detection of hemolysin and vancomycin resistance in enterococci of different origins. *Int J Food Microbiol.,* 84: 299–318

De Vuyst, L. 1995. Nutritional factors affecting nisin production by *Lactococcus lactis* subsp. *lactis* NIXO 22186 in a synthetic medium. *J. Appl. Microbiol.,* 78: 28-33.

De Vuyst, L., and Leroy, F. 2007. Bacteriocins from lactic acid bacteria: Production, purification, and food applications. *J Mol Microbiol Biotechnol.*, 13: 194–199.

De Vuyst, L., and Vandamme, E.J. 1994. *Bacteriocins of lactic acid bacteria: Microbiology, genetics and applications*. London, UK: Blackie Academic and Professional.

De Vuyst, L., Callewaert, R., and Crabbe, K. 1996. Primary metabolite kinetics of bacteriocin biosynthesis by *Lactobacillus amylovorus* and evidence for stimulation of bacteriocin production under unfavourable growth conditions. *Microbiology*, 142: 817–827.

Deegan, L.H., Cotter, P.D., Hill, C., and Ross, P. 2006. Bacteriocins: Biological tools for bio-preservation and shelf-life extension. *Int. Dairy J*, 16(9): 1058-1071.

Delaunay, J.L., Breton, M., Trugnan, G., and Maurice, M. 2008. Differential solubilization of inner plasma membrane leaflet components by Lubrol WX and Triton X-100. *Biochim Biophys Acta Biomembr.*, 1778(1): 105–112.

Delgado, A., Arroyo López, F. N., Brito, D., Peres, C., Fevereiro, P., and Garrido-Fernández, A. 2007. Optimum bacteriocin production by *Lactobacillus plantarum* 17.2b requires absence of NaCl and apparently follows a mixed metabolite kinetics. *J Biotechnol*, 130(2): 193-201.

DePaz, R.A. Dale, D.A., Barnett, C.C., Carpenter, J.F., Gaertner, A.L., and Randolph, T.W. 2002. Effects of drying methods and additives on the structure, function, and storage stability of subtilisin; role of protein conformation and molecular mobility. *Enzyme Microbial Technol*. 31: 765–774.

Devirgiliis, C., Zinno, P., and Perozzi, G. 2013. Update on antibiotic resistance in foodborne *Lactobacillus* and *Lactococcus* species. *Front Microbiol*, 4, 1-13.

Di Cagno, R., Coda, R., De Angelis, M., and Gobbetti, M. (2013). Exploitation of vegetables and fruits through lactic acid fermentation. *Food Microbiol*. 33: 1–10.

Dicks, L.M.T., Dellaglio, F., and Collins, M.D. 1995. Proposal to reclassify Leuconostoc oenos as *Oenococcus oeni* [corrig.] gen. nov., comb. nov. *Int J Syst Bacteriol*, 45: 395–7.

Dicks, L.M.T., Heunis, T.D.J., Van Staden, D.A., Brand, A., Sutyak Noll, K., and Chikindas, M.L. 2011. Medical and personal care applications of bacteriocins produced by lactic acid bacteria. In Drider, D., and Rebuffat, S., (Eds). *Prokaryotic antimicrobial peptides. From genes to applications* (pp. 391-421). New York (NY): Springer-Verlag.

Dimitrellou, D., Kandylis, P., and Kourkoutas, Y. 2016. Effect of cooling rate, freeze-drying, and storage on survival of free and immobilized *Lactobacillus casei* ATCC 393. *LWT - Food Sci. Technol.*, 69: 468–473.

Dimov, S., Peykov, S., Raykova, D., and Ivanova, P. 2008. Influence of diverse sugars on BLIS production by three different *Enterococcus* strains. *Trakia J. Sci.*, 6: 54–59.

Dinarvand, M., Rezaee, M., Masomian, M., Jazayeri, S., Zareian, M., Abbasi, S., and Ariff, A.B. 2013. Effect of C/N ratio and media optimization through response surface methodology on simultaneous productions of intra- and extracellular inulinase and invertase from *Aspergillus niger* ATCC 20611. *Biomed Res. Int.*, 1-13.

Drider, D., Fimland, G., Hechard, Y., McMullen, L.M., and Prevost, H. 2006. The continuing story of class IIa bacteriocins. *Microbiol Mol Biol Rev.*, 70: 564-582.

Dutra-Molino, J.V., Araujo-Feitosa, V., de Lencastre-Novaes, L.C., Santos-Ebinuma, V.C., Lopes, A.M., Jozala, A.F., Marques, D.A.V., Malpiedi, L.P., and Pessoa, A. Jr. 2014. Biomolecules extracted by ATPS: practical examples. *Rev. Mex. Ing. Quim.* 13(2): 359-377.

Duwat, P., Ehrlich, S.D., and Gruss, A. 1995. The recA gene of Lactococcus lactis: characterisation and involvement in oxidative and thermal stress. *Mol Microbiol* 17:1121–1131

EFSA. 2007. Scientific committee. introduction of a qualified presumption of safety (QPS) approach for assessment of selected microorganisms referred to EFSA1. *EFSA J,* 587: 1–16.

Egan, K., Field, D., Rea, M.C., Ross, R.P., Hill, C., and Cotter, P.D. 2016. Bacteriocins: novel solutions to age old spore-related problems? *Front. Microbiol,* 7: 461.

EI-Naggar, M.Y. 2004. Comparative study of probiotic cultures to control the growth of *E. coli* O157:H7 and *Salmonella typhimurium. Biotechnol,* 3(2): 173-180.

Elotmani, F., Revol-Junelles, A. M., Assobhei, O., and Milliére, J. 2002. Characterization of anti-*Listeria monocytogenes* bacteriocins from *Enterococcus faecalis*, *Enterococcus faecium* and *Lactococcus lactis* strains isolated from Raib, a Moroccan traditional fermented milk. *Curr. Microbiol.,* 44: 10-17.

Enan, G. and Amri, A.A.A. 2006. Novel plantaricin UG1 production by *Lactobacillus plantarum* UG1 in enriched whey permeate in batch fermentation processes. *J. Food, Agric. Environ.,* 4: 85–88

Enan, G., Essawy, A. A., Uyttendaele, M., and Debevere, J. 1996. Antibacterial activity of *Lactobacillus plantarum* UG1 isolated from dry sausage: Characterization, production and bactericidal action of plantaricin UG1. *Int. J. Food Microbiol.*, 30:189–215.

Erkkilä, S., and Petäjä, E. 2000. Screening of commercial meat starter cultures at low pH and in the presence of bile salts for potential probiotic use. *Meat Sci*, 55: 297–300.

FAO/WHO. 2001. Report of a joint FAO/WHO expert consultation on evaluation of health and nutritional properties of probiotics in food including powder milk with live lactic acid bacteria. Cordoba, Argentina, 1-4 October 2001.

FAO/WHO. 2002. Report of a joint FAO/WHO working group on drafting guidelines for the evaluation of probiotics in food. https://www.who.int/foodsafety/fs_management/en/probiotic_guidelines.pdf. Retrieved 15 October 2020.

FAO/WHO. 2006. *Probiotics in Food: Health and Nutritional Properties and Guidelines for Evaluation*. Rome: FAO.

Fatemeh, S., Mustafa, S., Ariff, A.B, and Manap, Y.A. 2011. Optimization of a cryoprotective medium and survival of freeze-dried *Bifidobacterium infantis* 20088 throughout storage, rehydration and gastrointestinal tract transit for infant formula probiotic applications. *Afr. J. Microbiol. Res.*, 5: 3373–3384.

Favaro, L., Penna, A.L.B., and Todorov, S.D. 2015. Bacteriocinogenic LAB from cheeses–application in biopreservation? *Trends Food Sci. Technol.* 41, 37–48.

Faye, T., Tamburello, A., Vegarud, G. E., and Skeie, S. 2012. Survival of lactic acid bacteria from fermented milks in an *in vitro* digestion model exploiting sequential incubation in human gastric and duodenum juice. *J Dairy Sci.*, 558-566.

Fazilah, N.F., Ariff, A.B., Khayat, M.E., Rios-Solis, L., and Halim, M. 2018. Influence of probiotics, prebiotics, synbiotics and bioactive phytochemicals on the formulation of functional yogurt. *J Funct Foods,* 48: 387-399.

Fazilah, N.F., Hamidon, N.H., Ariff, A.B., Khayat, M.E., Wasoh, H., and Halim, M. 2019. Microencapsulation of *Lactococcus lactis* Gh1 with gum Arabic and *Synsepalum dulcificum* via spray drying for potential inclusion in functional yogurt. *Molecules,* 24(7): 1-21.

FDA. 2010. Generally Recognized as Safe (GRAS) Notifications. https://www.fda.gov/food/food-ingredients-packaging/generally-recognized-safe-gras. Retrieved 15 October 2020.

Fenster, K., Freeburg, B., Hollard, C., Wong, C., Laursen, R.R. and Ouwehand, A.C. 2019. The production and delivery of probiotics: A review of a practical approach. *Microorganisms,* 7: 83.

Fernández, L., Delgado, S., Herrero, H., Maldonado, A., and Rodríguez, J.M. 2008. The bacteriocin nisin, as effective agent for the treatment of *Staphylococcal mastitis* during lactation. *J Hum Lact.*, 24: 311-316.

Field, D., Daly, K., O'Connor, P.M., Cotter, P.D., Hill, C., and Ross, R.P. 2015. Efficacies of nisin A and nisin V semipurified preparations alone and in combination with plant essential oils for controlling *Listeria monocytogenes*. *Appl. Environ. Microbiol.*, 81: 2762–2769.

Flórez, A.B., Ammor, M.S., and Mayo, B. 2008. Identification of tet(M) in two *Lactococcus lactis* strains isolated from a Spanish traditional starter-free cheese made of raw milk and conjugative transfer of tetracycline resistance to lactococci and enterococci. *Int J Food Microbiol,* 121(2): 189-194.

Flórez, A.B., Danielsen, M., Korhonen, J., Zycka, J., von Wright, A., Bardowski, J., and Mayo, B. 2007. Antibiotic survey of *Lactococcus lactis* strains to six antibiotics by Etest, and establishment of new susceptibility-resistance cut-off values. *J Dairy Res,* 74(3): 262-268.

Fonseca, F., Béal, C., and Corrieu, G. 2000. Method for quantifying the loss of acidification activity of lactic acid starters during freezing and frozen storage. *J. Dairy Res.* 67: 83–90.

Fonseca, F., Cenard, S., and Passot, S. 2015. *Freeze- drying of lactic acid bacteria*. New York: Springer.

Fonseca, F., Passot, S., Cunin, O., and Marin, M. 2004. Collapse temperature of freeze-dried *Lactobacillus bulgaricus* suspensions and protective media. *Biotechnol. Prog.,* 20: 229–238.

Fontana, C., Cocconcelli, P.S., Vignolo, G., and Saavedra, L. 2015. Occurrence of antilisterial structural bacteriocins genes in meat borne lactic acid bacteria. *Food Control*, 47: 53–59.

Fordyce, A.M., Crow, V.L., and Thomas, T.D. 1984. Regulation of product formation during glucose or lactose limitation in non-growing cells of *Streptococcus lactis. Appl Environ Microbiol*, 48: 332–7.

Fortune Business Insights. 2020. Probiotics Market Size, Share and Industry Analysis by Microbial Genus (Lactobacillus, Bifidobacterium, Yeast), by Application (Functional Food and Beverage, Dietary Supplement, Animal Feed), by Distribution Channel (Supermarkets/Hypermarkets, Pharmacies/Health Stores, Convenience Stores, Online Retail), and Regional Forecast 2018-2025. Fortune Business Insights https://www.fortunebusinessinsights.com/industry-reports/infographics/probioticsmarket-100083/. Accessed at 16 July 2021.

Foulquié-Moreno, M.R., Callewaert, R., and De Vuyst, L. 2001. Isolation of bacteriocins through expanded bed adsorption using a hydrophobic interaction medium. *Bioseparation*, 10: 45-50.

Fowler, A., and Toner, M. 2005. Cryoinjury and Biopreservation. *Ann. N. Y. Acad. Sci.,*.1066: 119–135.

Furuta, Y., Maruoka, N., Nakamura, A., Omori, T., and Sonomoto, K. 2008. Utilization of fermented barley extract obtained from a by-product of barley shochu for nisin production. *J Biosci Bioeng*, 106: 393-397.

Gandhi, A., and Shah, N.P. 2015. Effect of salt on cell viability and membrane integrity of *Lactobacillus acidophilus, Lactobacillus casei* and *Bifidobacterium longum* as observed by flow cytometry. *Food Microbiol.*, 49: 197-202.

Gandhi, M. and Chikindas, M.L. 2007. "Listeria: a foodborne pathogen that knows how to survive," *Int. J. Food Microbiol.*, 113(1): 1–15.

Gänzle, M., Weber, S., and Hammes, W. 1999 Effect of ecological factors on the inhibitory spectrum and activity of bacteriocins. *Int. J. Food Microbiol.,* 46(3): 207–217.

Garneau S., Martin N.I., and Vedras J.G. 2002. Two-peptide bacteriocins produced by lactic acid bacteria. *Journal of Biochimie*, 84: 577-592.

Garrigues, C., Loubiere, P., Lindley, N.D., and Cocaign–Bousquet. M. 1997. Control of shift from homolactic acid to mixed-acid fermentation in *Lactococcus lactis*: predominant role of the NADH/NAD ratio. *J Bacteriol*, 179: 5282–7.

Garsa, A.K., Kumariya, R., Sood, S.K., Kumar, A., and Kapila, S. 2014. Bacteriocin production and different strategies for their recovery and purification. *Probiotics and Antimicro. Prot.* 6: 47–58.

Garvie, E.I. 1980. Bacterial lactate dehydrogenases. *Microbiol Rev*, 44: 106–39.

Gaspar, C., Donders, G.G., Palmeira‐de‐Oliveira, R., Queiroz, J.A., Tomaz, C., Martinez‐de‐Oliveira, J., and Palmeira‐de‐Oliveira, A. 2018. Bacteriocin production of the probiotic *Lactobacillus acidophilus* KS400. *AMB Expr*, 8: 153.

Gaspar, P., Carvalho, A.L., Vinga, S., Santos, H., and Neves, A. R. 2013. From physiology to systems metabolic engineering for the production of biochemicals by lactic acid bacteria. *Biotechnol. Adv.*, 31: 764–788.

Ghosh, S.K., Pandey, A., Arora, S., and Dwivedi, V.D. 2013. Comparative modelling and docking studies of β-galactosidase from *Aspergillus niger. Netw Model Anal Health Inform Bioinforma*, 2: 297–302.

Gibson, G., and Collins, M.D. 1999. Concept of balanced colonic microbiota, prebiotics and synbiotics. In Hanson, L.A. and Yolken, R.H. (Eds.) *Probiotics, other Nutritional Factors and Intestinal Microflora. Nestle Nutrition Workshop Series, 42* (pp. 139-156). Philadelphia: Nestec Ltd. Vevey/Lippincott-Raven Publishers.

Gibson, G.R., Hutkins, R., Sanders, M.E., Prescott, S.L., Reimer, R.A., Salminen, S.J., Scott, K., Stanton, C., Swanson, K.S., Cani, P.D., Verbeke, K., and Reid, G. 2017. Expert consensus document: The international scientific association for probiotics and prebiotics (isapp) consensus statement on the definition and scope of prebiotics. *Nat. Rev. Gastroenterol. Amp Hepatol.* 14: 491.

Goh, H.F., and Philip, K. 2015. Purification and characterization of bacteriocin produced by *Weissella confusa* A3 of Dairy Origin. *PLoS ONE*, 10(10): e014043

Gonçalves, L.M.D., Ramos, A., Almeida, J.S., Xavier, A.M.R.B., and Carrondo, M.J.T. 1997. Elucidation of the mechanism of lactic acid growth inhibition and production in batch cultures of *Lactobacillus rhamnosus*. *Appl. Microbiol. Biotechnol*, 48: 346-350.

Gonzalez, R., Islas, L., Obregon, A.-M., Escalante, L., and Sanchez, S. 1995. Gentamicin formation in *Micromonospora purpurea*: stimulatory effect of ammonium. *J. Antibiot*. 48: 479–483.

Gonzalez-Toledo, S.Y., Dominguez-Dominguez, J., Garcia-Almendarez, B.E., Prado-Barragan, L.A., and Regalado-Gonzalez, C. 2010. Optimization of nisin production by *Lactococcus lactis* UQ2 using supplemented whey as alternative culture medium. J Food Sci, 75: M347-M353.

Goyal, C., Malik, R.K., and Pradhan, D. 2018. Purification and characterization of a broad spectrum bacteriocin produced by a selected *Lactococcus lactis* strain 63 isolated from Indian dairy products. *J. Food Sci. Technol.*, 55(9): 3683–3692.

Grande, M.J., Lucas, R., Abriouel, H., Valvidia, E., Ben Omar, N., Maqueda, M., Martínez-Cañamero, M., and Gálvez, A. 2006. Inhibition of *Bacillus licheniformis* LMG 19409 from ropy cider by enterocin AS-48. *J. Appl. Microbiol,* 101: 422–428.

Grazia, S. E., Sumayyah, S., Haiti, F. S., Sahlan, M., Heng, N. C. K., and Malik, A. 2017. Bacteriocin-like inhibitory substance (BLIS) activity of *Streptococcus macedonicus* MBF10-2 and its synergistic action in combination with antibiotics. *Asian Pac. J. Trop. Med.,* 10(12): 1140-1145.

Green, G., Dicks, L.M.T., Bruggeman, G., Vandamme, E.J., and Chikin-das, M.L. 1997. Pediocin PD-1, a bactericidal antimicrobial peptide from *Pediococcus damnosus* NCFB 1832. J. *Microbiol. Biotechnol*, 83: 127–132.

Grilo, A.L., Raquel Aires-Barros, M., and Azevedo, A.M. 2016. Partitioning in aqueous two-phase systems: Fundamentals, applications and trends. *Sep. Purif. Rev.,* 45: 68–80

Gueimonde, M., and Salminen, S. 2006. New methods for selecting and evaluating probiotics. *Dig Liver Dis*, 38 (2): S242-S247.

Guerra, N.P, and Pastrana, L. 2001. Enhanced nisin and pediocin production on whey supplemented with different nitrogen sources. *Biotechnol. Lett.*, 23: 609-612.

Guerra, N.P., Agrasar, A.T., Macias, C.L., and Pastrana, L. 2005. Modelling the fed-batch production of pediocin using mussel processing wastes. *Process Biochem.,* 40 (3-4): 1071–1083.

Guerra, N.P., Rua, M.L., and Pastrana, L. 2001. Nutritional factors affecting the production of two bacteriocins from lactic acid bacteria on whey. *Int J Food Microbiol,* 70(3): 267-281.

Guo, W.L., Zhang, Y.B., Lu, J.H., Jiang, L.Y., Teng, L.R., Wang, Y. and Liang, Y.C. 2010. Optimization of fermentation medium for nisin production from *Lactococcus lactis* subsp. *lactis* using response surface methodology (RSM) combined with artificial neural network-genetic algorithm (ANN-GA). *Afr. J. Biotechnol.,* 9(38): 6264-6272.

Gurry, T. 2017. Synbiotic approaches to human health and well-being. *Microb. Biotechnol*. 10: 1070–1073.

Guyonnet, D., Fremaux, C. and Cenatiempo, Y. 2000. Method for rapid purification of class IIa bacteriocins and comparison of their activities. *Appl. Environ. Microbiol.* 66:1744–1748.

Gwak, H.J., Lee, J., Kim, T., Choi, H., Jang, J., Lee, S.I. and Park, H.W. 2015. Protective effect of soy powder and microencapsulation on freeze-dried *Lactobacillus brevis* WK12 and *Lactococcus lactis* WK11 during storage. *Food Sci Biotechnol*, 24, 2155–2160.

Haindl, R., Neumayr, A., Frey, A. and Kulozik, U. 2020. Impact of cultivation strategy, freeze-drying process, and storage conditions on survival, membrane integrity, and inactivation kinetics of *Bifidobacterium longum. Folia Microbiol*, 65, 1039–1050.

Halim, M., Mohd Mustafa, N.A., Othman, M., Wasoh, H., Kapri, M.R., and Ariff, A.B. 2017. Effect of encapsulant and cryoprotectant on the viability of probiotic *Pediococcus acidilactici* ATCC 8042 during freeze-drying and exposure to high acidity, bile salts and heat. *LWT - Food Sci Technol*, 81: 210–216.

Han, B., Yu, Z., Liu, B., Ma, Q., and Zhang, R. 2011. Optimization of bacteriocin production by *Lactobacillus plantarum* YJG, isolated from the mucosa of the gut of healthy chickens. *Afr J Microbiol Res*, 5: 1147–55

Harzallah, D., and Belhadj, H. 2013. Lactic acid bacteria as probiotics: characteristics, selection criteria and role in immunomodulation of human GI muccosal barrier. In. Kongo, J.M (Ed), *Lactic acid bacteria – R and D for food, health and livestock purposes* (pp. 197-216). Rijeka, Croatia: IntechOpen.

Hassan, H., Gomaa, A., Subirade, M., Kheadr, E., St-Gelais, D., and Fliss, I. 2019. Novel design for alginate/resistant starch microcapsules controlling nisin release. *Int J Biol Macromol*. 153: 1186–92.

Hassan, M., Kjos, M., Nes, I. F., Diep, D. B., and Lotfipour, F. 2012. Natural antimicrobial peptides from bacteria: Characteristics and potential applications to fight against antibiotic resistance. *J Appl Microbiol*, 113: 723—736.

Hatti-Kaul R. 2000. *Aqueous Two-Phase Systems: Methods and Protocols*. Berlin: Springer Science and Business Media.

Heng, N.C.K., Wescombe, P.A., Burton, J.P., Jack, R.W. and Tagg, J.R. 2007. The diversity of bacteriocins in Gram positive bacteria. In Riley, M.A. and Chavan M.A (Eds), *Bacteriocins: Ecology and Evolution* (pp. 45–92). New York: Springer.

Hernández-González, J.C., Martínez-Tapia, A., Lazcano-Hernández, G., García-Pérez, B.E., and Castrejón-Jiménez, N.S. 2021. Bacteriocins from lactic acid bacteria. A powerful alternative as antimicrobials, probiotics, and immunomodulators in veterinary medicine. *Animals*, 11: 979.

Herreros, M., Sandoval, H., González, L., Castro, J., Fresno, J., and Tornadijo, M. 2005. Antimicrobial activity and antibiotic resistance of lactic acid bacteria isolated from Armada cheese (a Spanish goats' milk cheese). *Food Microbiol*, 22: 455–459.

Hightower, N.C., Sircus, W., Keeton, W.T., and Dworken, H.J. 2018. Human digestive system. Encyclopædia Britannica. Retrieved April 14, 2019, from https://www.britannica.com/science/human-digestive-system.

Hill, C., Guarner, F., Reid, G., Gibson, G.R., Merenstein, D.J., Pot, B., Morelli, L., Canani, R.B., Flint, H.J., Salminen, S., Calder, P.C., and Sanders, M.E. 2014. Expert consensus document: The international scientific association for probiotics and prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nat. Rev. Gastroenterol. Hepatol.*, 11(8): 506-514.

Hillman, E.T., Lu, H., Yao, T., and H. Nakatsu, C.H. 2017. Minireview- Microbial ecology along the gastrointestinal tract. *Microbes Environ*. 32 (4): 300-313.

H-Kittikun, A., Biscola, V., El-Ghaish, S., Jaffrès, E., Dousset, X., Pillot, G., Haertlé, T., Chobert, J. M. and Hwanhlem, N. 2015. Bacteriocin-producing Enterococcus faecalis KT2W2G isolated from mangrove forests in southern Thailand: Purification, characterization and safety evaluation. *Food Control*, 54: 126–134.

Hofvendahl, K., and Hahn-Hagerdal, B. 2000. Factors affecting the fermentative lactic acid production from renewable resources. *Enzyme Microb. Tech.*, 26: 87– 107.

Hofvendahl, K., van Niel, E.W.J., and Hahn–Hägerdal, B. 1999. Effect of temperature and pH on growth and product formation of *Lactococcus lactis* spp. *lactis* ATCC 19435 growing on maltose. *Appl Microbiol Biotechnol*, 51: 669–72.

Holzapfel, W.H., Haberer, P., Snel, J., Schillinger, U., and Huis in't Veld, J.H. 1998. Overview of gut flora and probiotics. *J. Food Microbiol.*, 41(2): 85-101.

Honda, K. and Littman, D.R. 2016. The microbiota in adaptive immune homeostasis and disease. *Nature*, 535: 75.

Huang, R., Tao, X., Wan, C., Li, S., Xu, H., Xu, F., Shah, N.P., and Wei, H. 2015. *In vitro* probiotic characteristics of *Lactobacillus plantarum* ZDY 2013 and its modulatory effect on gut microbiota of mice. *J Dairy Sci*, 98: 5850–5861.

Hubalek, Z. 2003. Protectants used in the cryopreservation of microorganisms. *Cryobiology*, 46: 205–229.

Hur, J.W., Hyun, H.H., Pyun, Y.R., Kim, T.S., Yeo, I.H., and Baik, H.D. 2000. Identification and partial characterization of lacticin BH5, a bacteriocin produced by *Lactococcus lactis* BH5 isolated from Kimchi. *J. Food Prot.*, 63: 1707–1712.

Iacumin, L., Cappellari, G., Colautti, A., and Comi, G. 2020. *Listeria monocytogenes* survey in cubed cooked ham packaged in modified atmosphere and bioprotective effect of selected lactic acid bacteria. *Microorganisms*, 8: 898.

Ibourahema, C., Dauphin, R. D., Jacqueline, D., and Thonart, P. 2008. Characterization of lactic acid bacteria isolated from poultry farms in Senegal. *Afr J Biotechnol*, 7: 2006-2012.

Ibrahim, S.B., Abdul Rahman, N.A., Mohamad, R., and Abdul Rahim, R. 2010. Effects of agitation speed, temperature, carbon and nitrogen sources on the growth of recombinant *Lactococcus lactis* NZ9000 carrying domain 1 of aerolysin gene. *Afr. J. Biotechnol.*, 9(33): 5392-5398.

Ivanova, I., Kabadjova, P., Pantev, P., Danova, S., and Dousset, X. 2000. Detection, purification and partial characterization of a novel bacteriocin substance produced by *Lactoccous lactis* subsp. Lactis B14 isolated from boza- Bulgarian traditional cereal beverage. *Vestn Mosk Univ.*, 41(6): 47-53.

Jamaluddin, N., Ariff, A.B., and Wong, F.W.F. 2019. Purification of a bacteriocin- like inhibitory substance derived from *Pediococcus acidilactici* Kp10 by an aqueous micellar two- phase system. *Biotechnol. Prog.*, 35 (1): e2719.

Jamaluddin, N., Stuckey, D.C., Ariff, A.B, and Wong, F.W.F. 2018. Novel approaches to purifying bacteriocin: A review. *Crit Rev Food Sci Nutr*, 58 (14): 2453–2465.

Jawan, R., Abbasiliasi, S., Mustafa, S., Kapri, M.R., Halim, M., and Ariff, A.B. 2020. *In vitro* evaluation of potential probiotic strain *Lactococcus lactis* Gh1 and its bacteriocin-like inhibitory substances for potential use in the food industry. *Probiotics Antimicrob. Proteins.*

Jennings, T. 2002. *Lyophilization: introduction and basic principles*. Washington, DC: CRC.

Jones, E., Salin, V., and Williams, G.W. 2005. NISIN and the Market for Commercial Bacteriocins. TAMRC Consumer and Product 2005, Research Report CP-01-05.

Joo, N.E., Ritchie, K., Kamarajan, P., Miao, D., and Kapila, Y.L. 2012. Nisin, an apoptogenic bacteriocin and food preservative, attenuates HNSCC tumorigenesis via CHAC 1. *Cancer Med*., 1: 295–305.

Jozala, A.F., de Lencastre Novaesa, L.C., Mazzolab, P.G., Nascimentoa, L.O., Pennaa, T.C.V., Teixeirac, J.A., Passarinhad, L.A., Queirozd, J.A., and Pessoa Jr., A. 2015. Low-cost purification of nisin from milk whey to a highly active product. *Food Bioprod Process*, 93: 115–121.

Jozala, A.F., Lopes, A.M., de Lencastre Novaes, L.C., Mazzola, P.G., Penna, T.C.V., and Júnior, A.P. 2012. Aqueous two-phase micellar system for nisin extraction in the presence of electrolytes. *Food Bioproc Tech.*, 6(12): 3456–3461.

Jozala, A.F., Lopes, A.M., Mazzola, P.G., Magalhães, P.O., Vessoni Penna, T.C., and Pessoa Jr., A. 2008. Liquid–liquid extraction of commercial and biosynthesized nisin by aqueous two-phase micellar systems. *Enzyme Microb. Technol.*, 42: 107–112.

Juárez Tomás, M.S., Bru, E., Martos, G., and Nader-Macías, M.E. 2009. Stability of freeze-dried vaginal *Lactobacillus* strains in the presence of different lyoprotectors. *Can J Microbiol,* 55: 544–552.

Juturu, V. and Wu, J.C. 2018. Microbial production of bacteriocins: Latest research development and applications. *Biotechnol Adv.*,36(8): 2187-2200.

Kaewsrichan, J, Peeyananjarassri, K., and Kongprasertkit, J. 2006. Selection and identification of anaerobic lactobacilli producing inhibitory compounds against vaginal pathogens. *FEMS Immunol Med Microbiol*, 48(1): 75–83

Kaiser, A.L., and Montville, T.J. 1993. The influence of pH and growth rate on production of the bacteriocin, bavaricin MN, in batch and continuous fermentations. *J Appl Bacteriol*, 75: 536–40.

Kandler O. 1983. Carbohydrate metabolism in lactic acid bacteria. *Antonie Van Leeuwenhoek*, 49: 209–24.

Kandylis, P., Manousi, M.-E., Bekatorou, A., and Koutinas, A. A. 2010. Freeze-dried wheat supported biocatalyst for low temperature wine making. *LWT Food Science and Technology*, 43: 1485-1493.

Kanmani, P., Kumar, R.S., Yuvaraj, N., Paari, K.A, Pattukumar, V., and Arul, V. 2012. Application of response surface methodology in the optimisation of a growth medium for enhanced natural preservative bacteriocin production by a probiotic bacterium. *Nat Prod Res*, 26: 1539-1543.

Karasova, P., Spiwok, V., Mala, S., Kralova, B., and Russell, N.J. 2002. Beta-galactosidase activity in psychrotrophic microorganisms and their potential use in food industry. *Czech J Food Sci*, 20: 43–47.

Karimi, R., Mortazavian, A.M., and Cruz, A.G. 2011. Viability of probiotic microorganisms in cheese during production and storage: a review. *Dairy Sci Technol.*, 91: 283-308.

Kashket, E.R. 1987. Bioenergetics of lactic acid bacteria: cytoplasmic pH and osmotolerance. *FEMS Microbiol Lett*, 46: 233–244.

Kaur, G., and Roy, I. 2015. Strategies for Large-scale Production of Polyhydroxyalkanoates. *Chem. Biochem. Eng. Q.*, 29(2): 157–172.

Kaur, S., and Kaur, S. 2015. Bacteriocins as Potential Anticancer Agents. *Front. Pharmacol.*, 10: 272

Kechagia, M., Basoulis, D., Konstantopoulou, S., Dimitriadi, D., Gyftopoulou, K., Skarmoutsou, N., and Fakiri, E. M. 2012. Health benefits of probiotics: a review. *ISRN Nutrition*, 1-7.

Keivani, F., Mokarram, R.R., Benis, K.Z., Gholian, M.M., Zendeboodi, F., and Zadeh, S.S. 2014. External and internal factors affecting survival of probiotic living cells during desiccation. *Int. J. Pharm.,* 3: 309-316.

Kennedy, M., and Krouse, D. 1999. Strategies for improving fermentation medium performance: a review. *J Ind Microbiol Biotechnol,* 23: 456–475

Khalil, R., Elbahloul, Y., Djadouni, F., and Omar, S. 2009. Isolation and partial characterization of a bacteriocin produced by a newly isolated *Bacillus megaterium* 19 strain. *Pakistan J Nutr*, 8(3): 242-250

Khay, E.Q., Ouhsassi, M., Harsal, A.E., Idaomar, M., and Abrini, J. 2013. Optimisation of bacteriocin like production by *Enterococcus durans* E204 isolated from camel milk of Morocco. *Current Research in Microbiology and Biotechnology,* 1(4): 155-159

Khoo, K.S., Chew, K.W., Ooi, C.W., Ong, H.C., Ling, T.C., and Show, P.L. 2019. Extraction of natural astaxanthin from *Haematococcus pluvialis* using liquid biphasic flotation system. *Bioresour. Technol.* 290: 121794

Khoramnia, A., Abdullah, N., Liew, S.L., Sieo, C.C., Ramasamy, K., and Yin, W.H. 2011. Enhancement of viability of a probiotic lactobacillus, strain for poultry during freeze-drying and storage using the response surface methodology. *Anim. Sci. J.*, 82(1): 127–135.

Kim, M.-H., Kong, Y.-J., Baek, H., and Hyun, H.-H. 2006. Optimization of culture conditions and medium composition for the production of micrococcin GO5 by *Micrococcus* sp. GO5. *J Biotechnol,* 121: 54-61.

Kim, W.S., Hall, R.J., and Dunn, N.W. 1997. The effect of nisin concentration and nutrient depletion on nisin production of *Lactococcus lactis*. *Appl. Microbiol. Biotechnol*. 48: 449–453.

Kivanç, M., Yilmaz, M., and Cakir, E. 2011. Isolation and identification of lactic acid bacteria from boza, and their microbial activity against several reporter strains. *Turk J Biol*, 35: 313-324.

Kleerebezem, M., and Hugenholtz, J. 2003. Metabolic pathway engineering in lactic acid bacteria. *Curr Opin Biotechnol,* 14: 232–7.

Korenblum, E., von der Weid, I., Santos, A.L.S., Rosado, A.S., Sebastian, G.V., Coutinho, C.M.L.M., Magalhães, F.C.M., Paiva, M.M., and Seldin, L. 2005. Production of antimicrobial substances by *Bacillus subtilis* LFE- 1, *B. firmus* H2O- 1 and *B. licheniformis* T6- 5 isolated from an oil reservoir in Brazil. *J Appl Microbiol,* 98: 667-675.

Kruger, M.F., Barbosa, M.D.S., Miranda, A., Landgraf, M., Destro, M.T., and Todorov, S.D. 2013. Isolation of bacteriocinogenic strain of *Lactococcus lactis* subsp. lactis from modification in the leader-peptide. *Food Control,* 33(6): 467-476.

Kubo, M.T.K., Augusto, P.E.D., and Cristianini, M. 2013. Effect of high-pressure homogenization (HPH) on the physical stability of tomato juice. *Food Res. Int*. 51: 170–179.

Kula, M.R., Korner, K.H., and Hustedt, H. 1982. *Purification of enzymes by liquid-liquid extraction.* (pp. 74-118). Fiechter: Springer-Verlag.

Kumar, M., Jain, A.K., Ghosh, M., and Ganguli, A. 2012. Statistical optimization of physical parameters for enhanced bacteriocin production by *L. casei*. *Biotechnol Bioprocess Eng.* 17: 606–616.

Kurtmann, L., Carlsen, C. U., Skibsted, L. H., and Risbo, J. 2009. Water activity-temperature state diagrams of freeze-dried *Lactobacillus acidophilus* (La-5): influence of physical state on bacterial survival during storage. *Biotechnol. Prog.*, 25: 265–270.

Lahiri, D., Chakraborti, S., Jasu, A., Nag, M., Dutta, B., Dash, S., and Ray, R.R. 2020. Production and purification of bacteriocin from *Leuconostoc lactis* SM 2 strain, *Biocatal. Agric. Biotechnol.*, 30: 101845.

Lajis, A.F. 2020. Biomanufacturing process for the production of bacteriocins from Bacillaceae family. *Bioresour. Bioprocess.*, 7(8): 2020.

Lampkowska, J., Feld, L., Monaghan, A., Toomey, N., Schjørring, S., Jacobsen, B., van der Voet, H., Andersen, S.R., Bolton, D. and Aarts, H. 2008. A standardized conjugation protocol to asses antibiotic resistance transfer between lactococcal species. *Int J Food Microbiol,* 127: 172–175.

Lappe, R., SantAnna, R. and Brandelli, A. 2012. Extraction of the antimicrobial peptide cerein 8A by aqueous two-phase systems and aqueous two-phase micellar systems. *Nat. Prod. Res.*, 26: 2259–2265.

Law, J.W.F., Ab Mutalib, N.S., Chan, K.G., and Lee, L.H. 2015. An insight into the isolation, enumeration, and molecular detection of *Listeria monocytogenes* in food. *Front Microbiol*, 6(1227): 1-15.

Lawton, E.M., Ross, R.P., Hill, C., and Cotter, P.D. 2007. Two-peptide lantibiotics: A medical perspective. *Mini Rev Med Chem*, 7: 1236–1247.

LeBlanc, J.G., Garro, M.S., and Savoy de Giori, G. 2004. Effect of pH on Lactobacillus fermentum growth, raffinose removal, α-galactosidase activity and fermentation products. *Appl. Microbiol. Biotechnol*, 65(1): 119-123.

Lechiancole, T., Ricciardi, A., and Parente, E. 2002. Optimization of media and fermentation conditions for the growth of *Lactobacillus sakei*. *Annals of Microbiology*, 52: 257-274.

Lee, N. K., Kim, S.Y., Han, K.J., Eom, S.J. and Paik, H.D. 2014. Probiotic potential of *Lactobacillus* strains with anti-allergic effects from kimchi for yogurt starters. *LWT-Food Sci. Tech.* 58,130–134.

Lee, S.Y., Khoiroh, I., Tau Chuan Ling, T.C., and Show, P.L. 2016. Aqueous two-phase flotation for the recovery of biomolecules. *Sep. Purif. Rev.*, 45(1): 81-92.

Lee, Y.M., Kim, J.S., and Kim, W.J. 2012. Optimization for the maximum bacteriocin production of *Lactobacillus brevis* DF01 using response surface methodology. *Food Sci. Technol*, 21: 653-659.

Leelavatcharamas, V., Arbsuwan, N., Apiraksakorn, J., Laopaiboon, P., and Kishida, M. 2011. Thermotolerant bacteriocin-producing lactic acid bacteria isolated from Thai local fermented foods and their bacteriocin productivity. *Biocontrol Sci.*, 16: 33-40.

Leite, A.M.O., Miguel, M.A.L., Peixoto, R.S., Ruas-Madiedo, P., Paschoalin, V. M. F., Mayo, B., and Delgado, S. 2015. Probiotic potential of selected lactic acid bacteria strains isolated from Brazilian kefir grains. *J Dairy Sci*, 98(6): 3622-3632.

Leroy, F., and De Vuyst, L. 1999. The presence of salt and a curing agent reduces bacteriocin production by *Lactobacillus sakei* CTC 494, a potential starter culture for sausage fermentation. *Appl Environl Microbiol*, 65: 5350–5358.

Leroy, F., and De Vuyst, L. 2002. Bacteriocin production by *Enterococcus faecium* RZS C5 is cell density limited and occurs in the very early growth phase. *Int J Food Microbiol*, 72(1): 155-164.

Leroy, F., and De Vuyst, L. 2004. Lactic acid bacteria as functional starter cultures for the food fermentation industry. *Trends Food Sci. Technol.* 15: 67–78.

Leroy, F., Vankrunkelsven, S., De Greef, J., and De Vuyst, L. 2003. The stimulating effect of a harsh environment on the bacteriocin activity by *Enterococcus faecium* RZS C5 and dependency on the environmental stress factor used. *Int J Food Microbiol*, 83(1): 27-38.

Leslie, S.B., Israeli, E., Lighthart, B., Crowe, J.H., and Crowe, L.M. 1995. Trehalose and sucrose protect both membranes and proteins in intact bacteria during drying. *Appl. Environ. Microbiol*. 61(10): 3592–3597.

Li, C., Bai, J., Cai, Z., and Ouyang, F. 2002. Optimization of a cultural medium for bacteriocin production by *Lactococcus lactis* using response surface methodology. *J Biotechnol*, 93(1): 27-34.

Li, C., Bai, J., Li, W., Cai, Z., and Ouyang, F. 2001. Optimization of conditions for bacteriocin extraction in PEG/salt aqueous two- phase systems using statistical experimental designs. *Biotechnol. Prog.,* 17: 366−368.

Li, C., Ouyang, F., and Bai, J. 2000. Extractive cultivation of *Lactococcus lactis* using a polyethylene glycol/$MgSO_4$. $7H_2O$ aqueous two-phase system to produce nisin. *Biotechnol. Lett.,* 22: 843–847.

Li, M. and Dong, H. 2010. The investigation on the aqueous two-phase floatation of lincomycin, *Separ. Purif. Technol.* 73: 208-212.

Li, N., Wang, Y., Xu, K., Huang, Y., Wen, Q., and Ding, X. 2016. Development of green betaine-based deep eutectic solvent aqueous two-phase system for the extraction of protein. *Talanta*, 152: 23–32.

Li, Q., Ma, Y., He, S., Elfalleh, W., Xu, W., Wang, J., and Qiu, L. 2014. Effect of pH on heat stability of yak milk protein. *Int Dairy J,* 35: 102–105.

Liao, C.C., Yousef, A.E., Richter, E.R., and Chism, G.W. 1993. *Pediococcus acidilactici* PO2 bacteriocin production in whey permeate and inhibition of *Listeria monocytogenes* in foods. *J Food Sci.,* 58: 430–4.

Liao, D.-H., Zhao, J.-B., and Gregersen, H. 2009. Gastrointestinal tract modelling in health and disease. *World J. Gastroenterol.*, 169-176.

Liasi, S., Azmi, T., Hassan, M., Shuhaimi, M., Rosfarizan, M., and Ariff, A.B. 2009. Antimicrobial activity and antibiotic sensitivity of three isolates of lactic acid bacteria from fermented fish product, Budu. *Malaysian J Microbiol,* 5: 33–37.

Lim, H.S., Yeu, J.E., Hong, S.P., and Kang, M.S. 2018. Characterization of antibacterial cell-free supernatant from oral care probiotic *Weissella cibaria*, CMU. *Molecules,* 23(8): 1-13.

Linders, J.M., de Jong, G.I.W., Meerdink, G., and Vantriet, K. 1997. Carbohydrates and the dehydration inactivation of *Lactobacillus plantarum*: The role of moisture distribution and water activity. *J. Food Eng.* 31: 237–250.

Liu, G., Ren, G., Zhao, L., Cheng, L., Wang, C., and Sun, B. 2017. Antibacterial activity and mechanism of bifidocin A against *Listeria monocytogenes*. *Food Control*, 73: 854–861.

Liu, G., Song, Z., Yang, X., Gao, Y., Wang, C., and Sun, B. 2016. Antibacterial mechanism of bifidocin A, a novel broad-spectrum bacteriocin produced by *Bifidobacterium animalis* BB04. *Food Control*, 62: 309–316.

Liu, Y., Guo, H., Gu, J., and Qin, W. 2019. Optimize purification of a cellulase from *Bacillus velezensis* A4 by aqueous two-phase system (ATPS) using response surface methodology. *Process Biochem*, 87: 196–203.

Loh, J.Y., Lim, Y.Y., and Ting, A.S.Y. 2017. Bacteriocin-like substances produced by *Lactococcus lactis* subsp. *lactis* CF4MRS isolated from fish intestine: Antimicrobial activities and inhibitory properties. *Int Food Res J*, 24(1): 394-400.

Lopetuso, L.R., Giorgio, M.E., Saviano, A., Scaldaferri, F., Gasbarrini, A., and Cammarota, G. 2019. Bacteriocins and bacteriophages: Therapeutic weapons for gastrointestinal diseases? *Int. J. Mol. Sci.,* 20: 183

López-González, M. J., Escobedo, S., Rodríguez, A., Neves, A. R., Janzen, T., and Martínez, B. 2018. Adaptive evolution of industrial Lactococcus lactis under cell envelope stress provides phenotypic diversity. *Front Microbiol.*, 9: 1-17.

Loubiere, P., Cocaign-Bousquet, M., Matos, J., Goma, G., and Lindley N.D. 1997. Influence of end-products inhibition and nutrient limitations on the growth of *Lactococcus lactis* subsp. *lactis. J. Appl. Microbiol.*, 82: 95-100.

Lü, X., Yi, L., Dang, J., Dang, Y., and Liu, B. 2014. Purification of novel bacteriocin produced by *Lactobacillus coryniformis* MXJ 32 for inhibiting bacterial foodborne pathogens including antibiotic-resistant microorganisms. *Food Control,* 46: 264–271.

Lu, Y., Huang, L., Yang, T., Lv, F., and Lu, Z. 2017. Optimization of a cryoprotective medium to increase the viability of freeze-dried *Streptococcus thermophilus* by response surface methodology. *Food Sci Technol,* 80: 92-97.

Lucey, J.A. 2016. *Acid coagulation of milk*. New York: Springer.

Lv, W., Zhang, X., and Cong, W. 2006. Modelling the production of nisin by *Lactococcus lactis* in fed-batch culture. *Appl. Microbiol. Biotechnol.*, 68: 322-326.

Ma, J., Yu, W., Hou, J., Han, X., Shao, H. and Liu, Y. 2020. Characterization and production optimization of a broad-spectrum bacteriocin produced by *Lactobacillus casei* KLDS 1.0338 and its application in soybean milk biopreservation. *Int. J. Food Prop.* 23(1): 677-692.

Malheiros, P.S., Sant'Anna, V., Todorov, S.D., and Franco, B.D. 2015. Optimization of growth and bacteriocin production by *Lactobacillus sakei* subsp. *sakei*2a. Brazilian journal of microbiology. *Braz. J. Microbiol.*, 46(3): 825–834.

Mandal, V., Sen, S.K., and Mandal, N.C. 2008. Optimized culture conditions for bacteriocin production by *Pediococcus acidilactici* LAB 5 and its characterization. *Indian J Biochem Biophys.*, 45: 106-110.

Mannan, S. J., Rezwan, R., Rahman, M. S., and Begum, K. 2017. Isolation and biochemical characterization of *Lactobacillus* species from yogurt and cheese samples in Dhaka metropolitan area. *Bangladesh J Pharmacol.* 20(1): 27-33.

Manning, M.C., Chou, D.K., Murphy, B.M., Payne, R.W., and Katayama, D.S. 2010. Stability of protein pharmaceuticals: An update. *Pharm Res*, 27: 544–575.

Margolles, A., and Yokota, A. 2011. Bile stress in lactic acid bacteria and bifidobacteria. In Sonomoto, K. and Yokota, A. (Eds.), *Lactic acid bacteria and bifidobacteria: Current progress in advanced research* (pp. 111–142). Norfolk, UK: Caister Academic Press.

Mariam, S.H., Zegeye, N., Tariku, T., Andargie, E., Endalafer, N., and Aseffa, A. 2014. Potential of cell-free supernatants from cultures of selected lactic acid bacteria and yeast obtained from local fermented foods as inhibitors of *Listeria monocytogenes*, *Salmonella* spp. and *Staphylococcus aureus*. *BMC Res Notes*, 7: 1-9.

Market Study Report. 2020. https://www.marketstudyreport.com/reports/global-food-additives-market-research-report-2020?gclid=Cj0KCQjw3f6HBhDHARIsAD_i3D8TQIqhmx-wMp8-htMLNdP8u8cUxqzqmZ2iGz5vLyCqWrycZx6hULQaAg9gEALw_wcB. Retrived 27 July 2021.

Martinez, R.C.R., and de Martinis, E.C.P. 2006. Effect of *Leuconostoc mesenteroides* 11 bacteriocin in the multiplication control of *Listeria monocytogenes* 4b. *Ciência e Tecnologia de Alimentos*, 26: 52-55.

Mataragas, M., Drosinos, E.H., Tsakalidou, E., and Metaxopoulos, J. 2004. Influence of nutrients on growth and bacteriocin production by *Leuconostoc mesenteroides* L124 and *Lactobacillus curvatus* L442. *Antonie van Leeuwenhoek*, 85(3): 191–198.

Mataragas, M., Metaxopoulos, J., Galiotou, M., and Drosinos, E. H. 2003. Influence of pH and temperature by *Leuconostoc mesenteroides* L124 and *Lactobacillus curvatus* L442. *Meat Sci.*, 64(3): 265-271.

Mathur, H., Field, D., Rea, M.C., Cotter, P.D., Hill, C., and Ross, R.P. 2018. Fighting biofilms with lantibiotics and other groups of bacteriocins. *NPJ Biofilms Microbiomes*, 4(9).

Matsusaki, H., Endo, N., Sonomoto, K., and Ishizaki, A. 1996. Lantibiotic nisin Z fermentative production by Lactococcus lactis IO-1: Relationship between production of the lantibiotic and lactate and cell growth. *Appl. Microbiol. Biotechnol.*, 45: 36-40.

Mauriello, G., Aponte, M., Andolfi, R., Moschetti, G., and Villani, F. 1999. Spray-drying of bacteriocin-producing lactic acid bacteria. *J Food Prot*, 62(7): 773–777.

Mayolo-Deloisa, K., Benavides, J., and Rito-Palomares, M. 2017. General concepts and definitions of aqueous two-phase systems. In Rito-Palomares, M., and Benavides, J. (Eds). *Aqueous two-phase systems for bioprocess development for the recovery of biological products* (pp. 1-18). Switzerland: Springer International.

Mc Groarty, J.A. 1993. Probiotic use of lactobacilli in the human female urogenital tract. *FEMS Immunol Med Microbiol*. 6: 251–264.

McCall, I.C., Betanzos, A., Weber, D.A., Nava, P., Miller, G.W., and Parkos, C.A. 2009. Effects of phenol on barrier function of a human intestinal epithelial cell line correlate with altered tight junction protein localization. *Toxicol Appl Pharmacol*, 241(1): 61-70.

McLean, M.J., Wolfe, K.H., and Deine, K.M. 1998. Base composition skews, replication orientation, and gene orientation in 12 prokaryote genomes. *J. Mol. Evol*. 47: 691–696.

Md. Sidek, N.L., Tan, J.S., Abbasiliasi, S., Wong, F.W.F., Mustafa, S., and Ariff, A.B. 2016. Aqueous two-phase flotation for primary recovery of bacteriocin-like inhibitory substance (BLIS) from *Pediococcus acidilactici* Kp10. *J. Chromatogr. B*, 1027: 81–87.

Md. Sidek, N.L.M., Halim, M., Tan, J.S., Abbasiliasi, S., Mustafa, S., and Ariff, A.B. 2018. Stability of bacteriocin-like inhibitory substance (BLIS) produced by *Pediococcus acidilactici* Kp10 at different extreme conditions. *BioMed Res Int.*, 5973484.

Mejia-Gomez, C.E., and Balcázar, N. 2020. Isolation, characterisation and continuous culture of *Lactobacillus spp*. and its potential use for lactic acid production from whey. *Food Sci. Technol, Campinas*, 40(4): 1021-1028.

Mensink, M.A., Frijlink, H. W., van der Voort Maarschalk, K., and Hinrichs, W.L.J. 2017. How sugars protect proteins in the solid state and during drying (review): Mechanisms of stabilization in relation to stress conditions. *Eur J Pharm Biopharm*, 114: 288–295.

Mesas, J.M., Rodríguez, M.C., and Alegre, M.T. 2011. Characterization of lactic acid bacteria from musts and wines of three consecutive vintages of *Ribeira sacra*. *Lett Appl Microbiol*, 52: 258– 268.

Messens, W., Neysens, P., Vansieleghem, W., Vanderhoeven, J., and De Vuyst, L. 2002. Modeling growth and bacteriocin production by *Lactobacillus amylovorus* DCE 471 in response to temperature and pH values used for sourdough fermentations. *Appl. Environ. Microbiol.*, 68(3): 1431-1435.

Mierau I., 2005. Optimization of the *Lactococcus lactis* nisin-controlled gene expression system NICE for industrial applications. *Microb. Cell Fact.*, 4: 16-28.

Mierau I., and Lei J.P. 2005. Industrial scale production and purification of heterogenous protein in *L.lactis* using the Nisin-controlled gene expression system NICE: The case of lysostaphin. *Microb. Cell Fact.*, 4: 1-9.

Millán, J.L. 2006. *Mammalian alkaline phosphatases: From biology to applications in medicine and biotechnology*. Weinheim: WILEY-VCH Verlag GmbH and Co.

Mills, S., Serrano, L., Griffin, C., O'connor, P.M., Schaad, G., Bruining, C., Hill, C., Ross, R., and Meijer, W.C. 2011. Inhibitory activity of *Lactobacillus plantarum* LMG P-26358 against *Listeria innocua* when used as an adjunct starter in the manufacture of cheese. *Microb Cell Fact*, 10: S7.

Miremadi, F., Ayyash, M., Sherkat, F., and Stojanovska, L. 2014. Cholesterol reduction mechanisms and fatty acid composition of cellular membranes of probiotic *Lactobacilli* and *Bifidobacteria*. *J Funct Foods,* 9: 295–305.

Miyamoto-Shinohara, Y., Sukenobe, J., Imaizumi, T., and Nakahara, T. (2006). Survival curves for microbial species stored by freeze-drying. *Cryobiology,* 52(1): 27–32.

Moghaddam, M.G., Ahmad, F.B.H., Basri, M., and Abdul Rahman, M.B. 2010. Artificial neural network modeling studies to predict the yield of enzymatic synthesis of betulinic acid ester. *Electron J Biotechnol.* 12: 1–12.

Moghaddam, M.G., and Khajeh, M. 2011. Comparison of response surface methodology and artificial neural network in predicting the microwave-assisted extraction procedure to determine zinc in fish muscles. *Food Nutr Sci.,* 2: 803–808.

Mohammed, A.R., Coombes, A.G.A., and Perrie, Y. 2007. Amino acids as cryoprotectants for liposomal delivery systems. *Eur J Pharm Sci*, 30(5): 406-413.

Mohd Taha, M.D., Mohd Jaini, M.F., Saidi, N.B., Abdul Rahim, R., Md Shah, U.K., and Mohd Hashim, A. 2019. Biological control of *Erwinia mallotivora*, the causal agent of papaya dieback disease by indigenous seed-borne endophytic lactic acid bacteria consortium. *PloS one*, 14(12): e0224431.

Mokoena, M.P. 2017. Lactic acid bacteria and their bacteriocins: classification, biosynthesis and applications against uropathogens: A Mini-Review. *Molecules*, 22: 1255.

Molino, J.V.D., Feitosa, V.A., Novaes, L.C.d.L., Ebinuma, V.D.C.S., Lopes, A.M., and Jozala, A.F. 2014. Biomolecules extracted by ATPS: Practical examples. *Rev. Mex. Ing. Quim.*, 13: 359-377.

Moll, G.N., Konings W. N., and Driessen, A.J.M. 1999. Bacteriocins: mechanism of membrane insertion and pore formation. *Antonie van Leeuwenhoek*, 3: 185-195.

Monteagudo-Mera, A., Caro, I., Rodriguez-Aparicio, L.B., Rua, J., Ferrero, M.A., and Garcia-Armesto, M.R. 2011. Characterization of certain bacterial strains for potential use as starter or probiotic cultures in dairy products. *J Food Prot,* 74: 1379–1386.

Montel Mendoza, G., Pasteris, S. E., Otero, M.C., and Fatima Nader-Macías, M.E. 2013. Survival and beneficial properties of lactic acid bacteria from raniculture subjected to freeze-drying and storage. *J Appl Microbiol,* 116: 157-166.

Mora-Villalobos, J.A., Montero-Zamora, J., Barboza, N., Rojas-Garbanzo, C., Usaga, J., Redondo-Solano, M., Schroedter, L., Olszewska-Widdrat, A. and López-Gómez, J.P. 2020. Multi-product lactic acid bacteria fermentations: a review. *Fermentation*, 6: 1–21.

Moreno, I., Lerayer, A.L.S., Baldini, V.L.S., and Leitão, M.F.F. 2000. Characterization of bacteriocins produced by *Lactococcus lactis* strains. *Braz J Microbiol,* 31: 183–191.

Morgan, C. A., Herman, N., White, P.A., and Vesey, G. 2006. Preservation of micro-organisms by drying; A review. *J Microbiol Methods,* 66: 183-193.

Morgan, C., and Vesey, G. (2009). *Encyclopedia of Microbiology*. 3rd Ed. (pp. 162–173). Oxford, UK: Academic Press.

Morichi, T. 1974. Preservation of lactic acid bacteria by freeze-drying. *JARQ*, 8 (3): 171-176.

Morrissey, I., and Smith, J.T. 1994. The importance of oxygen in the killing of bacteria by ofloxacin and ciprofloxacin. *Microbios,* 79(318): 43-53.

Mortvedt-Abildgaard, C.I., Nissen-Meyer, J., Jelle, B., Grenov, B., Skaugen M. and Nes, I.F. 1995. Production and pH-dependent bactericidal activity of lactocin S, a lantibiotic from *Lactobacillus sake* L45. *Appl. Environ. Microbiol*., 61: 175–179

Motta, A.S., and Brandelli, A. 2003. Influence of growth conditions on bacteriocin production by Brevibacterium linens. *Appl. Microbiol. Biotechnol.,* 62: 163-167.

Motta, A.S., and Brandelli, A. 2008. Evaluation of environmental conditions for production of bacteriocin-like substance by *Bacillus* sp. strain P34. *World J Microbiol Biotechnol,* 24: 641-646.

Muhamad Nor, N., Mohamed, M.S., Loh, T.C., Foo, H.L., Abdul Rahim, R., Tan, J.S., and Mohamad, R. 2017. Comparative analyses on medium optimization using one-factor-at-a-time, response surface methodology, and artificial neural network for lysine–methionine biosynthesis by *Pediococcus pentosaceus* RF-1. *Biotechnol. Biotechnol. Equip.*, 31(5): 935-947.

Muhammad Khan, B., Cheong, K.-L., and Liu, Y. 2019. ATPS: "Aqueous two-phase system" as the "answer to protein separation" for protein-processing food industry. *Crit Rev Food Sci Nutr,* 59(19): 3165–3178.

Mulaw, G., Tessema, T.S., Muleta, D., and Tesfaye, A. 2019. *In vitro* evaluation of probiotic properties of lactic acid bacteria isolated from some traditionally fermented Ethiopian food products. *Int J Microbiol*, 1-12.

Muriana, P.M. and Klaenhammer, T.R. 1991. Purification and partial characterization oflactacin F, a bacteriocin produced by *Lactobacillus acidophilus* 11088. *Appl. Environ. Microbiol.*, 57:114–121.

Mustapha, A., Jiang, T., and Savaiano, D.A. 1997. Improvement of lactose digestion by humans following ingestion of unfermented acidophilus milk: Influence of bile sensitivity, lactose transport, and acid tolerance of *Lactobacillus acidophilus*. *J Dairy Sci*, 80(8): 1537-1545.

Myers, R., and Montgomery, R.C. 2002. *Response surface methodology: Process and product optimization using designed experiments*. New York: Wiley

Naghmouchi, K., Le Lay, C., Baah, J., and Drider, D. 2012. Antibiotic and antimicrobial peptide combinations: synergistic inhibition of *Pseudomonas fluorescens* and antibiotic-resistant variants. *Res Microbiol.*, 163: 101-108.

National Institute for Communicable Diseases (NICD), South Africa. 2019. http://www.nicd.ac.za/wp-content/uploads/2018/08/An-update-on-the-outbreak-of-Listeria-monocytogenes-South-Africa.pdf. Accessed 7 January 2019.

Nguyen, T.T.T., Loiseau, G., Icard-Verniere, C., Rochette, I., Treche, S., and Guyot, J. P. 2007. Effect of fermentation by amylolytic lactic acid bacteria, in process combinations, on characteristics of rice/soybean slurries: A new method for preparing high energy density complementary foods for young children. *Food Chem,* 100: 623 – 631.

Nieto-Lozano, J.C., Reguera-Useros, J.I., Peláez-Martínez, M.C., Sacristán-Pérez-Minayo, G., Gutiérrez-Fernández, A.J., and dela Torre, A.H. 2010. Effect of the pediocin PA-1 produced by *Pediococcus acidilactici* against *Listeria monocytogenes* and *Clostridium perfringens* in Spanish dry fermented sausages and frankfurters. *Food Control*, 21(5): 679–685.

Nishant, T., Sathish Kumar, D., Arun Kumar, R., Hima Bindu, K., and Raviteja, Y. 2011. Bacteriocin producing probiotic lactic acid bacteria. *J Microbial Biochem Technol*, 3: 121-124.

Noonpakdee, W., Santivarangkna, C., Jumriangrit, P., Sonomoto, K., and Panyim, S. 2003. Isolation of nisin-producing *Lactococcus lactis* WNC 20 strain from nham, a traditional Thai fermented sausage. *Int. J. Food Microbiol.*, 81(2): 137–45.

Nor, N.M., Mohamed, M. S., Loh, T.C., Foo, H.L., Rahim, R.A., Tan, J.S., and Mohamad, R. 2017. Comparative analyses on medium optimization using one-factor-at-a-time, response surface methodology, and artificial neural network for lysine–methionine biosynthesis by *Pediococcus pentosaceus* RF-1. *Biotechnol. Biotechnol. Equip.*, 31(5): 935–947.

Nowak, A., and Libudzisz, Z. 2007. Ability of intestinal lactic bacteria to bind or/and metabolise phenol and p-cresol. *Ann Microbiol*, 57(3): 329-335.

O'Connor, P. M., Ross, R. P., Hill, C., and Cotter, P.D. 2015. Antimicrobial antagonists against food pathogens: a bacteriocin perspective. *Curr. Opin. Food Sci.* 2, 51–57.

O'Shea, E.F., O'Connor, P.M., O'Sullivan, O., Cotter, P.D., Ross, R.P., and Hill, C. 2013. Bactofencin A, a new type of cationic bacteriocin with unusual immunity. *mBio*. 4: 1–9.

Oh, S., Rheem, S., Sim, J., Kim, S., and Baek, Y. 1995. Optimizing conditions for the growth of *Lactobacillus casei* YIT 9018 in tryptone-glucose medium by using response surface methodology. *Appl. Environ. Microb*. 61: 3809-3814.

Oliveira, P., Nielsen, J., and Forster, J. 2005. Modelling *Lactococcus lactis* using a genome-scale flux model. *BMC Microbiology Journal*, 5: 39-48.

Ooi, C.W., Hii, S.L., Kamal, S.M.M., Ariff, A.B., and Ling, T.C. 2011. Extractive fermentation using aqueous two-phase systems for integrated production and purification of extracellular lipase derived from *Burkholderia pseudomallei*. *Process Biochem.*, 46 (1): 68–73.

Ooi, C.W., Tey, B.T., Hii, S.L., Mustapa Kamal, S.M., Lan, J.C.W. Ariff, A.B., and Ling, T.C. 2009. Direct purification of *Burkholderia Pseudomallei* lipase from fermentation broth using aqueous two-phase systems. *Biotechnol Bioproc Eng.*, 14(6): 811–818.

Ooi, M.F., Mazlan, N., Foo, H.L., Loh, T.C., Rosfarizan, M., Rahim, R.A., and Ariff, A.B. 2015. Effects of carbon and nitrogen sources on bacteriocin-inhibitory activity of postbiotic metabolites produced by *Lactobacillus plantarum* I-UL4. *Malays. J. Microbiol.*, 11(2): 176-184.

Ovchinnikov, K.V., Kranjec, C., Thorstensen, T., Carlsen, H., and Diep, D.B. 2020. Successful development of bacteriocins into therapeutic formulation for treatment of MRSA skin infection in a murine model. *Antimicrob Agents Chemother*, 64: e00829-20.

Özogul, F., and Hamed, I. 2018. The importance of lactic acid bacteria for the prevention of bacterial growth and their biogenic amines formation: A review. *Crit Rev Food Sci Nutr*, 1660-1670.

Pailin, T., Kang, D.H., Schmidt, K., and Fung, D.Y.C. 2001. Detection of extracellular bound proteinase in EPS-producing lactic acid bacteria cultures on skim milk agar. *Lett Appl Microbiol*, 33: 45-49.

Panda, B.P., Ali, M., and Javed, S. 2007. Fermentation process optimisation. *Res J Microbiol*, 2: 201–208

Pandey, S.K., and Banik, R.M. 2011. Extractive fermentation for enhanced production of alkaline phosphatase from *Bacillus licheniformis* MTCC 1483 using aqueous two-phase systems. *Bioresour. Technol*, 102: 4226–4231.

Panghal, A., Janghu, S., Virkara, K., Gat, Y., Kumar, V., and Chhikara, N. 2018. Potential non-dairy probiotic products – A healthy approach. *Food Biosci*, 21: 80-89.

Papagianni, M., and Anastasiadou, S. 2009. Pediocins: the bacteriocins of Pediococci. Sources, production, properties and applications. *Microb Cell Fact,* 8(3): 1–16.

Papagianni, M., Avramidis, N., Filioussis, G., Dasiou, D., and Ambrosiadis, I. 2006. Determination of bacteriocin activity with bioassays carried out on solid and liquid substrates: assessing the factor “indicator microorganism”. *Microb Cell Fact*., 5: 30.

Papamanoli, E., Tzanetakis, N., Litopoulou-Tzanetaki, E., and Kotzekidou, P. 2003. Characterisation of lactic acid bacteria isolated from a Greek dry-fermented sausage in respect of their technological and probiotic properties. *Meat Sci*, 65: 859-867.

Paquet, V., Myint, M., Roque, C., and Soucaille, P. 1994. Partitioning of pristinamycins in aqueous two-phase systems: a first step toward the development of antibiotic production by extractive fermentation. *Biotechnol. Bioeng*., 44: 445–451.

Parente, E., and Ricciardi, A. 1999. Production, recovery and purification of bacteriocins from lactic acid bacteria. *Appl. Microbiol. Biotechnol.*, 52: 628-638.

Parente, E., Brienza, C., Ricciardi, A., and Addario, G. 1997. Growth and bacteriocin production by *Enterococcus faecium* DPC1146 in batch and continuous culture. *J Ind Microbiol Biotechnol*. 18(1): 62-67.

Parente, E., Ricciardi, A., and Addario, G. 1994. Influence of pH on growth and bacteriocin production by *Lactococcus lactis* ssp. lactis 14NWC during batch fermentation. *Appl Microbiol Biotechnol,* 41: 388– 94.

Parvez, S., Malik, K. A., Ah Kang, S., and Kim, H. Y. 2006. Probiotics and their fermented food products are beneficial for health. *J. Appl. Microbiol*., 100: 1171-1185.

Passot, S., Cenard, S., Douania, I., Tréléa, I.C., and Fonseca, F. 2012. Critical water activity and amorphous state for optimal preservation of lyophilised lactic acid bacteria. *Food Chem*. 132: 1699–1705.

Pastar, I., Nusbaum, A.G., Gil, J., Patel, S.B., Chen, J., Valdes, J., Stojadinovic, O., Plano, L.R., Tomic-Canic, M., and Davis, S.C. 2013. Interactions of methicillin resistant *Staphylococcus aureus* USA300 and *Pseudomonas aeruginosa* in polymicrobial wound infection. *PLoS One,* 8: e56846.

Patton, G., and Don, K.A. 2005. New developments in lantibiotic biosynthesis and mode of action. *Curr. Opin. Microbiol.*, 8: 543-551.

Pavli, F.G., Argyri, A.A., Papadopoulou, O.S., Nychas, G.-J.E., Chorianopoulos, N.G., and Tassou, C.C. 2016. Probiotic potential of lactic acid bacteria from traditional fermented dairy and meat products: assessment by *in vitro* tests and molecular characterization. *Journal of Probiotics and Health,* 4(3): 1-8.

Pawar, D.D., Malik, S.V.S., Bhilegaonkar, K.N., and Barbuddhe, S.B. 2000. Effect of nisin and its combination with sodium chloride on the survival of *Listeria monocytogenes* added to raw buffalo meat mince. *Meat Sci*, 56: 215-219.

Pedersen, G.B.J., and Saermark, T. 2002. Phenol toxicity and conjugation in human colonic epithelial cells. *Scand J Gastroenterol*, 37: 74–79.

Peiren, J., Hellemans, A., and De Vos, P. 2016. Impact of the freeze-drying process on product appearance, residual moisture content, viability, and batch uniformity of freeze-dried bacterial cultures safeguarded at culture collections. *Appl. Microbiol. Biotechnol*, 100: 6239–6249.

Pennacchia, C., Ercolini, D., Blaiotta, G., Pepe, O., Mauriello, G., and Villani, F. 2004. Selection of *Lactobacillus* strains from fermented sausages for their potential use as probiotics. *Meat Sci*, 67(2): 309–317.

Perez, R.H., Zendo, T. and Sonomoto, K. 2014. Novel bacteriocins from lactic acid bacteria (LAB): various structures and applications. *Microb Cell Fact*, 13: S3.

Pfalzgraff, A., Brandenburg, K., and Weindl, G. 2018. Antimicrobial peptides and their therapeutic potential for bacterial skin infections and wounds. *Front. pharmacol.*, 9: 281.

Pingitore, E.V., Salvucci, E., Sesma, F., and Nader-Macias, M.E. 2007. Different strategies for purification of antimicrobial peptides from lactic acid bacteria (LAB). In Mendez Vilas, A., (Ed). *Communicating Current Research and Educational Topics and Trends in Applied Microbiology* (pp. 557–568). Badajoz, Spain: FORMATEX.

Pohl, T. (1990). Concentration of protein and removal of solutes. In Deutscher, M.P. (Ed). *Methods in Enzymology*: *Guide to Protein Purification* (pp. 68–83). San Deigo, California: Academic Press, Inc.

Poirazi, P., Leroy, F., Georgalaki, M. D., Aktypis, A., De Vuyst, L., and Tsakalidou, E. 2007. Use of artificial neural networks and a gamma-concept-based approach to model growth of and bacteriocin production by *Streptococcus macedonicus* ACA-DC 198 under simulated conditions of Kasseri cheese production. *Appl. Environ. Microbiol.*, 73(3): 768–776.

Ponce, A.G., Moreira, M.R., del Valle, C.E., and Roura, S.I. 2008. Preliminary characterization of bacteriocin-like substances from lactic acid bacteria isolated from organic leafy vegetables. *LWT - Food Sci Technol*, 41 (3): 432-441.

Poolman, B., and Konings, W.N. 1988. Relation of growth of *Streptococcus lactis* and *Streptococcus cremoris* to amino acid transport. *J. Bacteriol.*, 170: 700-707.

Porto, T.S., Medeiros e Silva, G.M., Porto, C.S., Cavalcanti, M.T.H., Neto, B.B., and Lima- Filho, J.L. 2008. Liquid–liquid extraction of proteases from fermented broth by PEG/citrate aqueous two-phase system. *Chem Eng Process: Process Intensification.*, 47: 716–21.

Prudêncio, C.V., dos Santos, M.T., and Vanetti, M.C.D. 2015. Strategies for the use of bacteriocins in Gram-negative bacteria: Relevance in food microbiology. *J Food Sci Technol.*, 52(9): 5408–5417.

Przybycien, T.M., Pujar, N.S., and Steele, L.M. 2004. Alternative bioseparation operations: Life beyond packed-bed chromatography. *Curr. Opin. Biotechnol.*, 15(5): 469–478.

Purwanto, L.A., Ibrahim, D., and Sudrajat, H. 2009. Effect of agitation speed on morphological changes in *Aspergillus niger* hyphae during production of tannase. *World J. Chem. Educ.*, 4(1): 34–38.

Qin, T., Ma, Q., Chen, H., and Shu, G.W. 2013. Effect of four materials including trehalose, soluble starch, raffinose and galactose on survival of *Lactobacillus acidophilus* during freeze-drying. *Adv Mat Res*, 700: 259-262.

Raja, S. and Murty, V.R. 2012. Development and evaluation of environmentally benign aqueous two-phase systems for the recovery of proteins from tannery waste water. *Int Sch Res Notices,* Article ID 290471.

Raja, S., Murty, V.R., Thivaharan, V., Rajasekar, V., and Ramesh, V. 2011. Aqueous two-phase systems for the recovery of biomolecules-a review. *Sci Technol.*, 1: 7–16.

Rajam, R., and Anandharamakrishnan, C. 2015. Spray freeze drying method for microencapsulation of *Lactobacillus plantarum*. *J. Food Eng.*, 166: 95-103.

Ramachandran, B., Srivathsan, J., Sivakami, V., Harish, J., Ravi Kumar, M., and Mukesh Kumar, D.J. 2012. Production and optimization of bacteriocin from *Lactococcus lactis*. *Journal of Academia and Industrial Research*, 1: 306–309.

Rangel-Yagui, C.O., Pessoa-Jr, A. and Blankschtein, D. (2004). Two-phase aqueous micellar systems—an alternative method for protein purification. *Braz. J. Chem. Eng.*, 21: 531–544.

Ratanapongleka, K. 2010. Recovery of biological products in aqueous two-phase systems. *Int. J. Chem. Eng.*, 1: 191-198.

Rather, I.A., Kim, B.C., and Bajpai, V. 2017. Self-medication and antibiotic resistance: Crisis, current challenges, and prevention. *Saudi J Biol Sci*, 24(4): 808-812.

Rathnayaka, R.M.U.S.K. 2013. Effect of freeze-drying on viability and probiotic properties of a mixture of probiotic bacteria. *ARPN J. Eng. Appl. Sci.*, 3(11): 1074-1078.

Reis, J.A., Paula, A.T., Casarotti, S.N., and Penna, A.L.B. 2012. Lactic acid bacteria antimicrobial compounds: Characteristics and application. *Food Eng Rev*, 4: 124–140.

Research and Markets, 2020. https://www.researchandmarkets.com/reports/5185400/probiotic-products-a-global-market-overview?utm_source=CI&utm_medium=PressRelease&utm_code=r6ggpf&utm_campaign=1462669+-+Probiotic+Products%3a+A+2020+Global+Market+Overview&utm_exec=cari18prd. Retrived 27 July 2021

Ribeiro, S.C., O'Connor, P.M., Ross, R.P., Stanton, C., and Silva, C.C. 2016. An anti-listerial *Lactococcus lactis* strain isolated from Azorean Pico cheese produces lacticin 481. *Int Dairy J.,* 63:18–28.

Riley, M.A., and Chavan, M.A. 2007. *Bacteriocins: Ecology and evolution*. Berlin: Springer-Verlag Berlin Heidelberg.

Rilla, N., Martinez, B., and Rodriguez, A. 2004. Inhibition of a methicillin-resistant *Staphylococcus aureus* strain in Afuega'I Pitu cheese by the nisin Z producing strain *Lactococcus lactis lactis* IPLA 729. *J. Food Prot.*, 67: 928-933.

Roberts, B.N., Chakravarty, D., Gardner, J.C., Ricke, S.C., and Donaldson, J.R. 2020. *Listeria monocytogenes* response to anaerobic environments. *Pathogens,* 9(3): 210

Rodriguez, E., Martinez, M.I., Horn, N., and Dodd. H.M. 2003. Heterologous production of bacteriocins by lactic acid bacteria. *Int. J. Food Microbiol.*, 80: 101-116.

Rodriguez, E.G.B., Gaya, P., Nanez, M., and Medina, M. 2000. Diversity of bacteriocins produced by lactic acid bacteria isolated from raw milk. *Int. Dairy J,* 10: 7-15.

Rosa, P.A.J., Azevedo, A.M., and Aires-Barros, M.R. 2007. Application of central composite design to the optimisation of aqueous two-phase extraction of human antibodies, *J. Chromatogr. A.* 1141(1): 50–60.

Rosa, P.A.J., Ferreira, I. F., Azevedo, A.M., and Aires-Barros, M.R. 2010. Aqueous two-phase systems: A viable platform in the manufacturing of biopharmaceuticals. *Journal of Chromatogr. A,* 1217: 2296–2305.

Ross, R.P., Morgan, S. and Hill, C. 2002. Preservation and Fermentation: past, present and future. *Int. J. Food Microbiol.*, 79: 3-16.

Sabo, S.D.S., Lopes, A.M., Ebinuma, V.D.S.S., Yagui, C.D.O.R., and Oliveira, R.P.D.S. 2018. Bacteriocin partitioning from a clarified fermentation broth of *Lactobacillus plantarum* ST16Pa in aqueous two-phase systems with sodium sulfate and choline-based salts as additives. *Process Biochem.*, 66: 212-22.

Sanders, E.R. 2012. Aseptic laboratory techniques: plating methods. *J Vis Exp*. 63: 3064.

Sankaran, R., Manickam, S., Yap, Y.J., Ling, T.C., Chang, J.-S., and Show, P.L. 2018. Extraction of proteins from microalgae using integrated method of sugaring-out assisted liquid biphasic flotation (LBF) and ultrasound. *Ultrason. Sonochem*, 48: 231–239.

Sankaran, R., Parra Cruz, R.A., Show, P.L., Haw, C.Y., Lai, S.H., Ng, E.-P., and Ling, T.C. 2019. Recent advances of aqueous two-phase flotation system for the recovery of biomolecules. *Fluid Phase Equilibria*, 112271.

Santivarangkna, C., Higl, B., and Foerst, P. 2008. Protection mechanisms of sugars during different stages of preparation process of dried lactic acid starter cultures. *Food Microbiol.*, 25: 429-441.

Santivarangkna, C., Kulozik, U., and Foerst, P. 2007. Alternative drying processes for the industrial preservation of lactic acid starter cultures. *Biotechnol. Prog*. 23: 302–315.

Saqib, S., Akram, A., Halim, S.A., and Tassaduq, R. 2017. Sources of β-galactosidase and its applications in food industry. *3 Biotech*, 7: 79.

Saravanan, S., Rao, J.R., Nair, B.U., and Ramasami, T. 2008. Aqueous two-phase poly (ethylene glycol)-poly (acrylic acid) system for protein partitioning: influence of molecular weight, pH and temperature. *Process Biochem.*, 43: 905–911.

Sarika, A.R., Lipton, A.P., and Aishwarya, M.S. 2019. Biopreservative efficacy of bacteriocin GP1 of *Lactobacillus rhamnosus* GP1 on stored fish filets. *Front. Nutr*., 6: 29.

Sarrai, A.E., Hanini, S., Merzouk, N.K., Tassalit, D., Szabó, T., Hernádi, K., and Nagy, L. 2016. Using central composite experimental design to optimize the degradation of tylosin from aqueous solution by photo-fenton reaction. *Materials,* 9(6): 428.

Sathyabama, S., Vijayabharathi, R., and Priyadarisini, V.B. 2012. Screening for probiotic properties of strains isolated from feces of various human groups. *J Microbiol,* 50: 603-612.

Savedboworn, W., Teawsomboonkit, K., Surichay, S., Riansa-ngawong, W., Rittisak, S., Charoen, R., and Phattayakorn, K. 2019. Impact of protectants on the storage stability of freeze-dried probiotic *Lactobacillus plantarum. Food Sci. Biotechnol,* 28(3): 795-805.

Schillinger, U., Geisen, R., and Holzapfel, W.H. 1996. Potential of antagonistic microorganisms and bacteriocins for the biological preservation of foods. *Trends Food Sci Technol.*, 7(5): 158-164.

Settanni, L. and Corsetti, A. 2008. Application of bacteriocins in vegetable food biopreservation. *Int. J. Food Microbiol.*, 121: 123–138.

Sha, Y., Wang, L., Liu, M., Jiang, K., Xin, F., and Wang, B. 2016. Effects of lactic acid bacteria and the corresponding supernatant on the survival, growth performance, immune response and disease resistance of *Litopenaeus vannamei. Aquaculture*, 452: 28–36.

Shannon, R., and Dejes, A.J. 1970. A colorimetric bioassay method for colicins. *J. Appl. Bacteriol.* 33: 555–565.

Sharma, G., Dang, S., Gupta, S., and Gabrani, R. 2018. Antibacterial activity, cytotoxicity, and the mechanism of action of bacteriocin from *Bacillus subtilis* GAS101. *Med Princ Pract*, 27(2): 186-192.

Sharma, P., Sharma, P., Kumar, N., Suman, and Dhingra, N. 2017. Identification and characterization of bile salt hydrolyzing *Lactobacillus* isolates. *Int J Curr Microbiol App Sci*, 6(3): 1655-1675.

Sharma, R., Sanodiya, B., Thakur, G., Jaiswal, P., Sharma, A., and Bisen, P. 2014. Standardization of lyophilization medium for *Streptococcus thermophilus* subjected to viability escalation on freeze drying. *Microbiol Res*, 5(1): 5402.

Shehata, M.G., El Sohaimy, S.A., El-Sahn, M.A., and Youssef, M.M. 2016. Screening of isolated potential probiotic lactic acid bacteria for cholesterol lowering property and bile salt hydrolase activity. *Ann Agric Sci*, 61(1): 65–75.

Shi, L.H., Balakrishnan, K., Thiagarajah, K., Ismail, N.I.M., and Yin, O.S., 2016. Beneficial properties of probiotics. *Trop. Life Sci. Res*. 27(2): 73.

Show, P.L., Tan, C.P., M.S., Ariff, A.B., Yusof, Y.A., Chen, S.K., and Ling, T.C. 2012. Extractive fermentation for improved production and recovery of lipase derived from *Burkholderia cepacia* using a thermoseparating polymer in aqueous two-phase systems. *Bioresour. Technol.*, 116: 226–233.

Shu, G., Wang, Z., Chen, L., Wan, H., and Chen, H. 2018. Characterization of freeze-dried *Lactobacillus acidophilus* in goat milk powder and tablet: Optimization of the composite cryoprotectants and evaluation of storage stability at different temperature. *Food Sci. Technol.*, 90: 70–76.

Siaterlis, A., Deepika, G., and Charalampopoulos, D. 2009. Effect of culture medium and cryoprotectants on the growth and survival of probiotic lactobacilli during freeze drying. *Lett. Appl. Microbiol.*, 48: 295-301

Silva, C., Bovarotti, E., Rodrigues, M., Hokka, C., and Barboza, M. 2009. Evaluation of the effects of the parameters involved in the purification of clavulanic acid from fermentation broth by aqueous two-phase systems. *Bioproc Biosyst Eng*. 32: 625–632.

Silva, C.C.G., Silva, S.P.M., and Ribeiro, S.C. 2018. Application of bacteriocins and protective cultures in dairy food preservation. *Front Microbiol*, 9(594): 1-15.

Simonová, M.P., Chrastinová, L'., Chrenková, M., Formelová, Z., and Lauková, A. 2019. Lantibiotic nisin applied in broiler rabbits and its effect on the growth performance and carcass quality. *Probiotics Antimicrob. Proteins*, 11: 1414–1417

Simonson, L., Hannu Salovaara, H., and Korhola, M. 2003. Response of wheat sourdough parameters to temperature, NaCl and sucrose variations. *Food Microbiol*, 20: 193–199.

Singh, K., Kallali, B., Kumar, A., and Thaker, V. 2011. Probiotics: a review. *Asian Pac. J. Trop. Biomed.* 1: 287–290.

Singh, V., Haque, S., Niwas, R., Srivastava, A., Pasupuleti, M., and Tripathi, C.K.M. 2017. Strategies for fermentation medium optimization: An in-depth review. *Front Microbiol*, 7: 2087.

Singh, V., Khan, M., Khan, S., and Tripathi, C.K.M. 2009. Optimization of actinomycin V production by *Streptomyces triostinicus* using artificial neural network and genetic algorithm. *Appl. Microbiol. Biotechnol.*

Singh, V.P. 2018. Recent approaches in food bio-preservation - a review. *Open Vet. J.*, 8(1): 104-111.

Sinha, J., Dey, P.K., and Panda, T. 2000. Aqueous two-phase: the system of choice for extractive fermentation. *Appl Microbiol Biotechnol*. 54(4): 476-86.

Smith, J.S., Hillier, A.J., and Lees, G.J. 1975. The nature of the stimulation of the growth of *Streptococcus* lactis by yeast extract. *J Dairy Res.*, 42: 123–38.

Sohail, A., Turner, M.S., Coombes, A., and Bhandari, B. 2013. The viability of *Lactobacillus rhamnosus* GG and *Lactobacillus acidophilus* NCFM following double encapsulation in alginate and maltodextrin. *Food Bioproc Tech.*, 6: 2763-2769.

Soleimanpour, S., Hasanian, S.M., Avan, A., Yaghoubi, A., and Khazaei, M. 2020. Bacteriotherapy in gastrointestinal cancer. *Life Sci.*, 254: 117754

Souza, E.C., de Azevedo, P.O. de S., Domínguez, J. M., Converti, A., and Oliveira, R. P. de S. 2017. Influence of temperature and pH on the production of biosurfactant, bacteriocin and lactic acid by *Lactococcus lactis* CECT-4434. *CYTA-J Food*, 15(4): 525-530.

Sridevi, V., Yasarapu, N.S., Kancharana, S., Silarapu, S., Yerri, N.A., and Garapati, H.R. 2017. Optimized production of bacteriocin from cheaper carbon and nitrogen sources using response surface methodology. *Res. J. Microbiol.* 12: 42–49.

Stephenie, W., Kabeir, B.M., Shuhaimi, M., Rosfarizan, M., and Yazid, A.M. 2007. Influence of pH and impeller tip speed on the cultivation of *Bifidobacterium pseudocatenulatum* G4 in a milk-based medium. *Biotechnol. Bioprocess Eng.*, 12(5): 475–483.

Stergiou, V.A., Thomas, L.V., and Adams, M.R. 2006. Interactions of nisin with glutathione in a model protein system and meat. *J Food Prot*, 69: 951–956.

Stolz, P., Vogel, R.F., and Hammes, W.P. 1995. Utilization of electron acceptors by lactobacilli isolated from sourdough. II. *Lactobacillus pontis*, *L. reuteri*, *L. amylovorus*, and *L. fermentum*. *Z Lebensm Unters Forch*, 201: 402-410.

Suganthi, V., and Mohanasrinivasan, V. 2015. Optimization studies for enhanced bacteriocin production by *Pediococcus pentosaceus* KC692718 using response surface methodology. *Int. J. Food Sci. Technol.*, 52(6): 3773–3783.

Sukumar, G., and Ghosh, A.R. 2010. *Pediococcus* spp.–A potential probiotic isolated from Khadi (an Indian fermented food) and identified by 16S rDNA sequence analysis. *Afr J Food Sci*, 4: 597–602.

Sylvester, B., Porfire, A., Van Bockstal, P.J., Porav, S., Achim, M., De Beer, T., and Tomuță, I. 2018. Formulation optimization of freeze-dried long-circulating liposomes and in-line monitoring of the freeze-drying process using an NIR spectroscopy tool. *J Pharm Sci*, 107: 139-148.

Szabóová, R., Lauková, A., Simonová, M. P., Strompfová, V., and Chrastinova, L. 2012. Bacteriocin-producing enterococci from rabbit meat. *Malays J Microbiol*, 8(4): 211-218.

Tagg, J.R., Dajani, A.S., and Wannamaker, L.W. 1976. Bacteriocins of Gram-positive bacteria. *Bacteriol rev*, 40(3): 722-756.

Taheri, P., Samadi, N., Ehsani, M.R., Khoshayand, M.R., and Jamalifar, H. 2012. An evaluation and partial characterization of a bacteriocin produced by *Lactococcus lactis* subsp *lactis* ST1 isolated from goat milk. *Braz J Microbiol*, 43(4): 1452-1462.

Talib, N.S.R., Halmi, M.I.E., Ghani, S.S.A., Zaidan, U.H., and Shukor, M.Y.A. 2019. Artificial neural networks (ANNs) and Response surface methodology (RSM) approach for modelling the optimization of chromium (VI) reduction by newly isolated *Acinetobacter radioresistens* strain NS-MIE from agricultural soil. *Biomed Res Int*., Article ID 5785387.

Tan, C.H., Show, P.L., Ooi, C.W., Ng, E.P., Lan, J.C.W. and Ling, T.C. 2015. Novel lipase purification methods- a review of the latest developments. *Biotechnol. J.*, 10(1): 31–44.

Teixeira, P., Castrol, H., and Kirbyl, R. 1996. Evidence of Membrane Lipid Oxidation of Spray-Dried *Lactobacillus bulgaricus* During Storage. *Lett. Appl. Microbiol*. 22: 34–38.

Teng, D., Kawai, K., Mikajiri, S., and and Hagura, Y. 2017. Stabilization of freeze-dried *Lactobacillus paracasei* subsp. *paracasei* JCM 8130T with the addition of disaccharides, polymers, and their mixtures. *Biosci. Biotechnol. Biochem,* 81(4): 768-773.

Teuber, M. 1993. Lactic acid bacteria. In: Rehm, H.-J., Reed, G. (Eds). *Biotechnologyt* (pp. 326–365). Weinheim: Verlag Chemie.

Thakkar, P., Modi, H., Dabhi, B., and Prajapati, J. 2014. Bile tolerance, bile deconjugation and cholesterol reducing properties of Lactobacillus strains isolated from traditional fermented foods. *Int J Fermented Foods*, 3(2): 157-165.

Thirumurugan, A., Ramachandran, S., and Gobikrishnan, S. 2015. Optimization of medium components for maximizing the bacteriocin production by Lactobacillus plantarum ATM11 using statistical design. *Int Food Res J*, 22(3): 1272–1279.

Thomas, T.D., Ellwood, D.C., and Longyear, M.C. 1979. Change from homo- to heterolactic fermentation by *Streptococcus lactis* resulting from glucose limitation in anaerobic chemostat cultures. *J Bacteriol*, 138: 109–17.

Todorov, S.D., and Dicks, L.M. 2005. Effect of growth medium on bacteriocin production by *Lactobacillus plantarum* ST194BZ, a strain isolated from boza. *Food Technol. Biotechnol.*, 43(2): 165-173.

Todorov, S.D., and Dicks, L.M.T. 2006. Medium components effecting bacteriocin production by two strains of Lactobacillus plantarum ST414BZ and ST664BZ isolated from boza. *Biologia* 61: 269–274.

Todorov, S.D., Gotcheva, B., Dousset, X., Onno, B., and Ivanova, I. 2000. Influence of growth medium on bacteriocin production in *Lactobacillus plantarum* ST31. *Biotechnol. Biotechnol. Equip.*, 14 (1): 50-55.

Todorov, S.D., Stojanovski, S., Iliev, I., Moncheva, P., Nero, L. A., and Ivanova, I. V. 2017. Technology and safety assessment for lactic acid bacteria isolated from traditional Bulgarian fermented meat product "lukanka". *Braz J Microbiol*, 48: 576–586.

Todorov, S.D., Vaz-Velho, M., de Melo Franco, B.D.G., and Holzapfel, W.H. 2013. Partial characterization of bacteriocins produced by three strains of *Lactobacillus sakei*, isolated from salpicao, a fermented meat product from North-West of Portugal. *Food Control,* 30(1): 111-121.

Torres-Acosta, M.A., Mayolo-Deloisa, K., González-Valdez, J., and Rito-Palomares, M. 2019. Aqueous two-phase systems at large scale: Challenges and Opportunities. *Biotechnol. J.*, 14(1): 1–12.

Tripathi, M.K., and Giri, S.K. 2014. Probiotic functional foods: Survival of probiotics during processing and storage. *J. Funct. Foods,* 9: 225–241.

Tsvetkol, T., and Brankoval, R. 1983. Viability of Micrococci and Lactobacilli upon freezing and freeze-drying in the presence of different cryoprotectants. *Cryobiology*. 20: 318–323.

Turcotte, C., Lacroix, C., Kheadr, E., Grignon, L., and Fliss, I. 2004. A rapid turbidometric microplate bioassay for accurate quantification of lactic acid bacteria bacteriocins. *Int. J. Food Microbiol.* 90: 283–293.

Ünlü, G., Nielsen, B., and Ionita, C. 2015. Production of antilisterial bacteriocins from lactic acid bacteria in dairy-based media: A comparative study. *Probiotics Antimicrob. Proteins*, 7(4): 259-274.

Valsaraj, K.T., Thoma, G.J., Thibodeaux, L.J., and Wilson, D.J. 1991. Nonfoaming adsorptive bubble separation processes, *Sep. Technol*. 1: 234-244.

Venigalla, S., Sindhuja, Y.N., Srujuna, K., Swathi, S., Naidu, Y., and Rao, G.H. 2017. Optimized production of bacteriocin from cheaper carbon and nitrogen sources using response surface methodology. *Res. J. Microbiol*., 12(1): 42–49.

Vieco-Saiz, N., Belguesmia, Y., Raspoet R, Auclair, E., Gancel, F., Kempf, I., and Drider, D. 2019. Benefits and inputs from lactic acid bacteria and their bacteriocins as alternatives to antibiotic growth promoters during food-animal production. *Front Microbiol*, 10: 1-17.

Vijayakumar, P.P., and Muriana, P.M. 2015. A microplate growth inhibition assay for screening bacteriocins against *Listeria monocytogenes* to differentiate their mode-of-action. *Biomolecules*, 5(2): 1178–1194.

Vinderola, C.G., and Reinheimer, J.A. 2003. Lactic acid starter and probiotic bacteria: A comparative "in vitro" study of probiotic characteristics and biological barrier resistance. *Food Res Int*, 36: 895-904.

Viniegra–Gonzàlez, G. and Gómez, J. 1984. Lactic acid production by pure and mixed bacterial cultures. In Wise, D.L., (Ed). *Bioconversion Systems* (pp. 17–39). Boca Raton, FL: CRC Press, Inc.

Vlková, E., Rada, V., Popelářová, P., Trojanová, I., and Killer, J. 2006. Antimicrobial susceptibility of Bifidobacteria isolated from gastrointestinal tract of calves. *Livestock Sci*., 105: 253-259.

Von Mollendorff, J.W., Todorov, S.D., and Dicks, L.M.T. 2009. Optimization of growth medium for production of bacteriocins produced by *Lactobacillus plantarum* Jw3Bz and Jw6Bz, and *Lactobacillus fermentum* Jw11Bz and Jw15Bz isolated from Boza. *Trakia J. Sci.*, 7(1): 22–33.

Vyas, U. and Ranganathan, N. 2012. Probiotics, prebiotics, and synbiotics: Gut and beyond. *Gastroenterol. Res. Pract*. 872716.

Wang, G., Luo, L., Dong, C., Zheng, X., Guo, B., Xia, Y., Tao, L., and Ai, L. 2021. Polysaccharides can improve the survival of *Lactiplantibacillus plantarum* subjected to freeze-drying, *J. Dairy Sci.*, 104(3): 2606-2614.

Wang, S.J. and Zhong, J.J. 2006. Bioreactor Engineering. In Yang, S.T. (Ed.), *Bioprocessing for Value-added Products from Renewable Resources* (pp.131–161). Elsevier: Amsterdam.

Wang, W., and Wang, H. 2014. The effect of lactic acid bacteria in food and feed and their impact in food safety. *Int. J. Food Eng.,* 10(2): 203.

WHO. 2015. Food safety. Retrieved from http://www.who.int/news-room/fact-sheets/detail/food- safety. Retrieved 15 October 2020.

Wood, B.J.B., and Holzapfel, W.H. 1995. *The genera of lactic acid bacteria*, 1st Ed. Glasgow, UK: Blackie Academic and Professional.

Woraprayote, W., Malila, Y., Sorapukdee, S., Swetwiwathana, A., Benjakul, S., and Visessanguan, W. 2016. Bacteriocins from lactic acid bacteria and their applications in meat and meat products. *Meat Sci.*, 120: 118-132.

Woraprayote, W., Pumpuang, L., Tosukhowong, A., Roytrakul, S., Perez, R., Zendo, T., Sonomoto, K., Benjakul, S., and Visessanguan, W. 2015. Two putatively novel bacteriocins active against Gram-negative food borne pathogens produced by *Weissella hellenica* BCC 7293. *Food Control,* 55: 176-184.

Wu, Z., Hu, G., Wang, K., Zaslavsky, B.Y., Kurgan, L., Uversky, V.N. 2017. What are the structural features that drive partitioning of proteins in aqueous two-phase systems?. *Biochim. Biophys. Acta*, 1865 (1): 113-120.

Xanthopoulos, V., Litopoulou-Tzanetaki, E., and Tzanetakis, N. 2000. Characterization of *Lactobacillus* isolates from infant faeces as dietary adjuncts. *Food Microbiol.*, 17(2): 205–215.

Xu, Y., Tian, Y., Cao, Y., Li, J., Guo, H., Su, Y., Tian, Y., Wang, C., Want, T., and Zhang, L. 2019. Probiotic properties of *Lactobacillus paracasei* subsp. *paracasei* L1 and its growth performance-promotion in chicken by improving the intestinal microflora. *Front Physiol.*, 10: 1-14.

Yadav, R., and Shukla, P. 2015. An overview of advanced technologies for selection of probiotics and their expediency: a review. *Crit. Rev. Food Sci. Nutr.* 57(15):3233-3242

Yaghoubi, A., Khazaei, M., Hasanian, S.M., Avan, A., C Cho, W., and Soleimanpour, S. 2019. Bacteriotherapy in breast cancer. *Int. J. Mol. Sci.*, 20(23): 5880.

Yang, E., Fan, L., Yan, J., Jiang, Y., Doucette, C., Fillmore, S., and Walker, B. 2018. Influence of culture media, pH and temperature on growth and bacteriocin production of bacteriocinogenic lactic acid bacteria. *AMB Express*. 8:10.

Yang, R., and Ray, B. 1994. Factor influencing production of bacteriocins by lactic acid bacteria. *Food Microbiol.,* 11: 281–91.

Yang, R., Johnson, M. C., and Ray, B. 1992. Novel method to extract large amounts of bacteriocins from lactic acid bacteria. *Appl. Environ. Microbiol.*, 58: 3355–3359.

Ye, P., Wang, J., Liu, M., Li, P., and Gu, Q. 2021. Purification and characterization of a novel bacteriocin from *Lactobacillus paracasei* ZFM54, *LWT*, 143: 111125.

Yeo, S., Shin, H.S., Lee, H.W., Hong, D., Park, H., Holzapfel, W., Kim, E.B., and Huh, C.S. 2018. Determination of optimized growth medium and cryoprotective additives to enhance the growth and survival of *Lactobacillus salivarius*. *J. Microbiol. Biotechnol.*, 28(5): 718–731.

Yerlikaya, O. 2019. Probiotic potential and biochemical and technological properties of *Lactococcus lactis* ssp. *lactis* strains isolated from raw milk and kefir grains. *J. Dairy Sci.,* 102(1): 124–134.

Yeu, J.-E., Lee, H.-G., Park, G.-Y., Lee, J., and Kang, M.-S. 2021. Antimicrobial and antibiofilm activities of *Weissella cibaria* against pathogens of upper respiratory tract infections. *Microorganisms*, 9: 1181.

Yi, H., Han, X., Yang, Y., Liu, W., Liu, H., Zhang, Y., Sun, K., Zhang, L., and Ma, F. 2013. Effect of exogenous factors on bacteriocin production from Lactobacillus paracasei J23 by using a resting cell system. *Int J Mol Sci,* 14(12): 24355–24365.

Yi, L., Li, X., Luo, L., Lu, Y., Yan, H., Qiao, Z., and Lü, X. 2018. A novel bacteriocin BMP11 and its antibacterial mechanism on cell envelope of *Listeria monocytogenes* and *Cronobacter sakazakii*. *Food Control*, 91: 160–169.

Yi, L., Qi, T., Hong, Y., Deng, L., and Zeng, K. 2020. Screening of bacteriocin-producing lactic acid bacteria in Chinese homemade pickle and dry-cured meat, and bacteriocin identification by genome sequencing, *LWT*, 125: 109177.

Yong, C.C., Khoo, B.Y., Sasidharan, S., Piyawattanametha, W., Kim, S.H., Khemthongcharoen, N., Chuah, L.O., Ang, M.Y., and Liong, M.T. 2015. Activity of crude and fractionated extracts by lactic acid bacteria (LAB) isolated from local dairy, meat, and fermented products against *Staphylococcus aureus*. *Ann. Microbiol.,* 65(2): 1037–1047.

Zayed, G., and Roos, Y.H. 2004. Influence of trehalose and moisture content on survival of *Lactobacillus salivarius* subjected to freeze-drying and storage. *Process Biochem.,* 39: 1081–1086.

Zeng, H. and Yang, A. 2020. Bridging substrate intake kinetics and bacterial growth phenotypes with fux balance analysis incorporating proteome allocation. *Sci. Rep.*, 10: 4283.

Zhang, D.Y., Zu, Y.G., Fu, Y.J., Wang, W., Zhang, L., Luo, M., Mu, F.S., Yao, X.H., and Duan, M.H. 2013. Aqueous two-phase extraction and enrichment of two main flavonoids from pigeon pea roots and the antioxidant activity. *Sep Purif Technol*, 102: 26–33.

Zhang, J., Yang, Y., Yang, H., Bu, Y., Yi, H., Zhang, L., Han, X., and Ai, L. 2018. Purification and partial characterization of bacteriocin Lac- B23, a novel bacteriocin production by *Lactobacillus plantarum* J23, isolated from Chinese traditional fermented milk. *Front. Microbiol.*, 9: 2165.

Zhang, Z., Yu, Y.X., Wang, Y.G., Wei, X.X., Liao, M.J., Rong, X.J., and Chen, J. 2020. Development of a new protocol for freeze-drying preservation of *Pseudoalteromonas nigrifaciens* and its protective effect on other marine bacteria. *Electron J Biotechnol*, 44: 1-5.

Zhao, L., Peng, Y.-L., Gao, J.-M., and Cai, W.M. 2014. Bioprocess intensification: An aqueous two-phase process for the purification of C-phycocyanin from dry Spirulina platensis. *Eur. Food Res. Technol*. 238: 451–457.

Zhi, W., Song, J., Ouyang, F. and Bi, J. 2005. Application of response surface methodology to the modeling of α-amylase purification by aqueous two-phase systems. *J. Biotechnol.*, 118(2): 157-165.

Zielińska, D., Rzepkowska, A., Radawska, A., and Zieliński, K. 2015. *In vitro* screening of selected probiotic properties of *Lactobacillus* strains isolated from traditional fermented cabbage and cucumber. *Curr Microbiol*, 70(2): 183–194.

BIODATA OF STUDENT

The student was born in Kota Kinabalu, Sabah, Malaysia on 1 December 1980. She had her primary and secondary education in S.K Kebagu, Menggatal and S.M.K. Menggatal, Kota Kinabalu, Sabah, respectively. She gained her graduation degree in BSc. (Biotechnology) from Universiti Putra Malaysia, Serdang, Selangor in 2002. She worked as a tutor at Universiti Malaysia Sabah and then continued her study at the master level in plant biotechnology at the same university in 2003. Upon graduation in 2008, she has been promoted as a lecturer in Biotechnology Programme in School of Science and Technology (currently known as Faculty of Science and Natural Resources), Universiti Malaysia Sabah.

LIST OF PUBLICATIONS

Published

Jawan, R., Abbasiliasi, S., Tan, J.S., Kapri, M.R., Mustafa, S., Halim, M., and Ariff, A.B. 2021. Influence of type and concentration of lyoprotectants, storage temperature and storage duration on cell viability and antibacterial activity of freeze-dried lactic acid bacterium, *Lactococcus lactis* Gh1. *Drying Technology*. DOI: 10.1080/07373937.2021.1874968.

Jawan, R., Abbasiliasi, S., Tan, J.S., Kapri, M.R., Mustafa, S., Halim, M., and Ariff, A.B. 2021. Evaluation of the estimation capability of response surface methodology and artificial neural network for the optimization of bacteriocin-like inhibitory substances production by *Lactococcus lactis* Gh1. *Microorganisms*, 9(3): 1 – 22, 579. DOI: 10.3390/microorganisms9030579.

Jawan, R., Abbasiliasi, S., Tan, J.S., Mustafa, S., Halim, M., and Ariff. A.B. 2020. Influence of culture conditions and medium compositions on the production of bacteriocin-like inhibitory substances by *Lactococcus lactis* Gh1. *Microorganisms*. 8, 1454. DOI: 10.3390/microorganisms8101454.

Jawan, R., Abbasiliasi, S., Mustafa, S., Kapri, M. R., Halim, M., and Ariff, A.B. 2020. *In vitro* evaluation of potential probiotic strain *Lactococcus lactis* Gh1 and its bacteriocin-like inhibitory substances for potential use in the food industry. *Probiotics and Antimicrobial Proteins*. DOI: 10.1007/s12602-020-09690-3.

Jawan, R., Abbasiliasi, S., Mustafa, S., Halim, M., and Ariff, A.B. 2018. *In vitro* analysis of potential probiotic of isolated lactic acid bacteria from milk by-product. *Borneo Journal of Medical Sciences*. 1: 61 – 62. DOI: 10.51200/bjms.v0i0.1402.

Other published work

Jawan, R., Kasimin, M.E., Jalal, S.N., Mohd. Faik, A.A., Abbasiliasi, S., and Ariff, A.B. 2019. Isolation, characterisation, and *in vitro* evaluation of bacteriocins-producing lactic acid bacteria from fermented products of Northern Borneo for their beneficial roles in food industry. *J. Phys.: Conf. Ser.* 1358012020.

Kasimin, M.E., Mohd. Faik, A.A., Jani, J., Abbasiliasi, S., Ariff, A.B., and Jawan, R., 2020. Probiotic properties of antimicrobial-producing lactic acid bacteria isolated from dairy products and raw milk of Sabah (Northern Borneo), Malaysia. *Malays. Appl. Biol.* 49(3): 1–12.

Conference

Jawan, R., Abbasiliasi, S., Mustafa, S., Halim, M., and Ariff, A.B. 2018. *In vitro* analysis of potential probiotic of isolated lactic acid bacteria from milk by-product. 4th Scientific Research Conference on Health and Medical Sciences. 25 April 2018. Faculty of Medicine and Health Science, Universiti Malaysia Sabah, Malaysia. Poster presentation.

Jawan, R., Abbasiliasi, S., Mustafa, S., Halim, M., and Ariff, A.B. 2018. Influence of type and production of lyoprotectants on survivability of a lactic acid bacterium, *Lactococcus lactis* Gh1, isolated from a milk by-product). International Conference on beneficial microbes: microbes for the benefit of mankind. 30th July-1st August 2018. The Waterfront Hotel, Kuching, Sarawak, Malaysia. Poster presentation.

Jawan, R., Abbasiliasi, S., Tan, J.S., Mustafa, S., Halim, M., and Ariff. A. 2017. Fermentation factors influencing the production of bacteriocin-like inhibitory substances by *Lactococcus lactis* Gh1. 2nd Bioprocessing and Biomanufacturing Symposium 2017 (BBS 2017). 13rd December 2017. Sains@USM Complex, Universiti Sains Malaysia, Penang, Malaysia. Oral presentation.

Jawan, R., Abbasiliasi, S., Mustafa, S., Halim, M., and Ariff, A.B. 2016. *In vitro* evaluation of *Lactococcus lactis* Gh1 for its potential use in the food industry. 5th International Conference on Biotechnology and Bioengineering-ICBB 2016 8 - 10 December 2016. Bangkok, Thailand. Poster presentation.

Jawan, R., Abbasiliasi, S., Mustafa, S., Halim, M., and Ariff, A.B 2015. *Lactococcus lactis* Gh1 for potential use as probiotic in the food industry. Inaugural Bioprocessing and Biomanufacturing Seminar 2015. 12nd November 2015. Bangunan Canselori Putra, Universiti Putra Malaysia. Poster presentation.

Jawan, R., and Ariff, A. 2014. Biomanufacturing of bacteriocin-like inhibitory substances by lactic acid bacteria isolated from traditional fermented fruit. 22nd Biotech Colloquium. 16th December 2014. Faculty of Biotechnology and Biomolecular Sciences, Universiti Putra Malaysia. Oral presentation.

Award

Jawan, R., Abbasiliasi, S., Mustafa, S., Halim, M., and Ariff, A.B. 2018. *In vitro* analysis of potential probiotic of isolated lactic acid bacteria from milk by-product. 4th Scientific Research Conference on Health and Medical Sciences. Universiti Malaysia Sabah, Malaysia. Best poster presenter.