UNIVERSITI PUTRA MALAYSIA

EPIDEMIOLOGY AND CHARACTERISATION OF MAJOR BOVINE MASTITIS PATHOGENS IN SELECTED DAIRY HERDS OF PENINSULAR MALAYSIA

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FPV 2021 5

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By

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

September 2020

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

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Bovine mastitis is a costly endemic disease in dairy cows. In recent times, there was need by Malaysian government to boost local dairy production in order to cater for local consumption. Mastitis research; involving the epidemiology and antimicrobial resistance profile studies as well as identification of vaccine candidate targets against major mastitis pathogens, is central in enhancing dairy production. This research was aimed at studying the epidemiology of bovine mastitis pathogens from selected states of Malaysia, molecular characterise the major pathogens implicated, and identify vaccine candidate target of selected mastitis pathogens. The objectives of the study were; to determine the bacterial pathogens associated with bovine intramammary infections from selected states of Malaysia and antimicrobial resistance pattern of most prevalent pathogens; to determine the prevalence of subclinical mastitis and its associated risk factors from selected states of Malaysia; to characterise *Staphylococcus aureus* isolates as the most prevalent implicated pathogens associated with mastitis in selected states of Malaysia; and to identify immunogenic targets for development of candidate vaccines against selected mastitis pathogens by reverse vaccinology approach. Total of 1945 quarter samples from 517 cows across 33 farms were collected using a cross-sectional study design. All samples were subjected for California mastitis test (CMT). Isolation and identification of mastitis pathogens was carried out based on standard bacteriological procedures for all CMT positive samples. Antimicrobial resistance profile of selected most prevalent pathogens associated with mastitis was conducted by disk diffusion

technique. Risk factors associated with subclinical mastitis were analysed. *Staphylococcus aureus* isolates implicated in mastitis were characterised by multi locus sequence typing (MLST). Immunogenic proteins as targets for candidate vaccine development against three mastitis isolates namely; *Staphylococcus aureus*, *Escherichia coli* and *Streptococcus agalactiae* were identified by reverse vaccinology approach. The overall culture proportion positive was recorded as 68.3% (n=503/736, CI= 64.9-71.6). The respective states' culture proportion positive was 68.3% (n=71/104, CI= 58.9-76.4), 60.5% (184/304, CI= 54.6-65.8), 58.4% (n=94/161, CI= 50-65.6), 100% (n=75/75, CI= 93.9-100), and 85.9% (n=79/92, CI= 73.8-89.8) for Pahang, Perak, Selangor, Negeri Sembilan and Johor respectively. Significant difference was observed between states' culture prevalence (χ^2=63.8, P<0.001). Mastitis risk factors such as breed, age, parity, lactation stage, teat lesion score, were found to be statistically associated with occurrence of mastitis (P < 0.05). The most prevalent isolates identified were non-aureus staphylococci (NAS) 39.5%, *S. aureus* 13.1%, *K. pneumoniae* 6.5%, *S. agalactiae* 4.8%, *S. uberis* 4.3% and *E. coli* 2.6%. Resistance profile of *K. pneumoniae* isolates against ampicillin and Penicillin G were 70.4% and 88.9% respectively while that of *Actinobacter* spp. against chloramphenicol and streptomycin were 71.4% and 35.7% respectively. For *S. uberis* isolates, 66.7% and 73.3% have shown resistance to tetracycline and streptomycin respectively. The multi-locus sequence and typing (MLST) identified six sequence types (STs) of *S. aureus* isolates. The ST97 was the most prevalent (40%) followed with ST1 (20%). The rest belong to ST1496 (10%), ST4427 (10%), ST221 (10%) and ST2125 (10%). A total of 18 immunogenic proteins comprising of surface exposed and secretory components were identified as targets for candidate vaccine against three major mastitis pathogens (*S aureus, S. agalactiae* and *E. coli*). Their conserved and consensus epitopes for B-cells and T-cells were identified. These composed of six from *E. coli*, three from *S. aureus* and nine from *S. agalactiae.* In conclusion, the prevalence of mastitis, the distribution and composition of mastitis associated pathogens as well as the key predisposing factors have been established. The molecular characteristics of *S. aureus* as the most prevalent mastitis associated pathogen were uncovered, targets for potential vaccine candidates against major mastitis pathogens were determined. These outcomes would assist in formulating policies and designing of mastitis control and preventive programs with the view to curbing the losses and costs incurred due to mastitis. This would ultimately help in meeting up the target for dairy milk self-sufficiency and improve the economies of dairy farmers in Malaysia.

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

EPIDEMIOLOGI DAN PENCIRIAN PATOGEN UTAMA MASTITIS PADA LEMBU TENUSU TERPILIH DI SEMENANJUNG MALAYSIA

Oleh

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Mastitis lembu merupakan satu penyakit endemik pada lembu tenusu yang menelan kos yang tinggi. Di kebelakangan ini, terdapat keperluan bagi kerajaan Malaysia untuk meningkatkan pengeluaran tenusu tempatan bagi memenuhi keperluan negara. Penyelidikan mastitis, termasuk kajian epidemiologi dan profil kerintangan antimikrobial termasuk pengenalpastian calon vaksin terhadap patogen utama mastitis adalah penting dalam meningkatkan pengeluaran tenusu. Kajian ini bertujuan untuk mengkaji epidemiologi patogen mastitis lembu dari negeri-negeri terpilih di Malaysia, pencirian molekul patogen utama yang terlibat, dan mengenal pasti sasaran calon vaksin patogen mastitis yang dipilih. Objektif yang terlibat dalam kajian ini adalah; untuk menentukan kaitan patogen mastitis dengan infeksi intramamari dari negeri-negeri terpilih di Malaysia; mengkaji corak kerintangan antimikrobial patogen paling lazim yang terpilih; untuk menentukan kelaziman mastitis subklinikal dan faktor risiko yang berkaitan dari negari terpilih di Malaysia; untuk menentukan jenis jujukan (ST) isolat *Staphylococcus aureus* yang menyebabkan mastitis dalam negeri-negeri terpilih di Malaysia; dan untuk mengenal pasti sasaran imunogenik untuk pembangunan vaksin terhadap patogen mastitis yang dipilih dengan pendekatan vaksinologi terbalik. Sejumlah 1945 sampel daripada 517 ekor lembu di 33 ladang telah dikumpulkan secara kajian keratan rentas. Kesemua sampel diuji menggunakan ujian mastitis California (CMT). Pengasingan dan pengenalpastian patogen mastitis dijalankan menurut prosedur bakteriologi piawai bagi sampel yang positif CMT. Profil kerintangan antimikrobial patogen prevalen yang terpilih dijalankan secara teknik difusi cakera. Faktor

risiko yang berkaitan dengan mastitis subklinikal dianalisis. Isolat *S. aureus* yang terlibat dalam mastitis dicirikan oleh teknik tip jujukan pelbagai lokus (MLST). Protin imunogenik sebagai sasaran untuk pembangunan vaksin terhadap tiga isolat mastitis iaitu; *Staphylococcus aureus*, *Escherichia coli* dan *Streptococcus agalactiae* telah dikenal pasti oleh pendekatan vaksinologi terbalik. Kelaziman isolat-isolat keseluruhannya dicatatkan sebagai 68.3% (n=503/736, CI= 64.9-71.6). Kelaziman isolat dari negeri-negeri yang terpilih adalah masing-masing 68.3% (n=71/104, CI= 58.9-76.4), 60.5% (184/304, CI= 54.6-65.8), 58.4% (n=94/161, CI= 50-65.6), 100% (n=75/75, CI= 93.9-100), and 85.9% (n=79/92, CI= 73.8-89.8) untuk Pahang, Perak, Selangor, Negeri Sembilan dan Johor. Perbezaan ketara lazim diperhatikan dalam kalangan kultur daripada negeri-negeri yang terpilih (χ^2=63.8, P<0.001). Faktor risiko mastitis seperti baka, umur, pariti, peringkat laktasi, skor lesi puting, didapati secara statistik dikaitkan dengan terjadinya mastitis (P <0.05). Pengasingan yang paling lazim dikenal pasti adalah staphylococci non-aureus (NAS) 39.5%, *S. aureus* 13.1%, *K. pneumoniae* 6.5%, *S. agalactiae* 4.8%, *S. uberis* 4.3% dan *E. coli* 2.6%. Profil rintangan isolat *K. pneumoniae* terhadap *ampicilin* dan Penicillin G masing-masing adalah 70.4% dan 88.9% manakala *Actinobacter* spp. terhadap *chloramphenicol* dan *streptomycin* masing-masing adalah 71.4% dan 35.7%. Bagi isolat *S. uberis*, 66.7% dan 73.3% menunjukkan rintangan terhadap *tetracycline* dan *streptomycin*. Penaipan urutan pelbagai lokus (MLST) mengenal pasti enam tip urutan (ST) isolat *S. aureus*. ST97 adalah yang paling lazim (40%) diikuti dengan ST1 (20%). Selebihnya adalah ST1496 (10%), ST4427 (10%), ST221 (10%) dan ST2125 (10%). Sejumlah 18 protin imunogenik yang terdiri daripada komponen terdedah dan penyingkiran permukaan dikenalpasti sebagai sasaran untuk calon vaksin terhadap tiga patogen mastitis utama (*S. aureus*, *S. agalactiae* dan *E. coli*). Mereka terpelihara dan konsensus epitop untuk sel B dan sel T telah dikenalpasti. Ini terdiri daripada enam daripada *E. coli*, tiga daripada *S. aureus* dan sembilan daripada *S. agalactiae*. Sebagai kesimpulan, kelaziman mastitis, distribusi dan komposisi patogen yang berkaitan dengan mastitis serta faktor-faktor predisposisi utama telah dikenalpasti. Ciri-ciri molekul *S. aureus* sebagai patogen yang paling lazim berkaitan dengan mastitis telah ditemui, sasaran untuk calon vaksin yang berpotensi terhadap patogen mastitis utama telah ditentukan. Penemuan ini akan membantu dalam merangka dasar dan reka bentuk kawalan mastitis dan program pencegahan dengan tujuan untuk membendung kerugian dan kos yang timbul akibat mastitis. Ini akhirnya akan membantu dalam memenuhi sasaran kemandirian susu tenusu dan memperbaiki ekonomi petani tenusu di Malaysia.

ACKNOWLEDGEMENTS

All thanks be to ALLAH (SWA) for the gifts of life, health and wisdom to reach this great height. May his (ALLAH) endless blessings be with his prophet and messenger, Muhammad (SAW). I would like to particularly thank my Supervisors, Professor Dr Zunita Zakaria, Professor Dr Jesse Faez Firdaus Abdullah and Dr Siti Zubaidah Ramanoon for their time, commitments, suggestions, supports and constructive criticisms throughout the course of this study. I would like to thank the management of my institution, Sule Lamido University Kafin-Hausa for given me this great opportunity of pursuing my PhD studies. My thanks also go to my parents for their supports, prayers and for building the foundations of where I stand today. I must acknowledge the support and accompany of my family, thank you for the prayers and patience. My appreciations also go to the staff of Bacteriology Lab, in person of Mr. Azri, Miss Kris, and Miss Ada. I must also put in record my thanks to Dr. Sabri Muhammad of Bacteriology, Mr. Jeffrey for their support and help during the course of this journey. I must also appreciate and acknowledge the support and help of the staff of Department of Veterinary Services (DVS) especially those in Perak and Pahang. My thanks also to all other staff and students of Bacteriology Lab for their help, supports, and prayers. My appreciations and thanks to all my colleagues in the Faculty of Veterinary Medicine whom we have been together throughout this period of study.

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

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Declaration by Members of Supervisory Committee

This is to certify that:

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

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µL	Microliter
µM	Micro Molar
AA	Amino acid
AMIR	Antibody-Mediated Immune Response
AMR	Antimicrobial Resistance
API	Analytical Profile Index
APPs	Acute Phase Proteins
BHI	Brain Heart Infusion
BLAST	Basic Local Alignment Search Tool
BOLA	Bovine Leukocyte Antigen
bp	Base pair
CC	Clonal Complex
CI	Confidence Interval
CM	Clinical Mastitis
CMT	California mastitis test
CNS	Coagulase-negative Staphylococci
Da	Daltons
DANMAP	Occurrence of Antimicrobial Resistance in Zoonotic, Indicator, and Pathogenic Bacteria from Animals, Food, and Humans in Denmark
DEG	Database of Essential Genes
DLV	Double Locus Variant
DNA	Deoxyribonucleic Acid
dNTPs	Deoxyribonucleotide triphosphates
DVS	Department of veterinary services
EC	Electrical Conductivity

EDCD	Epidemiology Disease Control Division
EMA	European Medicines Agency
ESBL	Extended-spectrum beta-lactamases
ESVAC	European Surveillance of Veterinary Antimicrobial Consumption
F	Forward Primer
FAO	Food and Agriculture Organization
GC	Guanine-Cytosine
GERMAP	Consumption of Antibiotics and the Spread of Antibiotic Resistance in Human and Veterinary Medicine in Germany
Hp	Haptoglobin
HPCIAs	Highest Priority Critically Important Antimicrobials
IBM	International Business Machine
IgG	Immunoglobulin G
IL	Interleukin
IMIs	Intramammary Infections
Kb	kilobyte
LDH	Lactate Dehydrogenase
LFQ	Left Front Quarter
LHQ	Left Hind Quarter
MARAN	Monitoring of Antimicrobial Resistance and Antibiotic usage in Animals in the Netherlands
Mb	Megabyte
MHC	Major Histocompatibility Complex
ml	Milliliter
MLEE	Multi-Locus Enzyme Electrophoresis
MLST	Multi-locus sequence typing
MRSA	Methicillin Resistant *Staphylococcus aureus*

MSA	Multiple Sequence Alignment
MSCC	Microscopic Somatic Cell Count
MSSA	Methicillin Susceptible *Staphylococcus aureus*
NAGase	N-acetyl-b-D-glucosaminidase
NAS	Non-aureus Staphylococci
NGS	Next Generation Sequencing
NMC	National Mastitis Council
NORM-VET	Usage of Antimicrobial Agents and Occurrence of Antimicrobial Resistance in Norway
OECD-FAO	Organisation for Economic Co-operation and Development and the Food and Agriculture Organization of the United Nations
PCR	Polymerase Chain Reaction
PFGE	Pulsed-Field Gel Electrophoresis
PG	Prostaglandin
PMNs	Polymorphonuclear Neutrophils
PPIs	Protein-Protein Interactions
QTL	Quantitative Trait Loci
R	Reverse Primer
RFQ	Right Front Quarter
RHQ	Right Hind Quarter
RNA	Ribonucleic Acid
RV	Reverse vaccinology
SAA	Serum Amyloid A
SCC	Somatic Cell Count
SFMT	Surf Field Mastitis Test
SLST	Sodium Laurylsulphate Test
SLV	Single Locus Variant

SM	Subclinical Mastitis
SPSS	Statistical Package for Social Science
STs	Sequence types
SVARM	Swedish Veterinary Antimicrobial Resistance Monitoring
TNF-a	Tumor Necrosis Factor-a
TSST- 1	Toxic Shock Syndrome Toxin-One
UK	United Kingdom
UPM	Universiti Putra Malaysia
USD	United State Dollar
VFdb	Virulence Factors Database
WHO	World Health Organization
WST	Whiteside Test

CHAPTER 1

INTRODUCTION

1.1 General overview

Historically, evidences suggested that dairy cows are known to produce milk since 3100 BC (Nemet-Nejat, 1998) and it is therefore likely that bovine mastitis has been in existence since that period. For thousands of years, the closely study needed by hand milking helped in easy detection of abnormal signs in milk and the mammary gland, but there was little or no knowledge of the causes or how to handle mastitis. A greater understanding of mastitis was not feasible until the advancement in microscopes that helped in detection of microorganisms which form the major mastitis aetiological agents (Ruegg, 2017).

Tremendous advancements in the area of animal breeding, animal nutrition, and animal husbandry practices have helped in boosting the milk quantity around the world from the last forty years. This helped in meeting the increasing need for milk and its products (Shook, 2006). As a result of better understanding of host responses to intramammary infections (IMIs) and treatment protocols resulting from adoption of a number of controls and preventive measures (Oviedo-Boyso et al., 2007; Atalla et al., 2010), continuous changes have been observed on the predominance of mastitis etiology (Zadoks and Fitzpatrick, 2009). The detrimental economic effects of bovine mastitis has largely remained unchanged over the last decades (Hogeveen et al., 2011; Detilleux et al., 2015).

Bovine mastitis is the infection of the mammary gland in cows (Mushtaq et al., 2018b). It is among one of the most prevalent health disorders of lactating cows in the world, caused by infectious and non-infectious agents. The infectious form is caused by invasion, colonization and inflammation of the mammary gland by disease causing microorganisms such as bacteria, fungi, or algae. The non-infectious mastitis is a result of injury, chilling, bruising or poor milking procedures (Kumar et al. 2011).

The most commonly isolated bacteria from bovine mastitis are the staphylococci (Leitner et al., 2011) and *S. aureus* is the most common cause of bovine mastitis (Oliveira et al., 2007). However, non-aureus staphylococci (NAS) have become the most prevalent isolates from bovine mastitis in many countries and are considered predominant over *S. aureus* in most countries, and could therefore be regarded as emerging mastitis pathogens (Tremblay et

al., 2013). In addition to staphylococci, coliforms, enterococci, and streptococci are also frequently isolated from intramammary infections (IMIs) (Bradley et al., 2007).

Staphylococcus aureus, although mostly considered as human pathogen, has been isolated from a number of vertebrate species, showing the ability to thrive in numerous host environments (Kloos, 1980). Some decades ago, phenotypic variations between human and animal strains of *S. aureus* were identified, signifying that *S aureus* strains associated with different animal habitat had acquired distinctive phenotypic features unique for their hosts (Fitzgerald, 2012).

The aptitude to correctly differentiate between strains of disease-causing agents is important for effective epidemiological and surveillance studies, determining the microbial population structure and dynamics, and at the end, developing better ways for tackling the spread of diseases in a community. To achieve these objectives, different molecular techniques for identifying and characterizing bacterial isolates from global or local disease outbreaks have been proposed (Foley et al., 2009) . However, multi-locus sequence typing (MLST) is a standard technique for molecular typing (Ibarz Pavón and Maiden, 2009).

Traditional vaccines are typically deactivated or attenuated vaccines resulting from inactivating the virulence of the pathogen through physical or chemical means (Skwarczynski and Toth, 2012; Karch and Burkhard, 2016). As a result of the incessant development in immunology and molecular biology, subunit vaccines have been studied based on small and specific pathogen fragments. This is to solve the problem associated with traditional vaccines, such as reversion, virulence, inability to culture pathogens, and problems resulted from allergies and autoimmunity induced by the traditional vaccines (Nezafat et al., 2016; Karch and Burkhard, 2016).

The combination of immuno-proteomics with bioinformatics tools, such as reverse vaccinology (RV) and other in silico approaches, were used to analyze the surface exposed proteome of *S. aureus* with the view to identify vaccine antigenic targets (Misra et al., 2018). This method have been employed to identify conserved targets for candidate vaccines against many bacterial pathogens like *Pseudomonas aeruginosa* (Rashid et al., 2017), *Helicobacter pylori* (Naz et al., 2015), *Brucella melitensis* (Vishnu et al., 2017), and *Vibrio cholerae* (Nezafat et al., 2016).

1.2 Problem statement and significance of the study

Dairy farming is an important universal agricultural production. It forms an essential part of global food system and serve critical role in the sustainability of people in the rural areas in particular. The Malaysian dairy sector which consists of about 32,826 heads of cattle, 826 dairy farms cannot produce the dairy milk needed for local consumption (DVS, 2018) and as such Malaysia depends heavily on imports with a value added chain of RM 1.2 billion (Sim and Suntharalingam, 2015).

In order to boost local dairy production, the Malaysian dairy sector has received more government attention in recent years than in the past, part of which mastitis research was identified as a means of boosting production, and addressing the challenges of huge losses faced by local dairy farmers due to subclinical mastitis. The research areas identified includes but not limited to studying the epidemiology of mastitis pathogens, investigating antibiotic resistance profiles of mastitis pathogens and identifying candidate vaccines against most common mastitis pathogens in Peninsular Malaysia.

In addition, mastitis poses potential danger to human health because of possible zoonotic infection and food poisoning (Fernandes et al., 2011). There is serious concern in veterinary medicine on the rise of antimicrobial resistance among infectious agents that affects animal health. This trend of increasing resistance in animals have continued to pose serious threat to humans through possible zoonotic infection by those resistant pathogens. Mastitis is considered one of the largest cause of antibiotic use in dairy farms (Moon et al., 2007). Treatment of mastitis is associated with some setbacks mainly caused as a result of antibiotic misuse before *in-vitro* testing against the causal agents. This tradition contributes not only to the increase of the treatment failures in association with commonly used antimicrobials, but also to the economic losses (Owens et al., 1997). To ensure best treatment, isolation of bacterial pathogen and antibiotic sensitivity testing is important (Kaliwal et al., 2011).

Large scale data on the pervasiveness and microbial etiology of mastitis pathogens associated with subclinical mastitis as well as their antimicrobial resistance profiles are scanty. Knowledge on the molecular epidemiology and population structure of *S. aureus* as probable most prevalent mastitis pathogen is lacking. Identification of conserved immunogenic targets for candidate vaccines against major mastitis pathogens in Malaysia have never been attempted.

1.3 Research hypothesis

Studying the epidemiology of bovine mastitis and identifying vaccine targets against most common mastitis pathogens in Peninsular Malaysia would help in enhancing local dairy milk production and boost economy.

1.4 Aim and specific objectives

The aim of this study is to determine the epidemiology and characterise major bovine mastitis pathogens in selected dairy herds of Peninsular Malaysia

The specific objectives of the study were:

1. to determine the bacterial pathogens associated with bovine IMIs in selected dairy herds of Peninsular Malaysia and antimicrobial resistance profile of selected prevalent pathogens;
2. to determine the prevalence and risk factors of subclinical mastitis in selected dairy herds of Peninsular Malaysia;
3. to characterise *S. aureus* isolates from bovine mastitis cases in Malaysia; and
4. to identify immunogenic targets for the development of candidate vaccines against selected mastitis pathogens of Malaysian origin by reverse vaccinology approach.

REFERENCES

Abebe, R., Hatiya, H., Abera, M., Megersa, B., & Asmare, K. (2016). Bovine mastitis: Prevalence, risk factors and isolation of *Staphylococcus aureus* in dairy herds at Hawassa milk shed, South Ethiopia. *BMC Veterinary Research*, *12*(1), 270.

Abrahmsén, M., Persson, Y., Kanyima, B. M., & Båge, R. (2014). Prevalence of subclinical mastitis in dairy farms in urban and peri-urban areas of Kampala, Uganda. *Tropical Animal Health and Production*, *46*(1), 99–105.

Abureema, S., Smooker, P., Malmo, J., & Deighton, M. (2014). Molecular epidemiology of recurrent clinical mastitis due to *Streptococcus uberis*: Evidence of both an environmental source and recurring infection with the same strain. *Journal of Dairy Science*, 97, 285–290.

Ahamed K. S-S., Gulam R. W., NadiahWa, W. A., & Chuah, L. O. (2016). Prevalence and antibiotics resistance of *Staphylococcus aureus* isolates isolated from raw milk obtained from small-scale dairy farms in Penang. *Pakistan Veterinary Journal,* 98–102.

Amer, S., Gálvez, F. L. A., Fukuda, Y., Tada, C., Jimenez, I. L., Valle, W. F. M., & Nakai, Y. (2018). Prevalence and etiology of mastitis in dairy cattle in El Oro Province, Ecuador. *The Journal of Veterinary Medical Science*, *80*(6), 861–868.

Andersen, H. J., L. H. Pedersen, F. M. Aarestrup, & M. Chriél. (2003). Evaluation of the surveillance program of *Streptococcus agalactiae* in Danish dairy herds. *Journal of Dairy Science*, 86, 1233–1239. Anderson, K. L., Lyman, R., Moury, K., Ray, D., Watson, D. W., & Correa, M. T. (2012). Molecular epidemiology of Staphylococcus aureus mastitis in dairy heifers. *Journal of Dairy Science*,95, 4921–4930.

Andrews, A. H. (1989). Veterinary medicine: A textbook of the diseases of cattle, sheep, pigs, goats and horses, 7th edition. *British Veterinary Journal*, *145*(5), 497–498.

Archer, G.L., Karchmer, A. W., Vishniavsky, N., & Johnston, J. L. (1984). Plasmid-pattern analysis for the differentiation of infecting from non-infecting *Staphylococcus epidermidis*. *Journal of Infectious Diseases*, 149, 913-920.

Arnould, V. M. R., Soyeurt, H., Gengler, N., Colinet, F. G., Georges, M. V., Bertozzi, C., Portetelle, D., & Renaville, R. (2009). Genetic analysis of lactoferrin content in bovine milk. *Journal of Dairy Science*, *92*(5), 2151–2158.

Asad, Y., Ahmad, S., Rungrotmongkol, T., Ranaghan, K. E., & Azam, S. S. (2018). Immuno-informatics driven proteome-wide investigation revealed novel peptide-based vaccine targets against emerging multiple drug resistant *Providencia stuartii*. *Journal of Molecular Graphics and Modelling*, *80*, 238–250.

Atalla, H., Wilkie, B., Gyles, C., Leslie, K., Mutharia, L., & Mallard, B. (2010). Antibody and cell-mediated immune responses to *Staphylococcus aureus* small colony variants and their parental strains associated with bovine mastitis. *Developmental and Comparative Immunology*, *34*(12), 1283–1290.

Awale M. M., Dudhatra G. B., Avinash K., Chauhan B.N., Kamani D. R., Modi C..M., P. H. B. & M. S. K. (2012). Bovine mastitis: a threat to economy. *Open Access Scientific Reports*. 1(5), 1–10.

Baba, K., Ishihara, K., Ozawa, M., Tamura, Y., & Asai, T. (2010). Isolation of meticillin-resistant *Staphylococcus aureus* (MRSA) from swine in Japan. *International Journal of Antimicrobial Agents*, *36*(4), 352–354.

Bankevich, A., Nurk, S., Antipov, D., Gurevich, A. A., Dvorkin, M., Kulikov, A. S., Lesin, M. V., Nikolenko, S. I., Pham, S., Prjibelski, A. D., Pyshkin, A. V., Sirotkin, N. V., Tesler, G., Alekseyev, M. A., & 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.

Bannerman, D. D., & Wall, R. J. (2005). *ISB News Report a novel strategy for the prevention of Staphylococcus aureus-induced mastitis in dairy cows*.

Bannerman, T. L., Hancock, G. A., Tenover, F. C., & Miller, J. M. (1995). Pulsed-field gel electrophoresis as a replacement for bacteriophage typing of *Staphylococcus aureus*. *Journal of Clinical Microbiology*, *33*(3), 551–555.

Bar, D., L. W. Tauer, G. Bennett, R. N. Gonzalez, J. A. Hertl, Y. H. Schukken, H. F. Schulte, F. L. Welcome, & Y. T. Gröhn. (2008b). The cost of generic clinical mastitis in dairy cows as estimated by using dynamic programming. *Journal of Dairy Science,* 91, 2205–2214.

Barbano, D. M., Y. Ma, & Santos, M. V. (2006). Influence of raw milk quality on fluid milk shelf life. *Journal of Dairy Science,* 89 (1), E15–E19.

Barh, D., Misra, A. N., Kumar, A., & Azevedo, V. (2010). A novel strategy of epitope design in *Neisseria gonorrhoeae*. *Bioinformation* 5, (2), 77.

Barkema, H. W., Y. H. Schukken, & R. N. Zadoks. (2006). Invited review: The role of cow, pathogen, and treatment regimen in the therapeutic success of bovine *Staphylococcus aureus* mastitis. *Journal of Dairy Science*,

89, 1877–1895.

Barkema, H. W., Green, M. J., Bradley, A. J., & Zadoks, R. N. (2009). Invited review : The role of contagious disease in udder health. *Journal of Dairy Science*, *92*(10), 4717–4729.

Baron, C., & Coombes, B. (2007). Targeting bacterial secretion systems: benefits of disarmament in the microcosm. *Infectious Disorders-Drug Targets*, 7(1), 19–27.

Bartlett, P. C., & Miller, G. Y. (1993). Managerial risk factors for intramammary coagulase-positive staphylococci in Ohio dairy herds. *Preventive Veterinary Medicine*, *17*(1–2), 33–40.

Batchelor, M., Hopkins, K. L., Liebana, E., Slickers, P., Ehricht, R., Mafura, M., Aarestrup, F., Mevius, D., Clipton-Hadley, F. A., Woodward, M. J., Davies, R. H., Threlfall, E. J. & Anjum, M. F. (2008). Development of a miniaturised microarray-based assay for the rapid identification of antimicrobial resistance genes in Gram-negative bacteria. *International Journal of Antimicrobial Agents*, *31*(5), 440–451.

Bergeron, M., Dauwalder, O., Gouy, M., Freydiere, A.-M., Bes, M., Meugnier, H., Benito, Y., Etienne, J., Lina, G., Vandenesch, F. & Boisset, S. (2011). Species identification of staphylococci by amplification and sequencing of the tuf gene compared to the gap gene and by matrix-assisted laser desorption ionization time-of-flight mass spectrometry. *European Journal of Clinical Microbiology & Infectious Diseases*, *30*(3), 343–354.

Berker, S., Hanage, W. P., & Holt, K. E. (2010). Navigating the future of bacterial molecular epidemiology. *Current Opinion in Microbiology*, 13, 640-645.

Birhanu, M., Leta, S., Mamo, G., & Tesfaye, S. (2017). Prevalence of bovine subclinical mastitis and isolation of its major causes in Bishoftu Town, Ethiopia. *BMC Research Notes*, *10*(1).

Blum, S., Heller, E. D., Krifucks, O., Sela, S., Hammer-Muntz, O., & Leitner, G. (2008). Identification of a bovine mastitis *Escherichia coli* subset. *Veterinary Microbiology*, *132*(1–2), 135–148.

Boehmer, J. L. (2011). Proteomic analyses of host and pathogen responses during bovine mastitis. *Journal of Mammary Gland Biology and Neoplasia*, *16*(4), 323–338.

Borm, A. A., Fox, L. K., Leslie, K. E., Hogan, J. S., Andrew, S. M., Moyes, K. M., Oliver, S. P., Schukken, Y. H., Hancock, D. D., Gaskins, C. T., Owens, W.E. & Norman, C. (2006). Effects of prepartum intramammary

antibiotic therapy on udder health, milk production, and reproductive performance in dairy heifers. *Journal of Dairy Science*, *89*(6), 2090–2098.

Bradley, A. J. (2002a). Bovine Mastitis: An evolving disease. *The Veterinary Journal*, *164*(2), 116–128.

Bradley, A. J., Breen, J. E., Payne, B., White, V., & Green, M. J. (2015). An investigation of the efficacy of a polyvalent mastitis vaccine using different vaccination regimens under field conditions in the United Kingdom. *Journal of Dairy Science*, *98*(3), 1706–1720.

Bradley, A. J., & Green, M. J. (2000). A study of the incidence and significance of intramammary enterobacterial infections acquired during the dry period. *Journal of Dairy Science*, *83*(9), 1957–1965.

Bradley, A. J., Leach, K. A., Breen, J. E., Green, L. E., & Green, M. J. (2007a). Survey of the incidence and aetiology of mastitis on dairy farms in England and Wales. *The Veterinary Record*, *160*(8), 253–257.

Bradley, A. J., & M. J. Green. (2001a). Adaptation of *Escherichia coli* to the bovine mammary gland. *Journal of Clinical Microbiol*ogy, 39, 1845–1849.

Bradley, A. J., Leach, K. A., Breen, J. E., Green, L. E., & Green, M. J. (2007b). Survey of the incidence and aetiology of mastitis on diary farms in England and Wales. *Veterinary Record*, *160*(8), 253–258.

Breed, R. S., & J. D. Brew. (1917).The control of public milk supplies by the use of the microscopic method. *Journal of Dairy Science,* 1, 259–271.

Briyne, Nde, Atkinson, J., Borriello, S.P., & Pokludová, L. (2014). Antibiotics used most commonly to treat animals in Europe. *Veterinary Record,* 175, 325.

Budd, K. E., Mitchell, J., & Keane, O. M. (2016). Lineage associated expression of virulence traits in bovine-adapted *Staphylococcus aureus. Veterinary Microbiology*, *189*, 24–31.

Burvenich, C., Van Merris, V., Mehrzad, J., Diez-Fraile, A., & Duchateau, L. (2003). Severity of *E. coli* mastitis is mainly determined by cow factors. *Veterinary Research,* 34(5):521–64.

Camacho, C., Coulouris, G., Avagyan, V., Ma, N., Papadopoulos, J., Bealer, K., & Madden, T. L. (2009). BLAST+: architecture and applications. *BMC Bioinformatics*, *10*(1), 421.

Cha, E., J. A. Hertl, Y. H. Schukken, L. W. Tauer, F. L. Welcome, and Y. T. Gröhn. (2013). The effect of repeated episodes of bacteria- specific clinical mastitis on mortality and culling in Holstein dairy cows. *Journal of Dairy Science,* 96, 4993–5007.

Capurro, A., Artursson, K., Waller, K. P., Bengtsson, B., Ericsson-Unnerstad, H., & Aspán, A. (2009). Comparison of a commercialized phenotyping system, antimicrobial susceptibility testing, and tuf gene sequence-based genotyping for species-level identification of coagulase-negative staphylococci isolated from cases of bovine mastitis. *Veterinary Microbiology*, *134*(3–4), 327–333.

Caruso, M., Latorre, L., Santagada, G., Fraccalvieri, R., Miccolupo, A., Sottili, R., Palazzo, L. & Parisi, A. (2016). Methicillin-resistant *Staphylococcus aureus* (MRSA) in sheep and goat bulk tank milk from Southern Italy. *Small Ruminant Research*, *135*, 26–31.

Caugant, D. A., Froholm, L. O., Bovre, K., Holten, E., Frasch, C. E., Mocca, L. F., Zollinger, W. D. & Selander, R. K. (1986). Intercontinental spread of a genetically distinctive complex of clones of *Neisseria meningitidis* causing epidemic disease. *Proceedings of the National Academy of Sciences*, 83, (13), 4927–4931.

Cervinkova, D., Vlkova, H., Borodacova, I., Makovcova, J., Babak, V., Lorencova, A., Vrtkova, I., Marosevic, D. & Jaglic, Z. (2013). Prevalence of mastitis pathogens in milk from clinically healthy cows. *Veterinarni Medicina*, 58 (11), 567-575.

Chen, L., Yang, J., Yu, J., Yao, Z., Sun, L., Shen, Y., & Jin, Q. (2005). VFDB: a reference database for bacterial virulence factors. *Nucleic Acids Research*, *33*(Database issue), D325-8.

Chen, W., Liu, Y., Yin, J., Deng, Y., Ali, T., Zhang, J., Cheng, J., Rahman, S., Gao, J., & Han, B. (2017). Cloning, expression, and immunogenicity of fimbrial-F17A subunit vaccine against *Escherichia coli* isolated from bovine mastitis. *BioMed Research International*, *2017*, 1–10.

Chen, X., Wang, W.-K., Han, L.-Z., Liu, Y., Zhang, H., Tang, J., Liu, Q-Z., Huangfu, Y-C., Ni, Y-X., W-k, W., & L-z, H. (2013). Epidemiological and genetic diversity of *Staphylococcus aureus* causing bloodstream infection in Shanghai. *PLoS ONE*, *8*(9), 72811.

Cheng, J., Qu, W., Barkema, H. W., Nobrega, D. B., Gao, J., Liu, G., Buck, J. D., Kastelic, P. J., Sun, H. & Han, B. (2019). Antimicrobial resistance profiles of 5 common bovine mastitis pathogens in large Chinese dairy herds. *Journal of Dairy Science*, *102*(3), 2416–2426.

Ching, K. L., Ramanoon, S. Z., & Bejo, S. K. (2011). Mastitis in the dairy herd at Taman Pertanian Universiti Putra Malaysia. *6th Proceedings of the Seminar on Veterinary Sciences*. pp. 121.

Chye, F. Y., Abdullah, A., & Ayob, M. K. (2004). Bacteriological quality and safety of raw milk in Malaysia. *Food Microbiology*, *21*(5), 535–541.

Compton, C. W. R., Heuer, C., Parker, K., & McDougall, S. (2007). Risk factors for peripartum mastitis in pasture-grazed dairy heifers. *Journal of Dairy Science*, *90*(9), 4171–4180.

Cullen, G. A., & Little, T. W. (1969). Isolation of *Streptococcus uberis* from the rumen of cows and from soil. *The Veterinary Record*, *85*(5), 115–118.

Dashti, A. A., Jadaon, M. M., Abdulsamad, A. M., & Dashti, H. M. (2009). Heat treatment of bacteria: s simple method of DNA extraction for molecular techniques. *Kuwait Medical Journal* 14(2), 117-122.

De Vliegher, S., Fox, L. K., Piepers, S., McDougall, S., & Barkema, H. W. (2012). Invited review: Mastitis in dairy heifers: nature of the disease, potential impact, prevention, and control. *Journal of Dairy Science*, *95*(3), 1025–1040.

Delany, I., Rappuoli, R., & Seib, K. L. (2013). Vaccines, reverse vaccinology, and bacterial pathogenesis. *Cold Spring Harbor Perspectives in Medicine*. 3, a012476.

Department of Veterinary Services (DVS). Veterinary services in Malaysia: It's relevance to nation building, keynote address, veterinary association of Malaysia congress (2018). *Proceedings of Veterinary Association of Malaysia Congress*, pp. 1-2.

Detilleux, J., Kastelic, J. P., & Barkema, H. W. (2015). Mediation analysis to estimate direct and indirect milk losses due to clinical mastitis in dairy cattle. *Preventive Veterinary Medicine*, *118*(4), 449–456.

Dimitrov, I., Flower, D. R., & Doytchinova, I. (2013). AllerTOP - a server for in *silico* prediction of allergens. *BMC Bioinformatics*, *14*(6), S4.

Dingwell, R. T., Leslie, K. E., Schukken, Y. H., Sargeant, J. M., & Timms, L. L. (2003). Evaluation of the California mastitis test to detect an intramammary infection with a major pathogen in early lactation dairy cows. *Canadian Veterinary Journal*, *44*(5), 413–416.

Dolder, C., van den Borne, B. H. P., Traversari, J., Thomann, A., Perreten, V., & Bodmer, M. (2017). Quarter- and cow-level risk factors for intramammary infection with coagulase-negative staphylococci species

in Swiss dairy cows. *Journal of Dairy Science*, *100*(7), 5653–5663.

Dolejska, M., Z. Jurcickova, I. Literak, L. Pokludova, J. Bures, A. Hera, L. Kohoutova, J. Smola, and A. Cizek. (2011). IncN plasmids carrying blaCTX-M-1 in *Escherichia coli* isolates on a dairy farm. *Veterinary Microbiol*ogy, (149), 513–516.

Donati, C., & Rappuoli, R. (2013). Reverse vaccinology in the 21st century: Improvements over the original design. *Annals of the New York Academy of Sciences*, 1285 (1), 115-132.

Döpfer, D., H. W. Barkema, T. J. G. M. Lam, Y. H. Schukken, & W. Gaastra. (1999). Recurrent clinical mastitis caused by *Escherichia coli* in dairy cows. *Journal of Dairy Science,* 82, 80–85.

Down, P. M., Bradley, A. J., Breen, J. E., Hudson, C. D., & Green, M. J. (2016). Current management practices and interventions prioritized as part of a nationwide mastitis control plan. *Veterinary Records*, 178(18),449.

Du, J., Wang, X., Luo, H., Wang, Y., Liu, X., & Zhou, X. (2018). Epidemiological investigation of non-albicans Candida species recovered from mycotic mastitis of cows in Yinchuan, Ningxia of China. *BMC Veterinary Research*, *14*(1), 251.

Eddy, S. R. (1998). Profile hidden Markov models. *Bioinformatics*, *14*(9), 755–763.

Elbably M, & Asmaa H. (2013). Risk factors associated with mastitis occurrence in dairy herds in Benisuef, Egypt. *Worlds Veterinary journal,* 6(1), 05.

Elbers, A. R. W., J. D. Miltenburg, D. De Lange, A. P. P. Crauwels, H. W. Barkema, & Y. H. Schukken. (1998). Risk factors for clinical mastitis in a random sample of dairy herds from the southern part of The Netherlands. *Journal of Dairy Science*, 81, 420–426.

Elghafghuf, A., S. Dufour, K. Reyher, I. Dohoo, & H. Stryhn. (2014). Survival analysis of clinical mastitis data using a nested frailty Cox model fit as a mixed-effects Poisson model. *Preventive Veterinary Medicine*, 117, 456–468.

El-Jakee, J. K., Aref, N. E., Gomaa, A., El-Hariri, M. D., Galal, H. M., Omar, S. A., & Samir, A. (2013). Emerging of coagulase negative staphylococci as a cause of mastitis in dairy animals: An environmental hazard. *International Journal of Veterinary Science and Medicine*, *1*(2), 74–78.

EL-Manzalawy, Y., Dobbs, D., & Honavar, V. G. (2017). *In silico* prediction of linear B-Cell epitopes on proteins. In *Methods in Molecular Biology*,1484, 255–264.

Emori, T. G., & Gaynes, R. P. (1993). An overview of nosocomial infections, including the role of the microbiology laboratory. *Clinical Microbiology Reviews*. 6(4), 428-442.

Enright, M. C., Day, N. P. J., Davies, C. E., Peacock, S. J., & Spratt, B. G. (2000a). Multilocus sequence typing for characterization of methicillin-resistant and methicillin-susceptible clones of *Staphylococcus aureus*. *Journal of Clinical Microbiology*, *38*(3), 1008–1015.

Enright, M. C., Day, N. P. J., Davies, C. E., Peacock, S. J., & Spratt, B. G. (2000b). Multilocus sequence typing for characterization of methicillin-resistant and methicillin-susceptible clones of *Staphylococcus aureus*. *Journal of Clinical Microbiology*, *38*(3), 1008.

Erskine, R. J., Walker, R. D., Bolin, C. A., Bartlett, P. C., & White, D. G. (2002). Trends in antibacterial susceptibility of mastitis pathogens during a seven-year period. *Journal of Dairy Science*, 85(5), 1111-1118.

Etifu, M., Afera, Y., & Trueha, K. (2018). Prevalence of mastitis at cow and quarter level and correlated threat factors in selected districts of Guraghe zone, Ethiopia. *International Journal of Scientific and Research Publications*, *8*(12), 582.

European Medicines Agency. (2017). Sales of veterinary antimicrobial agents in 30 European Countries in 2015: Trends from 2010 to 2015. Seventh European surveillance of veterinary antimicrobial consumption (ESVAC) Report. EMA/ 184855/2017.

European committee on antimicrobial susceptibility testing. (2019). Breakpoint tables for interpretation of MICs and zone diameters, Version 9.0, http://www.eucast.org.

FAO (2014). Food and Agriculture Organization of the United Nations, Rome, Italy. http://faostat.fao.org/default.aspx.

FAO. (2016). *OECD-FAO Agricultural Outlook 2019-2028*. *Food and Agriculture Organization*. OECD. https://doi.org/10.1787/agr_outlook-2019-en

Fávero, S., Portilho, F. V. R., Oliveira, A. C. R., Langoni, H., & Pantoja, J. C. F. (2015). Factors associated with mastitis epidemiologic indexes, animal hygiene, and bulk milk bacterial concentrations in dairy herds housed on compost bedding. *Livestock Science*, *181*, 220–230.

Feil, E. J., Li, B. C., Aanensen, D. M., Hanage, W. P., & Spratt, B. G. (2004). eBURST: Inferring patterns of evolutionary descent among clusters of related bacterial genotypes from multilocus sequence typing data. *Journal of Bacteriology*, *186*(5), 1518–1530.

Feng, Y., Qi, W., Xu-Rong, W., Ling, W., Li, X.-P., Jin-Yin, L., Zhang, S-D., & Li, H.-S. (2016). ScienceDirect genetic characterization of antimicrobial resistance in *Staphylococcus aureus* isolated from bovine mastitis cases in Northwest China. *Journal of Integrative Agriculture*, *15*(12), 2842–2847.

Fernandes, J. B. C., Zanardo, L. G., Galvão, N. N., Carvalho, I. A., Nero, L. A., & Moreira, M. A. S. (2011). *Escherichia coli* from clinical mastitis: Serotypes and virulence factors. *Journal of Veterinary Diagnostic Investigation*, *23*(6), 1146–1152.

Ferreira, R. L., Da Silva, B. C. M., Rezende, G. S., Nakamura-Silva, R., Pitondo-Silva, A., Campanini, E. B., Brito, M. C. A., Da Silva, E. M. L., Freire, C. C. D., Da Cunha, A. F., & Da Silva Pranchevicius, M. C. (2019). High prevalence of multidrug-resistant klebsiella pneumoniae harboring several virulence and β-lactamase encoding genes in a brazilian intensive care unit. *Frontiers in Microbiology*, *9:3198*.

Fey, P. D., T. J. Safranek, M. E. Rupp, E. F. Dunne, E. Ribot, P. C. Iwen, P. A. Bradford, F. J. Angulo, & S. H. Hinrichs. 2000. Ceftriaxone-resistant salmonella infection acquired by a child from cattle. *New England Journal of Medicine,* 342, 1242–1249.

Fitzgerald, J. R., Sturdevant, D. E., Mackie, S. M., Gill, S. R., & Musser, J. M. (2001). Evolutionary genomics of *Staphylococcus aureus*: Insights into the origin of methicillin-resistant strains and the toxic shock syndrome epidemic. *Proceedings of the National Academy of Sciences*, *98*(15), 8821–8826.

Fitzgerald, J. Ross. (2012). Livestock-associated *Staphylococcus aureus*: Origin, evolution and public health threat. *Trends in Microbiology*. 20(4):192–98.

Foley, S. L., Lynne, A. M., & Nayak, R. (2009). Molecular typing methodologies for microbial source tracking and epidemiological investigations of Gram-negative bacterial foodborne pathogens. *Infection, Genetics and Evolution : Journal of Molecular Epidemiology and Evolutionary Genetics in Infectious Diseases*, *9*(4), 430–440.

Fox, L. K. (2009). Prevalence, incidence and risk factors of heifer mastitis. *Veterinary Microbiology*, *134*(1–2), 82–88.

Fox, L. K., Chester, S. T., Hallberg, J. W., Nickerson, S. C., Pankey, J. W., & Weaver, L. D. (1995). *Survey of lntramammary Infections in Dairy Heifers*

at Breeding Age and First Parturition'. 78(7), 1619-1628.

Fox, L. K., & Gay, J. M. (1993). Contagious mastitis. *The Veterinary Clinics of North America. Food Animal Practice*, *9*(3), 475–487.

Freick, M., Frank, Y., Steinert, K., Hamedy, A., Passarge, O., & Sobiraj, A. (2016). Mastitis vaccination using a commercial polyvalent vaccine or a herd-specific *Staphylococcus aureus* vaccine. Results of a controlled field trial on a dairy farm. *Tierarztliche Praxis. Ausgabe G, Grosstiere/Nutztiere*, *44*(4), 219–229.

Fthenakis, G. C. (1995). California Mastitis Test and Whiteside Test in diagnosis of subclinical mastitis of dairy ewes. *Small Ruminant Research*, *16*(3), 271–276.

Galal, K., & Hameed, A. (2006). Major histocompatibility complex polymorphism y mastitis resistance-a review Prevalence of chryseobacterium species in milk and milk products View project Biodiversity and lipolytic activity of Acinatobacter species isolated from raw milk and some milk products i View project. *Animal Science Papers and Reports, 24: 11-25.*

Gao, J., Barkema, H. W., Zhang, L., Liu, G., Deng, Z., Cai, L., Shan, R., Zhang, S., Zou, J., Kastelic, P.J. & Han, B. (2017). Incidence of clinical mastitis and distribution of pathogens on large Chinese dairy farms. *Journal of Dairy Science*, *100*(6), 4797–4806.

Gardy, J. L., Laird, M. R., Chen, F., Rey, S., Walsh, C. J., Ester, M., & Brinkman, F. S. L. (2005). PSORTb v.2.0: Expanded prediction of bacterial protein subcellular localization and insights gained from comparative proteome analysis. *Bioinformatics*, *21*(5), 617–623.

Garg, A., & Gupta, D. (2008). VirulentPred: a SVM based prediction method for virulent proteins in bacterial pathogens. *BMC Bioinformatics*, *9*(1), 62.

Gasteiger, E., Hoogland, C., Gattiker, A., Duvaud, S., Wilkins, M. R., Appel, R. D., & Bairoch, A. (2005). Protein identification and analysis tools on the ExPASy Server. In *the proteomics protocols handbook* pp. 571–607. Totowa, NJ: Humana Press.

Ghaznavi-Rad, E., Shamsudin, M. N., Sekawi, Z., Khoon, L. Y., Aziz, M. N., Hamat, R. A., Othman, N., Chong, P. P., Belkum, A. V., Ghasemzadeh-Moghaddam, H. & Neela, V. (2010). Predominance and emergence of clones of hospital-acquired methicillin-resistant *Staphylococcus aureus* in Malaysia. *Journal of Clinical Microbiology*, *48*(3), 867–872.

Gianneechini, R., Concha, C., Rivero, R., Delucci, I., & Moreno López, J. (2002). Occurrence of clinical and sub-clinical mastitis in dairy herds in the West Littoral Region in Uruguay. *Acta Veterinaria Scandinavica*, *43*(4), 221–230.

Gołębiewski and Brzozowski. (2007). Comparison of dairy performance of Montbeliarde and Black and White cows housed at the same environmental conditions. *Annals of Animal Science*, 8(1), 3-11.

Gomes, F., & Henriques, M. (2016). Control of Bovine Mastitis: old and recent therapeutic approaches. *Current Microbiology*, 72(4):377–82.

Gomes, F., Saavedra, M. J., & Henriques, M. (2016). Bovine mastitis disease/pathogenicity: evidence of the potential role of microbial biofilms. (T. Coenye, Ed.), *Pathogens and Disease*, 74(3):ftw006.

Gonçalves, J. L., Kamphuis, C., Martins, C. M. M. R., Barreiro, J. R., Tomazi, T., Gameiro, A. H., Hogeveen, H. & Dos Santos, M. V. (2018). Bovine subclinical mastitis reduces milk yield and economic return. *Livestock Science*, *210*, 25–32.

Gordonl, W. A., Morris, H. A., & Packard , V. (1980). Methods to detect abnormal milk-A review.*Journal of Food Protection,* 43, 64.

Grimont, F & Grimont, P. A. (1986). Ribosomal ribonucleic acid gene restriction patterns as potential taxonomic tools. *Annales de l Institut Pasteur Microbiologie*, 137, B165-175.

Groot, M. J., & van't Hooft, K. E. (2016). The hidden effects of dairy farming on public and environmental health in the Netherlands, India, Ethiopia, and Uganda, considering the use of antibiotics and other agro-chemicals. *Frontiers in Public Health*, 4, 12.

Gröhn, Y. T., D. J. Wilson, R. N. González, J. A. Hertl, H. Schulte, G. Bennett, & Y. H. Schukken. (2004). Effect of pathogen-specific clinical mastitis on milk yield in dairy cows. *Journal of Dairy Science*, 87, 3358–3374.

Guan, P., Doytchinova, I. A., Zygouri, C., & Flower, D. R. (2003). MHCPred: A server for quantitative prediction of peptide-MHC binding. *Nucleic Acids Research*, *31*(13), 3621–3624.

Hamann, J. (2010).Mastitis and raw milk quality, safety and yield. In *Improving the Safety and Quality of Milk*, Elsevier Ltd., 246–63.

Hammad, A. M., A. M. Ahmed, Y. Ishida, & T. Shimamoto. (2008). First characterization and emergence of SHV-60 in raw milk of a healthy cow in Japan. *Journal of Veterinary, Medical Science*, (70), 1269–1272.

Hammer, J. F., J. M. Morton, & K. L. Kerrisk. (2012). Quarter milking-, quarter-,udder- and lactation-level risk factors and indicators for clinical mastitis during lactation in pasture-fed dairy cows man- aged in an automatic milking system. *Australian Veterinary Journal,* 90, 167–174.

Harmon, R. J. (1994). Physiology of mastitis and factors affecting somatic cell counts. *Journal of Dairy Science*, *77*(7), 2103–2112.

Hata, E., Katsuda, K., Kobayashi, H., Nishimori, K., Uchida, I., Higashide, M., Ishikawa, E., Sasaki, T. & Eguchi, M. (2008). Bacteriological characteristics of *Staphylococcus aureus* isolates from humans and bulk milk. *Journal of Dairy Science*, *91*(2), 564–569.

Hata, E., Katsuda, K., Kobayashi, H., Ogawa, T., Endô, T., & Eguchi, M. (2006). Characteristics and epidemiologic genotyping of *Staphylococcus aureus* isolates from bovine mastitic milk in Hokkaido, Japan. *Journal of Veterinary Medical Science*. *68*(2), 165-170.

Hegde, R., Isloor, S., Prabhu, K. N., Shome, B. R., Rathnamma, D., Suryanarayana, V. V. S., Yatiraj, S., Prasad, C. R., Krisnaveni, N., Sundareshan, S., Akhila, D. S., Gomes, A. R. & Hegde, N. R. (2013). Incidence of subclinical mastitis and prevalence of major mastitis pathogens in organized farms and unorganized sectors. *Indian Journal of Microbiology*, *53*(3), 315–320.

Heikkilä, A.-M., J. I. Nousiainen, & S. Pyörälä. (2012). Costs of clinical mastitis with special reference to premature culling. *Journal of Dairy Science*, 95, 139–150.

Hertl, J. A., Y. H. Schukken, D. Bar, G. J. Bennett, R. N. González, B. J. Rauch, F. L. Welcome, L. W. Tauer, & Y. T. Gröhn. 2011. The effect of recurrent episodes of clinical mastitis caused by Gram-positive and Gram-negative bacteria and other organ- isms on mortality and culling in Holstein dairy cows. *Journal of Dairy Science*, 94, 4863–4877.

Hillerton, J. E., & Berry, E. A. (2003). The management and treatment of environmental streptococcal mastitis. *The Veterinary Clinics of North America. Food Animal Practice*, *19*(1), 157–169.

Hillerton, J. E., J. A. Leigh, P. N. Ward, & T. J. Coffey. (2004). *Streptococcus agalactiae* infections in dairy cows. *Veterinary Record*, 154, 671–672.

Hillerton, J. E., A. J. Bramley, R. T. Staker, & C. H. McKinnon. (1995). Patterns of intramammary infection and clinical mastitis over a 5-year period in a closely monitored herd applying mastitis control measures. *Journal of Dairy Research*, 62, 39–50.

Hogan, J. S., Pankey, J. W., & Duthie, A. H. (1987). Growth inhibition of mastitis pathogens by long-chain fatty acids. *Journal of Dairy Science*, *70*(5), 927–934.

Hogeveen, H., Huijps, K., & Lam, T. J. G. M. (2011). Economic aspects of mastitis: New developments. *New Zealand Veterinary Journal*. 59(1):16–23.

Hoque, M. N., Das, Z. C., Rahman, A. N. M. A., Haider, M. G., & Islam, M. A. (2018a). Molecular characterization of *Staphylococcus aureus* strains in bovine mastitis milk in Bangladesh. *International Journal of Veterinary Science and Medicine*, *6*(1), 53–60.

Hoque, M. N., Das, Z. C., Rahman, A. N. M. A., Haider, M. G., & Islam, M. A. (2018b). Molecular characterization of *Staphylococcus aureus* strains in bovine mastitis milk in Bangladesh. *International Journal of Veterinary Science and Medicine*, *6*(1), 53–60.

Hosseinzadeh, S., & Dastmalchi Saei, H. (2014). Staphylococcal species associated with bovine mastitis in the North West of Iran: Emerging of coagulase-negative staphylococci. *International Journal of Veterinary Science and Medicine*, *2*, 27–34.

Hu, W., Sillaots, S., Lemieux, S., Davison, J., Kauffman, S., Breton, A., Linteau, A., Xin, C., Bowman, J., Becker, J., Jiang, B., & Roemer, T. (2007). Essential Gene Identification and Drug Target Prioritization in Aspergillus fumigatus. *PLoS Pathogens*, *3*(3), e24.

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

Ibarz Pavón, A. B., & Maiden, M. C. J. (2009). Multilocus sequence typing. *Methods in Molecular Biology (Clifton, N.J.)*. Humana Press, pp. 129-140.

Ismail, Z. B. (2017). Mastitis vaccines in dairy cows: Recent developments and recommendations of application. *Veterinary World*, *10*(9), 1057–1062.

Jaiswal, V., Chanumolu, S., Gupta, A., Chauhan, R. S., & Rout, C. (2013). Jenner-predict server: prediction of protein vaccine candidates (PVCs) in bacteria based on host-pathogen interactions. *BMC Bioinformatics*, *14*(1), 211.

Jarassaeng, C. (2012). Risk factors of subclinical mastitis in small holder dairy cows in Khon Kaen Province. *Thailand Journal of Veterinary Medicine,* 42(2), 143-151.

Jespersen, M. C., Peters, B., Nielsen, M., & Marcatili, P. (2017). BepiPred-2.0: improving sequence-based B-cell epitope prediction using conformational epitopes. *Nucleic Acids Research*, *45*(W1), W24–W29.

Jiang, P., Cai, Y., Chen, J., Ye, X., Mao, S., Zhu, S., Xue, X., Chen, S. & Zhang, L. (2017). Evaluation of tandem *Chlamydia trachomatis* MOMP multi-epitopes vaccine in BALB/c mice model. *Vaccine*, *35*(23), 3096–3103.

Joshi, S., & Gokhale, S. (2006). Status of mastitis as an emerging disease in improved and periurban dairy farms in India. *Annals of the New York Academy of Sciences*, *1081*(1), 74–83.

Kader M. A., Samad M. A., Saha S., & Taleb M. A. (2002). Prevalence and etiology of mastitis with antibiotic sensitivity in milking cows of Bangladesh. *Indian Journal of Dairy Science*, 55, 218-223.

Kaliwal, B. B., Kurjogi, M. M., & Sanakal, R. D. (2011). Prevalence and antimicrobial susceptibility of coagulase-negative Staphylococci isolated from bovine mastitis. *Veterinary World, 4*(4), 158-161.

Kapur, V., Sischo, W. M., Greer, R. S., Whittam, T. S., & Musser, J. M. (1995). Molecular population genetic analysis of *Staphylococcus aureus* recovered from Cows. *Journal of Clinical Microbiology, 33*(2), 376-380.

Karch, C. P., & Burkhard, P. (2016). Vaccine technologies: From whole organisms to rationally designed protein assemblies. *Biochemical Pharmacology*, *120*, 1–14.

Keefe, G. P. (1997). *Streptococcus agalactiae* mastitis: a review. *The Canadian Veterinary Journal = La Revue Veterinaire Canadienne*, *38*(7), 429–437.

Kelley, L. A., Mezulis, S., Yates, C. M., Wass, M. N., & Sternberg, M. J. E. (2015). The Phyre2 web portal for protein modeling, prediction and analysis. *Nature Protocols*, *10*(6), 845–858.

Khaki, P., Sharma, A., & Bhalla, P. (2014). Comparison of two disc diffusion methods with minimum inhibitory concentration for antimicrobial susceptibility testing of *Neisseria gonorrhoeae* isolates. *Annals of Medical and Health Sciences Research*, *4*(3), 453–456.

Kijanka, G., & Murphy, D. (2009). Protein arrays as tools for serum autoantibody marker discovery in cancer. *Journal of Proteomics*, *72*(6), 936–944.

Klaas, I. C., & Zadoks, R. N. (2018). An update on environmental mastitis: Challenging perceptions. *Transboundary and Emerging Diseases*, *65*, 166–185.

Kloos, W. E. : (1980). Natural populations of the genus Staphylococcus. *Annual Review in Microbiology, 34*:559-92.

Kocak, O. (2006). Influence of mastitis on milk yield in holstein cows. *Acta Veterinaria Brno, 75*,507-513.

Krogh, A., È rn Larsson, B., von Heijne, G., & L Sonnhammer, E. L. (2001.). Predicting transmembrane protein topology with a hidden markov model: Application to complete genomes. *Journal of Molecular Biology*, *305*(3), 567-580.

Król, J., Brodziak, A., Litwińczuk, Z., & Litwińczuk, A. (2013). Effect of age and stage of lactation on whey protein content in milk of cows of different breeds. *Polish Journal of Veterinary Sciences*, *16*(2), 395–397.

Krömker V., & Leimbach, S. (2017). Mastitis treatment—reduction in antibiotic usage in dairy cows. *Reproduction in Domestic Animals*, 52, 21–29.

Kumar, R., Yadav, B. R., Anand, S. K., & Singh, R. S. (2011). Molecular surveillance of putative virulence factors and antibiotic resistance in *Staphylococcus aureus* isolates recovered from intra-mammary infections of river buffaloes. *Microbial Pathogenesis*, *51*(1–2), 31–38.

Lagesen, K., Hallin, P., Rødland, E. A., Stærfeldt, H.-H., Rognes, T., & Ussery, D. W. (2007). RNAmmer: consistent and rapid annotation of ribosomal RNA genes. *Nucleic Acids Research*, *35*(9), 3100–3108.

Lalrintluanga C., Ralte E. L., & Markunga H. (2003). Incidence of mastitis, bacteriology and antibiogram in dairy cows in Mizoram. *Indian Veterinary Journal*, 80, 931-932.

Landin, H., Mörk, M. J., Larsson, M., & Waller, K. P. (2015). Vaccination against *Staphylococcus aureus* mastitis in two Swedish dairy herds. *Acta Veterinaria Scandinavica*. *57*(1), 81.

Larsen, M. V, Cosentino, S., Rasmussen, S., Friis, C., Hasman, H., Marvig, R. L., Jelsbak, L., Sicheritz-Ponten, T., Ussery, D., W., Aarestrup, F., M. & Lund, O. (2012). Multilocus sequence typing of total-genome-sequenced bacteria. *Journal of Clinical Microbiology*, *50*(4), 1355–1361.

Laslett, D., & Canback, B. (2004). ARAGORN, a program to detect tRNA genes and tmRNA genes in nucleotide sequences. *Nucleic Acids Research*, *32*(1), 11–16.

Leitner, G., Krifucks, O., Kiran, M. D., & Balaban, N. (2011). Vaccine development for the prevention of staphylococcal mastitis in dairy

cows. *Veterinary Immunology and Immunopathology*, *142*, 25–35.

Lindsay, J. A., & Holden, M. T. G. (2004). *Staphylococcus aureus*: Superbug, super genome? *Trends in Microbiology*. 12(8):378–85.

Loeffler, S. H., T. J. Lam, H. W. Barkema, D. Scholten, A. L. Hessels, & A. M. van Gestel. (1995). The dairying veterinary approach to a high bulk milk cell count caused by *Streptococcus agalactiae. Tijdschr. Diergeneeskd,* 120, 458–463.

Lowder, B. V., Guinane, C. M., Zakour, N. L. B., Weinert, L. A., Conway-Morris, A., Cartwright, R. A., Simpson, A. J., Rambout, A., Nübel, U. & Fitzgerald, J. R. (2009). Recent human-to-poultry host jump, adaptation, and pandemic spread of *Staphylococcus aureus*. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(46), 19545–19550.

Lu, Y., Deng, J., Rhodes, J. C., Lu, H., & Lu, L. J. (2014). Predicting essential genes for identifying potential drug targets in *Aspergillus fumigatus*. *Computational Biology and Chemistry*, *50*, 29–40.

Lukinmaa, S., Nakari, U. M., Eklund, M., & Siitonen, A. (2004). Application of molecular genetic methods in diagnostics and epidemiology of food-borne bacterial pathogen. *Acta Pathologica, Microbiologica, et Immunologica Scandinavica*, 112, 908-929.

Luo, H., Lin, Y., Gao, F., Zhang, C.-T., & Zhang, R. (2014). DEG 10, an update of the database of essential genes that includes both protein-coding genes and noncoding genomic elements. *Nucleic Acids Research*, *42*(Database issue), D574-80.

Madut, N. A., Elamin, A., Gadir, A., & Jalii, M. El. (2009). Host determinants of bovine mastitis in semi-intensive production system of Khartoum state, Sudan. *Journal of Cell and Animal Biology*, *3*(5), 71–077.

Maiden, M. C. J., Bygraves, J. A., Feil, E., Morelli, G., Russell, J. E., Urwin, R., Zhang, Q., Zhou, J., Zurth, K., Caugant, D. A., Feavers, I. M., Achtman, M. & Spratt, B. G. (1998). Multilocus sequence typing: A portable approach to the identification of clones within populations of pathogenic microorganisms. *Proceedings of the National Academy of Sciences USA, 95(*95), 3140-3145.

Maiden, Martin C.J. (2006). Multilocus sequence typing of bacteria. *Annual Review of Microbiology*, *60*(1), 561–588.

Makovec, J. A., & Ruegg, P. L. (2003). Antimicrobial resistance of bacteria isolated from dairy cow milk samples submitted for bacterial culture:

8,905 Samples (1994-2001). *Journal of the American Veterinary Medical Association*, *222*(11), 1582–1589.

Manning, S. D., Springman, A. C., Million, A. D., Milton, N. R., McNamara, S. E., Somsel, P. A., Bartlett, P., & Davies, H. D. (2010). Association of group B Streptococcus colonization and bovine exposure: A prospective cross-sectional cohort study. *PLoS ONE*. 5(1), e8795.

MARAN-2008. 2009. MARAN-2008—Monitoring of antimicrobial resistance and antibiotic usage in animals in the Netherlands in 2008. Accessed Jan. 23, 2018.http://www.cvi.wur.nl/NR/rdon-lyres/DDA15856-1179-4CAB-BAC6-28C4728ACA03/110563/ MARAN__2008__definitief_corrected.pdf.

Matthews, K. R., R. J. Harmon & B. E. Langlois, (1992). Prevalence of *Staphylococcus* species during the periparturient period in primiparous and multiparous cows. *Journal of Dairy Science*, 75, 1835-1839.

Max J. Paape, Douglas D. Bannerman, Xin Zhao, & J.-W. Lee. (2003). The bovine neutrophil: Structure and function in blood and milk. *Veterinary Research*, *34*(5), 597–627.

Mdegela, R. H., Ryoba, R., Karimuribo, E. D., Phiri, E. J., Løken, T., Reksen, O., Mtengeti, E. & Urio, N. A. (2009). Prevalence of clinical and subclinical mastitis and quality of milk on smallholder dairy farms in Tanzania. *Journal of the South African Veterinary Association*, *80*(3), 163–168.

Mein, G.A., F. Neijenhuis, W.F. Morgan, D.J. Reinemann, J.E. Hillerton, J.R. Baines, I. Ohnstad, M.D. Rasmussen, L. Timms, J.S. Britt, R. Farnsworth, and N.B. Cook. (2001). Evaluation of bovine teat condition in commercial dairy herds: 1. Non-infectious factors. *Proceedings of 2nd International Symposium on Mastitis and Milk Quality*. 347-351.

Mekonnen, S. A., Koop, G., Melkie, S. T., Getahun, C. D., Hogeveen, H., & Lam, T. J. G. M. (2017). Prevalence of subclinical mastitis and associated risk factors at cow and herd level in dairy farms in North-West Ethiopia. *Preventive Veterinary Medicine*, *145*.

Merlino, J. (2002). Detection and expression of methicillin/oxacillin resistance in multidrug-resistant and non-multidrug-resistant *Staphylococcus aureus* in Central Sydney, Australia. *Journal of Antimicrobial Chemotherapy*, *49*(5), 793–801.

Middleton, J. R., Fox, L. K., Gay, J. M., Tyler, J. W., & Besser, T. E. (2002a). Influence of Staphylococcus aureus strain-type on mammary quarter milk somatic cell count and N-acetyl-beta-D-glucosaminidase activity

in cattle from eight dairies. Journal of Dairy Science, 85,1133–1140.

Milner, P., Page, K. L., Walton, A. W., & Hillerton, J. E. (1996). Detection of clinical mastitis by changes in electrical conductivity of foremilk before visible changes in milk. *Journal of Dairy Science*, *79*(1), 83–86.

Miltenburg, J. D., De Lange, D., Crauwels, A. P. P., Bongers, J. H., Tielen, M. J. M., Schukken, Y. H., & Elbers, A. R. W. (1996). Incidence of clinical mastitis in a random sample of dairy herds in the southern Netherlands. *Veterinary Record*, *139*(9), 204–207.

Misra, N., Pu, X., Holt, D. N., McGuire, M. A., & Tinker, J. K. (2018). Immunoproteomics to identify *Staphylococcus aureus* antigens expressed in bovine milk during mastitis. *Journal of Dairy Science*, *101*(7), 6296–6309.

Misra, N., Wines, T. F., Knopp, C. L., Hermann, R., Bond, L., Mitchell, B., Mcguire, M. A. & Tinker, J. K. (2018). Immunogenicity of a *Staphylococcus aureus*-cholera toxin A 2 /B vaccine for bovine mastitis. *Vaccine*, 36(24), 3513-3521.

Monistero, V., Graber, H. U., Pollera, C., Cremonesi, P., Castiglioni, B., Bottini, E., Ceballos-Marquez, A., Lasso-Rojas, L., Kroemker, V., Wenti, N., Petzer, I., M., Santisteban, C., Runyan, J., Veiga dos Santos, M., Alves, B. G., Piccinini, R., Bronzo, V., Abbassai, M. S., Ben Said, M. & Moroni, P. (2018). *Staphylococcus aureus* isolates from bovine mastitis in eight countries: Genotypes, detection of genes encoding different toxins and other virulence genes. *Toxins*, *10*(6).

Moon, J. S., Lee, A. R., Kang, H. M., Lee, E. S., Joo, Y. S., Park, Y. H., Kim, M., N. & Koo, H. C. (2007). Antibiogram and coagulase diversity in staphylococcal enterotoxin-producing *Staphylococcus aureus* from bovine mastitis. *Journal of Dairy Science*, *90*(4), 1716–1724.

Mora, M., Donati, C., Medini, D., Covacci, A., & Rappuoli, R. (2006). Microbial genomes and vaccine design: refinements to the classical reverse vaccinology approach. *Current Opinion in Microbiology*. 9(5):532–36.

Moriel, D. G., Bertoldi, I., Spagnuolo, A., Marchi, S., Rosini, R., Nesta, B., Pastorello, I., Corea, V. A. M., Torricelli, G., Cartocci, E., Savino, S., Scarselli, M., Dobrindt, U., Hacker, J., Tettelin, H., Tallon, L. J., Sullivan, S., Wieler, L. H., Ewers, C., Pickard, D., Dougan, G., Fontana, M. R., Rappuoli, R., Pizza, M., & Serino, L. (2010). Identification of protective and broadly conserved vaccine antigens from the genome of extraintestinal pathogenic *Escherichia coli*. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(20), 9072–9077.

Movahedi, A. (R), & Hampson, D. J. (2008). New ways to identify novel bacterial antigens for vaccine development. *Veterinary Microbiology*, 131(1-2), 1-13.

Mpatswenumugabo, J. P., Bebora, L. C., Gitao, G. C., Mobegi, V. A., Iraguha, B., Kamana, O., & Shumbusho, B. (2017). Prevalence of subclinical mastitis and distribution of pathogens in dairy farms of Rubavu and Nyabihu Districts, Rwanda. *Journal of Veterinary Medicine*, *2017*, 1–8.

Muhammad, G., Naureen, A., Asi, M. N., Saqib, M., & Fazal-ur-Rehman. (2010). Evaluation of a 3% surf solution (surf field mastitis test) for the diagnosis of subclinical bovine and bubaline mastitis. *Tropical Animal Health and Production*, *42*(3), 457–464.

Muhammad, S. A., Ahmed, S., Ali, A., Huang, H., Wu, X., Yang, X. F., Naz, A., & Chen, J. (2014). Prioritizing drug targets in *Clostridium botulinum* with a computational systems biology approach. *Genomics*, *104*(1), 24–35.

Mureithi, D. K., & Njuguna, M. N. (2016). Prevalence of subclinical mastitis and associated risk factors in dairy farms in urban and peri-urban areas of Thika Sub County, Kenya. *Livestock Research for Rural Development*, *28*(2).

Murugaiyah, M., Faez Firdaus, J. A., Konto, M., Poshpum, S. S., Lawan, A., Abdinasir Yusuf, O., Yusuf, A. & Abdulnasir, T. (2014). Prevalence and antimicrobial resistance assessment of subclinical mastitis in milk samples from selected dairy farms. *American Journal of Animal and Veterinary Sciences*, *9*(1), 65–70.

Mushtaq, S., Shah, A. M., Shah, A., Lone, S. A., Hussain, A., Hassan, Q. P., & Ali, M. N. (2018a). Bovine mastitis: An appraisal of its alternative herbal cure. *Microbial Pathogenesis*. 114:357–61.

Nam, H.-M., Lim, S.-K., Kang, H.-M., Kim, J.-M., Moon, J.-S., Jang, K.-C., Kim, J. M., Joo, & Y. S.Jung, S.-C. (2009). Antimicrobial resistance of streptococci isolated from mastitic bovine milk samples in Korea. *Journal of Veterinary Diagnostic Investigation*, *21*(5), 698–701.

Nam, H. M., Lim, S. K., Kang, H. M., Kim, J. M., Moon, J. S., Jang, K. C., Joo, Y. S., Kang, M. I., & Jung, S. C. (2009). Prevalence and antimicrobial susceptibility of Gram-negative bacteria isolated from bovine mastitis between 2003 and 2008 in Korea. *Journal of Dairy Science*, *92*(5), 2020–2026.

Nash, D. L., G. W. Rogers, J. B. Cooper, G. L. Hargrove, J. F. Keown, & L. B. Hansen. (2000). Heritability of clinical mastitis incidence and relationships with sire transmitting abilities for somatic cell score,

udder type traits, productive life, and protein yield. *Journal of Dairy Science*, 83, 2350–2360.

Naz, A., Awan, F. M., Obaid, A., Muhammad, S. A., Paracha, R. Z., Ahmad, J., & Ali, A. (2015). Identification of putative vaccine candidates against *Helicobacter pylori* exploiting exoproteome and secretome: A reverse vaccinology based approach. *Infection, Genetics and Evolution*, *32*, 280–291.

Neijenhuis, F., Barkema, H. W., Hogeveen, H., & Noordhuizen, J. P. T. M. (2001). Relationship between teat-end callosity and occurrence of clinical mastitis. *Journal of Dairy Science* 84(12) 2664-2672.

Nemet-Nejat, K. (1998). Daily life in ancient Mesopotamia. Greenwood Press, Westport, CT.

Nezafat, N., Karimi, Z., Eslami, M., Mohkam, M., Zandian, S., & Ghasemi, Y. (2016). Designing an efficient multi-epitope peptide vaccine against Vibrio cholerae via combined immunoinformatics and protein interaction based approaches. *Computational Biology and Chemistry*, *62*, 82–95.

Nickerson S. C., & Sordillo, L. M. (2017). Modulation of the bovine mammary gland. Third edition. Champaign (IL). pp. 907–19.

NMC. 1999. Laboratory Handbook on Bovine Mastitis. NMC Inc., Madison, WI.

Nyhan, J. F. and Cowhing, M., J. (1967). Inadequate milking machine vacuum reserve and mastitis. *Journal of Veterinary Resources* ,44,1433-1438.

Nyman, A., Fasth, C., & Waller, K. P. (2018). Intramammary infections with different non- aureus staphylococci in dairy cows. *Journal of Dairy Science*, *101*(2), 1403–1418.

Ogorevc, J., Kunej, T., Razpet, A., & Dovc, P. (2009). Database of cattle candidate genes and genetic markers for milk production and mastitis. *Animal Genetics*, *40*(6), 832–851.

Olde Riekerink, R. G. M., H. W. Barkema, D. F. Kelton, & D. T. Scholl. (2008). Incidence rate of clinical mastitis on Canadian dairy farms. *Journal of Dairy Science*, 91, 1366–1377.

Olde Riekerink, R. G. M., H. W. Barkema, S. Veenstra, D. E. Poole, R. T. Dingwell, & G. P. Keefe. (2006). Prevalence of contagious mastitis pathogens in bulk tank milk in Prince Edward Island. *Canadian Veterinary Journal*, 47, 567–572.

Olivares-Pérez, J., Kholif, A. E., Rojas-Hernández, S., Elghandour, M. M. M. Y., Salem, A. Z. M., Bastida, A. Z., Velazquez-Reynoso,D., Cipriano-Salazar, M., Camacho-Diaz, M., Alonso-Fresan, M. U., & DiLorenzo, N. (2015). Prevalence of bovine subclinical mastitis, its etiology and diagnosis of antibiotic resistance of dairy farms in four municipalities of a tropical region of Mexico. *Tropical Animal Health and Production*, *47*(8), 1497–1504.

Oliveira, L., & Ruegg, P. L. (2014). Treatments of clinical mastitis occurring in cows on 51 large dairy herds in Wisconsin. *Journal of Dairy Science*, *97*(9), 5426–5436.

Oliveira, M., Nunes, S. F., Carneiro, C., Bexiga, R., Bernardo, F., & Vilela, C. L. (2007). Time course of biofilm formation by *Staphylococcus aureus* and *Staphylococcus epidermidis* mastitis isolates. *Veterinary Microbiology*, *124*(1–2), 187–191.

Oliver, S. P. (2004). Microbiological procedures for the diagnosis of bovine udder infection and determination of milk quality. Verona, Wis. pp.47.

Oliver, S. P., B. M. Jayarao, & R. A. Almeida. (2005). Foodborne pathogens in milk and the dairy farm environment: Food safety and public health implications. Foodborne *Pathogens and Disease*, 2, 115– 129.

Othman, N., & Bahaman, A. (2005). Prevalence of subclinical mastitis and antibiotic resistant bacteria in three selected cattle farms in Serdang, Selangor and Kluang. *Journal of Veterinary Malaysia*, 17(1), 27-31.

Oviedo-Boyso, J., Valdez-Alarcón, J. J., Cajero-Juárez, M., Ochoa-Zarzosa, A., López-Meza, J. E., Bravo-Patiño, A., & Baizabal-Aguirre, V. M. (2007). Innate immune response of bovine mammary gland to pathogenic bacteria responsible for mastitis. *Journal of Infection*, *54*(4), 399–409.

Owen, C. A., & Campbell, E. J. (1999). The cell biology of leukocyte-mediated proteolysis. *Journal of Leukocyte Biology*, *65*(2), 137–150.

Owens, W. E., Nickerson, S. C., Boddle, R. L., & Ray, C. H. (2000). The effect of methoprene on horn fly numbers and mastitis in dairy heifers. *Large Animal Practice*, *21*(1), 26–28.

Owens, W. E., Ray, C. H., Watts, J. L., & Yancey, R. J. (1997). Comparison of success of antibiotic therapy during lactation and results of antimicrobial susceptibility tests for bovine mastitis. *Journal of Dairy Science,* 80(2), 313-317.

Pankey, J. W., Drechsler, P. A., & Wildman, E. E. (1991). Mastitis prevalence in primigravid heifers at parturition. *Journal of Dairy Science, 74*(5), 1550-

1552.

Parker, K. I., Compton, C. W. R., Anniss, F. M., Weir, A. M., & McDougall, S. (2007). Management of dairy heifers and its relationships with the incidence of clinical mastitis. *New Zealand Veterinary Journal*, *55*(5), 208–216.

Paulrud, C., Clausen, S., Andersen, P., & Rasmussen, M. (2005). Infrared thermography and ultrasonography to indirectly monitor the influence of liner type and overmilking on teat tissue recovery. *Acta Veterinaria Scandinavica*, *46*(3), 137.

Pawlik, A., Sender, G., Sobczynska, M., Korwin-Kossakowska, A., Oprzadek, J., & Lukaszewicz, M. (2014). Association between lactoferrin single nucleotide polymorphisms and milk production traits in Polish Holstein cattle. *Archives Animal Breeding*, *57*(1), 1–12.

Penasa, M., Cassandro, M., Pretto, D., De Marchi, M., Comin, A., Chessa, S., Zotto, R. D. & Bittante, G. (2010). Short communication: Influence of composite casein genotypes on additive genetic variation of milk production traits and coagulation properties in Holstein-Friesian cows. *Journal of Dairy Science*, *93*(7), 3346–3349.

Pereira, U. P., Oliveira, D. G. S., Mesquita, L. R., Costa, G. M., & Pereira, L. J. (2011). Efficacy of *Staphylococcus aureus* vaccines for bovine mastitis: A systematic review. *Veterinary Microbiology*, *148*(2–4), 117–124.

Pérez-Cabal, M. A., G. De los Campos, A. I. Vazquez, D. Gianola, G. J. M. Rosa, K. A. Weigel, & R. Alenda. (2009). Genetic evaluation of susceptibility to clinical mastitis in Spanish Holstein cows. *Journal of Dairy Science,* 92, 3472–3480.

Pérez-Losada, M., Porter, M. L., Viscidi, R. P., & Crandall, K. A. (2011). Multilocus sequence typing of pathogens. *Genetics and Evolution of Infectious Diseases*, 503–521.

Perilli, M., Felici, A., Oratore, A., Cornaglia, G., Bonfiglio, G., Rossolini, G. M., & Amicosante, G. (1996). Characterization of the chromosomal cephalosporinases produced by *Acinetobacter lwoffii* and *Acinetobacter baumannii* clinical isolates. *Antimicrobial Agents and Chemotherapy,* 40(3), 715-719.

Petzer, I. M., Karzis, J., Watermeyer, J. C., Van der Schans, T. J., & Van Reenen, R. (2009). Trends in udder health and emerging mastitogenic pathogens in South African dairy herds. *Journal of the South African Veterinary Association*, *80*(1), 17-22.

Pezzella, C., Ricci, A., DiGiannatale, E., Luzzi, I., & Carattoli, A. (2004). Tetracycline and streptomycin resistance genes, transposons, and plasmids in *Salmonella enterica* Isolates from Animals in Italy. *Antimicrobial Agents and Chemotherapy*, *48*(3), 903–908.

Phuektes, P., Mansell, P. D., Dyson, R. S., Hopper, N. D., Dick, J. S., & Browning, G. F. (2001). Molecular epidemiology of *Streptococcus uberis* isolates from dairy cows with mastitis. *Journal of Clinical Microbiology*, *39*(4), 1460–1466.

Piddock, L. J. (1996). Does the use of antimicrobial agents in veterinary medicine and animal husbandry select antibiotic-resistant bacteria that infect man and compromise antimicrobial chemotherapy? *Journal of Antimicrobial Chemotherapy*, 38, 1–3.

Piepers, S., L. De Meulemeester, A. de Kruif, G. Opsomer, H. W. Barkema, & S. de Vliegher. (2007). Prevalence & distribution of mastitis pathogens in subclinically infected dairy cows in Flanders, Belgium. *Journal of Dairy Research*, 74, 478–483.

Pitkälä, A., Haveri, M., Pyörälä, S., Myllys, V., & Honkanen-Buzalski, T. (2004a). Bovine mastitis in Finland 2001—Prevalence, distribution of bacteria, and antimicrobial resistance. *Journal of Dairy Science*, *87*(8), 2433–2441.

Pitkälä, A., Haveri, M., Pyörälä, S., Myllys, V., & Honkanen-Buzalski, T. (2004b). Bovine mastitis in Finland 2001 - Prevalence, distribution of bacteria, and antimicrobial resistance. *Journal of Dairy Science*, *87*(8), 2433–2441.

Pitkälä, A., Haveri, M., Pyörälä, S., Myllys, V., & Honkanen-Buzalski, T. (2010). Bovine mastitis in Finland 2001—Prevalence, distribution of bacteria, and antimicrobial resistance. *Journal of Dairy Science*, *87*(8), 2433–2441.

Pizza, M., Scarlato, V., Masignani, V., Giuliani, M. M., Aricò, B., Comanducci, M., Jennings, G. T., Baldi, L., Bartolini, E., Capecchi, B., Galeotti, C. L., Luzzi, E., Manetti, R., Marchetti, E., Mora, M., Nuti, S., Ratti, G., Santini, L., Savino, S., Scarselli, M., Storni, E., Zuo, P., Broeker, M., Hundt, E., Knapp, B., Blair, E., Mason, T., Tettelin, H., Hood, D. W., Jeffrie, A. C., Saounders, N. J., Granoff, D. M., Venter, J. C., Maxon, E. R., Grandi, G., & Rappuoli, R. (2000). Identification of vaccine candidates against serogroup B meningococcus by whole-genome sequencing. *Science*, *287*(5459), 1816–1820.

Plastridge, W. N. (1958). Bovine mastitis: A review. *Journal of Dairy Science,* 41,

1141–1181.

Plozza, K., Lievaart, J., Potts, G., & Barkema, H. (2011a). Subclinical mastitis and associated risk factors on dairy farms in New South Wales. *Australian Veterinary Journal*, *89*(1–2), 41–46.

Plozza, K., Lievaart, J., Potts, G., & Barkema, H. (2011b). Subclinical mastitis and associated risk factors on dairy farms in New South Wales. *Australian Veterinary Journal*, *89*(1–2), 41–46.

Podder, M. P., Rogers, L., Daley, P. K., Keefe, G. P., Whitney, H. G., & Tahlan, K. (2014). Klebsiella species associated with bovine mastitis in Newfoundland. *PLoS ONE*, *9*(9).

Pryor S.M., Cursons R. T., Turner S. A., Williamson J. H., & Lacy Hulbert S. J. (2010). Experimentally induced intramammary infection with multiple strains of *Streptococcus uberis* In: Proceedings of the 5th IDF Mastitis Conference, Christchurch pp. 688-689.

Pyörälä S. (2009). Treatment of mastitis during lactation. *Irish Veterinary Journal*, 62, S40.

Pyörälä, S. (2002). New strategies to prevent mastitis. In *Reproduction in Domestic Animals*, 37, 211–216.

Quinn, P. J., Markey, B. K., Leonard, F. C., Hartigan, P., Fanning, S., & FitzPatrick, E. S. (2011). Veterinary microbiology and microbial disease. John Wiley & Sons.pp.2498.

Rabello, R. F., Moreira, B. M., Lopes, R. M. M., Teixeira, L. M., Riley, L. W., & Castro, A. C. D. (2007). Multilocus sequence typing of *Staphylococcus aureus* isolates recovered from cows with mastitis in Brazilian dairy herds. *Journal of Medical Microbiology*, *56*(11), 1505–1511.

Rainard, P., & Riollet, C. (2006). Innate immunity of the bovine mammary gland. *Veterinary Research*, *37*(3), 369–400.

Rainerd, P., Foucras, G., Fitzgerald, J. R., Watts, J. L., Koop, G., & Middleton, J. R. (2018). Knowledge gaps and research priorities in *Staphylococcus aureus* mastitis control. *Transboundary Emerging Disease*. 65(1), 149–165.

Ramírez, N. F., Keefe, G., Dohoo, I., Sánchez, J., Arroyave, O., Cerón, J., Jaramillo, M. & Palacio, L. G. (2014). Herd- and cow-level risk factors associated with subclinical mastitis in dairy farms from the High Plains of the northern Antioquia, Colombia. *Journal of Dairy Science*, *97*(7), 4141–4150.

Rana, A., Thakur, S., Kumar, G., & Akhter, Y. (2018). Recent trends in system-scale integrative approaches for discovering protective antigens against Mycobacterial Pathogens. *Frontiers in Genetics*, 9, 572.

Rappuoli, R., Bottomley, M. J., D'Oro, U., Finco, O., & De Gregorio, E. (2016). Reverse vaccinology 2.0: Human immunology instructs vaccine antigen design. *The Journal of Experimental Medicine,* 213(4), 469-481.

Rappuoli, R., Mandl, C. W., Black, S., & De Gregorio, E. (2011). Vaccines for the twenty-first century society. *Nature Reviews Immunology*, 11(12), 865-872.

Rashid, M. I., Naz, A., Ali, A., & Andleeb, S. (2017). Prediction of vaccine candidates against *Pseudomonas aeruginosa*: An integrated genomics and proteomics approach. *Genomics*, *109*(3–4), 274–283.

Raspanti, C. G., Bonetto, C. C., Vissio, C., Pellegrino, M. S., Reinoso, E. B., Dieser, S. A., Bogni, C. I., Larriestra, A. J. & Odierno, L. M. (2016). Prevalencia y sensibilidad a antibióticos de especies de estafilococos coagulasanegativos provenientes de mastitis subclínica en bovinos de tambos de la regióncentral de Argentina. *Revista Argentina de Microbiologia*, *48*(1), 50–56.

Resch, G., François, P., Morisset, D., Stojanov, M., Bonetti, E. J., Schrenzel, J., Sakwinska, O. & Moreillon, P. (2013). Human-to-bovine jump of *Staphylococcus aureus* CC8 is associated with the loss of a β-hemolysin converting prophage and the acquisition of a new staphylococcal cassette chromosome. *PLoS ONE*, *8*(3), e58187.

Richardson, J. F., & Reith, S. (1993). Characterization of a strain of methicillin-resistant *Staphylococcus aureus* (EMRSA-15) by conventional and molecular methods. *The Journal of Hospital Infection*, *25*(1), 45–52.

Roman, R. S., Smith, J., Walker, M., Byrne, S., Ramotar, K., Dyck, B., Kabani, A. & Nicolle, L. E. (2007). Rapid geographic spread of a methicillin-resistant *Staphylococcus aureus* strain . *Clinical Infectious Diseases*, 25(3), 689-705.

Ruegg, P. L. (2017). A 100-year review: Mastitis detection, management, and prevention. *Journal of Dairy Science*, *100*(12), 10381–10397.

Rupp, R., & Boichard, D. (2003). Genetics of resistance to mastitis in dairy cattle. *Veterinary Research*. 34(5):671–88.

Sasheen, M., Tantary, H. A., & Nabi, S. U. (2015). A Treatise on bovine mastitis: disease and disease economics, etiological basis, risk factors, impact on human health, therapeutic management, prevention and control

strategy. *Advances in Dairy Research*, *04*(01), 1–10.

Saini, V., McClure, J., Léger, D., Keefe, G., Scholl, D., Morck, D., & Barkema, H. (2012). Antimicrobial resistance profiles of common mastitis pathogens on Canadian dairy farms. *Journal of Dairy Science*, *95*(8), 4319–4332.

Saini, V., J. T. McClure, D. Léger, S. Dufour, A. G. Sheldon, D. T. Scholl, & H. W. Barkema. (2012). Antimicrobial use on Canadian dairy farms. *Journal of Dairy Science*, 95, 1209–1221.

Sakharkar, K. R., Sakharkar, M. K., & Chow, V. T. K. (2004). A novel genomics approach for the identification of drug targets in pathogens, with special reference to Pseudomonas aeruginosa. *In Silico Biology*, *4*(3), 355–360.

Sampimon, O. C., Barkema, H. W., Berends, I. M. G. A., Sol, J., & Lam, T. J. G. M. (2009). Prevalence and herd-level risk factors for intramammary infection with coagulase-negative staphylococci in Dutch dairy herds. *Veterinary Microbiology*, *134*(2).

Sampimon, O., H. W. Barkema, J. Sol, & T. Lam. (2009). Prevalence of intramammary infection in Dutch dairy herds. *Journal of Dairy Research*, 76, 129–136.

Schreiner, D. A., & Ruegg, P. L. (2003). Relationship between udder and leg hygiene scores and subclinical mastitis. *Journal of Dairy Science*, *86*(11), 3460–3465.

Schreiner DA, RueggViguier, C., Arora, S., Gilmartin, N., Welbeck, K., & O'Kennedy, R. (2009). Mastitis detection: current trends and future perspectives. *Trends in Biotechnology*, *27*(8), 486–493.

Schukken, Y. H., D. Bar, J. Hertl, & Y. T. Gröhn. 2010. Correlated time to event data: Modeling repeated clinical mastitis data from dairy cattle in New York State. *Preventive Veterinary Med*icine, 97, 150–156.

Schukken, Y. H., J. Hertl, D. Bar, G. J. Bennett, R. N. González, B. J. Rauch, C. Santisteban, H. F. Schulte, L. Tauer, & F. L. Welcome. (2009). Effects of repeated Gram-positive and Gram-negative clinical mastitis episodes on milk yield loss in Holstein dairy cows. *Journal of Dairy Science*, 92, 3091–3105.

Schrick, F. N., Hockett, M. E., Saxton, A. M., Lewis, M. J., Dowlen, H. H., & Oliver, S. P. (2001). Influence of subclinical mastitis during early lactation on reproductive parameters. *Journal of Dairy Science*, *84*(6), 1407–1412.

Schroeder, J. W. (1997). Mastitis control programs bovine mastitis and milking management. North Dokota University Press, Fargo, ND 58105, pp.1-12.

Seib, K. L., Zhao, X., & Rappuoli, R. (2012). Developing vaccines in the era of genomics: a decade of reverse vaccinology. *Clinical Microbiology and Infection*, 18, 109–116.

Senghore, M., Bayliss, S. C., Kwambana-Adams, B. A., Foster-Nyarko, E., Manneh, J., Dione, M., Badji, H., Ebruke, C., Doughty, E., L., Thorpe, H., A., Jasinska, A. J., & Antonio, M. (2016). Transmission of *Staphylococcus aureus* from humans to green monkeys in the Gambia as revealed by whole-genome sequencing. *Applied and Environmental Microbiology*, *82*(19), 5910–5917.

Sette, A., Vitiello, A., Reherman, B., Fowler, P., Nayersina, R., Kast, W. M., Melief, C. J., Oseroff, C., Yuan, L., Ruppert, J., Sidney, J., del Guercio, M., F., Southwood, S., Kubo, R. T., Chesnut, R. W., Grey, H. M. & Chisari, F. V. (1994). The relationship between class I binding affinity and immunogenicity of potential cytotoxic T cell epitopes. *Journal of Immunology (Baltimore, Md. : 1950)*, *153*(12), 5586–5592.

Sharif, A., Muhammad, U., & Ghulam, M. (2009). Mastitis control in dairy production. *Journal of Agric and Social Science*, *5*(3), 102–105.

Sharma, R. M., & Packer, R. A. (1970). Occurrence and ecologic features of *Streptococcus uberis* in the dairy cow. *American Journal of Veterinary Research*, *31*(7), 1197–1202.

Sharma, N., Pandey, V., & Sudhan, N. A. (2010). Comparison of some indirect screening tests for detection of subclinical mastitis in dairy cows. *Bulgarian Journal of Veterinary Medicine*, *13*(2), 98–103.

Shearer J. K., & Harris B. Jr (2003). Mastitis in dairy goats. Animal science department, Florida cooperative extension service institute of food and agricultural sciences, university of Florida Gainesville, USA. pp: 1-6.

Shearn, M. F., & Hillerton, J. E. (1996). Hyperkeratosis of the teat duct orifice in the dairy cow. *The Journal of Dairy Research*, *63*(4), 525–532.

Shirai, H., Prades, C., Vita, R., Marcatili, P., Popovic, B., Xu, J., Overrington, J. P., Hirayama, K., Lefranc, M-P. & Ikeda, K. (2014). Antibody informatics for drug discovery. *Biochimica et Biophysica Acta (BBA) - Proteins and Proteomics*, *1844*(11), 2002–2015.

Shittu, A., Abdullahi, J., Jibril, A., Mohammed, A. A., & Fasina, F. O. (2012). Sub-clinical mastitis and associated risk factors on lactating cows in the

Savannah Region of Nigeria. *BMC Veterinary Research*, *8*(1), 134.

Shook, G. E. (2006). Major advances in determining appropriate selection goals. *Journal of Dairy Science*, *89*(4), 1349–1361.

Shuster D. E., Lee E. K., & Kehrli M.E. Jr (1996). Bacterial growth, inflammatory cytokine production, and neutrophil recruitment during coliform mastitis in cows within ten days after calving, compared with cows at midlactation. *American Journal of Veterinary Resource*, 57, 1569-1575.

Siljanoski, A., Ciglarič, R., Pezdir, T., Lainšček, P. R., Dolenc, J., Starič, J., & Šinigoj-Gačnik, K. (2018). Detection of tetracycline and other antimicrobial residues in milk from cows with clinical mastitis treated by combination therapy. *Journal of Dairy Research*, *85*(3), 321–326.

Singh, A., Goering, R. V., Simjee, S., Foley, S. L., & Zervos, M. J. (2006). Application of molecular techniques to the study of hospital infection. *Clinical Microbiology Review*s, 19, 512-530.

Singh, V., Singh, V. K., Doley, P., & Singh, A. (2014). Association between teat condition score and udder health status in dairy bovines. *Journal of Agriculture and Veterinary Science,* 7(5), 9-11.

Skwarczynski, M., & Toth, I. (2012). Peptide-based subunit nanovaccines. *Current Drug Delivery*, *8*(3), 282–289.

Smith, E. M., Green, L. E., Medley, G. F., Bird, H. E., Fox, L. K., Schukken, Y. H., Kruze, J. V., Bradley, A. J., Zadoks, R. N. & Dowson, C. G. (2005). Multilocus sequence typing of intercontinental bovine *Staphylococcus aureus* isolates. *Journal of Clinical Microbiology*, *43*(9), 4737–4743.

Smith, K. L., Todhunter, D. A., & Schoenberger, P. S. (1985). Environmental mastitis: Cause, prevalence, prevention. *Journal of Dairy Science*, *68*(6), 1531–1553.

Sordillo, L. M. (2018). Mammary gland immunobiology and resistance to mastitis. *Veterinary Clinics of North America: Food Animal Practice*, *34*(3), 507–523.

Sordillo, L. M., & Streicher, K. L. (2002, April). Mammary gland immunity and mastitis susceptibility. *Journal of Mammary Gland Biology and Neoplasia*. 7(2):135–46.

Speer, B. S., Shoemaker, N. B., & Salyers, A. A. (1992). Bacterial resistance to tetracycline: mechanisms, transfer, and clinical significance. *Clinical Microbiology Reviews*, 5(4), 389-399.

Steeneveld, W., H. Hogeveen, H. W. Barkema, J. van den Broek, & R. B. M. Huirne. (2008).The influence of cow factors on the incidence of clinical mastitis in dairy cows. *Journal of Dairy Science*, 91, 1391–1402.

Sukumaran, B., & Madhubala, R. (2004). Leishmaniasis: current status of vaccine development. *Current Molecular Medicine*, *4*(6), 667–679.

Suleiman, T. S., Karimuribo, E. D., & Mdegela, R. H. (2018). Prevalence of bovine subclinical mastitis and antibiotic susceptibility patterns of major mastitis pathogens isolated in Unguja island of Zanzibar, Tanzania. *Tropical Animal Health and Production*, *50*(2), 259–266.

Sumon, S., Ehsan, M., & Islam, M. (2017). Subclinical mastitis in dairy cows: somatic cell counts and associated bacteria in Mymensingh, Bangladesh. *Journal of the Bangladesh Agricultural University*, *15*(2), 266–271.

Swartz, T. & Christina, S., P. (2016). Bacillus spp. : a practical summary for controlling mastitis. Virginia Tech. Virginia University, pp.1-2.

Swinkels, J. M., T. J. G. M. Lam, M. J. Green, & A. J. Bradley. (2013). Effect of extended cefquinome treatment on clinical persistence or recurrence of environmental clinical mastitis. *Veterinary Journal*, 197, 682–687.

Syed, S., Hasson, A. A., Khalifa, J., Al-Busaidi, Z., & Sallam, T. A. (2015). The past, current and future trends in DNA vaccine immunisations. *Asian Pacific Journal of Tropical Biomedicine*, *5*(5), 344–353.

Talbot, B. G., & Lacasse, P. (2005). Progress in the development of mastitis vaccines. *Livestock Production Science*, *98*(1–2), 101–113.

Tavakol, M., Riekerink, R. G. M. O., Sampimon, O. C., van Wamel, W. J. B., van Belkum, A., & Lam, T. J. G. M. (2012). Bovine-associated MRSA ST398 in the Netherlands. *Acta Veterinaria Scandinavica*, 54(1), 28.

Tenhagen, B.-A, Kö, G., Wallmann, J., & Heuwieser, W. (2006). Prevalence of mastitis pathogens and their resistance against antimicrobial agents in dairy cows in Brandenburg, Germany. *Journal of Dairy Science*, *89*, 2542–2551.

Tenhagen, Bernd-Alois, Hansen, I., Reinecke, A., & Heuwieser, W. (2009). Prevalence of pathogens in milk samples of dairy cows with clinical mastitis and in heifers at first parturition. *Journal of Dairy Research*, *76*(2), 179–187.

Tesfu K., Genechu W., & Azage T. (1999). Survey of mastitis in dairy herds in Ethopia. *Ethiopian Journal of Science*, 22, 291-301.

Tettelin, H. (2000). Complete genome sequence of *Neisseria meningitidis* Serogroup B Strain MC58. *Science*, *287*(5459), 1809–1815.

Tettelin, H., Saunders, N. J., Heidelberg, J., Jeffries, A. C., Nelson, K. E., Eisen, J. A., Michelle, L. G., Robert, D., Jeremy, D. P., Erin, K. H., Daniel, H. H., Steven, L. S., Owen, W., Robert, D. F., Brian, A. D., Tanya, M., Anne, C., Debbie, S. P., Eric, B., Henry, C., Emily, B. C., Matthew, D. C., Terry, R. U., Hoda, K., Haiying, Q., Jessica, V., John, G., Vincenzo, S., Vega, M., Mariagraz, P., Guido, G., Li, S., Hamilton, O. S., Claire, M. F., E. Moxon, E. R., Rappuoli, R. & Craig Venter, J. (2000). Complete genome sequence of *Neisseria meningitidis* serogroup B strain MC58. *Science*, 287(5459), 1809-1815.

Thompson-Crispi, K. A., Miglior, F., & Mallard, B. A. (2013). Incidence rates of clinical mastitis among Canadian Holsteins classified as high, average, or low immune responders. *Clinical and Vaccine Immunology, 20*(1), 106–112.

Thompson-Crispi, K., Atalla, H., Miglior, F., & Mallard, B. A. (2014). Bovine mastitis: Frontiers in immunogenetics. *Frontiers in Immunology*, 5:493.

Thompson, J. D., Higgins+, D. G., & Gibson, T. J. (1994). *CLUSTAL W:* improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. *Nucleic Acids Research*, 22, 4673-4680.

Thorberg, B.-M., Danielsson-Tham, M.-L., Emanuelson, U., & Persson Waller, K. (2009). Bovine subclinical mastitis caused by different types of coagulase-negative staphylococci. *Journal of Dairy Science*, *92*(10), 4962–4970.

Tiwari, J., Babra, C., Tiwari, H. K., Williams, V., Wet, S. De, Gibson, J., Paxman, A., Morgan, E., Sunagar, R., Isloor, S., Hegde, N. R. & Mukkur, T. (2013). Trends in therapeutic and prevention strategies for management of bovine mastitis: An Overview. *Journal of Vaccines & Vaccination*, *04*(02).

Tolosa, T., Verbeke, J., Piepers, S., Supré, K., & De Vliegher, S. (2013). Risk factors associated with subclinical mastitis as detected by California mastitis test in smallholder dairy farms in Jimma, Ethiopia using multilevel modelling. *Preventive Veterinary Medicine*, *112*(1–2), 68–75.

Traversari, J., Van Den Borne, B. H. P., Dolder, C., Thomann, A., Perreten, V., & Bodmer, M. (2019). Non-aureus staphylococci species in the teat canal and milk in four commercial swiss dairy herds. *Frontiers in Veterinary Science*, *6*, 11–14.

Tremblay, Y. D. N., Lamarche, D., Chever, P., Haine, D., Messier, S., & Jacques, M. (2013). Characterization of the ability of coagulase-negative staphylococci isolated from the milk of Canadian farms to form biofilms. *Journal of Dairy Science*, *96*(1), 234–246.

Turner, K. M. E., & Feil, E. J. (2007). The secret life of the multilocus sequence type. *International Journal of Antimicrobial Agents*, 29(2):129–35.

Thrusfield, M. (2007).Veterinary Epidemiology. *Third edition*. Oxford: Blackwell science Ltd; pp. 183–9.

USDA. 1996a. Part I: Reference of 1996 dairy management practices. USDA-animal and plant health inspection service (APHIS)-veterinary services (VS)-center for epidemiology and animal health (CEAH) national animal health monitoring system (NAHMS), Fort Collins, CO.

USDA. 1996b. Part III: Reference of 1996 dairy health and health management. C. USDA-animal and plant health inspection service (APHIS)-veterinary services (VS), Fort Collins, CO.

USDA. 2015. Determining U.S. milk quality using bulk-tank somatic cell counts, 2015. C. USDA-animal and plant health inspection service (APHIS)-veterinary services (VS), Fort Collins, CO.

USDA. 2016. Dairy 2014, milk quality, milking procedures and mastitis in the United States, 2014. USDA-animal and plant health inspection service (APHIS)-veterinary services (VS)-center for epidemiology and animal health (CEAH) national animal health monitoring system (NAHMS), Fort Collins, CO.

van den Borne, B. H. P., van Schaik, G., Lam, T. J. G. M., & Nielen, M. (2010). Variation in herd level mastitis indicators between primi- and multiparae in Dutch dairy herds. *Preventive Veterinary Medicine*, *96*(1–2), 49–55.

Vanderhaeghen, W., Cerpentier, T., Adriaensen, C., Vicca, J., Hermans, K., & Butaye, P. (2010). Methicillin-resistant *Staphylococcus aureus* (MRSA) ST398 associated with clinical and subclinical mastitis in Belgian cows. *Veterinary Microbiology,* 144, 166–171.

Virdis, S., Scarano, C., Cossu, F., Spanu, V., Spanu, C., & De Santis, E. P. L. (2010). Antibiotic resistance in *staphylococcus aureus* and coagulase negative staphylococci isolated from goats with subclinical mastitis. *Veterinary Medicine International*, *2010*. 517060, 1-6.

Vishnu, U. S., Sankarasubramanian, J., Gunasekaran, P., & Rajendhran, J. (2017). Identification of potential antigens from non-classically secreted

proteins and designing novel multitope peptide vaccine candidate against *Brucella melitensis* through reverse vaccinology and immunoinformatics approach. *Infection, Genetics and Evolution*, *55*, 151–158.

von Eiff, C., Becker, K., & Skov, R. L. (2015). Staphylococcus, Micrococcus, and other catalase-positive cocci. In manual of clinical microbiology, 11th edition American society of microbiology. pp. 354–382.

Wagner, S., & R. Erskine. (2006). Antimicrobial drug use in bovine mastitis. Page 511 in Antimicrobial therapy in veterinary medicine. S. Giguère, J. F. Prescott, J. D. Baggot, R. D. Walker, and P. M. Dowling, ed. Iowa State University Press, Ames.pp.511.

Walsh, S., Buckley, F., Berry, D. P., Rath, M., Pierce, K., Byrne, N., & Dillon, P. (2007). Effects of breed, feeding system, and parity on udder health and milking characteristics. *Journal of Dairy Science*, *90*(12), 5767–5779.

Wang, D., Wang, Z., Yan, Z., Wu, J., Ali, T., Li, J., Lv, Y. & Han, B. (2015). Bovine mastitis *Staphylococcus aureus*: Antibiotic susceptibility profile, resistance genes and molecular typing of methicillin-resistant and methicillin-sensitive strains in China. *Infection, Genetics and Evolution*, *31*, 9–16.

Wang, W., Lin, X., Jiang, T., Peng, Z., Xu, J., Yi, L., Li, F., Fanning, S., & Baloch, Z. (2018). Prevalence and characterization of *Staphylococcus aureus* cultured from raw milk taken from dairy cows with mastitis in Beijing, China. *Frontiers in Microbiology*, *9*, 1123.

White, D. G., & McDermott, P. F. (2001). Emergence and transfer of antibacterial resistance. *Journal of Dairy Science*, *84*, E151–E155.

Williams, W. L. (1927). The detection of shedders of the streptococcus of mastitis in composite control milk samples. *Journal of Dairy Science*, 20, 711–717.

Wilson, D. J., Mallard, B. A., Burton, J. L., Schukken, Y. H., & Grohn, Y. T. (2009). Association of *Escherichia coli* J5-specific serum antibody responses with clinical mastitis outcome for J5 vaccinate and control dairy cattle. *Clinical and Vaccine Immunology, 16*(2), 209–217.

Wilson, B. A., Salyers, A. A., Whitt, D. D., & Winkler, M., E. (2011). Bacterial pathogenesis: A molecular approach. Third Edition. American Society for Microbiology Press. Washington DC, pp. 526.

Wong, C. T. and Ramanoon, S. Z. (2002). Prevalence of bovine subclinical mastitis in five dairy farms in Selangor. A final year project submitted

to the Faculty of Veterinary Medicine, Universiti Putra Malaysia. pp.20.

Wolf, J., M. Wolfová, & M. Štípková. (2010). A model for the genetic evaluation of number of clinical mastitis cases per lactation in Czech Holstein cows. *Journal of Dairy Science,* 93, 1193–1204.

World Health Organization (WHO). 1997. Recommendations:the medical impact of the use of antimicrobials in food animals.WHO-Proceedings. WHO/EMC/ZOO/97.4, 1997. WHO, Geneva, Switzerland. pp. 11–16.

Wyder, A. B., Boss, R., Naskova, J., Kaufmann, T., Steiner, A., & Graber, H. U. (2011). Streptococcus spp. and related bacteria: their identification and their pathogenic potential for chronic mastitis - A molecular approach. *Research in Veterinary Science*, *91*(3), 349–357.

Xu, H., Hu, C., Gong, R., Chen, Y., Ren, N., Xiao, G., Xie, Q., Zhang, M., Liu,Q., Guo,A. & Chen, H. (2011). Evaluation of a novel chimeric B cell epitope-based vaccine against mastitis induced by either *Streptococcus agalactiae* or *Staphylococcus aureus* in mice. *Clinical and Vaccine Immunology*, *18*(6), 893–900.

Yancey, R. J., M. S. Sanchez, & C. W. Ford. (1991). Activity of antibiotics against *Staphylococcus aureus* within polymorphonuclear neutrophils. *European Journal of Clinical Microbiology of Infectious Diseases*, 10, 107–113.

Yang, Y., Liu, Y., Ding, Y., Yi, L., Ma, Z., Fan, H., & Lu, C. (2013). Molecular characterization of *Streptococcus agalactiae* isolated from bovine mastitis in Eastern China. *PLoS ONE*, *8*(7), 1–8.

Ye, X., Wang, X., Fan, Y., Peng, Y., Li, L., Li, S., Huang, J., Yao, Z. & Chen, S. (2016). Genotypic and phenotypic markers of livestock-associated methicillin-resistant *Staphylococcus aureus* CC9 in humans. *Applied and Environmental Microbiology*, *82*(13), 3892–3899.

Yu, C.-S., Cheng, C.-W., Su, W.-C., Chang, K.-C., Huang, S.-W., Hwang, J.-K., & Lu, C.-H. (2014). CELLO2GO: A web server for protein subcellular localization prediction with functional gene ontology annotation. *PLoS ONE*, *9*(6), e99368.

Zadoks, R. N., Van Leeuwen, W. B., Kreft, D., Fox, L. K., Barkema, H. W., Schukken, Y. H., & Van Belkum, A. (2002). Comparison of *Staphylococcus aureus* isolates from bovine and human skin, milking equipment, and bovine milk by phage typing, pulsed-field gel electrophoresis, and binary typing. *Journal of Clinical Microbiology*, *40*(11), 3894–3902.

Zadoks, Ruth N., & Fitzpatrick, J. L. (2009). Changing trends in mastitis. *Irish Veterinary Journal*. 62(4):59–70. Zadoks, R. N., H. G. Allore, T. J. Hagenaars, H. W. Barkema, & Y. H. Schukken. (2002). A mathematical model of *Staphylococcus aureus* control in dairy herds. *Epidemiology and Infection*, 129, 397–416.

Zadoks, R. N., & J. L. Fitzpatrick. 2009. Changing trends in mastitis. *Irish Veterinary Journal* 62, 59–70.

Zadoks, R. N., Middleton, J. R., McDougall, S., Katholm, J., & Schukken, Y. H. (2011). Molecular epidemiology of mastitis pathogens of dairy cattle and comparative relevance to humans. *Journal of Mammary Gland Biology and Neoplasia*, *16*(4), 357–372.

Zadoks, R., van Leeuwen, W., Barkema, H., Sampimon, O., Verbrugh, H., Schukken, Y. H., & van Belkum, A. (2000). Application of pulsed-fieldgel electrophoresis and binary typing as tools in veterinary clinical microbiology and molecular epidemiologic analysis of bovine and human *Staphylococcus aureus* isolates. *Journal of Clinical Microbiology,38, 1931–1939.*

Zadoks, R. N., B. E. Gillespie, H. W. Barkema, O. C. Sampimon, S. P. Oliver, & Y. H. Schukken. (2003). Clinical, epidemiological and molecular characteristics of *Streptococcus uberis* infections in dairy herds. *Epidemiology and Infection,* 130, 335–349.

Zadoks, R. N., H. G. Allore, H. W. Barkema, O. C. Sampimon, G. J. Wellenberg, Y. T. Gröhn, & Y. H. Schukken. (2001). Cow- and quarter-level risk factors for *Streptococcus uberis* and *Staphylococcus aureus* mastitis. *Journal of Dairy Science,* 84, 2649–2663.

Zenebe, N., Habtamu, T., & Endale, B. (2014). Study on bovine mastitis and associated risk factors in Adigrat, Northern Ethiopia. *African Journal of Microbiology Research, 8*(4), 327–331.

Zeryehun, T, Aya, T., & Bayecha, R. (2013). Study on prevalence, bacterial pathogens and associated risk factors of bovine mastitis in small holder dairy farms in and around Addis Ababa, Ethiopia. *Journal of Animal and Plant Science*, 23(1), 50-55.

Zeryehun, Tesfaheywet, & Abera, G. (2017). Prevalence and bacterial isolates of mastitis in dairy farms in selected districts of eastern Harrarghe zone, eastern Ethiopia. *Journal of Veterinary Medicine*, (6498618), 1-7.

Zhang, Q. Y., Jones, D. M., Sáez Nieto, J. A., Pérez Trallero, E., & Spratt, B. G. (1990). Genetic diversity of penicillin-binding protein 2 genes of penicillin-resistant strains of *Neisseria meningitidis* revealed by

fingerprinting of amplified DNA. *Antimicrobial Agents and Chemotherapy*, *34*(8), 1523–1528.

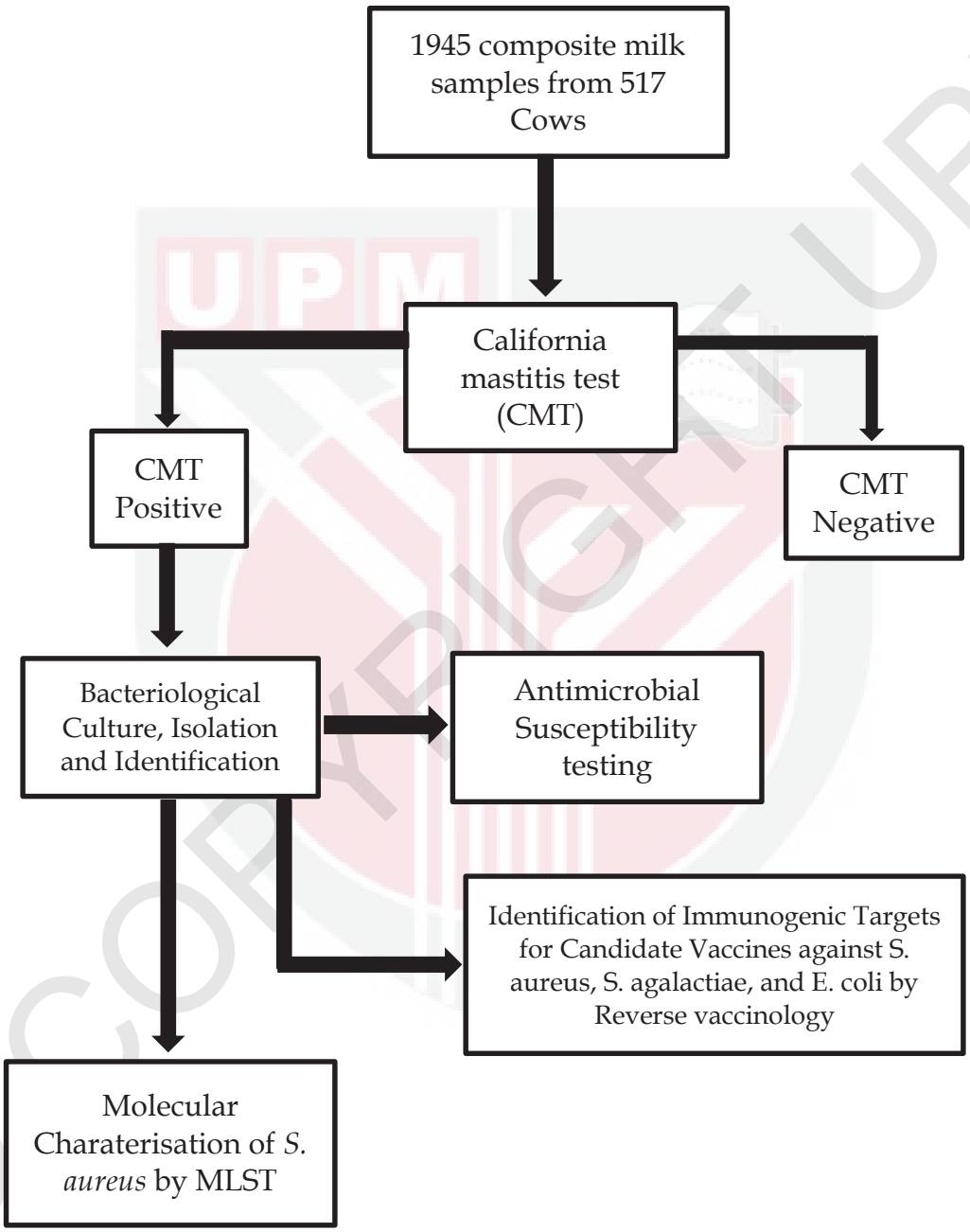
Zhao, X., & Lacasse, P. (2008). Mammary tissue damage during bovine mastitis: Causes and control. *Journal of Animal Science*, *86*(13), 57–65.

Zhou, W. Y., Shi, Y., Wu, C., Zhang, W. J., Mao, X. H., Guo, G., Li, H., X. & Zou, Q. M. (2009). Therapeutic efficacy of a multi-epitope vaccine against *Helicobacter pylori* infection in BALB/c mice model. *Vaccine*, *27*(36), 5013–5019.

APPENDICIES

Appendix A

General methodology flow chart



Appendix B

QUESTIONNAIRE ON BOVINE MASTITIS IN PENINSULAR MALAYSIA ADMINISTERED TO DAIRY FARMERS

SOAL SELIDIK MASTITIS PADA LEMBU DI SEMENANJUNG MALAYSIA YANG DIBERIKAN KEPADA PENTERNAK TENUSU

NB: All information obtained from this questionnaire will be used for the purpose of research only and nothing else and will be treated with utmost confidentiality.

Nota: Semua maklumat yang diperolehi dari soal selidik ini akan digunakan untuk tujuan penyelidikan sahaja. Semua maklumat adalah dirahsiakan.

FARM LOCATION (LADANG):.....

1. What is your farm size (Apakah saiz ladang anda)?
   a) >50 cows (> 50 lembu) ☐
   b) 50 – 150 cows (50 – 100 ekor lembu) ☐
   c) >150 cows (> 150 ekor lembu) ☐

2. What system of management do you practice in the farm (Apakah sistem pengurusan yang anda amalkan di ladang)?
   a) Intensive (Intensif) ☐
   b) Semi intensive (Semi intensif) ☐
   c) Extensive (Ekstensif) ☐

3. How often do you vaccinate your animals in the farm (Berapa kerap anda memvaksinasikan haiwan di ladang)?
   a) Never vaccinate(tidak pernah) ☐
   b) Rarely vaccinate (jarang) ☐
   c) Occasionally vaccinate (kadang-kadang) ☐
   d) Regularly vaccinate (sentiasa memvaksinasi) ☐
   e) Usually vaccinate (biasa memvaksinasi) ☐

4. How often do you deworm your animals in the farm (Berapa kerap anda nyahcacing haiwan di ladang)?
   a) Never deworm (tidak pernah) ☐
   b) Rarely deworm (jarang) ☐
   c) Occasionally deworm (kadang-kadang) ☐

Appendix C

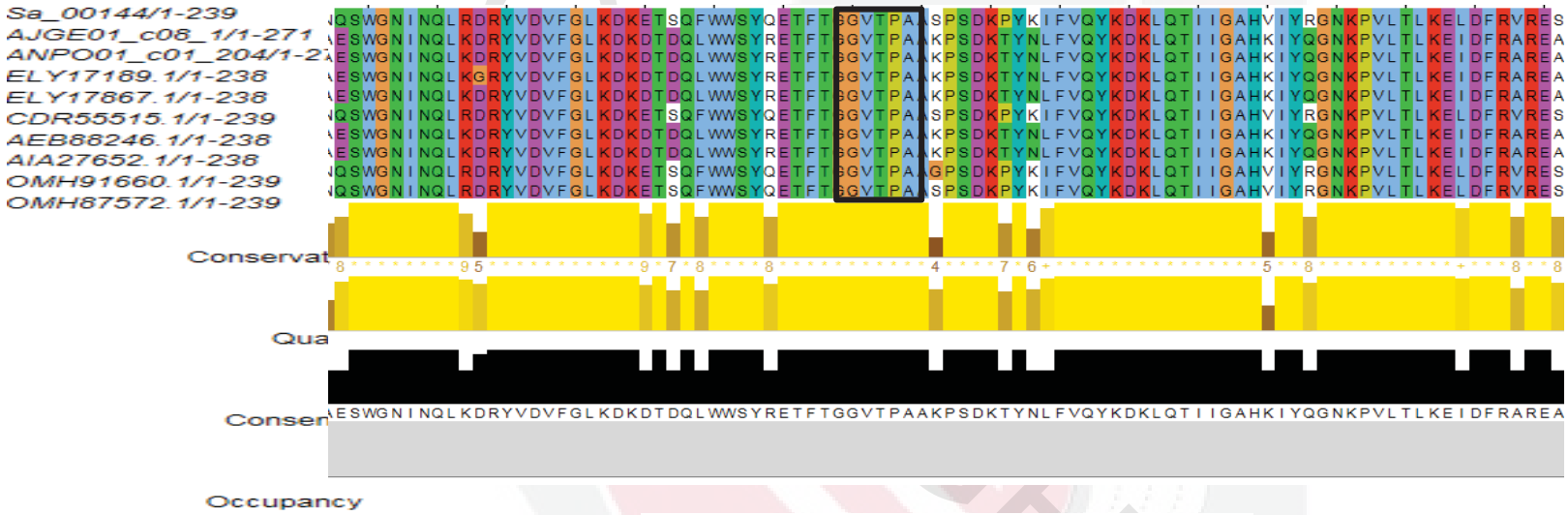
ANIMAL DATA FORM (DATA HAIWAN BORANG)

Farm Location *(Farm lokasi)* .....

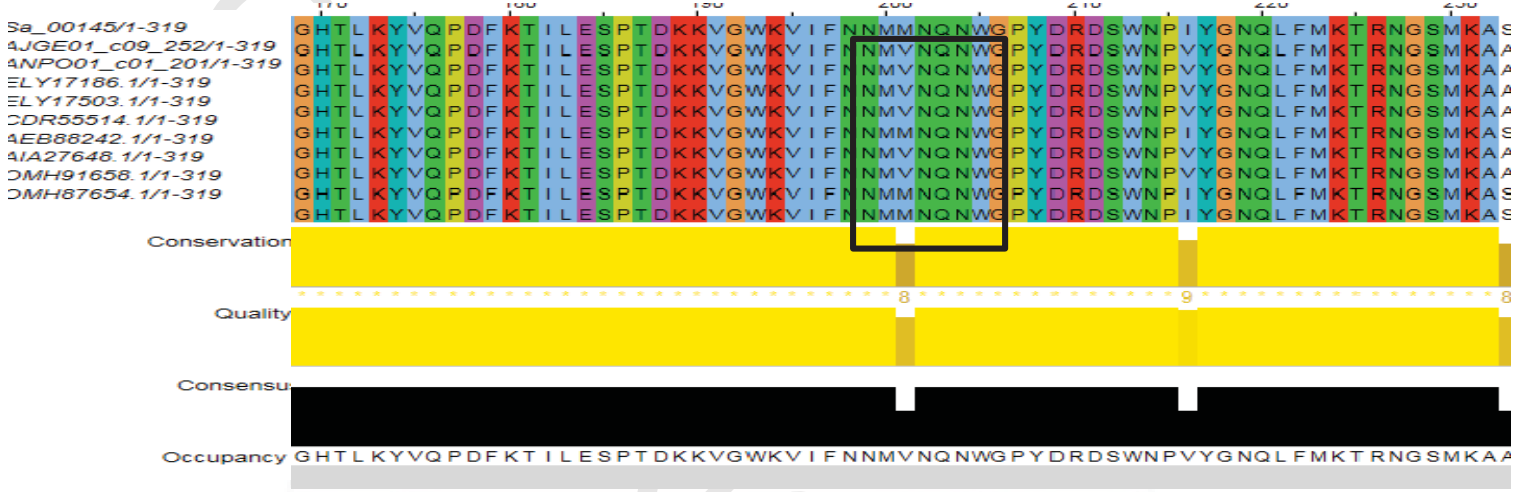
1. Tag No (Tag No.). .....
2. Sample No. (No. sampel) .....
3. Age (Umur) .....
4. Breed (baka) .....
5. Parity
   a) Primiparous ☐
   b) Multiparous ☐
6. Stage of lactation (Peringkat laktasi)
   a) Early lactation (laktasi awal) ☐
   b) Mid lactation (Mid laktasi) ☐
   c) Late lactation (Laktasi lewat) ☐
   d) Dry and calving period (Tempoh kering dan melahirkan) ☐
7. Milking interval (Selang memerah susu)
   a) Once daily (sekali setiap hari) ☐
   b) Twice daily (dua kali setiap hari) ☐
8. Milk yield per head/day (hasil susu seekor/hari)
   .....
9. Type of mastitis (jenis mastitis)
   a) Clinical (klinikal) ☐
   b) Subclinical (subklinikal) ☐
10. Udder quarter(s) affected (suku raba(s) terjejas
    a) Front Right (depan kanan) ☐
    b) Hind Right (belakang kanan) ☐
    c) Front Left (depan kiri) ☐
    d) Hind Left (belakang kiri) ☐
11. Previous treatment history for mastitis (sejarah rawatan mastitis)
    a) Treated (dirawat) ☐
    b) Never treated (tidak dirawat) ☐

Appendix D

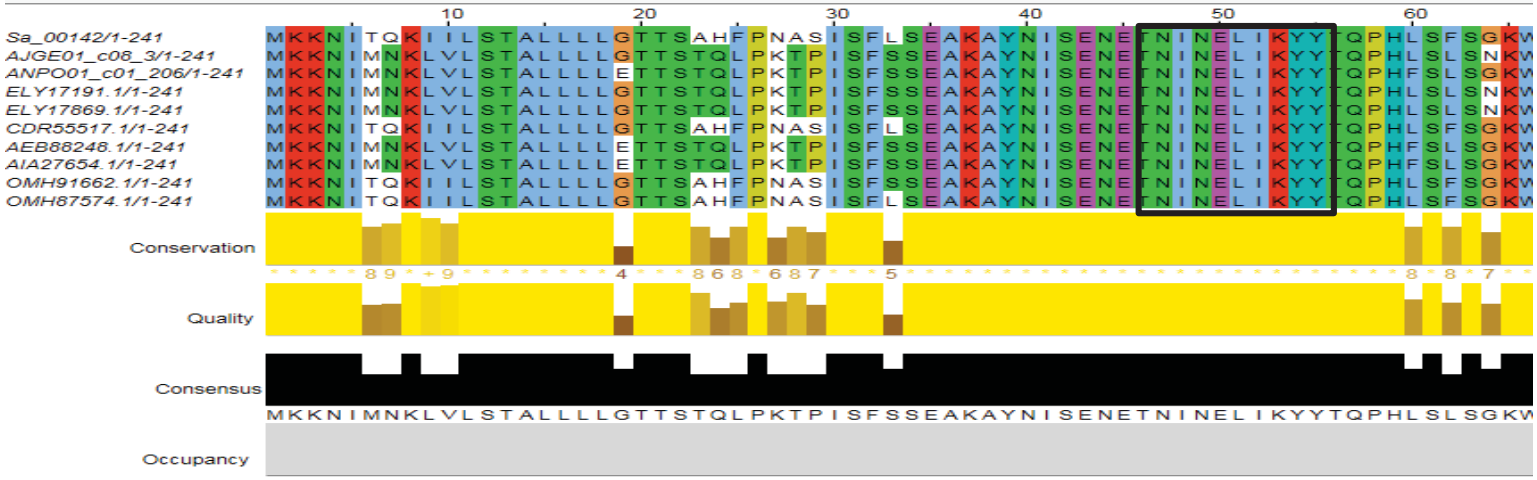
Aligned regions showing conserved epitopes among various strains of *S. aureus* for each prioritized protein.



a. **Super antigen-like protein SSL12**



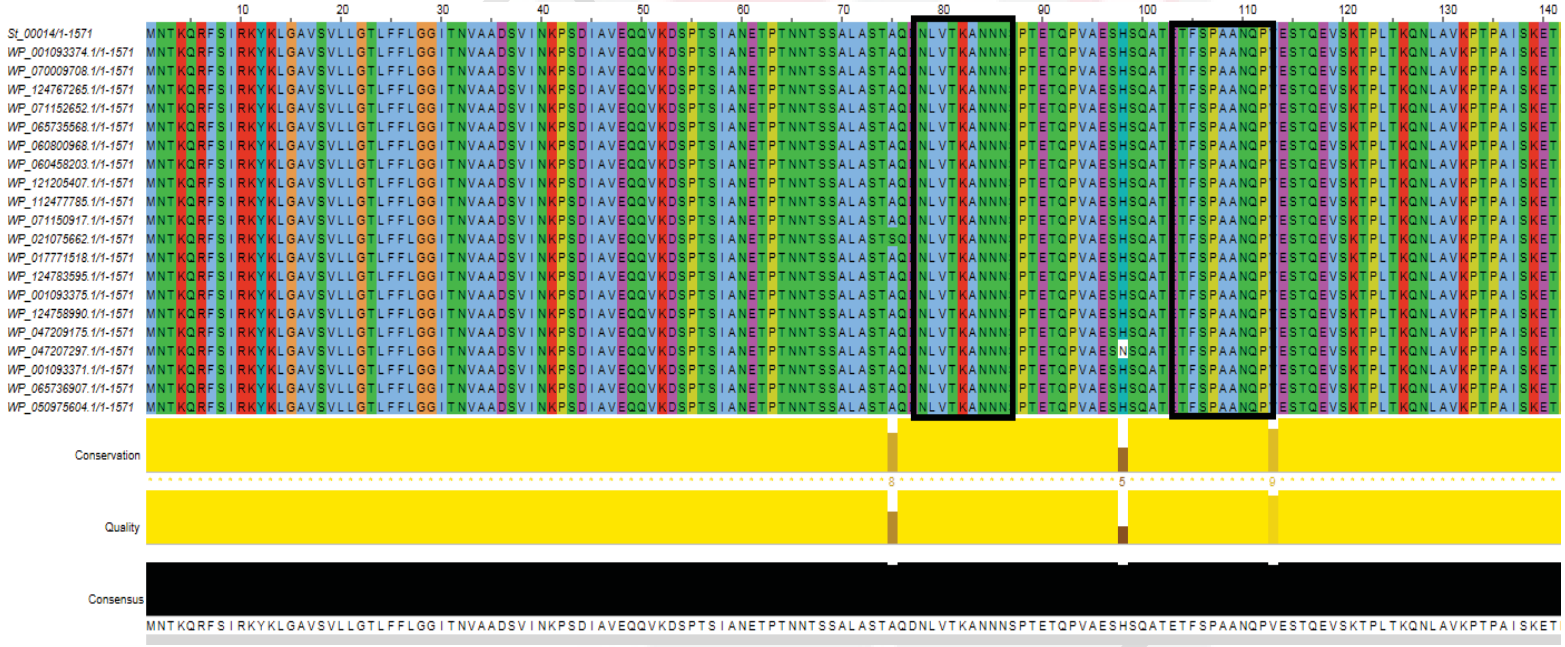
b. Cytolycin



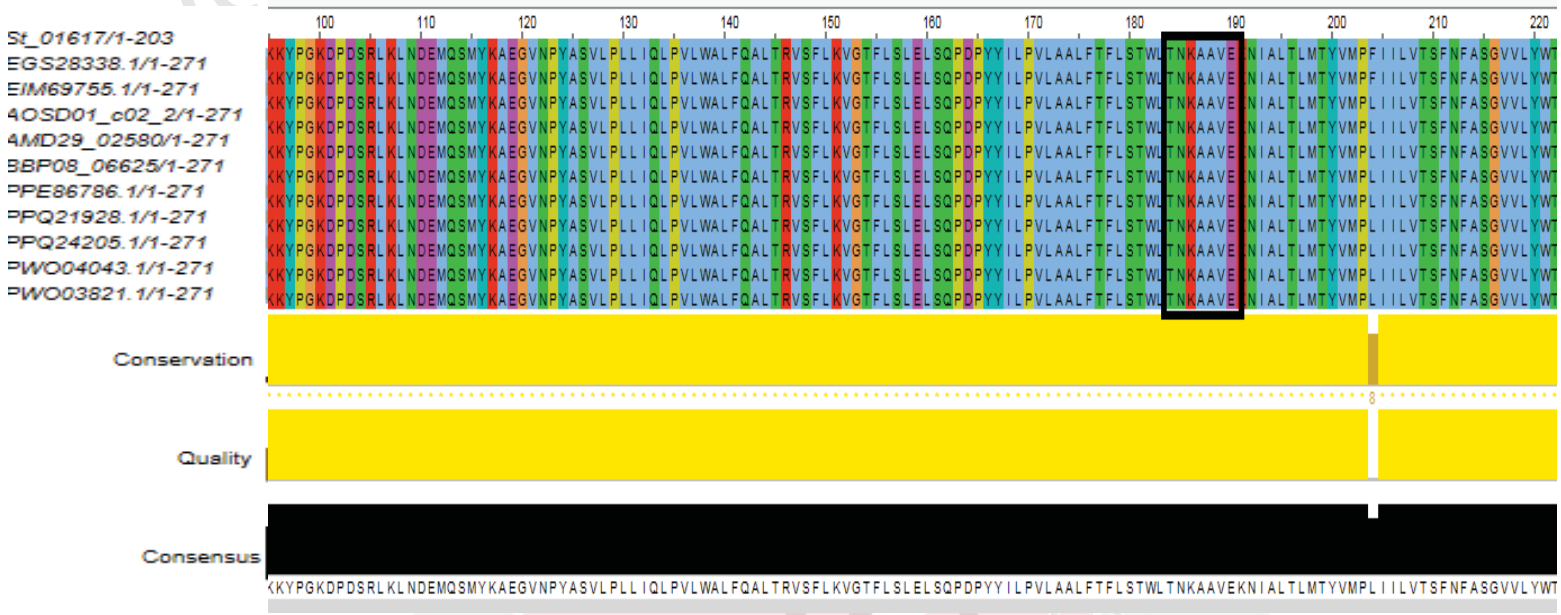
c. Super antigen-like protein SSL14

Appendix E

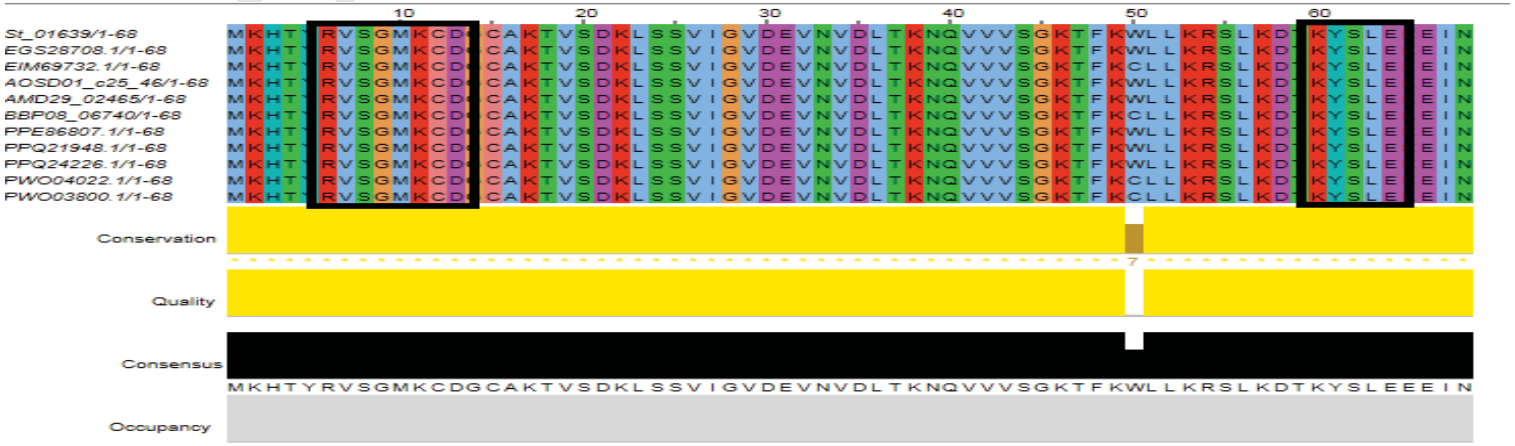
Aligned regions showing conserved epitopes among various strains of *S. agalactiae* for some of the prioritized proteins.



a. Signal peptide protein



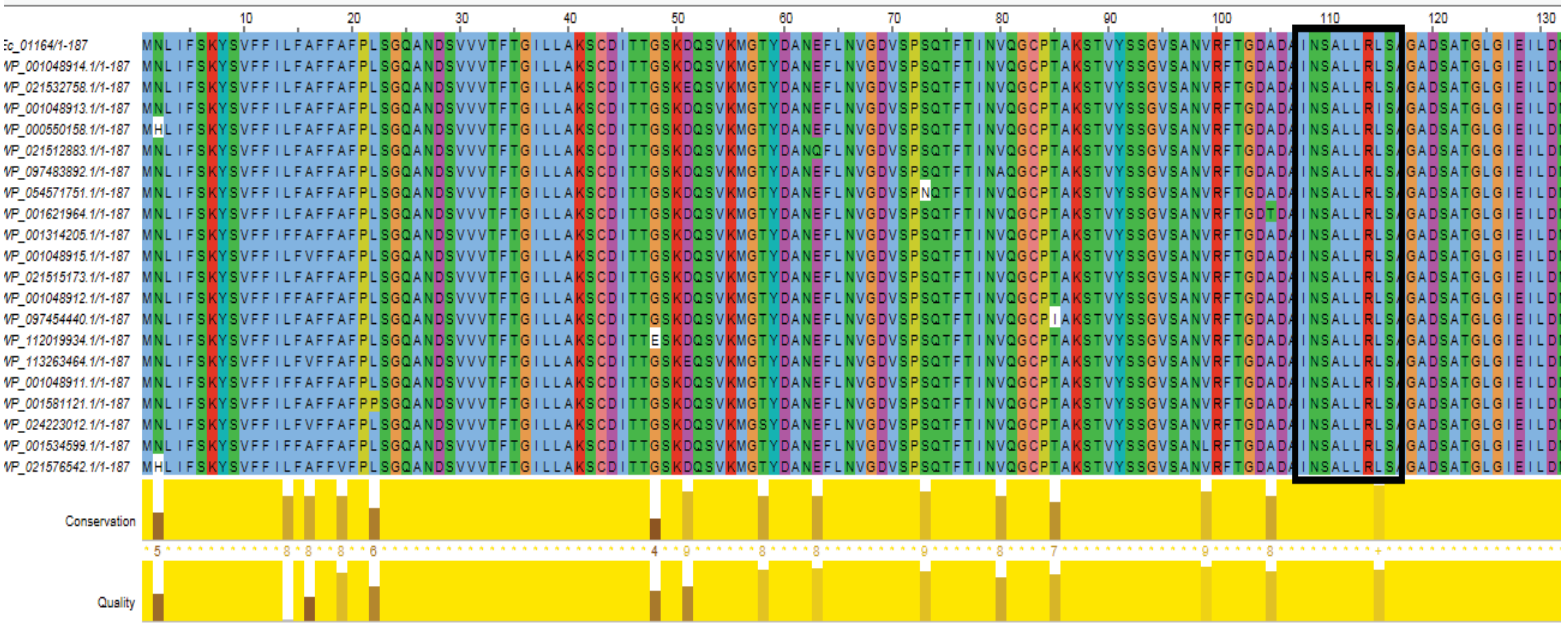
b. Stage III sporulation protein



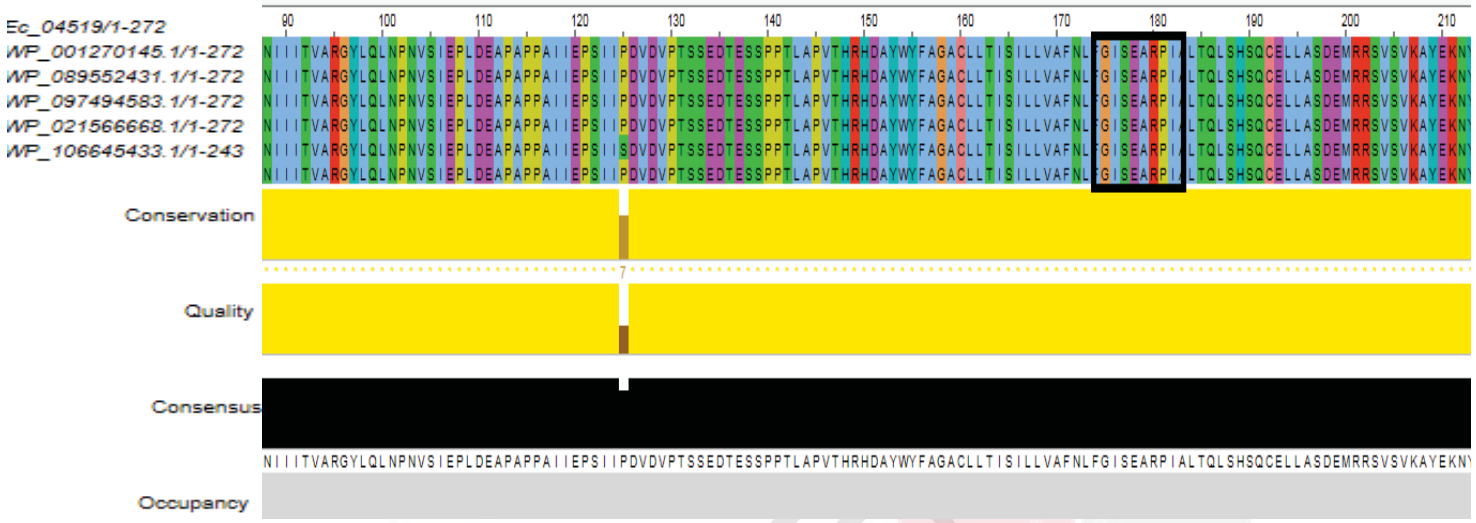
c. Cation transporter

Appendix F

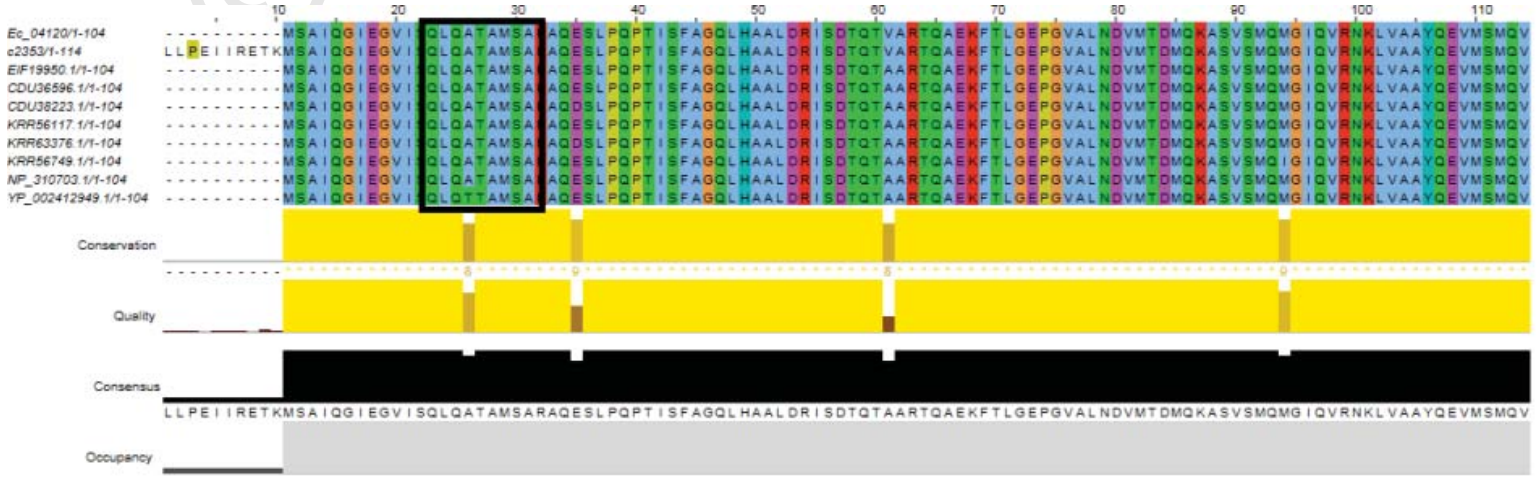
Aligned regions showing conserved epitopes among various strains of *E. coli* for some of the prioritized proteins.



a. Type 1 fimbrial protein



b. Winged helix family transcriptional



c. Flagella hook body complex

BIODATA OF STUDENT

Bashir Ali was born in Sabon Garin Ya'ya' Town of Taura Local Government on 20th January 1984, to the family of Alhaji Ali Yaro and Mallama Rafi'atu Muhammad. He attended Sabon Garin Ya'ya' Primary School from the year 1989 to 1995. In the year 1995 he went to Government Secondary School Roni, Jigawa State for his Junior Secondary School education. When he was in JS two, he was chosen to write Science and Technical School's Entrance Examination in the year 1997. He proceeded with his Secondary School education at Science Secondary School Kafin-Hausa from 1997 to 2000. In the year 2001 Bashir Ali was enrolled into the Interim Joint Matriculation Board (IJMB) programme at then Hussaini Adamu Polytechnic, College of Engineering and Technology, now Federal Polytechnic, Kazaure. In the year 2004, Bashir Ali started his undergraduate studies at Department of Biological Sciences, Bayero University, Kano, where he obtained his first degree in Microbiology (B.Sc.) in the year 2008. In August 2008, He went for National Youth Service Corps, where he served at Ibn Fartuwa Islamic Science Secondary School, Monguno in Borno State. During his service year, he held a position of Vice Principal Academics and President of Peer Education Trainers (PETs), a group shouldered with the responsibility of campaigns and awareness on HIV/AIDS and reproductive health. In the year 2009, Bashir Ali started his working career as Education Officer II under the Ministry of Education Jigawa State, where taught in Government Secondary School Harbo in Jahun Local Government, Jigawa State until the year 2011. In the year 2011, Bashir Ali moved to Joint Admissions and Matriculation Board (JAMB) where he served as Administrative Officer II until 2014. In the year 2014, because of his readiness to accept academic challenges, Bashir Ali moved to the then newly established Jigawa State University, now Sule Lamido University as Graduate Assistant. He obtained his master's degree in Medical Microbiology in the 2015 from Bayero University Kano. In the year 2017 he started his PhD studies in Faculty of Veterinary Medicine, Universiti Putra Malaysia where he is enrolled to study PhD Bacteriology. Bashir Ali is happily married and blessed with three children.

LIST OF PUBLICATIONS

Bashir, A., Zunita, Z., Jesse, F. F. A., Ramanoon, S. Z., & Mohd-Azmi, M. L. (2019b). Whole-Genome Shotgun Sequence of *Streptococcus agalactiae* Sequence Type 176 Strain 3966RFQB from a Dairy Herd in Selangor, Malaysia. https://doi.org/10.1128/MRA.01618-18.

Bashir, A., Zunita, Z., Jesse, F. F. A., Ramanoon, S. Z., & Mohd-Azmi, M. L. (2019). Contagious and Environmental Bacterial Species Implicated in Bovine Mastitis from Some Selected Dairy Farms in Perak, Malaysia. *Proceedings of ICOOH-International Congress on One Health and AAVS-WPSA Malaysia 2019*. pp. 58-59.

Bashir, A., Zunita, Z., Jesse, F. F. A., Ramanoon, S. Z., & Mohd-Azmi, M. L. (2019). Emergence of *staphylococcus argenteus* as Bovine Mastitis Pathogen in Malaysia. *14th Proceedings of Seminar on Veterinary Sciences, Veterinary Association of Malaysia Congress.*pp.68.

Bashir, A., Zunita, Z., Jesse, F. F. A., Ramanoon, S. Z., & Mohd-Azmi, M. L. (2019a). Interrogating the Whole-Genome Shotgun Sequence of *Escherichia coli* Sequence Type 127 Strain 1538RHQ, Which Harbors Virulent Antigenic Factors, Isolated from a Mastitic Cow. *Microbiology Resource Announcements*, *8*(48). https://doi.org/10.1128/MRA.01057-19.

Short Communication: Genomic Based Antimicrobial Resistance and Virulence Genes of *Staphylococcus argenteus* ST2250 Associated with Bovine Mastitis in Malaysia. (Submitted)

Prevalence of Subclinical mastitis and its associated risk factors in Malaysian Dairy herds. (Submitted).

Prevalence of Pathogens Associated with Intramammary Infections and Antimicrobial Resistance Profiles from Dairy herds in Malaysia. (Submitted).

Multilocus sequence typing of *S. aureus* isolates from subclinical mastitis in Malaysia. (Drafted Manuscript).

Identification of Candidate Vaccine Targets against Mastitis Pathogens in Malaysia: A Reverse Vaccinology Approach. (Drafted Manuscript).

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