UNIVERSITI PUTRA MALAYSIA

ISOLATION, CHARACTERIZATION OF SPECIFIC BACTERIOPHAGES AND THEIR EFFECTIVENESS AS BIOCONTROLS ON RAW SEAFOODS CONTAMINATED WITH Vibrio parahaemolyticus

TAN CHIA WANQ

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By

TAN CHIA WANQ

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Chairman : Associate Professor Yaya Rukayadi, PhD
Faculty : Food Science and Technology

Vibrio parahaemolyticus is among the leading foodborne pathogens that can cause gastroenteritis, wound infections, and/or septicaemia in humans. Antimicrobial resistance also poses a significant global health issue. Research on alternative approaches such as the application of bacteriophage has become a potential solution to minimize the use of antibiotics. In this study, the prevalence and antibiotic-resistant patterns of *V. parahaemolyticus* were determined, and *V. parahaemolyticus* bacteriophages naturally present in seafood samples were isolated and characterized in detail. The genome of bacteriophages was later sequenced through whole-genome sequencing, followed by genome annotation. Finally, the characterized bacteriophages were used as a biocide to control the growth of *V. parahaemolyticus* in the food samples. According to the results, blood clams were detected at the highest prevalence rate (91.43%), followed by shrimp (88.57%), surf clams (82.86%), and squid (80.00%). Besides, 90.83% of the *V. parahaemolyticus* isolates were detected to be multidrug-resistant (MDR). Six *V. parahaemolyticus* species-specific bacteriophages were isolated from blood clam, shrimp, and surf clam samples. Morphological analysis revealed that bacteriophages ϕVp33, ϕVp22, ϕVp21 and ϕVp02 isolated from the shrimp samples belonged to the Podoviridae family. Bacteriophages ϕVp08 and ϕVp11 isolated from the blood clam and surf clam samples, respectively, were categorised into the Siphoviridae family. The optimal MOI for bacteriophage propagation was determined to be in the range of 0.001 to 1. The latent period of bacteriophages falls in the range of 10 to 20 min, and the burst size was approximately 17 to 51 PFU/cell. All bacteriophages were optimally stable over a wide range of temperature levels (20 to 50ºC) and pH levels (5 to 11). After the whole-genome sequencing analysis, the genome of bacteriophages was detected to be between 42,896 and 76,128 bp, with a GC content of 48.93 to 49.33%, and 47 to 101 open reading frames (ORFs). The annotation of each

predicted sequence revealed the presence of functional groups such as DNA regulation, structure, packaging, host lysis, hydrolysis, conjugation, and oxidation-reduction. In terms of the biological control application, bacteriophage suspensions achieved an average log reduction of *V. parahaemolyticus* in 2.85 ± 0.07 to 4.81 ± 0.14. Bacteriophage cocktails were observed to have an improved in vitro lytic activity compared to a single bacteriophage suspension. Oyster meat samples artificially contaminated with *V. parahaemolyticus* and treated with the bacteriophage cocktail also noticed a significant bacterial load reduction ($P < 0.05$) of 2.77 ± 0.53 to 3.07 ± 0.03 log CFU/g after 48 h of treatment. In conclusion, bacteriophages ϕVp33, ϕVp22, ϕVp21, ϕVp02, ϕVp08, and ϕVp11 isolated from the seafood samples demonstrated strong lytic activity against the growth of *V. parahaemolyticus*. Two bacteriophage cocktails (cocktail A and B) used in the inhibition of biofilm and biocontrol agents in food were found to have statistically significant effects in the reduction of biofilm formation and microbial loads of *V. parahaemolyticus* on the oyster meat samples. Bacteriophages in this study consequently proved to be practicable as biocontrol agents for the control of *V. parahaemolyticus*.

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

PENGASINGAN, PENCIRIAN BAKTERIOFAG TERTENTU DAN KEBERKESANANNYA SEBAGAI AGEN BIOKONTROL PADA MAKANAN LAUT MENTAH YANG TERCEMAR DENGAN *Vibrio parahaemolyticus*

Oleh

TAN CHIA WANQ

Mei 2021

Pengerusi : Profesor Madya Yaya Rukayadi, PhD
Fakulti : Sains dan Teknologi Makanan

Vibrio parahaemolyticus adalah salah satu patogen bawaan makanan terkemuka yang boleh menyebabkan gastroenteritis, jangkitan luka, dan/atau septikemia pada manusia. Selain itu, rintangan antimikroba adalah masalah penting yang menimbulkan masalah ancaman global terhadap kesihatan awam. Penyelidikan mengenai pendekatan alternatif seperti penerapan bakteriofag telah menjadi solusi berpotensi untuk meminimumkan penggunaan antibiotik. Dalam kajian ini, prevalens dan pola tahan antibiotik *V. parahaemolyticus* akan diperiksa. *V. parahaemolyticus* bakteriofag yang terdapat secara semula jadi dalam sampel makanan akan diasingkan dan dicirikan secara terperinci. Genom bakteriofag akan dijelaskan kemudian melalui penjujukan genom keseluruhan, diikuti dengan penjelasan genom. Terakhir, bakteriofag yang dicirikan akan digunakan sebagai biosida untuk meningkatkan tahap keselamatan makanan dengan mengawal pertumbuhan *V. parahaemolyticus* dalam sampel makanan. Dari hasilnya, kerang darah dikesan pada kadar prevalensi tertinggi (91,43%) diikuti oleh udang (88,57%), lala (82,86%), dan sotong (80,00%). Selain itu, 90.83% *V. parahaemolyticus* bakteria mempunyai ketahanan rintangan pelbagai ubat (MDR). Satu *V. parahaemolyticus* bakteria dari kerang darah menunjukkan nilai indeks MAR tertinggi 0.71 dan menunjukkan ketahanan terhadap 17 antibiotik. Enam spesies-spesifik *V. parahaemolyticus* bakteriofag diasingkan dari sampel kerang darah, udang, dan lala. Analisis morfologi menunjukkan bahawa bakteriofag ϕVp33, ϕVp22, ϕVp21 dan ϕVp02 yang diasingkan dari sampel udang adalah milik keluarga *Podovirida*. Bakteriofag ϕVp08 dan ϕVp11 diasingkan dari kerang darah dan lala dikategorikan dalam keluarga *Siphoviridae*. MOI optimum untuk pembiakan bakteriofag ditentukan 0,001 hingga 1. Tempoh laten bakteriofag berkisar antara 10 hingga 20 minit, dan ukuran pecah kira-kira 17 hingga 51 PFU/sel. Semua bakteriofag stabil secara optimum dalam pelbagai suhu dari 20ºC hingga 50ºC dan tahap pH dari 5

hingga 11. Analisis penjujukan genom keseluruhan menunjukkan genom bakteriofag dikesan antara 42,896 hingga 76,128 bp, kandungan GC 48,93 hingga 49,33%, dan dikodkan 47 hingga 101 bingkai bacaan terbuka (ORF). Anotasi setiap urutan yang diramalkan menunjukkan adanya kumpulan fungsional seperti peraturan DNA, struktur, pembungkusan, lisis inang, hidrolisis, konjugasi, dan pengurangan oksidasi. Untuk aplikasi kawalan biologi, penggantungan bakteriofag mencapai pengurangan log purata *V. parahaemolyticus* pada 2.85 ± 0.07 hingga 4.81 ± 0.14. Koktel bakteriofag dilihat mempunyai aktiviti lisis *in vitro* yang lebih baik berbanding dengan suspensi bakteriofag tunggal. Sampel daging tiram dicemari secara buatan dengan *V. parahaemolyticus* dan dirawat dengan koktel bakteriofag juga diperhatikan penurunan beban bakteria yang signifikan ($P < 0.05$) pada 2.77 ± 0.53 hingga 3.07 ± 0.03 log CFU/g setelah 48 jam rawatan.Kesimpulannya, bakteriofag ϕVp33, ϕVp22, ϕVp21, ϕVp02, ϕVp08, dan ϕVp11 yang diasingkan dari sampel makanan laut menunjukkan aktiviti litik yang kuat terhadap pertumbuhan *V. parahaemolyticus*. Dua koktel bakteriofag (koktel A dan B) yang digunakan dalam penghambatan agen biofilm dan biokontrol dalam makanan didapati mempunyai kesan yang signifikan secara statistik dalam pengurangan pembentukan biofilm dan muatan mikroba *V. parahaemolyticus* pada sampel daging tiram. Bakteriofag dalam kajian ini terbukti dapat dilaksanakan sebagai agen biokontrol untuk kawalan *V. parahaemolyticus*.

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Yaya Rukayadi, PhD
Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Hanan bin Hasan, PhD
Senior Lecturer
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Hirofumi Hara, PhD
Associate Professor
Malaysia-Japan International Institute of Technology (MJIIT)
University Teknologi Malaysia
(Member)

_____
ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

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LIST OF ABBREVIATIONS

APW	Alkaline peptone water
AST	Antibiotic susceptibility test
ATCC	American Type Culture Collection
BAM	Bacteriological Analytical Manual
CDC	Centers for Disease Control and Prevention
CFU	Colony forming unit
CFU/cm^2	Colony forming unit centimetre square
CFU/g	Colony forming unit per gram
CFU/ml	Colony forming unit per millilitre
CLSI	Clinical and Laboratory Standards Institute
COVIS	Cholera and Other Vibrio Illness Surveillance
CV	CHROMagar™ *Vibrio*
dNTPs	Deoxynucleotides
EPS	Exopolysaccharides
GC	Guanine-cytosine
INDEL	Insertion and deletion
LAMP	Loop-mediated isothermal amplification
MAR	Multiple antibiotic resistance
MCP	Major capsid protein
MDR	Multidrug-resistant
MHA	Mueller-Hinton agar
MIC	Minimal inhibitory concentration
MOI	Multiplicity of infection
MPa	Megapascal

MSP	Major sheath protein
NGS	Next generation sequencing
OD	Optical density
ORF	Open reading frame
PEG	Polyethylene glycol
PFU	Plaque forming unit
PFU/g	Plaque forming unit per gram
PHACTS	Phage Classification Tool Set
RFLP	Restriction fragment length polymorphism
RTE	Ready to eat
SDS-PAGE	Sodium dodecyl sulfate polyacrylamide gel electrophoresis
SM	Salt of magnesium
SNP	Single nucleotide polymorphisms
T3SS	Type III secretion system
T6SS	Type VI secretion system
TCBS	Thiosulfate citrate bile salts sucrose
TDH	Thermostable direct hemolysin
TE	Tris-EDTA
TEM	Transmission electron microscopy
TLH	Thermolabile hemolysin
TRH	Thermostable direct-related hemolysin
TSA	Tryptic soy agar
TSB	Tryptic soy broth
TTP	Tail tube protein
VBNC	Viable but non-culturable

CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

Vibrio parahaemolyticus was first discovered in 1950 by Tsunesaburo Fujino, after the outbreak of shirasu food poisoning in Japan. The classification of this microorganism was initially grouped under the genus *Pasteurella*, and is referred to as *Pasteurella parahaemolytica*. This species was later assigned to the *Vibrio* genus, because of its basic similarity with halophilic organisms. The new scientific name *Vibrio parahaemolyticus* was later proposed by Riichi Sakazaki, Setsuo Iwanami, and Hideo Fukumi, and was concluded by Tsunesaburo Fujino (Shinoda, 2011).

Vibrio parahaemolyticus is a natural microflora of marine and coastal water bodies that has been widely disseminated throughout the world (Alagappan *et al*., 2010). The ecological habitat of *V. parahaemolyticus* can be as free-living as bacterioplankton, and associated with seafood surfaces and parasites in the gastrointestinal tract of fish. Many higher organisms such as crustaceans and molluscan shellfish are frequently associated with *V. parahaemolyticus*. Shellfish and other aquatic organisms are thus often served as vehicles for the transmission of this foodborne pathogen. *V. parahaemolyticus* is identified as among the most prevalent foodborne pathogens in China, Japan, Taiwan, and the USA (Su and Liu, 2007; Wang *et al*., 2017; Ndraha *et al*., 2020). Infection of *V. parahaemolyticus* can cause gastroenteritis, wound infection or septicaemia. Gastroenteritis resulting from the consumption of *V. parahaemolyticus*-contaminated food may include abdominal cramps, diarrhoea, fever, nausea, tenesmus, and vomiting (Daniels *et al*., 1998). The syndromes of gastroenteritis are typically mild and self-limited. However, septicaemia can be fatal in some cases. The onset time after ingestion is 4 to 90 hours, with a mean of 17 hours and the median duration of the illness is 2 to 6 days (DePaola and Jones, 2012).

Antibiotics are utilized as antibacterial agents to fight off bacterial infections in humans. They are broadly used as growth-promoting agents as well as feed additives in food animals. Hence, the invention of antibiotics has completely revolutionised medical treatment, and saved millions of lives from bacterial infections. However, unmonitored, extensive use and misuse of antibiotics in medicine, agriculture, and aquaculture over the years has led to the development and global spread of antibiotic-resistant bacteria. Antimicrobial residues present in the environment resultant in selection pressure for antimicrobial-resistant bacteria. Moreover, the ever-increasing emergence of multidrug-resistant (MDR) bacteria which is resistant over two classes of antimicrobial agents poses a serious global health threat.

Bacteriophages, or phages, are bacteria viruses that have the ability to attack and destroy bacterial cells. Bacteriophages constitute a majority of organisms in the biosphere, and it is estimated that the global population of bacteriophages on Earth exceeds 10^{30} (Mushegian, 2020). Prior to the discovery of antibiotics, it was found that bacteriophages could be used as potential therapeutic agents to treat infectious diseases. However, the use of phage therapy had gradually declined at that time, primarily due to arguable phage preparation experiments, poor understanding of phage biology and the discovery of antibiotics. More recently, there has been a surge of interest in the study and application of bacteriophages as bio-controlling agents. In addition, gaining higher knowledge in molecular biology, advances in transmission electron microscopy and global antibiotics resistance threats eventually relighted the potential use of bacteriophages.

Bacteriophages will bind to their bacterial host, replicate with the use of host cellular mechanisms and cause lysis of bacterial cells. Most bacteriophages are highly host specific and usually infect only certain bacteria species or specific subspecies. From a clinical standpoint, bacteriophages are innocuous to health, and do not attack normal gut flora (Ghannad and Mohammadi, 2012). Bacteriophages can be used as natural antimicrobials alongside farm-to-fork production throughout the entire food chain (Jones *et al*., 2020). In the food industry, bacteriophages can be widely applied along the food chain to enhance food safety. The application of bacteriophages in phage therapy can potentially reduce or even prevent the colonization of bacterial pathogens in farm animals, thus reducing the morbidity and mortality rate in livestock. Moreover, they can be used for the protection of food products at the pre- and postharvest stage as preservatives to extend the expiry date of food products, and as bio-sanitizers to decontaminate raw products and equipment surfaces used in production plants (Połaska and Sokołowska, 2019).

1.2 Problem Statement

Vibrio parahaemolyticus is a Gram-negative halophilic bacterium that naturally occurs in marine environments, and is recognised to be among the leading foodborne pathogens that is frequently isolated from a variety of seafood sources (Wang *et al*., 2015). Gastroenteritis, which is characterised by abdominal pain, diarrhoea, fever and nausea, is an example of a common syndrome caused by the consumption of food contaminated with *V. parahaemolyticus*. Open wounds in contact with *V. parahaemolyticus* may also result in wound infection and life-threatening septicemia.

Based on the number of vibriosis infections reported to the Cholera and Other Vibrio Illness Surveillance (COVIS) system and Centers for Disease Control and Prevention (CDC) from 1996 to 2014, *V. parahaemolyticus* was identified to be the most common foodborne pathogen which caused 39–51% of *Vibrio* infections as compared to other *Vibrio* species such as *V. vulnificus*, *V. cholerae* (non-O1 and non-O139), *V. alginolyticus*, *V. fluvialis*, *V. mimicus*, and *V. hollisae* (Newton *et al*., 2012; CDC, 2019). The epidemiology of foodborne disease outbreaks caused by *Vibrio parahaemolyticus* has resulted in high medical costs on a global scale.

In the USA, almost 35,000 individuals domestically acquire foodborne *V. parahaemolyticus* illnesses annually (Scallan *et al*., 2011). In Japan, it is estimated that 500 to 800 *V. parahaemolyticus* outbreaks affect approximately 10,000 people annually, where sashimi and sushi are responsible for 26% and 23% of outbreaks, respectively (FAO/WHO, 2008). In Malaysia, *V. parahaemolyticus* outbreaks were likely unreported, but several studies reported that the high prevalence rate of *V. parahaemolyticus* was frequently detected in seafood (Letchumanan *et al.,* 2015; Malcolm *et al.,* 2015; Tan et al., 2017).

The incidence of antibiotic-resistant bacteria associated with food products is another serious healthcare issue. The development of foodborne pathogens that are resistant to several antibiotics classes has been reported in numerous studies. For example, Oh *et al*. (2011) reported that 65.1% of 218 *V. parahaemolyticus* strains isolated from farmed fish in Korea showed antimicrobial resistance to multiple antimicrobial agents. Yang *et al*. (2017) also reported that 68.38% of 98 *V. parahaemolyticus* isolates from seafood in China developed resistance to over three antibiotics. The higher prevalence of multidrug-resistant *V. parahaemolyticus* is most likely, due to the widespread use of antibiotics in the past, which allows foodborne pathogens to acquire antimicrobial resistance genes and express drug resistance. Hence, research on other alternative approaches such as the use of bacteriophages is a promising solution that could replace or potentially reduce the usage of antibiotics in food production and processing in the near future.

The application of *V. parahaemolyticus* bacteriophages as biocontrol agents in food products was limited in extent. To our knowledge, no *Vibrio* spp. specific bacteriophage-based products have been developed commercially for usage in aquaculture, biotherapy and food products. Only a few reports were found to demonstrate the usage of *V. parahaemolyticus* bacteriophages in reducing the concentration of *V. parahaemolyticus* in oysters (Jun *et al*., 2014a; Rong *et al*., 2014). For example, Jun *et al*. (2014a) reported the use of *V. parahaemolyticus* pVp-1 bacteriophages on live oysters through surface application and bath immersion. Rong *et al*. (2014) reported that the application of VPp1 bacteriophages during the depuration of oysters. The results were obtained with a significant reduction of *V. parahaemolyticus* following bacteriophage treatment. Hence, there is no doubt that *V. parahaemolyticus* bacteriophages can be used as biocontrol agents in the food and aquaculture industry to inhibit the growth of the *V. parahaemolyticus* foodborne pathogen. In addition, the use of bacteriophages could help to reduce the microbial contamination of food, improve food safety, supply safe food, and ensure a high level of public health protection (Principi *et al*., 2019; Vikram *et al*., 2021). In the near future, it is believed that a list of novel bacteriophage-based products which target *V. parahaemolyticus* as well as many other different foodborne pathogens and food spoilage bacteria will be available in the market, and will be widely applied in industry.

1.3 Objectives

Based on the hypotheses in the problem statement, the objectives of the present study are as follows:

a) To determine the prevalence and antibiotic-resistant patterns of *V. parahaemolyticus*

b) To screen and isolate for host specificity of *V. parahaemolyticus* bacteriophages

c) To characterize *V. parahaemolyticus* bacteriophage isolates that cause cell lysis in *V. parahaemolyticus*

d) To perform whole-genome sequencing and bioinformatics analysis of *V. parahaemolyticus* bacteriophages genome

e) To determine the in-vitro lytic ability of *V. parahaemolyticus* bacteriophages and examine the effectiveness of *V. parahaemolyticus* bacteriophages on biofilm and oyster meat samples

REFERENCES

Abanto, M., Gavilan, R. G., Baker-Austin, C., Gonzalez-Escalona, N. and Martinez-Urtaza, J. (2020). Global expansion of pacific northwest *Vibrio parahaemolyticus* sequence type 36. *Emerging Infectious Diseases*, 26(2), 323–326. https://doi.org/10.3201/eid2602.190362

Abedon, S. T., Kuhl, S. J., Blasdel, B. G. and Kutter, E. M. (2011). Phage treatment of human infections. *Bacteriophage,* 1(2), 66-85. https://doi.org/10.4161/bact.1.2.15845

Abedon, S. T. (2019). Look who's talking: T-even phage lysis inhibition, the granddaddy of virus-virus intercellular communication research. *Viruses*, 11(10), 951. https://doi.org/10.3390/v11100951

Abuladze, T., Li, M., Menetrez, M. Y., Dean, T., Senecal, A. and Sulakvelidze, A. (2008). Bacteriophages reduce experimental contamination of hard surfaces, tomato, spinach, broccoli, and ground beef by *Escherichia coli* O157:H7. *Applied and Environmental Microbiology*, 74(20), 6230 – 6238. https://doi.org/10.1128/AEM.01465-08

Ahmad, A., Brumble, L. and Maniaci, M. (2013). *Vibrio parahaemolyticus* induced necrotizing fasciitis: an atypical organism causing an unusual presentation. *Case Reports in Infectious Diseases*, 216854. https://doi.org/10.1155/2013/216854

Ahmadi, H., Radford, D., Kropinski, A. M., Lim, L. T. and Balamurugan, S. (2017). Thermal-stability and reconstitution ability of *Listeria* phages P100 and A511. *Frontiers in Microbiology*, 8, 2375. https://doi.org/10.3389/fmicb.2017.02375

Ahmed, H. A., El Bayomi, R. M., Hussein, M. A., Khedr, M. H. E., Abo Remela, E. M. and El-Ashram, A. M. M. (2018). Molecular characterization, antibiotic resistance pattern and biofilm formation of *Vibrio parahaemolyticus* and *V. cholerae* isolated from crustaceans and humans. *International Journal of Food Microbiology*, 274, 31–37. https://doi.org/10.1016/j.ijfoodmicro.2018.03.013

Akhwale, J. K., Rohde, M., Rohde, C., Bunk, B., Spröer, C., Boga, H. I., Klenk, H. P. and Wittmann, J. (2019). Isolation, characterisation and analysis of bacteriophages from the haloalkaline lake Elmenteita, Kenya. *PLOS ONE*, 14(4), e0215734. https://doi.org/10.1371/journal.pone.0215734

Alagappan, K. M., Deivasigamani, B., Somasundaram, S. T. and Kumaran, S. (2010). Occurrence of *Vibrio parahaemolyticus* and its specific phages from shrimp ponds in east coast of India. *Current Microbiology*, 61(4), 235–240. https://doi.org/10.1007/s00284-010-9599-0

Al-Othrubi, S. M., Kqueen, C. Y., Mirhosseini, H., Hadi, Y. A. and Radu, S., (2014). Antibiotic resistance of *Vibrio parahaemolyticus* isolated from cockles and shrimp sea food marketed in Selangor, Malaysia. *Clinical Microbiology*， 3, 148–154. https://doi.org/10.4172/2327-5073.1000148

Amalina, N.Z., Santha, S., Zulperi, D., Amal, M. N. A., Yusof, M. T., Zamri-Saad, M. and Ina-Salwany, M. Y. (2019). Prevalence, antimicrobial susceptibility and plasmid profiling of *Vibrio* spp. isolated from cultured groupers in Peninsular Malaysia. *BMC Microbiology*, 19**,** 251. https://doi.org/10.1186/s12866-019-1624-2

Anderson, B., Rashid, M. H., Carter, C., Pasternack, G., Rajanna, C., Revazishvili, T., Dean, T., Senecal, A. and Sulakvelidze, A. (2011). Enumeration of bacteriophage particles: Comparative analysis of the traditional plaque assay and real-time QPCR- and nanosight-based assays. *Bacteriophage*, 1(2), 86–93. https://doi.org/10.4161/bact.1.2.15456

Ashrafudoulla, M., Mizan, M. F. R., Park, H., Byun, K. H., Lee, N., Park, S. H. and Ha, S. D. (2019). Genetic relationship, virulence factors, drug resistance profile and biofilm formation ability of *Vibrio parahaemolyticus* isolated from mussel. *Frontiers in Microbiology*, 10, 513. https://doi.org/10.3389/fmicb.2019.00513

Aslam, B., Wang, W., Arshad, M. I., Khurshid, M., Muzammil, S., Rasool, M. H., Nisar, M. A., Alvi, R. F., Aslam, M. A., Qamar, M. U., Salamat, M. K. F. and Baloch, Z. (2018). Antibiotic resistance: a rundown of a global crisis. *Infection and Drug Resistance*, 11, 1645–1658. https://doi.org/10.2147/IDR.S173867

Ateba, C.N. and Akindolire, M.A. (2019). Isolation and characterisation of bacteriophages with lytic activity against virulent *Escherichia coli* O157:H7: potential bio-control agents. *Preprints*, 2019010132 https://doi.org/10.20944/preprints201901.0132.v1

Baba, K., Yamasaki, S., Nishibuchi, M. and Takeda, Y. (1992). Examination by site-directed mutagenesis of the amino acid residues of the thermostable direct hemolysin of *Vibrio parahaemolyticus* required for its hemolytic activity. *Microbial Pathogenesis,* 12(4), 279-287. http://dx.doi.org/10.1016/0882-4010(92)90046-Q

Bach, S.J., McAllister, T.A., Veira, D.M., Gannon, V.P. and Holley, R.A. (2003). Effect of bacteriophage DC22 on *Escherichia coli* O157:H7 in an artificial rumen system (Rusitec) and inoculated sheep. *Animal Research,* 52, 89-101. https://doi.org/10.1051/animres:2003009

Bai, J., Jeon, B. and Ryu, S. (2019). Effective inhibition of *Salmonella* Typhimurium in fresh produce by a phage cocktail targeting multiple host receptors. *Journal of Food Microbiology*, 77, 52–60. https://doi.org/10.1016/j.fm.2018.08.011

Baker, G. L. (2016). Food safety impacts from post-harvest processing procedures of molluscan shellfish. *Foods (Basel, Switzerland)*, 5(2), 29. https://doi.org/10.3390/foods5020029

Baker, M. (2012). De novo genome assembly: what every biologist should know. *Nature Methods*, 9(4), 333–337. https://doi.org/10.1038/nmeth.1935

Baker-Austin, C., Stockley, L., Rangdale, R. and Martinez-Urtaza, J. (2010). Environmental occurrence and clinical impact of *Vibrio vulnificus* and *Vibrio parahaemolyticus*: a European perspective. *Environmental Microbiology Reports,* 2, 7-18. http://dx.doi.org/10.1111/j.1758-2229.2009.00096.x

Baker-Austin, C., Oliver, J. D., Alam, M., Ali, A., Waldor, M. K., Qadri, F. and Martinez-Urtaza, J. (2018). *Vibrio* spp. infections. *Nature Reviews Disease Primers*, 4(1), 1–19. https://doi.org/10.1038/s41572-018-0005-8

Bankevich, A., Nurk, S., Antipov, D., Gurevich, A. A., Dvorkin, M., Kulikov, A. S., Lesin, V. M., Nikolenko, S. I., Pharma, S., Prjibelski, A. D., Pyshkin, A. V., Sirotkin, A. V., Vyahhi, N., Tesler, G., Alekseyev, M. A. and Pevzner, P. A. (2012). SPAdes: a new genome assembly algorithm and its applications to single-cell sequencing. *Journal of Computational Biology*, 19(5), 455–477.

Bastías, R., Higuera, G., Sierralta, W. and Espejo, R. T. (2010). A new group of cosmopolitan bacteriophages induce a carrier state in the pandemic strain of *Vibrio parahaemolyticus*. *Environmental Microbiology*, 12(4), 990–1000. https://doi.org/10.1111/j.1462-2920.2010.02143.x

Baudoux, A. C., Hendrix, R. W., Lander, G. C., Bailly, X., Podell, S., Paillard, C., Johnson, J. E., Potter, C. S., Carragher, B. and Azam, F. (2012). Genomic and functional analysis of *Vibrio* phage SIO-2 reveals novel insights into ecology and evolution of marine siphoviruses. *Environmental Microbiology*, 14(8), 2071–2086. https://doi.org/10.1111/j.1462-2920.2011.02685.x

Bauer, A. W., Kirby, W. M. M., Sherris, J. C. and Turck, M. (1966). Antibiotic susceptibility testing by a standardized single disk method. *American Journal of Clinical Pathology*, 45, 493.

Beltrame, C. A., Kubiak, G. B., Lerin, L. A., Rottava, I., Mossi, A. J., Oliveira, D. de, Cansian, R. L., Treichel., H. and Toniazzo, G. (2012). Influence of different sanitizers on food contaminant bacteria: effect of exposure temperature, contact time, and product concentration. *Food Science and Technology*, 32, 228–232. https://doi.org/10.1590/S0101-20612012005000046

Beck, N. K., Callahan, K., Nappier, S. P., Kim, H., Sobsey, M. D. and Meschke, J. S. (2009). Development of a spot-titer culture assay for quantifying

bacteria and viral indicators. *Journal of Rapid Methods & Automation in Microbiology*, 17(4), 455–464. https://doi.org/10.1111/j.1745-4581.2009.00182.x

Bej, A. (2011). Vibrio. In *Molecular detection of human bacterial pathogens,* ed. D. Liu, pp. 1073–1088. Boca Raton, Florida: CRC Press.

Bej, A. K., Patterson, D. P., Brasher, C. W., Vickery, M. C. L., Jones, D. D. and Kaysner, C. A. (1999). Detection of total and hemolysin-producing *Vibrio parahaemolyticus* in shellfish using multiplex PCR amplification of *tlh*, *tdh* and *trh*. *Journal of Microbiological Methods*, 36(3), 215–225. http://doi.org/10.1016/S0167-7012(99)00037-8

Berutti, T., Williams, R., Shen, S., Taylor, M. and Grimes, D. (2014). Prevalence of urease in *Vibrio parahaemolyticus* from the Mississippi Sound.
Letters in Applied Microbiology, 58, 624-628. https://doi.org/10.1111/lam.12237

Beshiru, A., Okareh, O. T., Okoh, A. I. and Igbinosa, E. O. (2020). Detection of antibiotic resistance and virulence genes of *Vibrio* strains isolated from ready-to-eat shrimps in Delta and Edo States, Nigeria. *Journal of Applied Microbiology*, 14590. https://doi.org/10.1111/jam.14590

Bhoopong, P., Palittapongarnpim, P., Pomwised, R., Kiatkittipong, A., Kamruzzaman, M., Nakaguchi, Y., Nishibuchi, M., Ishibashi, M. and Vuddhakul, V. (2007). Variability of properties of *Vibrio parahaemolyticus* strains isolated from individual patients. *Journal of Clinical Microbiology*, 45(5), 1544-1550. http://dx.doi.org/10.1128/JCM.02371-06

Bhuiyan, N. A., Ansaruzzaman, M., Kamruzzaman, M., Alam, K., Chowdhury, N. R., Nishibuchi, M., Faruque, S. H., Sack, D. A., Takeda, Y. and Nair, G. B. (2001). Prevalence of the pandemic genotype of *Vibrio parahaemolyticus* in Dhaka, Bangladesh, and significance of its distribution across different serotypes. *Journal of Clinical Microbiology,* 40(1), 284-286. http://dx.doi.org/10.1128/JCM.40.1.284-286.2002

Biswas, B., Adhya, S., Washart, P., Paul, B., Trostel, A. N., Powell, B., Carlton, R. and Merril, C. R. (2002). Bacteriophage therapy rescues mice bacteremic from a clinical isolate of vancomycin-resistant Enterococcus faecium. *Infection and Immunity*, 70(1), 204–210. https://doi.org/10.1128/iai.70.1.204-210.2002

Bonilla, N., Rojas, M. I., Netto Flores Cruz, G., Hung, S. H., Rohwer, F. and Barr, J. J. (2016). Phage on tap-a quick and efficient protocol for the preparation of bacteriophage laboratory stocks. *PeerJ*, 4, e2261–e2261. https://doi.org/10.7717/peerj.2261

Bremner, W., Campbell, T., Ferera, J. and Zaman, R. (2016). Evaluating double agar overlay assay and flow cytometry as methods for

characterising competition between T4 and T7 bacteriophages in *Escherichia coli* C600. *Journal of Experimental Microbiology and Immunology*, 20, 69–77.

Bryan, D., El-Shibiny, A., Hobbs, Z., Porter, J. and Kutter, E. M. (2016). Bacteriophage T4 infection of stationary phase *E. coli*: life after log from a phage perspective. *Frontiers in Microbiology*, *7*, 1391. https://doi.org/10.3389/fmicb.2016.01391

Buttimer, C., McAuliffe, O., Ross, R. P., Hill, C., O'Mahony, J. and Coffey, A. (2017). Bacteriophages and bacterial plant diseases. *Frontiers in Microbiology,* 8, 34. http://doi.org/10.3389/fmicb.2017.00034

Callaway, T. R., Edrington, T. S., Brabban, A. D., Anderson, R. C., Rossman, M. L., Engler, M. J., Carr, M. A., Genovese, K. J., Keen, J. E., Looper, M. L., Kutter, E. M. and Nisbet, D. J. (2008). Bacteriophage isolated from feedlot cattle can reduce Escherichia coli O157:H7 populations in ruminant gastrointestinal tracts. *Foodborne Pathogens and Disease*, 5(2), 183–191. https://doi.org/10.1089/fpd.2007.0057

Camacho, C., Coulouris, G., Avagyan, V., Ma, N., Papadopoulos, J., Bealer, K. and Madden, T. L. (2009). BLAST+: architecture and applications. *BMC Bioinformatics*, 10(1), 421. https://doi.org/10.1186/1471-2105-10-421

Carrias, A., Welch, T. J., Waldbieser, G. C., Mead, D. A., Terhune, J. S. and Liles, M. R. (2011). Comparative genomic analysis of bacteriophages specific to the channel catfish pathogen *Edwardsiella ictaluri*. *Virology Journal*, 8, 6. https://doi.org/10.1186/1743-422X-8-6

Carter, C. D., Parks, A., Abuladze, T., Li, M., Woolston, J., Magnone, J., Senecal, A., Kropinski, A. M. and Sulakvelidze, A. (2012). Bacteriophage cocktail significantly reduces *Escherichia coli* O157: H7 contamination of lettuce and beef, but does not protect against recontamination. *Bacteriophage*, 2(3), 178–185. https://doi.org/10.4161/bact.22825

Carvalho, C. M., Gannon, B. W., Halfhide, D. E., Santos, S. B., Hayes, C. M., Roe, J. M. and Azeredo, J. (2010). The in vivo efficacy of two administration routes of a phage cocktail to reduce numbers of *Campylobacter coli* and *Campylobacter jejuni* in chickens. *BMC Microbiology*, 10, 232. https://doi.org/10.1186/1471-2180-10-232

Ceccarelli, D., Hasan, N. A., Huq, A. and Colwell, R. R. (2013). Distribution and dynamics of epidemic and pandemic *Vibrio parahaemolyticus* virulence factors. *Frontiers in Cellular and Infection Microbiology,* 3, 97. http://dx.doi.org/10.3389/fcimb.2013.00097

Centers for Disease Control and Prevention (CDC) (2013). Signs & symptoms: *Vibrio parahaemolyticus* illnesses associated with consumption of shellfish, United States, 2013.

https://www.cdc.gov/vibrio/investigations/vibriop-09-13/signs-symptoms.html (accessed 20 October 2019).

Centers for Disease Control and Prevention (CDC) (2019). Cholera and Other Vibrio Illness Surveillance (COVIS). https://www.cdc.gov/vibrio/investigations/vibriop-09-13/signs-symptoms.html (accessed 22 October 2019).

Chang, Y., Lee, J. H., Shin, H., Heu, S. and Ryu, S. (2013). Characterization and complete genome sequence analysis of *Staphylococcus aureus* bacteriophage SA12. *Virus Genes*, 47(2), 389–393. https://doi.org/10.1007/s11262-013-0938-7

Chen, J., Zhang, R., Qi, X., Zhou, B., Wang, J., Chen, Y. and Zhang, H. (2017). Epidemiology of foodborne disease outbreaks caused by *Vibrio parahaemolyticus* during 2010–2014 in Zhejiang province, China. *Food Control*, 77, 110–115. https://doi.org/10.1016/j.foodcont.2017.02.004

Chen, X., Li, Y., Yao, W., Wu, T., Zhu, Q., Zhang, Y., Ye, H., Wang, R., Zheng, S., Yu, F., Chen, W., Zhu, Z., Mao, L., Hu, Q., Tang, Z., Chen, H., Liu, Y. and Chen, Y. (2019). A new emerging serotype of *Vibrio parahaemolyticus* in China is rapidly becoming the main epidemic strain. *Clinical Microbiology and Infection*. https://doi.org/10.1016/j.cmi.2019.09.024

Chiou, C., Hsu, S., Chiu, S., Wang, T. and Chao, C. (2000). *Vibrio parahaemolyticus* serovar O3:K6 as cause of unusually high incidence of food-borne disease outbreaks in Taiwan from 1996 to 1999. *Journal of Clinical Microbiology,* 38(12), 4621-4625.

Chowdhury, A., Ishibashi, M., Thiem, V. D., Tuyet, D. T., Tung, T. V., Chien, B. T., Seidlein, L. V., Canh, D. G., Clemens, J., Trach, D. and Nishibuchi, M. (2004). Emergence and serovar transition of *Vibrio parahaemolyticus* pandemic strains isolated during a diarrhea outbreak in Vietnam between 1997 and 1999. *Microbiology and Immunology,* 48(4), 319-327. https://doi.org/10.1111/j.1348-0421.2004.tb03513.x

Christensen, J.R. (1965). The kinetics of reversible and irreversible attachment of bacteriophage T 1. *Virology*, 26(4), 727-737. https://doi.org/10.1016/0042-6822(65)90336-3

Chun, J., Oren, A., Ventosa, A., Christensen, H., Arahal, D. R., da Costa, M. S., Rooney, A. P., Yi, H., Xu, X. W., Meyer, S. D. and Trujillo, M. E. (2018). Proposed minimal standards for the use of genome data for the taxonomy of prokaryotes. *International Journal of Systematic and Evolutionary Microbiology*, 68(1), 461–466. https://doi.org/10.1099/ijsem.0.002516

Clark, J. R. and March, J. B. (2006). Bacteriophages and biotechnology: vaccines, gene therapy and antibacterials. *Trends in Biotechnology*, 24(5), 212–218. https://doi.org/10.1016/j.tibtech.2006.03.003

CLSI (2010). Methods for Antimicrobial Dilution and Disk Susceptibility Testing of Infrequently Isolated or Fastidious Bacteria; Approved Guideline - Second Edition. CLSI document M45-A2. Clinical and Laboratory Standards Institute, Pennsylvania.

Comeau, A. M., Hatfull, G. F., Krisch, H. M., Lindell, D., Mann, N. H. and Prangishvili, D. (2008). Exploring the prokaryotic virosphere. *Research in Microbiology*, 159(5), 306–313. https://doi.org/10.1016/j.resmic.2008.05.001

Courchesne, N. M. D., Parisien, A. and Lan, C. Q. (2009). Production and application of bacteriophage and bacteriophage-encoded lysins. *Recent Patents on Biotechnology*, 3(1), 37–45. https://doi.org/10.2174/187220809787172678

Coutard, F., Crassous, P., Droguet, M., Gobin, E., Colwell, R. R., Pommepuy, M. and Hervio-Heath, D. (2007). Recovery in culture of viable but nonculturable *Vibrio parahaemolyticus*: regrowth or resuscitation? *The ISME Journal*, 1(2), 111–120. https://doi.org/10.1038/ismej.2007.1

Dai, J. H., Lee, Y. S. and Wong, H. C. (1992). Effects of iron limitation on production of a siderophore, outer membrane proteins, and hemolysin and on hydrophobicity, cell adherence, and lethality for mice of *Vibrio parahaemolyticus*. *Infection and Immunity*, 60(7), 2952–2956.

Dakheel, K. H., Rahim, R. A., Neela, V. K., Al-Obaidi, J. R., Hun, T. G., Isa, M. N. M. and Yusoff, K. (2019). Genomic analyses of two novel biofilm-degrading methicillin-resistant Staphylococcus aureus phages. *BMC Microbiology*, 19(1), 114. https://doi.org/10.1186/s12866-019-1484-9

Daniels, N. A., Mackinnon, L., Bishop, R., Altekruse, S., Ray, B., Hammond, R. M., Thompson, S., Wilson, S., Bean, N. H., Griffin, P. M. and Griffin, P. M. (1998). *Vibrio parahaemolyticus Infections in the United States, 1973 – 1998*. *The Journal of Infectious Diseases*, 181(5), 1661–1666. https://doi.org/10.1086/315459

de Melo, L. M., Almeida, D., Hofer, E., Dos Reis, C. M., Theophilo, G. N., Santos, A. F. and Vieira, R. H. (2011). Antibiotic resistance of *Vibrio parahaemolyticus* isolated from pond-reared *Litopenaeus vannamei* marketed in natal, Brazil. *Brazilian Journal of Microbiology*, 42(4), 1463–1469. https://doi.org/10.1590/S1517-838220110004000032

Delost, M. D. (2014). *Introduction to diagnostic microbiology for the laboratory Sciences*. Burlington, Massachusetts: Jones & Bartlett Learning.

DePaola, A. and Jones, J. L. (2012). *Vibrio parahaemolyticus*. In *Bad bug book, foodborne pathogenic microorganisms and natural toxins*, ed. K. A. Lampel, S. Al-Khaldi, and S. M. Cahill, 2nd edition, pp. 26-29. Retrieved March 18, 2020, from https://www.fda.gov/files/food/published/Bad-Bug-Book-2nd-Edition-%28PDF%29.pdf

Deshpande, S. S. (2002). *Handbook of food toxicology*. New York, NY: Marcel Dekker.

Desjardins, P. and Conklin, D. (2010). NanoDrop microvolume quantitation of nucleic acids. *Journal of Visualized Experiments: JoVE*, 45, 2565. https://doi.org/10.3791/2565

Dion, M. B., Oechslin, F. and Moineau, S. (2020). Phage diversity, genomics and phylogeny. *Nature Reviews Microbiology*, 18(3), 125–138. https://doi.org/10.1038/s41579-019-0311-5

Dong, X., Li, Z., Wang, X., Zhou, M., Lin, L., Zhou, Y. and Li, J. (2016). Characteristics of *Vibrio parahaemolyticus* isolates obtained from crayfish (*Procambarus clarkii*) in freshwater. *International Journal of Food Microbiology*, 238, 132–138. https://doi.org/https://doi.org/10.1016/j.ijfoodmicro.2016.09.004

Doss, J., Culbertson, K., Hahn, D., Camacho, J. and Barekzi, N. (2017). A review of phage therapy against bacterial pathogens of aquatic and terrestrial organisms. *Viruses*, 9(3). https://doi.org/10.3390/v9030050

Douglass, A. P., O'Brien, C. E., Offei, B., Coughlan, A. Y., Ortiz-Merino, R. A., Butler, G., Byrne, K. P. and Wolfe, K. H. (2019). Coverage-versus-length plots, a simple quality control step for de novo yeast genome sequence assemblies. *G3 (Bethesda, Md.)*, 9(3), 879–887. https://doi.org/10.1534/g3.118.200745

Drulis-Kawa, Z., Mackiewicz, P., Kęsik-Szeloch, A., Maciaszczyk-Dziubinska, E., Weber-Dąbrowska, B., Dorotkiewicz-Jach, A., Augustyniak, D., Majkowska-Skrobek, G., Bocer, T., Empel, J. and Kropinski, A. M. (2011). Isolation and characterisation of KP34—a novel φKMV-like bacteriophage for *Klebsiella pneumoniae*. *Applied Microbiology and Biotechnology*, 90(4), 1333–1345. https://doi.org/10.1007/s00253-011-3149-y

Drulis-Kawa, Z., Majkowska-Skrobek, G., Maciejewska, B., Delattre, A. S. and Lavigne, R. (2012). Learning from bacteriophages - advantages and limitations of phage and phage-encoded protein applications. *Current Protein & Peptide Science*, 13(8), 699–722. https://doi.org/10.2174/138920312804871193

Dykes, G. A. and Moorhead, S. M. (2002). Combined antimicrobial effect of nisin and a listeriophage against *Listeria monocytogenes* in broth but not

in buffer or on raw beef. *International Journal of Food Microbiology*, 73(1), 71–81. https://doi.org/10.1016/s0168-1605(01)00710-3

Elbreki, M., Ross, R. P., Hill, C., O'Mahony, J., McAuliffe, O. and Coffey, A. (2014). Bacteriophages and their derivatives as biotherapeutic agents in disease prevention and treatment. *Journal of Viruses*, 382539. https://doi.org/10.1155/2014/382539

Elmahdi, S., Parveen, S., Ossai, S., DaSilva, L. V., Jahncke, M., Bowers, J. and Jacobs, J. (2017). *Vibrio parahaemolyticus* and *Vibrio vulnificus* recovered from oysters during an oyster relay study. *Applied and Environmental Microbiology,* 84(3), e01790-17. https://doi.org/10.1128/aem.01790-17

Endersen, L., Buttimer, C., Nevin, E., Coffey, A., Neve, H., Oliveira, H., Lavigne, R. and O'Mahony, J. (2017). Investigating the biocontrol and anti-biofilm potential of a three phage cocktail against *Cronobacter sakazakii* in different brands of infant formula. *International Journal of Food Microbiology*, 253, 1–11. https://doi.org/https://doi.org/10.1016/j.ijfoodmicro.2017.04.009

Fabbri, A., Falzano, L., Frank, C., Donelli, G., Matarrese, P., Raimondi, F., Fasano, A. and Fiorentini, C. (1998). *Vibrio parahaemolyticus* thermostable direct hemolysin modulates cytoskeletal organization and calcium homeostasis in intestinal cultured cells. *Infection and Immunity,* 67(3), 1139-1148.

FAO/WHO. (2008). *Risk assessment of Vibrio parahaemolyticus in seafood*: *interpretative summary and technical report*. Food and Agriculture Organization of the United Nations/World Health Organization. Retrieved April 29, 2020, from http://www.fao.org/3/a-i2225e.pdf

Fernández, B., Barrios, M. E., Cammarata, R. V, Torres, C. and Mbayed, V. A. (2019). A65 Characterization of endolysin gene of bacteriophages infecting *Listeria* spp. isolated from dairy industry wastewater. *Virus Evolution*, *5*(Supplement_1). https://doi.org/10.1093/ve/vez002.064

Fernández, L., Escobedo, S., Gutiérrez, D., Portilla, S., Martínez, B., García, P. and Rodríguez, A. (2017). Bacteriophages in the dairy environment: from enemies to allies. *Antibiotics (Basel, Switzerland)*, 6(4), 27. https://doi.org/10.3390/antibiotics6040027

Ferriol-González, C. and Domingo-Calap, P. (2020). Phages for biofilm removal. *Antibiotics (Basel, Switzerland)*, 9(5), 268. https://doi.org/10.3390/antibiotics9050268

Fong, K., LaBossiere, B., Switt, A. I. M., Delaquis, P., Goodridge, L., Levesque, R. C., Danyluk, M. D. and Wang, S. (2017). Characterisation of four novel bacteriophages isolated from British Columbia for control of non-

typhoidal *Salmonella* in vitro and on sprouting alfalfa seeds. *Frontiers in Microbiology*, 8, 2193. https://doi.org/10.3389/fmicb.2017.02193

Galié, S., García-Gutiérrez, C., Miguélez, E. M., Villar, C. J. and Lombó, F. (2018). Biofilms in the food industry: health aspects and control methods. *Frontiers in Microbiology*, 9, 898. https://doi.org/10.3389/fmicb.2018.00898

García, P., Martínez, B., Obeso, J. M. and Rodríguez, A. (2008). Bacteriophages and their application in food safety. *Letters in Applied Microbiology*, 47(6), 479–485. http://doi.org/10.1111/j.1472-765X.2008.02458.x

García, P., Rodríguez, L., Rodríguez, A. and Martínez, B. (2010). Food biopreservation: promising strategies using bacteriocins, bacteriophages and endolysins. *Trends in Food Science & Technology*, 21(8), 373–382. https://doi.org/https://doi.org/10.1016/j.tifs.2010.04.010

Geng, Y., Tan, K., Liu, L., Sun, X. X., Zhao, B. and Wang, J. (2019). Development and evaluation of a rapid and sensitive RPA assay for specific detection of *Vibrio parahaemolyticus* in seafood. *BMC Microbiology*, 19(1), 186. https://doi.org/10.1186/s12866-019-1562-z

Ghannad, M. S. and Mohammadi, A. (2012). Bacteriophage: time to re-evaluate the potential of phage therapy as a promising agent to control multidrug-resistant bacteria. *Iranian Journal of Basic Medical Sciences*, 15(2), 693–701.

Ghenem, L., Elhadi, N., Alzahrani, F. and Nishibuchi, M. (2017). *Vibrio Parahaemolyticus*: a review on distribution, pathogenesis, virulence determinants and epidemiology. *Saudi Journal of Medicine & Medical Sciences*, 5(2), 93–103. https://doi.org/10.4103/sjmms.sjmms_30_17

Givens, C. E., Bowers, J. C., Depaola, A., Hollibaugh, J. T. and Jones, J. L. (2014). Occurrence and distribution of *Vibrio vulnificus* and *Vibrio parahaemolyticus* - potential roles for fish, oyster, sediment and water. *Letters in Applied Microbiology*, 58(6), 503-510. https://doi.org/10.1111/lam.12226

Golec, P., Karczewska-Golec, J., Łoś, M. and Węgrzyn, G. (2014). Bacteriophage T4 can produce progeny virions in extremely slowly growing Escherichia coli host: comparison of a mathematical model with the experimental data. *FEMS Microbiology Letters*, 351(2), 156–161. https://doi.org/10.1111/1574-6968.12372

Goodridge, L. D. and Bisha, B. (2011). Phage-based biocontrol strategies to reduce foodborne pathogens in foods. *Bacteriophage*, 1(3), 130–137. https://doi.org/10.4161/bact.1.3.17629

Grant, A., Parveen, S., Schwarz, J., Hashem, F. and Vimini, B. (2017). Reduction of *Salmonella* in ground chicken using a bacteriophage. *Poultry Science*, 96(8), 2845–2852. https://doi.org/10.3382/ps/pex062

Greer, G. G. (2005). Bacteriophage control of foodborne bacteria. *Journal of Food Protection*, 68(5), 1102–1111. https://doi.org/10.4315/0362-028x-68.5.1102

Gufe, C., Hodobo, T. C., Mbonjani, B., Majonga, O., Marumure, J., Musari, S., Jongi, G., Makaya, P. V. and Machakwa, J. (2019). Antimicrobial profiling of bacteria isolated from fish sold at informal market in Mufakose, Zimbabwe. *International Journal of Microbiology*, 8759636. https://doi.org//10.1155/2019/8759636.

Haendiges, J., Jones, J., Myers, R. A., Mitchell, C. S., Butler, E., Toro, M. and Gonzalez-Escalona, N. (2016). A nonautochthonous U.S. strain of *Vibrio parahaemolyticus* isolated from Chesapeake Bay oysters caused the outbreak in Maryland in 2010. *Applied and Environmental Microbiology,* 82(11), 3208-3216. http://dx.doi.org/10.1128/AEM.00096-16

Hagens, S. and Loessner, M. J. (2007). Application of bacteriophages for detection and control of foodborne pathogens. *Applied Microbiology and Biotechnology*, 76(3), 513–519. https://doi.org/10.1007/s00253-007-1031-8

Hagens, S. and Loessner, M. J. (2010). Bacteriophage for biocontrol of foodborne pathogens: calculations and considerations. *Current Pharmaceutical Biotechnology*, 11(1), 58–68. https://doi.org/10.2174/138920110790725429

Ham, H. and Orth, K. (2012). The role of type III secretion system 2 in *Vibrio parahaemolyticus* pathogenicity. *Journal of Microbiology*, 50(5), 719–25. http://doi.org/10.1007/s12275-012-2550-2

Hanlon, G. W. (2007). Bacteriophages: an appraisal of their role in the treatment of bacterial infections. *International Journal of Antimicrobial Agents*, 30, 118–128. http://doi.org/10.1016/j.ijantimicag.2007.04.006

Hara-Kudo, Y., Sugiyama, K., Nishibuchi, M., Chowdhury, A., Yatsuyanagi, J., Saito, A., Nagano, H., Nakagawa, H. and Konuma, H. (2003). Prevalence of pandemic thermostable direct hemolysin-producing *Vibrio parahaemolyticus* O3:K6 in seafood and the coastal environment in Japan. *Applied and Environmental Microbiology*, 69(7), 3883–3891. https://doi.org/10.1128/AEM.69.7.3883

Hardies, S. C., Comeau, M., Serwer, P. and Suttle, C. A. (2003). The complete sequence of marine bacteriophage VpV262 infecting *Vibrio parahaemolyticus* indicates that an ancestral component of a T7 viral

supergroup is widespread in the marine environment. *Virology*, 310, 359–371. https://doi.org/10.1016/S0042-6822(03)00172-7

Hatfull, G. F., Jacobs-Sera, D., Lawrence, J. G., Pope, W. H., Russell, D. A., Ko, C. C., Weber, R. J., Patel, M.C., Germane, K. L., Edgar, R. H., Hoyte, N. N., Bowman, C. A., Tantoco, A. T., Paladin, E. C., Myers, M. S., Smith, A. L., Grace, M. S., Pham, T. T., O'Brien, M. B., Vogelsberger, A. M., Hryckowian, A. J., Wynalek, J. L., Donis-Keller, H., Bogel, M. W., Peebles, C. L., Cresawn, S. G. and Hendrix, R. W. (2010). Comparative genomic analysis of 60 mycobacteriophage genomes: genome clustering, gene acquisition, and gene size. *Journal of molecular biology, 397*(1), 119-143. https://doi.org/10.1016/j.jmb.2010.01.011

Haq, I. U., Chaudhry, W. N., Akhtar, M. N., Andleeb, S. and Qadri, I. (2012). Bacteriophages and their implications on future biotechnology: a review. *Virology Journal*, 9, 9. https://doi.org/10.1186/1743-422X-9-9

Healey, A., Furtado, A., Cooper, T. and Henry, R. J. (2014). Protocol: a simple method for extracting next-generation sequencing quality genomic DNA from recalcitrant plant species. *Plant Methods*, 10(1), 21. https://doi.org/10.1186/1746-4811-10-21

Hermoso, J. A., Garcia, J. L. and Garcia, P. (2007). Taking aim on bacterial pathogens: from phage therapy to enzybiotics. *Current Opinion in Microbiology*, 10(5), 461–472. https://doi.org/10.1016/j.mib.2007.08.002

Ho, K. (2001). Bacteriophage therapy for bacterial infections. Rekindling a memory from the pre-antibiotics era. *Perspectives in Biology and Medicine*, 44(1), 1–16. https://doi.org/10.1353/pbm.2001.0006

Hobbs, Z. and Abedon, S. T. (2016). Diversity of phage infection types and associated terminology: the problem with 'lytic or lysogenic.' *FEMS Microbiology Letters*, 363(7). https://doi.org/10.1093/femsle/fnw047

Honda, T. and Iida, T. (1993). The pathogenicity of *Vibrio parahaemolyticus* and the role of the thermostable direct haemolysin and related haemolysins. *Reviews in Medical Microbiology*, 4(2), 106–113. http://doi.org/10.1097/00013542-199304000-00006

Honda, T., Ni, Y. X. and Miwatani, T. (1988). Purification and characterization of a hemolysin produced by a clinical isolate of Kanagawa phenomenon-negative *Vibrio parahaemolyticus* and related to the thermostable direct hemolysin. *Infection and Immunity,* 56(4), 961-965.

Honda, T., Ni, Y., Miwatani, T., Adachi, T. and Kim, J. (1992). The thermostable direct hemolysin of *Vibrio parahaemolyticus* is a pore-forming toxin. *Canadian Journal of Microbiology,* 38(11), 1175-1180. http://doi.org/10.1139/m92-192

Hong, Y., Pan, Y. and Ebner, P. D. (2014). Meat science and muscle biology symposium: development of bacteriophage treatments to reduce *Escherichia coli* O157:H7 contamination of beef products and produce1. *Journal of Animal Science*, 92(4), 1366–1377. https://doi.org/10.2527/jas.2013-7272

Hongping, W., Jilun, Z., Ting, J., Yixi, B. and Xiaoming, Z. (2011). Insufficiency of the Kanagawa hemolytic test for detecting pathogenic *Vibrio parahaemolyticus* in Shanghai, China. *Diagnostic Microbiology and Infectious Disease*, 69(1), 7–11. https://doi.org/10.1016/j.diagmicrobio.2010.08.016

Hu, M., Zhang, H., Gu, D., Ma, Y. and Zhou, X. (2020). Identification of a novel bacterial receptor that binds tail tubular proteins and mediates phage infection of Vibrio parahaemolyticus. *Emerging Microbes & Infections*, 9(1), 855–867. https://doi.org/10.1080/22221751.2020.1754134

Hu, Y. O. O., Hugerth, L. W., Bengtsson, C., Alisjahbana, A., Seifert, M., Kamal, A., Sjöling, A., Midtvedt, T., Norin, E., Du, J. and Engstrand, L. (2018). Bacteriophages synergize with the gut microbial community to combat *Salmonella*. *MSystems*, 3(5), e00119-18. https://doi.org/10.1128/mSystems.00119-18

Huang, C., Virk, S. M., Shi, J., Zhou, Y., Willias, S. P., Morsy, M. K., Abdelnabby, H. E., Liu, J., Wang, X. and Li, J. (2018). Isolation, characterisation, and application of bacteriophage LPSE1 against *Salmonella enterica* in ready to eat (RTE) foods. *Frontiers in Microbiology,* 9, 1046. https://doi.org/10.3389/fmicb.2018.01046

Huang, J. Y., Henao, O. L., Griffin, P. M., Vugia, D. J., Cronquist, A. B., Hurd, S., Tobin D'Angelo, M., Ryan, P., Smith, K., Lathrop, S., Zansky, S., Cieslak, P. R., Dunn, J., Holt, K. G., Wolpert, B. J. and Patrick, M. E. (2016). Infection with pathogens transmitted commonly through food and the effect of increasing use of culture-independent diagnostic tests on surveillance – foodborne diseases active surveillance network, 10 U.S. sites, 2012-2015. *Morbidity and Mortality Weekly Report,* 65, 368-371. http://dx.doi.org/10.15585/mmwr.mm6514a2

Huff, W. E., Huff, G. R., Rath, N. C. and Donoghue, A. M. (2006). Evaluation of the influence of bacteriophage titer on the treatment of colibacillosis in broiler chickens. *Poultry Science*, 85(8), 1373–1377. https://doi.org/10.1093/ps/85.8.1373

Hyatt, D., Chen, G. L., LoCascio, P. F., Land, M. L., Larimer, F. W. and Hauser, L. J. (2010). Prodigal: prokaryotic gene recognition and translation initiation site identification. *BMC Bioinformatics*, 11(1), 119. https://doi.org/10.1186/1471-2105-11-119

Ibrahim, W. N. W., Aznan, A. S., Saari, N. A., Leong, L. K., Musa, N., Razzak, L. A., Danish-Daniel, M., Zainathan, S. C., Din, M. S. M., Ghaffar, M. A.

and Musa, N. (2017). In-vitro characterization of lytic bacteriophage PhVh6 as potential biocontrol agent against pathogenic *Vibrio harveyi*. *Aquaculture, Aquarium, Conservation & Legislation*, 10(1), 64–76.

Jakočiūnė, D. and Moodley, A. (2018). A rapid bacteriophage DNA extraction method. *Methods and Protocols*, 1(3), 27. https://doi.org/10.3390/mps1030027

Jassim, S. A. A. and Limoges, R. G. (2014). Natural solution to antibiotic resistance: bacteriophages "The Living Drugs." *World Journal of Microbiology & Biotechnology*, 30(8), 2153–2170. https://doi.org/10.1007/s11274-014-1655-7

Javan, R.R., Ramos-Sevillano, E., Akter, A., Brown, J. and Brueggemann, A. B. (2019). Prophages and satellite prophages are widespread in *Streptococcus* and may play a role in pneumococcal pathogenesis. *Nature Communications*, 10(1), 4852. https://doi.org/10.1038/s41467-019-12825-y

Johnson, A. P. (2015). Surveillance of antibiotic resistance. Phil. Trans. R. Soc. B. 370, 20140080. https://doi.org/10.1098/rstb.2014.0080

Johnson, C. N., Bowers, J. C., Griffitt, K. J., Molina, V., Clostio, R. W., Pei, S., Laws, E., Paranjpye, R. N., Strom, M. S., Chen, A., Hasan, N. A., Huq, A., Noriea, N. F. III., Grimes, D. J. and Colwell, R. R. (2012). Ecology of *Vibrio parahaemolyticus* and *Vibrio vulnificus* in the coastal and estuarine waters of Louisiana, Maryland, Mississippi, and Washington (United States). Applied and Environmental Microbiology**,** 78(20), 7249-7257. https://doi.org/10.1128/AEM.01296-12

Johnson, D. E., Weinberg, L., Ciarkowski, J., West, P. and Colwell, R. R. (1984). Wound infection caused by Kanagawa-negative *Vibrio parahaemolyticus*. *Journal of Clinical Microbiology,* 20(4), 811-812.

Jończyk, E., Kłak, M., Międzybrodzki, R. and Górski, A. (2011). The influence of external factors on bacteriophages - review. *Folia Microbiologica*, 56(3), 191–200. https://doi.org/10.1007/s12223-011-0039-8

Jones, J. L., Ludeke, C. H., Bowers, J. C., Garrett, N., Fischer, M., Parsons, M. B., Bopp, C. A. and DePaola, A. (2012). Biochemical, serological, and virulence characterization of clinical and oyster *Vibrio parahaemolyticus* isolates. *Journal of Clinical Microbiology*, 50, 2343–2352. https://doi.org/10.1128/JCM.00196-12

Jones, H. J., Shield, C. G. and Swift, B. M. C. (2020). The Application of bacteriophage diagnostics for bacterial pathogens in the agricultural supply chain: from farm-to-fork. *PHAGE*, 1(4), 176–188. https://doi.org/10.1089/phage.2020.0042

Jorgensen, J. H. and Ferraro M. J. (2009). Antimicrobial susceptibility testing: a review of general principles and contemporary practices. *Clinical Infectious Diseases,* 49, 1749–1755. https://doi.org/10.1086/647952

Jun, J. W., Kim, H. J., Yun, S. K., Chai, J. Y. and Park, S. C. (2014a). Eating oysters without risk of vibriosis: application of a bacteriophage against *Vibrio parahaemolyticus* in oysters. *International Journal of Food Microbiology*, 188, 31–35. https://doi.org/https://doi.org/10.1016/j.ijfoodmicro.2014.07.007

Jun, J. W., Shin, T. H., Kim, J. H., Shin, S. P., Han, J. E., Heo, G. J., Zoysa, M. D., Shin, G. W., Chai, J. Y. and Park, S. C. (2014b). Bacteriophage therapy of a *Vibrio parahaemolyticus* infection caused by a multiple-antibiotic–resistant O3:K6 pandemic clinical strain. *Journal of Infectious Diseases*, 210(1), 72–78. https://doi.org/10.1093/infdis/jiu059

Jurczak-Kurek, A., Gąsior, T., Nejman-Faleńczyk, B., Bloch, S., Dydecka, A., Topka, G., Necel, A., Jakubowska-Deredas, M., Narajczyk, M., Richert, M., Mieszkowska, A., Wróbel, B., Wegrzyn, G. and Węgrzyn, A. (2016). Biodiversity of bacteriophages: morphological and biological properties of a large group of phages isolated from urban sewage. *Scientific Reports*, 6(1), 34338. https://doi.org/10.1038/srep34338

Kaiser, A. D. (1957). Mutations in a temperate bacteriophage affecting its ability to lysogenise Escherichia coli. *Virology*, 3(1), 42–61. https://doi.org/https://doi.org/10.1016/0042-6822(57)90022-3

Kalatzis, P. G., Castillo, D., Katharios, P. and Middelboe, M. (2018). Bacteriophage interactions with marine pathogenic vibrios: implications for phage therapy. *Antibiotics (Basel, Switzerland)*, 7(1), 15. https://doi.org/10.3390/antibiotics7010015

Kalburge, S. S., Whitaker, W. B. and Boyd, E. F. (2014). High-salt preadaptation of *Vibrio parahaemolyticus* enhances survival in response to lethal environmental stresses. *Journal of Food Protection,* 77(2), 246-253. http://doi.org/10.4315/0362-028X.JFP-13-241

Kang, C.H., Shin, Y., Kim, W., Kim, Y., Song, K., Oh, E.G., Kim, S., Yu, H. and So, J. S. (2016). Prevalence and antimicrobial susceptibility of *Vibrio parahaemolyticus* isolated from oysters in Korea. *Environmental Science and Pollution Research*, 23(1), 918–926. https://doi.org/10.1007/s11356-015-5650-9

Kaysner, C. A. and DePaola, A. J. (2004). Bacteriological analytical manual: methods for specific pathogens. U. S. Food and Drug Administration. Chapter 9 *Vibrio*. https://www.fda.gov/food/laboratory-methods-food/bam-vibrio (accessed 12 March 2018).

Keen, E. C. (2015). A century of phage research: bacteriophages and the shaping of modern biology. *BioEssays : News and Reviews in Molecular,*

Cellular and Developmental Biology, 37(1), 6–9. https://doi.org/10.1002/bies.201400152

Kelly, D., McAuliffe, O., Ross, R. P. and Coffey, A. (2012). Prevention of *Staphylococcus aureus* biofilm formation and reduction in established biofilm density using a combination of phage K and modified derivatives. *Letters in Applied Microbiology*, 54(4), 286–291. https://doi.org/10.1111/j.1472-765X.2012.03205.x

Khan, A. R., Pervez, M. T., Babar, M. E., Naveed, N. and Shoaib, M. (2018). A comprehensive study of *de novo* genome assemblers: current challenges and future prospective. *Evolutionary Bioinformatics Online*, 14, 1176934318758650–1176934318758650. https://doi.org/10.1177/1176934318758650

Kim, I. J., Kim, Y. S., Kim, H. I., Choi, H. C., Jeon, D. H., Lee, Y. J. and Ha, S. D. (2007). Assessment of both standard and isolated *Vibrio parahaemolyticus* on efficacy of commercial sanitizers and disinfectants. *Journal of Food Hygiene and Safety*, 22(2), 127–131.

Kim, S. G., Jun, J. W., Giri, S. S., Yun, S., Kim, H. J., Kim, S. W., Kang, J. W., Han, S. J., Jeong, D. and Park, S. C. (2019). Isolation and characterisation of pVa-21, a giant bacteriophage with anti-biofilm potential against *Vibrio alginolyticus*. *Scientific Reports*, 9(1), 6284. https://doi.org/10.1038/s41598-019-42681-1

Kim, Y. and McCarter, L. L. (2000). Analysis of the polar flagellar gene system of *Vibrio parahaemolyticus*. *Journal of Bacteriology,* 182(13), 3693-3704. http://doi.org/10.1128/JB.182.13.3693-3704.2000

Kim, Y. B. U., Okuda, J. U. N., Matsumoto, C., Takahashi, N., Hashimoto, S. and Nishibuchi, M. (1999). Identification of *Vibrio parahaemolyticus* strains at the species level by PCR targeted to the toxR gene. *Journal of Clinical Microbiology*, 37, 1173–1177.

Kim, Y. B. U., Okuda, J. U. N., Matsumoto, C., Takahashi, N., Hashimoto, S. and Nishibuchi, M. (1999). Identification of *Vibrio parahaemolyticus* strains at the species level by PCR targeted to the toxR gene. *Journal of Clinical Microbiology*, 37(4), 1173–1177.

Kirs, M., DePaola, A., Fyfe, R., Jones, J. L., Krantz, J., Van Laanen, A., Cotton, D. and Castle, M. (2011). A survey of oysters (*Crassostrea gigas*) in New Zealand for *Vibrio parahaemolyticus* and *Vibrio vulnificus*. *International Journal of Food Microbiology,* 147(2), 149-153. http://dx.doi.org/10.1016/j.ijfoodmicro.2011.03.012

Klumpp, J. and Loessner, M. J. (2013). Listeria phages: Genomes, evolution, and application. *Bacteriophage*, 3(3), e26861–e26861. https://doi.org/10.4161/bact.26861

Klumpp, J., Fouts, D. E. and Sozhamannan, S. (2012). Next generation sequencing technologies and the changing landscape of phage genomics. *Bacteriophage*, 2(3), 190–199. https://doi.org/10.4161/bact.22111

Koskella, B. and Brockhurst, M. A. (2014). Bacteria–phage coevolution as a driver of ecological and evolutionary processes in microbial communities. *FEMS Microbiology Reviews*, 38(5), 916–931. https://doi.org/10.1111/1574-6976.12072

Kot, W., Kilstrup, M., Vogensen, F. K. and Hammer, K. (2016). Clear plaque mutants of lactococcal phage TP901-1. *PLOS ONE*, 11(6), e0155233. https://doi.org/10.1371/journal.pone.0155233

Kropinski, A.M., Mazzocco, A., Waddell, T.E., Lingohr, E. and Johnson, R.P. (2009). Enumeration of bacteriophages by double agar overlay plaque assay. In Bacteriophages: methods in molecular biology, ed. M. R. Clokie & Kropinski A.M, pp. 69-76. Totowa, New Jersey: Humana Press. https://doi.org/10.1007/978-1-60327-164-6_7

Krumperman, P. H. (1983). Multiple antibiotic resistance indexing of *Escherichia coli* to identify high-risk sources of fecal contamination of foods. *Applied and Environmental Microbiology*, 46(1), 165-170.

Krupovic, M., Prangishvili, D., Hendrix, R. W. and Bamford, D. H. (2011). Genomics of bacterial and archaeal viruses: dynamics within the prokaryotic virosphere. *Microbiol. Mol. Biol. Rev., 75*(4), 610-635. https://doi.org/10.1128/MMBR.00011-11

Lagesen, K., Hallin, P., Rødland, E. A., Staerfeldt, H. H., Rognes, T. and Ussery, D. W. (2007). RNAmmer: consistent and rapid annotation of ribosomal RNA genes. *Nucleic Acids Research*, 35(9), 3100–3108. https://doi.org/10.1093/nar/gkm160

Lal, T. M., Sano, M. and Ransangan, J. (2016). Genome characterization of a novel vibriophage VpKK5 (Siphoviridae) specific to fish pathogenic strain of *Vibrio parahaemolyticus*. *Journal of Basic Microbiology*, 56(8), 872–888. https://doi.org/10.1002/jobm.201500611

Lamon, S., Consolati, S. G., Fois, F., Cambula, M. G., Pes, M., Porcheddu, G., Agus, V., Esposito, G., Mureddu, A. and Meloni, D. (2019). Occurrence, seasonal distribution, and molecular characterization of *Vibrio vulnificus*, *Vibrio cholerae*, and *Vibrio parahaemolyticus* in shellfish (*Mytilus galloprovincialis* and *Ruditapes decussatus*) collected in Sardinia (Italy). *Journal of Food Protection*, 82(11), 1851–1856. https://doi.org/10.4315/0362-028X.JFP-19-021

Langlet, J., Gaboriaud, F. and Gantzer, C. (2007). Effects of pH on plaque forming unit counts and aggregation of MS2 bacteriophage. *Journal of*

Applied Microbiology, 103(5), 1632–1638. https://doi.org/10.1111/j.1365-2672.2007.03396.x

Laslett, D. and Canback, B. (2004). ARAGORN, a program to detect tRNA genes and tmRNA genes in nucleotide sequences. *Nucleic Acids Research*, 32(1), 11–16. https://doi.org/10.1093/nar/gkh152

Lee, H. S., Choi, S., Shin, H., Lee, J. H. and Choi, S. H. (2014). Vibrio vulnificus Bacteriophage SSP002 as a Possible Biocontrol Agent. *Applied and Environmental Microbiology*, 80(2), 515 LP – 524. https://doi.org/10.1128/AEM.02675-13

Lee, L. H., Mutalib, N. S. A., Law, J. W. F., Wong, S. H. and Letchumanan, V. (2018). Discovery on antibiotic resistance patterns of *Vibrio parahaemolyticus* in Selangor reveals carbapenemase producing *Vibrio parahaemolyticus* in marine and freshwater fish. *Frontiers in Microbiology*, 9, 2513. http://doi.org/10.3389/fmicb.2018.02513

Lei, T., Jiang, F., He, M., Zhang, J., Zeng, H., Chen, M., Pang, R., Wu, S., Wei, L., Wang, J., Ding, Y. and Wu, Q. (2019). Prevalence, virulence, antimicrobial resistance, and molecular characterization of fluoroquinolone resistance of *Vibrio parahaemolyticus* from different types of food samples in China. *International Journal of Food Microbiology*, 317, 108461. https://doi.org/10.1016/j.ijfoodmicro.2019.108461

Leiman, P.G., Arisaka, F., van Raaij, M.J., Kostyuchenko, V.A., Aksyuk, A.A., Kanamaru, S. and Rossmann, M.G. (2010). Morphogenesis of the T4 tail and tail fibers. *Virology Journal*, 7, 355. https://doi.org/10.1186/1743-422X-7-355

Lenski, R. E. (1988). Dynamics of interactions between bacteria and virulent bacteriophage. *Advances in Microbial Ecology*, 10, 1–44.

León-Sicairos, N., Angulo-Zamudio, U. A., de la Garza, M., Velázquez-Román, J., Flores-Villaseñor, H. M. and Canizalez-Román, A. (2015). Strategies of *Vibrio parahaemolyticus* to acquire nutritional iron during host colonization. *Frontiers in Microbiology*, 6, 702. https://doi.org/10.3389/fmicb.2015.00702

Letchumanan, V., Chan, K. G. and Lee, L. H. (2014). *Vibrio parahaemolyticus*: a review on the pathogenesis, prevalence, and advance molecular identification techniques. *Frontiers in Microbiology*, 5, 705. https://doi.org/10.3389/fmicb.2014.00705

Letchumanan, V., Yin, W. F., Lee, L. H. and Chan, K. G. (2015). Occurrence and antibiotic resistance of *Vibrio parahaemolyticus* from shellfish in Selangor, Malaysia. *Frontiers in Microbiology*, 6, 1417. https://doi.org/10.3389/fmicb.2015.01417

Leverentz, B., Conway, W. S., Camp, M. J., Janisiewicz, W. J., Abuladze, T., Yang, M., Saftner, R. and Sulakvelidze, A. (2003). Biocontrol of *Listeria monocytogenes* on fresh-cut produce by treatment with lytic bacteriophages and a bacteriocin. *Applied and Environmental Microbiology*, 69(8), 4519–4526. https://doi.org/10.1128/AEM.69.8.4519-4526.2003

Levin, R. E. (2006). *Vibrio parahaemolyticus*, a notably lethal human pathogen derived from seafood: a review of its pathogenicity, characteristics, subspecies characterization, and molecular methods of detection. *Food Biotechnology*, 20(1), 93–128. http://doi.org/10.1080/08905430500524275

Lewis, R. and Hill, C. (2020). Overcoming barriers to phage application in food and feed. *Current Opinion in Biotechnology*, 61, 38–44. https://doi.org/https://doi.org/10.1016/j.copbio.2019.09.018

Li, F., Xing, S., Fu, K., Zhao, S., Liu, J., Tong, Y. and Zhou, L. (2019). Genomic and biological characterization of the *Vibrio alginolyticus*-infecting "Podoviridae" bacteriophage, vB_ValP_IME271. *Virus Genes*, 55(2), 218–226. https://doi.org/10.1007/s11262-018-1622-8

Li, J., Xue, F., Yang, Z., Zhang, X., Zeng, D., Chao, G., Jiang, Y. and Li, B. (2016). *Vibrio parahaemolyticus* strains of pandemic serotypes identified from clinical and environmental samples from Jiangsu, China. *Frontiers in Microbiology*, 7, 787. https://doi.org/10.3389/fmicb.2016.00787

Li, Y., Pei, X., Yan, J., Liu, D., Zhang, H., Yu, B., Li, N. and Yang, D. (2019). Prevalence of foodborne pathogens isolated from retail freshwater fish and shellfish in China. *Food Control*, 99, 131–136. https://doi.org/10.1016/j.foodcont.2018.12.024

Li, Y., Xie, X, Shi., X, Lin., Y., Qiu, Y., Mou, J., Chen, Q., Lu, Y., Zhou, L., Jiang, M., Sun, H., Ma, H., Cheng, J. and Hu, Q. (2014). *Vibrio parahaemolyticus*, southern coastal region of China, 2007-2012. *Emerging Infectious Diseases*, 20, 685–88. https://doi.org/10.3201/eid2004.130744

Lin, C. C., Lin, P. S., Kou, L. L., Hong, Y. P. and Wu, H. S. (2015). Epidemiology of *Vibrio parahaemolyticus* in southern Taiwan, 2004–2013. *Taiwan Epidemiology Bulletin*, 31, 194– https://doi.org/195. 10.6525/TEB.20151124.31(22).001

Lin, D. M., Koskella, B. and Lin, H. C. (2017). Phage therapy: an alternative to antibiotics in the age of multi-drug resistance. *World Journal of Gastrointestinal Pharmacology and Therapeutics*, 8(3), 162–173. https://doi.org/10.4292/wjgpt.v8.i3.162

Liu, P. F., Avramova, L. V. and Park, C. (2009). Revisiting absorbance at 230nm as a protein unfolding probe. *Analytical Biochemistry*, 389(2), 165–170. https://doi.org/https://doi.org/10.1016/j.ab.2009.03.028

Liu, W., Ye, D., Luo, Z., Yu, Y. and Gong, T. (2013). Isolation and characterisation of five lytic bacteriophages infecting a Vibrio strain closely related to *Vibrio owensii*. *FEMS Microbiology Letters*, 348(2), 112–119. https://doi.org/10.1111/1574-6968.12277

Łobocka, M. B., Rose, D. J., Plunkett 3rd, G., Rusin, M., Samojedny, A., Lehnherr, H., Yarmolinsky, M. B. and Blattner, F. R. (2004). Genome of bacteriophage P1. *Journal of Bacteriology*, 186(21), 7032–7068. https://doi.org/10.1128/JB.186.21.7032-7068.2004

Lopatek, M., Wieczorek, K. and Osek, J. (2015). Prevalence and antimicrobial resistance of *Vibrio parahaemolyticus* isolated from raw shellfish in Poland. *Journal of Food Protection*, 78(5), 1029–1033. https://doi.org/10.4315/0362-028x.jfp-14-437

Lourenço, M., Sordi, L. De. and Debarbieux, L. (2018). The diversity of bacterial lifestyles hampers bacteriophage tenacity. *Viruses*, 10(6), 1–11. https://doi.org/10.3390/v10060327

Lovell, C. R. (2017). Ecological fitness and virulence features of *Vibrio parahaemolyticus* in estuarine environments. *Applied Microbiology and Biotechnology*, 101(5), 1781–1794. https://doi.org/10.1007/s00253-017-8096-9

Luo, Z. H., Yu, Y. P., Jost, G., Liu, W. H., Huang, X. L. and Gu, L. (2016). Characterization of two bacteriophages for specific treatment of biofilm formed by a *Vibrio* sp. isolated from an abalone farm. *Aquaculture Research*, 47(12), 3964–3972. https://doi.org/10.1111/are.12846

Luria, S. E. and Delbrück, M. (1943). Mutations of bacteria from virus sensitivity to virus resistance. *Genetics,* 28(6), 491.

Lurz, R., Orlova, E.V., Günther, D., Dube, P., Dröge, A., Weise, F., van Heel, M. and Tavares, P. (2001), Structural organisation of the head-to-tail interface of a bacterial virus. *Journal of Molecular Biology*, 310(5), 1027-37. https://doi.org/10.1006/jmbi.2001.4800

Lwoff, A. (1953). Lysogeny. *Bacteriological Reviews*, 17(4), 269–337.

Ly-Chatain, M. H. (2014). The factors affecting effectiveness of treatment in phages therapy. *Frontiers in Microbiology*, 5(51), 1–7. https://doi.org/10.3389/fmicb.2014.00051

Makino, K., Oshima, K., Kurokawa, K., Yokoyama, K., Uda, T., Tagomori, K., Iijima, Y., Najima, M., Nakano, M., Yamashita, A., Kubota, Y., Kimura, S., Yasunaga, T., Honda, T., Shinagawa, H., Hattori, M. and Iida, T.

(2003). Genome sequence of *Vibrio parahaemolyticus*: a pathogenic mechanism distinct from that of *V cholerae*. *Lancet*, 361(9359), 743–749. http://doi.org/10.1016/S0140-6736(03)12659-1

Mala, W., Alam, M., Angkititrakul, S., Wongwajana, S., Lulitanond, V., Huttayananont, S., Kaewkes, W., Faksri, K. and Chomvarin, C. (2016). Serogroup, virulence, and molecular traits of *Vibrio parahaemolyticus* isolated from clinical and cockle sources in northeastern Thailand. *Infection, Genetics and Evolution,* 39, 212-218. http://doi.org/10.1016/j.meegid.2016.01.006

Malcolm, T. T. H., Cheah, Y. K., Radzi, C. W. J. W. M., Kantilal, H. K., Martinez-Urtaza, J., Nishibuchi, M. and Son, R. (2016). Microbial risk assessment of *Vibrio parahaemolyticus* in bloody clams in Malaysia: a preliminary model from retail to consumption. *Microbial Risk Analysis*, 4, 43–51. https://doi.org/10.1016/j.mran.2016.07.002

Malcolm, T. T. H., Cheah, Y. K., Radzi, C. W. J. W. M., Kasim, F. A., Kantilal, H. K., John, T. Y. H., Martinez-Urtaza, J., Nakaguchi, Y., Nishibuchi, M. and Son, R. (2015). Detection and quantification of pathogenic *Vibrio parahaemolyticus* in shellfish by using multiplex PCR and loop-mediated isothermal amplification assay. *Food Control,* 47, 664-671. http://dx.doi.org/10.1016/j.foodcont.2014.08.010

Manyi-Loh, C., Mamphweli, S., Meyer, E. and Okoh, A. (2018). Antibiotic use in agriculture and its consequential resistance in environmental sources: potential public health implications. *Molecules (Basel, Switzerland)*, 23(4), 795. https://doi.org/10.3390/molecules23040795

Mapes, A. C., Trautner, B. W., Liao, K. S. and Ramig, R. F. (2016). Development of expanded host range phage active on biofilms of multi-drug resistant *Pseudomonas aeruginosa*. *Bacteriophage*, 6(1), e1096995. https://doi.org/10.1080/21597081.2015.1096995

Martinez-Urtaza, J., Powell, A., Jansa, J., Rey, J. L. C., Montero, O. P., Campello, M. G., Lopez, M. J., Pousa, A., Valles, M. J., Trinanes, J., Hervio-Heath, D., Keay, W., Bayley, A., Hartnell, R. and Baker-Austin, C. (2016). Epidemiological investigation of a foodborne outbreak in Spain associated with U.S. west coast genotypes of *Vibrio parahaemolyticus*. *SpringerPlus,* 5(1), 1-8. http://dx.doi.org/10.1186/s40064-016-1728-1

Matamp, N. and Bhat, S. G. (2020). Genome characterisation of novel lytic Myoviridae bacteriophage ϕVP-1 enhances its applicability against MDR-biofilm-forming *Vibrio parahaemolyticus*. *Archives of Virology*, 165(2), 387–396. https://doi.org/10.1007/s00705-019-04493-6

Mateus, L., Costa, L., Silva, Y. J., Pereira, C., Cunha, A. and Almeida, A. (2014). Efficiency of phage cocktails in the inactivation of *Vibrio* in aquaculture. *Aquaculture*, 424–425, 167–173. https://doi.org/10.1016/j.aquaculture.2014.01.001

McCarter, L. L. (2001). Polar flagellar motility of the vibrionaceae. *Microbiology and Molecular Biology Reviews,* 65(3), 445-462. http://doi.org/10.1128/MMBR.65.3.445-462.2001

McCarter, L.L. (1999). The multiple identities of *Vibrio parahaemolyticus*. *Journal of Molecular Microbiology and Biotechnology,* 11, 51-7.

McLaughlin, J. B., DePaola, A., Bopp, C. A., Martinek, K. A., Napolilli, N. P., Allison, C. G., Murray, S. L., Thompson, E. C., Bird, M. M. and Middaugh, J. P. (2005). Outbreak of *Vibrio parahaemolyticus* gastroenteritis associated with Alaskan oysters. *New England Journal of Medicine,* 353(14), 1463-1470. http://dx.doi.org/10.1056/NEJMoa051594

McNair, K., Bailey, B. A. and Edwards, R. A. (2012). PHACTS, a computational approach to classifying the lifestyle of phages. *Bioinformatics*, 28(5), 614–618. https://doi.org/10.1093/bioinformatics/bts014

Merino, S., Shaw, J. G. and Tomas, J. M. (2006). Bacterial lateral flagella: an inducible flagella system. *FEMS Microbiology Letters,* 263(2), 127-135. http://doi.org/10.1111/j.1574-6968.2006.00403.x

Middelboe, M. (2000). Bacterial growth rate and marine virus–host dynamics. *Microbial Ecology*, 40, 114–124. https://doi.org/10.1007/s002480000050

Miguéis, S., Saraiva, C. and Esteves, A. (2017). Efficacy of LISTEX P100 at different concentrations for reduction of *Listeria monocytogenes* inoculated in sashimi. *Journal of Food Protection*, 80(12), 2094–2098. https://doi.org/10.4315/0362-028X.JFP-17-098

Miller, E. S., Kutter, E., Mosig, G., Arisaka, F., Kunisawa, T. and Rüger, W. (2003). Bacteriophage T4 genome. *Microbiology and molecular biology reviews: MMBR*, 67(1), 86–156. https://doi.org/10.1128/mmbr.67.1.86-156.2003

Ming, Z., Su, Y. C., DeWitt, C. M. and Waite-Cusic, J. (2018). Flow rate of depuration system has minimal impact on *Vibrio parahaemolyticus* decontamination in Pacific oysters (*Crassostrea gigas*). *Journal of Food Safety*, 38(6), e12531. https://doi.org/10.1111/jfs.12531

Miranda, C. D., Godoy, F. A. and Lee, M. R. (2018). Current status of the use of antibiotics and the antimicrobial resistance in the Chilean salmon farms. *Frontiers in Microbiology*, 9, 1284. https://doi.org/10.3389/fmicb.2018.01284

Mirzaei, M. K. and Nilsson, A. S. (2015). Isolation of phages for phage therapy: a comparison of spot tests and efficiency of plating analyses for determination of host range and efficacy. *PloS One*, 10(3), e0118557–e0118557. https://doi.org/10.1371/journal.pone.0118557

Mitarai, N., Brown, S. and Sneppen, K. (2016). Population dynamics of phage and bacteria in spatially structured habitats using phage λ and *Escherichia coli*. *Journal of Bacteriology*, 198(12), 1783–1793. https://doi.org/10.1128/JB.00965-15

Miyamoto, Y., Kato, T., Obara, Y., Akiyama, S., Takizawa, K. and Yamai, S. (1969). In vitro hemolytic characteristic of *Vibrio parahaemolyticus*: its close correlation with human pathogenicity. *Journal of Bacteriology,* 100(2), 1147-1149.

Mizunoe, Y., Wai, S. N., Ishikawa, T., Takade, A. and Yoshida, S. (2000). Resuscitation of viable but nonculturable cells of *Vibrio parahaemolyticus* induced at low temperature under starvation. *FEMS Microbiology Letters*, 186(1), 115–120. https://doi.org/10.1111/j.1574-6968.2000.tb09091.x

Mushegian, A. R. (2020). Are there 10^{31} virus particles on Earth, or more, or less? *Journal of Bacteriology*, 1-13. https://doi.org/10.1128/JB.00052-20

Myelnikov, D. (2018). An alternative cure: the adoption and survival of bacteriophage therapy in the USSR, 1922-1955. *Journal of the History of Medicine and Allied Sciences*, 73(4), 385–411. https://doi.org/10.1093/jhmas/jry024

Nabergoj, D., Modic, P. and Podgornik, A. (2018). Effect of bacterial growth rate on bacteriophage population growth rate. *MicrobiologyOpen*, 7(2), e00558–e00558. https://doi.org/10.1002/mbo3.558

Nair, G. B., Ramamurthy, T., Bhattacharya, S. K., Dutta, B., Takeda, Y. and Sack, D. A. (2007). Global dissemination of *Vibrio parahaemolyticus* serotype O3:K6 and its serovariants. *Clinical Microbiology Reviews,* 2(1), 39-48. https://doi.org/10.1128/CMR.00025-06

Narayanan, S. V, Joseph, T. C., Peeralil, S., Mothadaka, M. P. and Lalitha, K. V. (2020). Prevalence, virulence characterization, AMR pattern and genetic relatedness of *Vibrio parahaemolyticus* isolates from retail seafood of Kerala, India. *Frontiers in Microbiology*, 11, 592. https://doi.org/10.3389/fmicb.2020.00592

Navarro-Garcia, F., Ruiz-Perez, F., Cataldi, Á. and Larzábal, M. (2019). Type VI secretion system in pathogenic *Escherichia coli*: structure, role in virulence, and acquisition. *Frontiers in Microbiology*, 10, 1965. https://doi.org/10.3389/fmicb.2019.01965

Ndraha, N. and Hsiao, H. I. (2019). The risk assessment of *Vibrio parahaemolyticus* in raw oysters in Taiwan under the seasonal variations, time horizons, and climate scenarios. *Food Control*, 102, 188–196. https://doi.org/10.1016/j.foodcont.2019.03.020

Ndraha, N., Wong, H. and Hsiao, H. I. (2020). Managing the risk of *Vibrio parahaemolyticus* infections associated with oyster consumption: a review. *Comprehensive Reviews in Food Science and Food Safety*, 19(3), 1187–1217. https://doi.org/10.1111/1541-4337.12557

Necel, A., Bloch, S., Nejman-Faleńczyk, B., Grabski, M., Topka, G., Dydecka, A., Kosznik-Kwaśnicka, K., Grabowski, Ł., Jurczak-Kurek, A., Wołkowicz, T., Węgrzyn, G. and Węgrzyn, A. (2020). Characterization of a bacteriophage, vB_Eco4M-7, that effectively infects many *Escherichia coli* O157 strains. *Scientific Reports*, 10(1), 3743. https://doi.org/10.1038/s41598-020-60568-4

Nelapati, S. and Krishnaiah, N. (2010). Detection of total and pathogenic *Vibrio parahaemolyticus* by polymerase chain reaction using *toxR*, *tdh* and *trh* genes. *Veterinary World*, 3(6), 268-271.

Nelson, D. W., Moore, J. E. and Rao, J. R. (2019). Antimicrobial resistance (AMR): significance to food quality and safety. *Food Quality and Safety*, 3(1), 15–22. https://doi.org/10.1093/fqsafe/fyz003

Newton, A., Kendall, M., Vugia, D. J., Henao, O. L. and Mahon, B. E. (2012). Increasing rates of vibriosis in the United States, 1996–2010: review of surveillance data from 2 systems. *Clinical Infectious Diseases*, 54, S391–S395. https://doi.org/10.1093/cid/cis243

Ng, P. C. and Kirkness, E. F. (2010). Whole genome sequencing. *Methods in Molecular Biology (Clifton, N.J.)*, 628, 215–226. https://doi.org/10.1007/978-1-60327-367-1_12

Nishibuchi, M. and Kaper, J. B. (1990). Duplication and variation of the thermostable direct haemolysin (TDH) gene in *Vibrio parahaemolyticus*. *Molecular Microbiology,* 4(1), 87-99. http://dx.doi.org/10.1111/j.1365-2958.1990.tb02017.x

Nishibuchi, M. and Kaper, J. B. (1995). Thermostable direct hemolysin gene of *Vibrio parahaemolyticus*: a virulence gene acquired by a marine bacterium. *Infection and Immunity,* 63(6), 2093-2099.

Nishibuchi, M., Kumagai, K. and Kaper, J. B. (1991). Contribution of the tdh 1 gene of Kanagawa phenomenon-positive *Vibrio parahaemolyticus* to production of extracellular thermostable direct hemolysin. *Microbial Pathogenesis,* 11(6), 453-460. http://dx.doi.org/10.1016/0882-4010(91)90042-9

Nishibuchi, M., Taniguchi, T., Misawa, T., Khaeomanee-Iam, V., Honda, T. and Miwatani, T. (1989). Cloning and nucleotide sequence of the gene (trh) encoding the hemolysin related to the thermostable direct hemolysin of *Vibrio parahaemolyticus*. *Infection and Immunity*, 57(9), 2691–2697.

Nolan, C. M., Ballard, J., Kaysner, C. A., Lilja, J. L., Williams, L. P. J. and Tenover, F. C. (1984). *Vibrio parahaemolyticus* gastroenteritis an outbreak associated with raw oysters in the Pacific Northwest. *Diagnostic Microbiology & Infectious Disease*, 2(2), 119–128.

Noorlis, A., Ghazali, F. M., Cheah, Y. K., Tuan Zainazor, T. C., Ponniah, J., Tunung, R., Tang, J. Y. H., Nishibuchi, M., Nakaguchi, Y. and Son, R. (2011). Prevalence and quantification of vibrio species and *Vibrio parahaemolyticus* in freshwater fish at hypermarket level. *International Food Research Journal,* 18,689-695.

Nouws, S., Bogaerts, B., Verhaegen, B., Denayer, S., Piérard, D., Marchal, K., Roosens, N. H. C., Vanneste, K. and De Keersmaecker, S. C. J. (2020). Impact of DNA extraction on whole genome sequencing analysis for characterization and relatedness of Shiga toxin-producing *Escherichia coli* isolates. *Scientific Reports*, 10(1), 14649. https://doi.org/10.1038/s41598-020-71207-3

O'Flynn, G., Ross, R. P., Fitzgerald, G. F. and Coffey, A. (2004). Evaluation of a cocktail of three bacteriophages for biocontrol of *Escherichia coli* O157:H7. *Applied and Environmental Microbiology*, 70(6), 3417–3424. https://doi.org/10.1128/AEM.70.6.3417-3424.2004

Oakey, H. J., Cullen, B. R. and Owens, L. (2002). The complete nucleotide sequence of the *Vibrio harveyi* bacteriophage VHML. *Journal of Applied Microbiology*, 93(6), 1089–1098. https://doi.org/10.1046/j.1365-2672.2002.01776.x

Oberhofer, T. R. and Podgore, J. K. (1982). Urea-hydrolyzing *Vibrio parahaemolyticus* associated with acute gastroenteritis. *Journal of Clinical Microbiology*, 16(3), 581–583.

Oh, E. G., Son, K. T., Yu, H., Lee, T. S., Lee, H. J., Shin, S., Kwon, J. Y., park, K. and Kim, J. (2011). Antimicrobial resistance of *Vibrio parahaemolyticus* and *Vibrio alginolyticus* strains isolated from farmed fish in Korea from 2005 through 2007. *Journal of Food Protection*, 74(3), 380–386. https://doi.org/10.4315/0362-028X.JFP-10-307

Okuda, J., Ishibashi, M., Hayakawa, E., Nishino, T., Takeda, Y., Mukhopadhyay, A. K., Garg, S., Bhattacharya, S. K., Nair, G. B. and Nishibuchi, M. (1997a). Emergence of a unique O3:K6 clone of *Vibrio parahaemolyticus* in Calcutta, India, and isolation of strains from the same clonal group from Southeast Asian travelers arriving in Japan. *Journal of Clinical Microbiology,* 35(12), 3150-3155.

Okuda, J., Ishibashi, M., Abbot, S.L., Janda, J.M. and Nishibuchi, M. (1997b). Analysis of the thermostable direct hemolysin (tdh) gene and the tdh-related hemolysin (trh) genes in urease- positive strains of *Vibrio parahaemolyticus* isolated on the west coast of the United States. *Journal of Clinical Microbiology*, 35, 1965–1971.

Oliveira, A., Sereno, R. and Azeredo, J. (2010). In vivo efficiency evaluation of a phage cocktail in controlling severe colibacillosis in confined conditions and experimental poultry houses. *Veterinary Microbiology*, 146(3), 303–308. https://doi.org/10.1016/j.vetmic.2010.05.015

Oliveira, H., Azeredo, J., Lavigne, R. and Kluskens, L. D. (2012). Bacteriophage endolysins as a response to emerging foodborne pathogens. *Trends in Food Science & Technology*, 28(2), 103–115. https://doi.org/https://doi.org/10.1016/j.tifs.2012.06.016

Oliver, J. D. (2012). Culture media for the isolation and enumeration of pathogenic *Vibrio* species in foods and environmental samples. In *Handbook of culture media for food and water microbiology*, ed. J. E. L. Corry, G. D. W. Curtis, and R. M. Baird, 3rd edition, pp. 377–402. Cambridge: Royal Society of Chemistry.

Orlova, E.V., Gowen, B., Dröge, A., Stiege, A., Weise, F., Lurz, R., van Heel, M. and Tavares, P. (2003), Structure of a viral DNA gatekeeper at 10 A resolution by cryo-electron microscopy. *The EMBO Journal*, 22(6), 1255-62. https://doi.org/10.1093/emboj/cdg123

Otomo, Y., Hossain, F., Rabbi, F., Yakuwa, Y. and Ahsan, C. R. (2013). Pre-enrichment of estuarine and fresh water environmental samples with sodium chloride yields in better recovery of *Vibrio parahaemolyticus*. *Advances in Microbiology*, 3, 21-25. http://doi.org/10.4236/aim.2013.31003

Pallavali, R. R., Degati, V. L., Lomada, D., Reddy, C., Raghava, V. and Durbaka, P. (2017). *Isolation and in vitro evaluation of bacteriophages against MDR-bacterial isolates from septic wound infections*. *PLoS One*, 12(7), e0179245.

Park, K. S., Ono, T., Rokuda, M., Jang, M. H., Okada, K., Iida, T. and Honda, T. (2004). Functional characterization of two type III secretion systems of *Vibrio parahaemolyticus*. *Infection and Immunity*, 72(11), 6659. http://doi.org/10.1128/IAI.72.11.6659

Park, S. T. and Kim, J. (2016). Trends in next-generation sequencing and a new era for whole genome sequencing. *International Neurourology Journal*, 20(Suppl 2), S76–S83. https://doi.org/10.5213/inj.1632742.371

Pazhana GP, Bhowmik SK, Ghosh S, Guin S, Dutta S, Rajendran K, Saha, D. R., Nandy, R. K., Bhattacharya, M. K., Mukhopadhyay, A. K. and Ramamurthy, T. (2014). Trends in the epidemiology of pandemic and non-pandemic strains of *Vibrio parahaemolyticus* isolated from diarrheal patients in Kolkata, India. *PLOS Neglected Tropical Diseases*, 8(5), e2815. https://doi.org/10.1371/journal.pntd.0002815

Pinto, A. D., Terio, V., Novello, L. and Tantillo, G. (2011). Comparison between thiosulphate-citrate-bile salt sucrose (TCBS) agar and CHROMagar

Vibrio for isolating *Vibrio parahaemolyticus*. *Food Control*, 22(1), 124–127. http://doi.org /10.1016/j.foodcont.2010.06.013

Pires, D. P., Melo, L. D. R., Vilas Boas, D., Sillankorva, S. and Azeredo, J. (2017). Phage therapy as an alternative or complementary strategy to prevent and control biofilm-related infections. *Current Opinion in Microbiology*, 39, 48–56. https://doi.org/10.1016/j.mib.2017.09.004

Plaza, N., Castillo, D., Pérez-Reytor, D., Higuera, G., García, K., & Bastías, R. (2018). Bacteriophages in the control of pathogenic vibrios. *Electronic Journal of Biotechnology*, 31, 24–33. https://doi.org/https://doi.org/10.1016/j.ejbt.2017.10.012

Plisson, C., White, H. E., Auzat, I., Zafarani, A., São-José, C., Lhuillier, S., Tavares, P. and Orlova, E. V. (2007). Structure of bacteriophage SPP1 tail reveals trigger for DNA ejection. *The EMBO Journal*, 26(15), 3720–3728. https://doi.org/10.1038/sj.emboj.7601786

Połaska, M. and Sokołowska, B. (2019). Bacteriophages - a new hope or a huge problem in the food industry. *AIMS Microbiology*, 5(4), 324–346. https://doi.org/10.3934/microbiol.2019.4.324

Pollard, M. O., Gurdasani, D., Mentzer, A. J., Porter, T. and Sandhu, M. S. (2018). Long reads: their purpose and place. *Human Molecular Genetics*, 27(R2), R234–R241. https://doi.org/10.1093/hmg/ddy177

Prada-Peñaranda, C., Salazar, M., Güiza, L., Pérez, M. I., Leidy, C. and Vives-Florez, M. J. (2018). Phage preparation FBL1 prevents *Bacillus licheniformis* biofilm, bacterium responsible for the mortality of the Pacific White Shrimp *Litopenaeus vannamei*. *Aquaculture*, 484, 160–167. https://doi.org/https://doi.org/10.1016/j.aquaculture.2017.11.007

Principi, N., Silvestri, E. and Esposito, S. (2019). Advantages and limitations of bacteriophages for the treatment of bacterial infections. *Frontiers in Pharmacology*, 10, 513. https://doi.org/10.3389/fphar.2019.00513

Raimondi, F., Kao, J. P. Y., Fiorentini, C., Fabbri, A., Donelli, G., Gasparini, N., Rubino, A. and Fasano, A. (2000). Enterotoxicity and cytotoxicity of *Vibrio parahaemolyticus* thermostable direct hemolysin in in vitro systems. *Infection and Immunity,* 68(6), 3180-3185. http://dx.doi.org/10.1128/IAI.68.6.3180-3185.2000

Rajnovic, D., Muñoz-Berbel, X. and Mas, J. (2019). Fast phage detection and quantification: an optical density-based approach. *PLOS ONE*, 14(5), e0216292. https://doi.org/10.1371/journal.pone.0216292

Ralston, E. P., Kite-Powell, H. and Beet, A. (2011). An estimate of the cost of acute health effects from food- and water-borne marine pathogens and toxins in the USA. *Journal of Water and Health*, 9(4), 680–694. https://doi.org/10.2166/wh.2011.157

Ramesh, N., Archana, L., Royam, M. M. and Manohar, P. (2019). Effect of various bacteriological media on the plaque morphology of *Staphylococcus* and *Vibrio* phages. *Access Microbiology*, 1(4), 1–4. https://doi.org/10.1099/acmi.0.000036

Ramirez, K., Cazarez-Montoya, C., Lopez-Moreno, H. S. and Castro-del Campo, N. (2018). Bacteriophage cocktail for biocontrol of *Escherichia coli* O157:H7: stability and potential allergenicity study. *PLOS ONE*, 13(5), e0195023. https://doi.org/10.1371/journal.pone.0195023

Ren, H., Li, Z., Xu, Y., Wang, L. and Li, X. (2019). Protective effectiveness of feeding phage cocktails in controlling *Vibrio parahaemolyticus* infection of sea cucumber *Apostichopus japonicus*. *Aquaculture*, 503, 322–329. https://doi.org/10.1016/j.aquaculture.2019.01.006

Rodgers, C., Parveen, S., Chigbu, P., Jacobs, J., Rhodes, M. and Harter-Dennis, J. (2014). Prevalence of *Vibrio parahaemolyticus* and *Vibrio vulnificus* in blue crabs (*Callinectes sapidus*), seawater and sediments of the Maryland Coastal Bays. *Journal of Applied Microbiology*, 117(4), 1198-1209. http://dx.doi.org/10.1111/jam.12608

Rodriguez-Castro, A., Ansede-Bermejo, J., Blanco-Abad, V., Varela-Pet, J., Garcia-Martin, O. and Martinez-Urtaza, J. (2010). Prevalence and genetic diversity of pathogenic populations of *Vibrio parahaemolyticus* in coastal waters of Galicia, Spain. *Environmental Microbiology Reports*, 2(1), 58–66. http://doi.org/10.1111/j.1758-2229.2009.00064.x

Rodríguez-Melcón, C., Capita, R., García-Fernández, C. and Alonso-Calleja, C. (2018). Effects of bacteriophage P100 at different concentrations on the structural parameters of *Listeria monocytogenes* biofilms. *Journal of Food Protection*, 81(12), 2040–2044. https://doi.org/10.4315/0362-028X.JFP-18-177

Rohde, C., Wittmann, J. and Kutter, E. (2018). Bacteriophages: a therapy concept against multi-drug-resistant bacteria. *Surgical Infections*, 19(8), 737–744. https://doi.org/10.1089/sur.2018.184

Rollie, C., Chevallereau, A., Watson, B. N. J., Chyou, T., Fradet, O., McLeod, I., Brown, C. M., Gandon, S. and Westra, E. R. (2020). Targeting of temperate phages drives loss of type I CRISPR–Cas systems. *Nature*, 578(7793), 149–153. https://doi.org/10.1038/s41586-020-1936-2

Rong, R., Lin, H., Wang, J., Khan, M. N. and Li, M. (2014). Reductions of *Vibrio parahaemolyticus* in oysters after bacteriophage application during depuration. *Aquaculture*, 418–419, 171–176. https://doi.org/10.1016/j.aquaculture.2013.09.028

Salifu, S. P., Casey, S. A. C. and Foley, S. (2013). Isolation and characterisation of soilborne virulent bacteriophages infecting the

pathogen *Rhodococcus equi*. *Journal of Applied Microbiology*, 114(6), 1625–1633. https://doi.org/10.1111/jam.12194

Salomon, D., Gonzalez, H., Updegraff, B. L. and Orth, K. (2013). *Vibrio parahaemolyticus* type VI secretion system 1 is activated in marine conditions to target bacteria, and is differentially regulated from system 2. *PLoS ONE*, 8(4), e61086. http://doi.org/10.1371/journal.pone.0061086

São-José, C., Lhuillier, S., Lurz, R., Melki, R., Lepault, J., Santos, M.A. and Tavares, P. (2006), The ectodomain of the viral receptor YueB forms a fiber that triggers ejection of bacteriophage SPP1 DNA. *The Journal of Biological Chemistry*, 281(17), 11464-11470. https://doi.org/10.1074/jbc.M513625200

Scallan, E., Hoekstra, R. M., Angulo, F. J., Tauxe, R. V., Widdowson, M. A., Roy, S. L., Jones, J. L. and Griffin, P. M. (2011). Foodborne illness acquired in the United States - major pathogens. *Emerging Infectious Diseases*, 17(1), 7–15. https://doi.org/10.3201/eid1701.p11101

Schmid, M., Frei, D., Patrignani, A., Schlapbach, R., Frey, J. E., Remus-Emsermann, M. N. P. and Ahrens, C. H. (2018). Pushing the limits of de novo genome assembly for complex prokaryotic genomes harboring very long, near identical repeats. *Nucleic Acids Research*, 46(17), 8953–8965. https://doi.org/10.1093/nar/gky726

Schramlová, J., Arientová, S. and Hulínská, D. (2010). The role of electron microscopy in the rapid diagnosis of viral infections--review. *Folia Microbiologica*, 55(1), 88–101. https://doi.org/10.1007/s12223-010-0015-8

Schroven, K., Aertsen, A. and Lavigne, R. (2021). Bacteriophages as drivers of bacterial virulence and their potential for biotechnological exploitation. *FEMS Microbiology Reviews*, 45(1). https://doi.org/10.1093/femsre/fuaa041

Schwab F, Gastmeier P. and Meyer E. (2014). The warmer the weather, the more Gram-negative bacteria - Impact of temperature on clinical isolates in intensive care units. *PLoS One*, 9(3), e91105. https://doi.org/10.1371/journal.pone.0091105

Seemann, T. (2014). Prokka: rapid prokaryotic genome annotation. *Bioinformatics*, 30(14), 2068–2069. https://doi.org/10.1093/bioinformatics/btu153

Sevilla-Navarro, S., Catalá-Gregori, P., García, C., Cortés, V. and Marin, C. (2020). *Salmonella* Infantis and *Salmonella* Enteritidis specific bacteriophages isolated form poultry faeces as a complementary tool for cleaning and disinfection against *Salmonella*. *Comparative Immunology, Microbiology and Infectious Diseases*, 68, 101405. https://doi.org/https://doi.org/10.1016/j.cimid.2019.101405

Sharma, M., Patel, J. R., Conway, W. S., Ferguson, S. and Sulakvelidze, A. (2009). Effectiveness of bacteriophages in reducing *Escherichia coli* O157:H7 on fresh-cut cantaloupes and lettuce. *Journal of Food Protection*, 72(7), 1481–1485. https://doi.org/10.4315/0362-028x-72.7.1481

Shen, X., Liu, W. and Liu, C. (2010). Effects of cold storage and thermal treatment on growth and survival of pathogenic *Vibrio parahaemolyticus*. *International Conference on Bioinformatics and Biomedical Technology*, 371–373. https://doi.org/10.1109/ICBBT.2010.5478939

Shen, X., Su, Y. C., Liu, C., Oscar, T. and DePaola, A. (2019). Efficacy of *Vibrio parahaemolyticus* depuration in oysters (*Crassostrea gigas*). *Food Microbiology*, 79, 35–40. https://doi.org/10.1016/j.fm.2018.10.005

Shende, R. K., Hirpurkar, S. D., Sannat, C., Rawat, N. and Pandey, V. (2017). Isolation and characterisation of bacteriophages with lytic activity against common bacterial pathogens. *Veterinary World*, 10(8), 973–978. https://doi.org/10.14202/vetworld.2017.973-978

Shinoda, S. (2011). Sixty years from the discovery of *Vibrio parahaemolyticus* and some recollections. *Biocontrol Science,* 16(4), 129-137. http://doi.org/10.4265/bio.16.129

Shinoda, S., Matsuoka, H., Tsuchie, T., Miyoshi, S., Yamamoto, S., Taniguchi, H. and Mizuguchi, Y. (1991). Purification and characterization of a lecithin-dependent haemolysin from *Escherichia coli* transformed by a *Vibrio parahaemolyticus* gene. *Journal of General Microbiology*, 137(12), 2705–11. http://doi.org/10.1099/00221287-137-12-2705

Shousha, A., Awaiwanont, N., Sofka, D., Smulders, F. J. M., Paulsen, P., Szostak, M. P., Humphrey, T. and Hilbert, F. (2015). Bacteriophages isolated from chicken meat and the horizontal transfer of antimicrobial resistance genes. *Applied and Environmental Microbiology*, 81(14), 4600–4606. https://doi.org/10.1128/AEM.00872-15

Snoussi, M., Noumi, E., Cheriaa, J., Usai, D., Sechi, L. A., Zanetti, S. and Bakhrouf, A. (2008). Adhesive properties of environmental *Vibrio alginolyticus* strains to biotic and abiotic surfaces. *The New Microbiologica*, 31(4), 489–500.

Sobrinho, P. D. S. C., Destro, M. T., Franco, B. D. G. M. and Landgraf, M. (2014). A quantitative risk assessment model for *Vibrio parahaemolyticus* in raw oysters in Sao Paulo State, Brazil. *International Journal of Food Microbiology*, 180, 69–77. https://doi.org/10.1016/j.ijfoodmicro.2014.04.008

Soffer, N., Woolston, J., Li, M., Das, C. and Sulakvelidze, A. (2017). Bacteriophage preparation lytic for *Shigella* significantly reduces *Shigella*

sonnei contamination in various foods. *PloS One*, 12(3), e0175256–e0175256. https://doi.org/10.1371/journal.pone.0175256

Srinivasan, P. and Ramasamy, P. (2009). Occurrence, distribution and antibiotic resistance patterns of *Vibrio* species associated with viral diseased shrimp of South Indian aquaculture environment. *International Journal of Agricultural Science*, 1, 1-10. https://doi.org/10.9735/0975-3710.1.2.1-10

Stalin, N. and Srinivasan, P. (2016). Characterization of *Vibrio parahaemolyticus* and its specific phage from shrimp pond in Palk Strait, South East coast of India. *Biologicals: Journal of the International Association of Biological Standardization*, 44(6), 526–533. https://doi.org/10.1016/j.biologicals.2016.08.003

Stalin, N. and Srinivasan, P. (2017). Efficacy of potential phage cocktails against *Vibrio harveyi* and closely related *Vibrio* species isolated from shrimp aquaculture environment in the south east coast of India. *Veterinary Microbiology*, 207, 83–96. https://doi.org/https://doi.org/10.1016/j.vetmic.2017.06.006

Stoica, M. (2018). Sustainable sanitation in the food industry. In *Sustainable food systems from agriculture to industry: improving production and processing*, ed. C. M. Galanakis, pp. 309–339. Cambridge: Academic Press. https://doi.org/10.1016/B978-0-12-811935-8.00009-3

Sterk, A., Schets, F. M., de Roda Husman, A. M., de Nijs, T. and Schijven, J. F. (2015). Effect of climate change on the concentration and associated risks of *Vibrio* Spp. in Dutch recreational waters. *Risk Analysis*, 35(9), 1717-1729. https://doi.org/10.1111/risa.12365

Stewart, A. C., Osborne, B. and Read, T. D. (2009). DIYA: a bacterial annotation pipeline for any genomics lab. *Bioinformatics (Oxford, England)*, 25(7), 962–963. https://doi.org/10.1093/bioinformatics/btp097

Strydom, A. and Witthuhn, C. R. (2015). Listeria monocytogenes: a target for bacteriophage biocontrol. *Comprehensive Reviews in Food Science and Food Safety*, 14(6), 694–704. https://doi.org/10.1111/1541-4337.12153

Stulnig, T. M. and Amberger, A. (1994). Exposing contaminating phenol in nucleic acid preparations. *BioTechniques*, 16(3), 402–404.

Su, Y. C. and Liu, C. (2007). *Vibrio parahaemolyticus*: a concern of seafood safety. *Food Microbiology*, 24(6), 549–558. https://doi.org/10.1016/j.fm.2007.01.005

Sudha, S., Mridula, C., Silvester, R. and Hatha, A. A. (2014). Prevalence and antibiotic resistance of pathogenic vibrios in shellfishes from Cochin market. *Indian Journal of Geo-Marine Sciences*, 43, 815-824.

Sukumaran, A. T., Nannapaneni, R., Kiess, A. and Sharma, C. S. (2016). Reduction of *Salmonella* on chicken breast fillets stored under aerobic or modified atmosphere packaging by the application of lytic bacteriophage preparation SalmoFresh™. *Poultry Science*, 95(3), 668–675. https://doi.org/10.3382/ps/pev332

Sulakvelidze, A., Alavidze, Z. and Morris, J. G. (2001). Bacteriophage therapy. *Antimicrobial Agents and Chemotherapy*, 45(3), 649–659. https://doi.org/10.1128/AAC.45.3.649-659.2001

Sun, Y., Guo, D., Hua, Z., Sun, H., Zheng, Z., Xia, X. and Shi, C. (2019). Attenuation of multiple *Vibrio parahaemolyticus* virulence factors by Citral. *Frontiers in Microbiology*, 10, 894. https://doi.org/10.3389/fmicb.2019.00894

Suthienkul, O., Ishibashi, M., Iida, T., Nettip, N., Supavej, S., Eampokalap, B., Makino, M. and Honda, T. (1995). Urease production correlates with possession of the *trh* gene in *Vibrio parahaemolyticus* strains isolated in Thailand. *Journal of Infectious Diseases,* 172(5), 1405–1408. http://doi.org/10.1093/infdis/172.5.1405

Syal, K., Mo, M., Yu, H., Iriya, R., Jing, W., Guodong, S., Wang, S., Grys, T. E., Haydel., S. E. and Tao, N. (2017). Current and emerging techniques for antibiotic susceptibility tests. *Theranostics*, 7(7), 1795–1805. https://doi.org/10.7150/thno.19217

Tada, J., Ohashi, T., Nishimura, N., Shirasaki, Y., Ozaki, H., Fukushima, S., Takano, J., Nishibuchi, M. and Takeda, Y. (1992). Detection of the thermostable direct hemolysin gene (*tdh*) and the thermostable direct hemolysin-related hemolysin gene (*trh*) of *Vibrio parahaemolyticus* by polymerase chain reaction. *Molecular and Cellular Probes*, 6(6), 477–487. http://doi.org/ 10.1016/0890-8508(92)90044-X

Takahashi, A., Kenjyo, N., Imura, K., Myonsun, Y. and Honda, T. (2000a). Cl^- secretion in colonic epithelial cells induced by the *Vibrio parahaemolyticus* hemolytic toxin related to thermostable direct hemolysin. *Infection and Immunity,* 68(9), 5435-5438. https://doi.org/10.1128/IAI.68.9.5435-5438.2000

Takahashi, A., Sato, Y., Shiomi, Y., Cantarelli, V. V., Lida, T., Lee, M. and Honda, T. (2000b). Mechanisms of chloride secretion induced by thermostable direct haemolysin of *Vibrio parahaemolyticus* in human colonic tissue and a human intestinal epithelial cell line. *Journal of Medical Microbiology,* 49(9), 801-810. https://doi.org/10.1099/0022-1317-49-9-801

Tan, C. W., Malcolm, T., Kuan, C. H., Thung, T. Y., Chang, W. S., Loo, Y. Y., Premarathne, J. M. K. J. K., Ramzi, O. B., Norshafawatie, M. F. S., Yusralimuna, N., Rukayadi, Y., Nakaguchi, Y., Nishibuchi, M. and Radu, S. (2017). Prevalence and antimicrobial susceptibility of *Vibrio*

parahaemolyticus isolated from short mackerels (*Rastrelliger brachysoma*) in Malaysia. *Frontiers in Microbiology*, 8, 1087. https://doi.org/10.3389/fmicb.2017.01087

Tan, C. W., Rukayadi, Y., Hasan, H., Thung, T. Y., Lee, E., Rollon, W. D., Hara, H., Kayali, A. Y., Nishibuchi, M. and Radu, S. (2020). Prevalence and antibiotic resistance patterns of *Vibrio parahaemolyticus* isolated from different types of seafood in Selangor, Malaysia. *Saudi Journal of Biological Sciences*, 27(6), 1602-1608. https://doi.org/10.1016/j.sjbs.2020.01.002

Tang, F., Zhang, P., Zhang, Q., Xue, F., Ren, J., Sun, J., Qu, Z., Zhuge, X., Li, D., Wang, J., Jiang, M. and Dai, J. (2019). Isolation and characterisation of a broad-spectrum phage of multiple drug resistant *Salmonella* and its therapeutic utility in mice. *Microbial Pathogenesis*, 126, 193–198. https://doi.org/https://doi.org/10.1016/j.micpath.2018.10.042

Tanji, Y., Furukawa, C., Na, S. H., Hijikata, T., Miyanaga, K. and Unno, H. (2004a). *Escherichia coli* detection by GFP-labeled lysozyme-inactivated T4 bacteriophage. *Journal of Biotechnology*, 114(1–2), 11–20. https://doi.org/10.1016/j.jbiotec.2004.05.011

Tanji, Y., Shimada, T., Yoichi, M., Miyanaga, K., Hori, K. and Unno, H. (2004b). Toward rational control of *Escherichia coli* O157:H7 by a phage cocktail. *Applied Microbiology and Biotechnology*, 64(2), 270–274. https://doi.org/10.1007/s00253-003-1438-9

Tena, D., Arias, M., Alvarez, B. T., Mauleón, C., Jimenez, M. P. and Bisquert, J. (2010). Fulminant necrotizing fasciitis due to *Vibrio parahaemolyticus*. Journal of medical microbiology, 59(2), 235-238. https://doi.org/10.1099/jmm.0.014654-0

Thammatinna, K., Egan, M. E., Htoo, H. H., Khanna, K., Sugie, J., Nideffer, J. F., Villa, E., Tassanakajon, A., Pogliano, J., Nonejuie, P. and Chaikeeratisak, V. (2020). A novel vibriophage exhibits inhibitory activity against host protein synthesis machinery. *Scientific Reports*, 10(1), 2347. https://doi.org/10.1038/s41598-020-59396-3

Thanki, A. M., Brown, N., Millard, A. D. and Clokie, M. R. J. (2019). Genomic characterization of jumbo *Salmonella* phages that effectively target United Kingdom pig-associated *Salmonella* serotypes. *Frontiers in Microbiology*, 10, 1491. https://doi.org/10.3389/fmicb.2019.01491

Thongjun, J., Mittraparp-arthorn, P., Yingkajorn, M., Kongreung, J., Nishibuchi, M. and Vuddhakul, V. (2013). The trend of *Vibrio parahaemolyticus* infections in southern Thailand from 2006 to 2010. *Tropical Medicine and Health,* 41(4), 151-156. https://doi.org/10.2149/tmh.2013-06

Tran, T., Yanagawa, H., Nguyen, K. T., Hara-Kudo, Y., Taniguchi, T. and Hayashidani, H. (2018). Prevalence of *Vibrio parahaemolyticus* in

seafood and water environment in the Mekong Delta, Vietnam. *Journal of Veterinary Medical Science*, 80(11), 1737–1742. https://doi.org/10.1292/jvms.18-0241

Tuyet, D. T., Thiem, V. D., Seidlein, L. V., Chowdhury, A., Park, E., Canh, D. G., Chien, B. T., Tung, T. V., Naficy, A., Rao, M. R., Ali, M., Lee, H., Sy, T. H., Nichibuchi, M. and Cle, J. (2002). Clinical, epidemiological, and socioeconomic analysis of an outbreak of *Vibrio parahaemolyticus* in Khanh Hoa province, Vietnam. *The Journal of Infectious Diseases,* 186(11), 1615-1620. https://doi.org/10.1086/345731

Usman, T., Yu, Y., Liu, C., Fan, Z. and Wang, Y. (2014). Comparison of methods for high quantity and quality genomic DNA extraction from raw cow milk. *Genetics and Molecular Research: GMR*, 13(2), 3319–3328. https://doi.org/10.4238/2014.April.29.10

Vandy, S., Leakhann, S., Phalmony, H., Denny, J. and Roces, M. C. (2012). *Vibrio parahaemolyticus* enteritis outbreak following a wedding banquet in a rural village - Kampong Speu, Cambodia, April 2012. *Western Pacific Surveillance and Response Journal,* 3(4), 25-28. https://doi.org/10.5365/WPSAR.2012.3.4.004

Velazquez-Roman, J., León-Sicairos, N., Hernandez-Diaz, L., & Canizalez-Roman, A. (2013). Pandemic *Vibrio parahaemolyticus* O3:K6 on the American continent. *Frontiers in Cellular and Infection Microbiology*, 3, 110. https://doi.org/10.3389/fcimb.2013.00110

Viazis, S., Akhtar, M., Feirtag, J. and Brabban, A. D. (2011). Isolation and characterisation of lytic bacteriophages against enterohaemorrhagic *Escherichia coli*. *Journal of Applied Mircobiology*, 110, 1323–1331. https://doi.org/10.1111/j.1365-2672.2011.04989.x

Vikram, A., Woolston, J. and Sulakvelidze, A. (2021). Phage biocontrol applications in food production and processing. *Current Issues in Molecular Biology*, *40*, 267–302. https://doi.org/10.21775/cimb.040.267

Villa, A. A., Kropinski, A. M., Abbasifar, R., Abbasifar, A. and Griffiths, M. W. (2012). Genome sequence of temperate *Vibrio parahaemolyticus* bacteriophage vB_VpaS_MAR10. *Journal of Virology*, 86(24), 13851–13852. https://doi.org/10.1128/JVI.02666-12

Viswanathan, V. K., Hodges, K. and Hecht, G. (2009). Enteric infection meets intestinal function: how bacterial pathogens cause diarrhoea. *Nature Reviews Microbiology,* 7(2), 110-119. http://doi.org/10.1038/nrmicro2053

Vu, T. T. T., Alter, T., Braun, P. G., Dittrich, A. J. and Huehn, S. (2018). Inactivation of *Vibrio* sp. in pure cultures and mussel homogenates using high hydrostatic pressure. *Letters in Applied Microbiology*, 67(3), 220–225. https://doi.org/10.1111/lam.13044

Wagner, P. L. and Waldor, M. K. (2002). Bacteriophage control of bacterial virulence. *Infection and Immunity*, 70(8), 3985–3993. https://doi.org/10.1128/IAI.70.8.3985-3993.2002

Wang, J., Hu, B. E. I., Xu, M., Yan, Q. U. N., Liu, S., Zhu, X., Sun, Z., Tao, D., Ding, T., Reed, E., Gong, J., Li, Q. Q. and Hu, J. (2006). Therapeutic effectiveness of bacteriophages in the rescue of mice with extended spectrum ß-lactamase-producing *Escherichia coli* bacteremia. *International Journal of Molecular Medicine*, 17(2), 347–355. https://doi.org/10.3892/ijmm.17.2.347

Wang, J., Jiang, Y., Vincent, M., Sun, Y., Yu, H., Wang, J., Bao, Q., Kong, H. and Hu, S. (2005). Complete genome sequence of bacteriophage T5. *Virology*, 332(1), 45-65. https://doi.org/10.1016/j.virol.2004.10.049

Wang, W., Li, M. and Li, Y. (2015). Intervention strategies for reducing *Vibrio parahaemolyticus* in seafood: a review. *Journal of Food Science*, 80(1), R10–R19. https://doi.org/10.1111/1750-3841.12727

Wang, H., Tang, X., Su, Y. C., Chen, J. and Yan, J. (2017). Characterization of clinical V*ibrio parahaemolyticus* strains in Zhoushan, China, from 2013 to 2014. *PLOS ONE*, 12(7), e0180335. https://doi.org/10.1371/journal.pone.0180335

Watanabe, R., Matsumoto, T., Sano, G., Ishii, Y., Tateda, K., Sumiyama, Y., Uchiyama, J., Sakurai, S., Matsuzaki, S., Imai, S. and Yamaguchi, K. (2007). Efficacy of bacteriophage therapy against gut-derived sepsis caused by *Pseudomonas aeruginosa* in mice. *Antimicrobial Agents and Chemotherapy*, 51(2), 446–452. https://doi.org/10.1128/AAC.00635-06

Weinbauer, M. G. (2004). Ecology of prokaryotic viruses. *FEMS Microbiology Reviews*, 28(2), 127–181. https://doi.org/10.1016/j.femsre.2003.08.001

Whitaker, W. B., Parent, M. A., Naughton, L. M., Richards, G. P., Blumerman, S. L. and Boyd, E. F. (2010). Modulation of responses of *Vibrio parahaemolyticus* O3:K6 to pH and temperature stresses by growth at different salt concentrations. *Applied and Environmental Microbiology,* 76(14), 4720-4729. https://doi.org/10.1128/AEM.00474-10

Whitman, W. B., Coleman, D. C. and Wiebe, W. J. (1998). Prokaryotes: the unseen majority. *Proceedings of the National Academy of Sciences*, 95(12), 6578 – 6583. https://doi.org/10.1073/pnas.95.12.6578

Wiegand, I., Hilpert, K. and Hancock, R. (2008). Agar and broth dilution methods to determine the minimal inhibitory concentration (MIC) of antimicrobial substances. *Nature Protocols*, 3, 163–175 https://doi.org/10.1038/nprot.2007.521

Wommack, K. E. and Colwell, R. R. (2000). Virioplankton: viruses in aquatic ecosystems. *Microbiology and Molecular Biology Reviews: MMBR*, 64(1), 69–114. https://doi.org/10.1128/mmbr.64.1.69-114.2000

Wong, H. and Lee, Y. (1994). Regulation of iron on bacterial growth and production of thermostable direct hemolysin by *Vibrio parahaemolyticus* in intraperitoneal infected mice. *Microbiology and Immunology*, 38(5), 367–371. https://doi.org/10.1111/j.1348-0421.1994.tb01792.x

Wong, H. C., Wang, T. Y., Yang, C. W., Tang, C. T., Ying, C., Wang, C. H. and Chang, W. H. (2019). Characterization of a lytic vibriophage VP06 of *Vibrio parahaemolyticus*. *Research in Microbiology*, 170(1), 13–23. https://doi.org/10.1016/j.resmic.2018.07.003

Woolston, J., Parks, A. R., Abuladze, T., Anderson, B., Li, M., Carter, C., Hanna, L. F., Heyse, S., Charbonneau, D. and Sulakvelidze, A. (2013). Bacteriophages lytic for *Salmonella* rapidly reduce *Salmonella* contamination on glass and stainless steel surfaces. *Bacteriophage*, 3(3), e25697. https://doi.org/10.4161/bact.25697

Wu, B., Gong, H., Zhang, H., Chen, J. and Wang, H. (2019). Detection and quantification of total and pathogenic *Vibrio parahaemolyticus* in *Anadara subcrenata* in the Zhoushan archipelago. *Canadian Journal of Infectious Diseases and Medical Microbiology*, 5481935. https://doi.org/10.1155/2019/5481935

Wu, Y., Wen, J., Ma, Y., Ma, X. and Chen, Y. (2014). Epidemiology of foodborne disease outbreaks caused by *Vibrio parahaemolyticus*, China, 2003–2008. *Food Control*, 46, 197–202. https://doi.org/10.1016/j.foodcont.2014.05.023

Xie, T., Wu, G., He, X., Lai, Z., Zhang, H. and Zhao, J. (2019). Prevalence and genetic diversity of *Vibrio parahaemolyticus* strains from salmon in Chinese markets. *FEMS Microbiology Letters*, 366(9), 1–8. https://doi.org/10.1093/femsle/fnz103

Xu, X., Cheng, J., Wu, Q., Zhang, J. and Xie, T. (2016). Prevalence, characterization, and antibiotic susceptibility of *Vibrio parahaemolyticus* isolated from retail aquatic products in North China. *BMC Microbiology*, 16(32), 1-9. https://doi.org/10.1186/s12866-016-0650-6

Yanagihara, I., Nakahira, K., Yamane, T., Kaieda, S., Mayanagi, K., Hamada, D., Fukui, T., Ohnishi, K., Kajiyama, S., Shimizu, T., Sato, M., Ikegami, T., Ikeguchi, M., Honda, T. and Hashimoto, H. (2010). Structure and functional characterization of *Vibrio parahaemolyticus* thermostable direct hemolysin. *The Journal of Biological Chemistry,* 285(21), 16267-16274. http://dx.doi.org/10.1074/jbc.M109.074526

Yang, M., Liang, Y., Huang, S., Zhang, J., Wang, J., Chen, H., Ye, Y., Gao, X., Wu, Q. and Tan, Z. (2020a). Isolation and characterization of the novel phages vB_VpS_BA3 and vB_VpS_CA8 for lysing *Vibrio parahaemolyticus*. *Frontiers in Microbiology,* 11, 259. https://doi.org/10.3389/fmicb.2020.00259

Yang, Y., Shen, W., Zhong, Q., Chen, Q., He, X., Baker, J. L., Xiong, K., Jin, X., Wang, J., Hu, F. and Le, S. (2020b). Development of a bacteriophage cocktail to constrain the emergence of phage-resistant *Pseudomonas aeruginosa*. *Frontiers in Microbiology,* 11, 327. https://doi.org/10.3389/fmicb.2020.00327

Yang, M., Liang, Y., Su, R., Chen, H., Wang, J., Zhang, J., Ding, Y., Kong, L., Zeng, H., Xue, L., Wu, H. and Wu, Q. (2019). Genome characterization of the novel lytic *Vibrio parahaemolyticus* phage vB_VpP_BA6. *Archives of Virology*, 164(10), 2627–2630. https://doi.org/10.1007/s00705-019-04351-5

Yang, Y., Xie, J., Li, H., Tan, S., Chen, Y. and Yu, H. (2017). Prevalence, antibiotic susceptibility and diversity of *Vibrio parahaemolyticus* isolates in seafood from South China. *Frontiers in Microbiology*, 8, 2566. https://doi.org/10.3389/fmicb.2017.02566

Yano, Y., Hamano, K., Satomi, M., Tsutsui, I., Ban, M. and Aue-umneoy, D. (2014a). Prevalence and antimicrobial susceptibility of *Vibrio* species related to food safety isolated from shrimp cultured at inland ponds in Thailand. *Food Control*, 38, 30–36. https://doi.org/https://doi.org/10.1016/j.foodcont.2013.09.019

Yano, Y., Hamano, K., Satomi, M., Tsutsui, I. and Aue-umneoy, D. (2014b). Diversity and characterization of oxytetracycline-resistant bacteria associated with non-native species, white-leg shrimp (*Litopenaeus vannamei*), and native species, black tiger shrimp (*Penaeus monodon*), intensively cultured in Thailand. *Journal of Applied Microbiology*, 110, 713–722. https://doi.org/10.1111/j.1365-2672.2010.04926.x

Ye, M., Huang, Y., Gurtler, J. B., Niemira, B. A., Sites, J. E. and Chen, H. (2013). Effects of pre- or post-processing storage conditions on high-hydrostatic pressure inactivation of *Vibrio parahaemolyticus* and *V. vulnificus* in oysters. *International Journal of Food Microbiology*, 163(2), 146–152. https://doi.org/10.1016/j.ijfoodmicro.2013.02.019

Yin, Y., Ni, P., Liu, D., Yang, S., Almeida, A., Guo, Q., Zhang, Z., Deng, L. and Wang, D. (2019). Bacteriophage potential against *Vibrio parahaemolyticus* biofilms. *Food Control*, 98, 156–163. https://doi.org/https://doi.org/10.1016/j.foodcont.2018.11.034

You, L., Suthers, P. F. and Yin, J. (2002). Effects of *Escherichia coli* physiology on growth of Phage T7 in vivo and in silico. *Journal of Bacteriology*, 184(7), 1888–1894. https://doi.org/10.1128/JB.184.7.1888-1894.2002

Yu, Q., Niu, M., Yu, M., Liu, Y., Wang, D. and Shi, X. (2016). Prevalence and antimicrobial susceptibility of *Vibrio parahaemolyticus* isolated from retail shellfish in Shanghai. Food Control, 60, 263–268. https://doi.org/10.1016/j.foodcont.2015.08.005

Yu, Y., Yang, H., Li, J., Zhang, P., Wu, B., Zhu, B., Zhang, Y. and Fang, W. (2012). Putative type VI secretion systems of *Vibrio parahaemolyticus* contribute to adhesion to cultured cell monolayers. *Archives of Microbiology,* 194(10), 827–835. http://doi.org/10.1007/s00203-012-0816-z

Zampieri, A., Carraro, L., Cardazzo, B., Milan, M., Babbucci, M., Smits, M., Boffo, L. and Fasolato, L. (2020). Depuration processes affect the *Vibrio* community in the microbiota of the Manila clam, *Ruditapes philippinarum*. *Environmental Microbiology*, 22(10), 4456–4472. https://doi.org/10.1111/1462-2920.15196

Zanetti, S., Spanu, T., Deriu, A., Romano, L., Sechi, L.A. and Fadda, G. (2001). In vitro susceptibility of *Vibrio* spp. isolated from the environment. *International Journal of Antimicrobial Agents*, 17, 407-409. https://doi.org/10.1016/s0924-8579(01)00307-7

Zhang, H., Li, L., Zhao, Z., Peng, D. and Zhou, X. (2016). Polar flagella rotation in Vibrio parahaemolyticus confers resistance to bacteriophage infection. *Scientific Reports*, 6(1), 26147. https://doi.org/10.1038/srep26147

Zhang, H., Yang, Z., Zhou, Y., Bao, H., Wang, R., Li, T., Pang, M., Sun, L. and Zhou, X. (2018). Application of a phage in decontaminating *Vibrio parahaemolyticus* in oysters. *International Journal of Food Microbiology*, 275, 24–31. https://doi.org/10.1016/j.ijfoodmicro.2018.03.027

Zhang, X., Niu, Y. D., Nan, Y., Stanford, K., Holley, R., McAllister, T. and Narváez-Bravo, C. (2019). SalmoFresh™ effectiveness in controlling Salmonella on romaine lettuce, mung bean sprouts and seeds. *International Journal of Food Microbiology*, 305, 108250. https://doi.org/10.1016/j.ijfoodmicro.2019.108250

Zhong, Q., Wang, B., Wang, J., Liu, Y., Fang, X. and Liao, Z. (2019). Global proteomic analysis of the resuscitation state of *Vibrio parahaemolyticus* compared with the normal and viable but non-culturable state. *Frontiers in Microbiology*, 10, 1045. https://doi.org/10.3389/fmicb.2019.01045

Zou, P., Yang, Q., Wang, H., Xie, G., Cao, Z., Chen, X., Gao, W. and Huang, J. (2020). *In vitro* disinfection efficacy and clinical protective effects of common disinfectants against acute hepatopancreatic necrosis disease (AHPND)-causing *Vibrio* isolates in Pacific white shrimp *Penaeus vannamei*. *Journal of Microbiology*, 58(8), 675–686. https://doi.org/10.1007/s12275-020-9537-1