ANTIMICROBIAL ACTIVITY OF INDIAN OREGANO (*Coleus aromaticus*) AGAINST DIABETIC WOUND PATHOGENS

Kalesware A/P Muniandy  
(Matric No. 3110185)

Thesis submitted in fulfillment for the degree of  
MASTER OF SCIENCE

Faculty of Science and Technology  
UNIVERSITI SAINS ISLAM MALAYSIA  
Nilai

October 2015
AUTHOR DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

Date: 9th OCTOBER 2015

Signature: [Signature]
Name: Kalesware A/P Muniandy
Matric No: 3110185
Address: 146, Jalan Baiduri 2,
          Taman Baiduri, 70200,
          Seremban, Negeri Sembilan
APPROVAL

UNIVERSITI SAUNS ISLAM MALAYSIA

FACULTY OF SCIENCE AND TECHNOLOGY

The undersigned certify that they have read, and recommend to the Faculty of Science and Technology for acceptance, a thesis entitled “Antimicrobial Activity of Indian Oregano (Coleus aromaticus) against Diabetic Wound Pathogens” submitted by Kalesware A/P Muniandy in fulfilment of the requirements for the degree of Master of Science.

Main Supervisor, Associate Professor Dr. Zaiton Binti Hassan,
Faculty of Science and Technology

Co-supervisor, Dr. Mohd Hafiez Bin Mohd Isa,
Faculty of Science and Technology

9th October 2015
BIODATA OF AUTHOR

Kalesware A/P Muniandy (Matric number: 3110185) was born in 24th January 1981 in the state of Perak and her identity card number is 810124-08-6374. She is a Malaysian citizen who is residing in 146, Jalan Baiduri 2, Taman Baiduri, 70200 Seremban, Negeri Sembilan. She had obtained her medical degree from Crimea State Medical University (Ukraine, 2007) and had experiences of practicing as medical personnel in Malacca General Hospital. She is currently working in Nightingale International College, Seremban with the job title of Academic Coordinator cum Head of Foundation Studies and she is exploring the world of teaching as a lecturer covering medical and non-medical modules. She is at present a master student at USIM majoring in Microbiology.
ACKNOWLEDGEMENTS

I would like thank Universiti Sains Islam Malaysia for giving me this golden opportunity to establish my capabilities throughout the dissertation preparation. I would like to extend my deepest sense of appreciation and gratitude to Assoc. Professor Dr. Zaiton Binti Hassan and Dr. Mohd Hafez Bin Mohd Isa for the extreme guidelines that were smeared on me to provide a challenging yet exploring route for accomplishing all the required tasks during the research as well as during the dissertation preparation. I am honoured to be able to work under their supervision that constantly motivates me to be persistent and to fulfil myself with perseverance towards achieving my goal. They had encouraged and had supported pretty well to place me fitted perfectly to the right track of research kinetics.

My kind appreciation to all the lecturers and administrative executives of Nightingale International College for supplying me with constant support and motivation to make this project to realm in reality and for nurturing me with conducive environment that stimulated my scientific thoughts and thinking. I would like to thank BP Healthcare on the other hand as well for providing all the necessary cooperation needed to achieve whatever I had ahead waiting for me to achieve successfully. I also would like to thank Syarikat Perniagaan Murni-Media Sdn Bhd for supplying all the chemicals needed for initiation of research by purchase. Finally, my special appreciation is dedicated to my beloved husband for all the unconditional love and moral support that was filled with motivation to help me diving through difficulties. I would like to thank my husband again and my mother in law who looked after my four years old son while I am busy focusing my fullest attention on my research project.
ABSTRACT

The antimicrobial activity of unsterilized and sterilized ethanolic extract of *Coleus aromaticus* was evaluated by deploying disc diffusion, Minimum Inhibitory Concentration (MIC), Minimum Bactericidal Concentration (MBC) and time kill studies on *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa* and *Proteus mirabilis*. Zone of inhibition was 17.50 to 27.00 mm for unsterilized extract, 11.00 to 20.00 mm for heat sterilized extract, 6.00 to 12.00 mm for filter sterilized extract, 18.00 to 21.00 mm for ampicillin, 19.50 to 24.00 mm for chloramphenicol and 11.50 to 19.00 mm for streptomycin. MIC is 1.02 to 2.60 mg/ml for unsterilized extract, 2.60 to 5.21 mg/ml for heat sterilized extract, 8.33 to 18.75 mg/ml for filter sterilized extract and 0.02 mg/ml for chloramphenicol. MBC ranged from 2.60 to 8.33 mg/ml for unsterilized extract and from 0.03 to 0.04 mg/ml for chloramphenicol. Higher values were noted with heat (4.17 to 20.83 mg/ml) and filter sterilized extract (20.83 to 41.67 mg/ml). Time kill assay showed log reduction of more than 3 in 2 x MIC unsterilized extract on microorganisms tested. Greater log reduction was observed with heat sterilized extract compared to filter sterilized extract. The extract was also evaluated for its wound healing activity in induced diabetic mice. Excision wound model showed 76.6% of wound area reduction with higher rate of wound epithelialization in the presence of extract whereas the controls just exhibited 55.9% of wound area reduction. Dead space wound model showed increased granulation tissue and its histopathological investigation showed good proliferation of collagen tissue with satisfactory angiogenesis. This study showed the activity of *C. aromaticus* as a diabetic wound antimicrobial agent.
ABSTRAK

Aktiviti antimikrobial ekstrak *Coleus aromaticus* yang telah dan tidak disterilkan dinilai menggunakan kaedah cakera serapan, kepekatan perencatan minima, kepekatan pembunuhan bakteria minimum dan kajian masa pembunuhan bakteria terhadap *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa* dan *Proteus mirabilis*. Zon perencatan adalah 17.50 hingga 27.00 mm bagi ekstrak yang tidak disterilkan, 11.00 hingga 20.00 mm bagi ekstrak yang telah dihabasterikan, 6.0 hingga 12.0 mm bagi ekstrak yang telah disterilkan dengan penapis, 18.00 hingga 21.00 mm bagi ampicillin, 19.50 hingga 24.00 mm bagi chloramphenicol dan 11.50 hingga 19.00 mm bagi streptomycin. MIC adalah 1.02 hingga 2.60 mg/ml bagi ekstrak yang tidak disterilkan, 2.60 hingga 5.21 mg/ml bagi ekstrak yang telah dihabasterikan, 8.33 hingga 18.75 mg/ml bagi ekstrak yang telah disterilkan dengan penapis dan 0.02 mg/ml bagi chloramphenicol. MBC adalah 2.60 hingga 8.33 mg/ml bagi ekstrak yang tidak disterilkan dan 0.03 hingga 0.04 mg/ml bagi chloramphenicol. Nilai MBC bagi ekstrak yang dihabasterikan (4.17 hingga 20.83 mg/ml) dan yang disterilkan dengan penapis (20.83 hingga 41.67 mg/ml) tercatat lebih tinggi. Kajian masa pembunuhan bakteria bakteria menunjukkan pengurangan lebih 3 log dalam kepekatan 2 x MIC ekstrak yang tidak disterilkan. Pengurangan log yang lebih memuaskan telah diperhatikan dalam ekstrak yang dihabasterikan jika dibandingkan dengan ekstrak yang telah disterilkan dengan penapis. Ekstrak juga dinilai bagi aktiviti penyembuhan luka ke atas tikus yang diaru dengan kencing manis. Model pemotongan luka menunjukkan 76.6% pengurangan kawasan luka dengan kadar penyembuhan yang lebih tinggi manakala tikus kawalan hanya menunjukkan 55.9% pengurangan kawasan luka. Model luka ruang mati menunjukkan peningkatan tisu granulasi dan siasatan histopatologi menunjukkan pemendapan tisu kolagen dan pembentukan salur darah yang memuaskan. Kajian ini menunjukkan *C. aromaticus* sebagai agen antimikrobial yang mujarab.
الملخص

تم تقييم النشاط المضاد للبكتيريا بواسطة مستخلصات Coleus aromaticus المعمرة والغير معمرة بواسطة الكحول الإيثيلي. طرق التقييم التي استخدمت هي التوزيع الطبقي. التركيز الإلائل المثبط Escherichia coli, Staphylococcus aureus, Klebsiella التركيز الإلائل القاتل وقت القتل ضد S. pneumonia, Pseudomonas aeruginosa and Proteus mirabilis. 6.2 ملم/مل للمستخلص الغير معقم 0.12 إلى 0.31 ملم/مل للمستخلص المعقم بالبروتيقينين. التأثير الإلائل المثبط تراوح مابين 0.10 إلى 0.26 ملم/مل للمستخلص الغير معقم 0.33 إلى 0.75 ملم/مل للمستخلص المعقم. للمعمرة. التأثير الإلائل القاتل تراوح مابين 0.33 إلى 0.60 ملم/مل للمستخلص الغير معقم 7.5 إلى 21.2 ملم/مل للمستخلص المعقم بالبروتيقينين.

النتائج:
- في جميع البكتيريا المستخدمة، أظهر مستخلص C. aromaticus نتائج إيجابية.
- العلاج الفعال للمعمرة والغير معمرة.

الملاحظات:
- مستخلص C. aromaticus يمكن استخدامه كعلاج أولوري.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTHOR DECLARATION</td>
<td>ii</td>
</tr>
<tr>
<td>APPROVAL</td>
<td>iii</td>
</tr>
<tr>
<td>BIODATA OF AUTHOR</td>
<td>iv</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>v</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>vi</td>
</tr>
<tr>
<td>ABTSRAK</td>
<td>vii</td>
</tr>
<tr>
<td>الملخص</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xiv</td>
</tr>
<tr>
<td>LIST OF APPENDICES</td>
<td>xv</td>
</tr>
<tr>
<td>ABBREVIATIONS AND SYMBOLS</td>
<td>xvi</td>
</tr>
<tr>
<td>CHAPTER I: INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>CHAPTER II: LITERATURE REVIEW</td>
<td></td>
</tr>
<tr>
<td>2.1 Common Diabetic Wound Pathogens</td>
<td>4</td>
</tr>
<tr>
<td>2.2 Wound Healing and Diabetes mellitus</td>
<td>6</td>
</tr>
<tr>
<td>2.3 Wound Healing Mechanism and Current Treatment of Wounds</td>
<td>10</td>
</tr>
<tr>
<td>2.4 Diabetes mellitus</td>
<td>14</td>
</tr>
<tr>
<td>2.5 Coleus aromaticus</td>
<td>17</td>
</tr>
<tr>
<td>2.6 Earlier Investigations on the Antimicrobial Action of Coleus</td>
<td>20</td>
</tr>
<tr>
<td>aromaticus</td>
<td></td>
</tr>
<tr>
<td>2.7 Earlier Investigations on Coleus aromaticus in the Area of</td>
<td>24</td>
</tr>
<tr>
<td>Wound Healing</td>
<td></td>
</tr>
<tr>
<td>CHAPTER III: COMPARISON OF ANTIMICROBIAL ACTIVITY</td>
<td></td>
</tr>
<tr>
<td>OF INDIAN OREGANO (Coleus aromaticus) AND ANTIBIOTICS AGAINST DIABETIC</td>
<td></td>
</tr>
<tr>
<td>WOUND PATHOGENS</td>
<td></td>
</tr>
<tr>
<td>3.1 Introduction</td>
<td>26</td>
</tr>
<tr>
<td>3.2 Materials and Methods</td>
<td>27</td>
</tr>
<tr>
<td>3.2.1 Preparation of Ethanolic Extract of C. aromaticus</td>
<td>27</td>
</tr>
<tr>
<td>3.2.2 Preparation of Turbidity Standard Equivalent to</td>
<td></td>
</tr>
<tr>
<td>McFarland 0.5</td>
<td>27</td>
</tr>
<tr>
<td>3.2.3 Evaluation of Antimicrobial Activity of Ethanolic C. aromaticus</td>
<td>28</td>
</tr>
<tr>
<td>Extracts by Disc Diffusion Method</td>
<td></td>
</tr>
<tr>
<td>3.2.4 Determination of Minimum Inhibition Concentration (MIC)</td>
<td>29</td>
</tr>
<tr>
<td>and Minimum Bactericidal Concentration (MBC)</td>
<td></td>
</tr>
</tbody>
</table>
3.2.5 Bacterial Killing Study
3.2.6 Statistical Analysis
3.3 Results
3.3.1 Disc Diffusion Analysis
3.3.2 Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC)
3.3.3 Bacterial Killing Study
3.4 Discussion
3.5 Conclusion

CHAPTER IV: EFFECT OF HEAT AND FILTER STERILIZATION ON THE EFFICIENCY OF INDIAN OREGANO (C. aromatica) AS AN ANTIMICROBIAL AGENT AGAINST DIABETIC WOUND PATHOGENS

4.1 Introduction
4.2 Materials and Methods
4.2.1 Preparation of Ethanolic Extract of C. aromatica
4.2.2 Sterilization of Ethanolic Extract of C. aromatica
   4.2.2.1 Heat Sterilization
   4.2.2.2 Filter Sterilization
4.2.3 Preparation of Turbidity Standard Equivalent to McFarland 0.5
4.2.4 Disc Diffusion Susceptibility Test
4.2.5 Determination of Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of Sterilized C. aromatica Ethanolic Extracts
4.2.6 Bacterial Killing Study
4.2.7 Statistical Analysis
4.3 Results
4.3.1 Disc Diffusion Analysis
4.3.2 Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC)
4.3.3 Bacterial Killing Study
4.4 Discussion
4.5 Conclusion

CHAPTER V: WOUND HEALING EFFECT OF INDIAN OREGANO (C. aromatica) IN EXPERIMENTALLY INDUCED DIABETIC MICE

5.1 Introduction
5.2 Materials and Methods
5.2.1 Preparation of Ethanolic Extract of C. aromatica for External Application
5.2.2 Preparation of Dried Extract of C. aromatica for Oral Administration
5.2.3 Mice Husbandry
5.2.4 Induction of Diabetes mellitus in Mice 58
5.2.5 Excision Wound Model 58
5.2.6 Dead Space Wound Model 59
5.2.7 Statistical Analysis 60
5.3 Results 60
5.3.1 Wound Area Reduction 60
5.3.2 Epithelialization Day 62
5.3.3 Weight of Granulation Tissue 63
5.3.4 Histopathological Investigation of Granulation Tissue 64
5.4 Discussion 66
5.5 Conclusion 68
CHAPTER VI: CONCLUSION AND RECOMMENDATIONS 69
REFERENCES 71
APPENDICES 93
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Monofilament Test for Light Touch Sensation</td>
<td>8</td>
</tr>
<tr>
<td>Figure 2</td>
<td>The Beta Cells of the Pancreas are the Cells that are Responsible in the Production of Insulin</td>
<td>15</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Histological Examples of 4 Atherosclerotic Plaque Types. (A) Coronary Fibrous Cap Atheroma in a 24-Year-Old Man. (B) Thin Fibrous Cap Atheroma. (C) Healed Plaque Rupture. (D) Stenosis of the Anterior Descending Coronary Artery in a 40-Year-Old Man</td>
<td>16</td>
</tr>
<tr>
<td>Figure 4</td>
<td>The Morphological Features of the Leaves of Coleus</td>
<td>18</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Epizootic Ulcerative Syndrome in Channa marulius</td>
<td>24</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Template for Applying Antimicrobial Discs (90 mm Diameter Petri Dish)</td>
<td>29</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Effect of 2.60 mg/ml Ethanolic C. aromaticus Extract on the Growth of S. aureus</td>
<td>33</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Effect of 2.08 mg/ml Ethanolic C. aromaticus Extract on the Growth of E. coli</td>
<td>34</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Effect of 4.16 mg/ml Ethanolic C. aromaticus Extract on the Growth of P. aeruginosa</td>
<td>34</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Effect of 5.20 mg/ml Ethanolic C. aromaticus Extract on the Growth of K. pneumonia</td>
<td>35</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Effect of 2.08 mg/ml Ethanolic C. aromaticus Extract on the Growth of P. mirabilis</td>
<td>35</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Effect of (A) 2.60 mg/ml C. aromaticus Ethanolic Extract, (B) 9.38 mg/ml Heat Sterilized Ethanolic C. aromaticus extract and (C) 37.50 mg/ml Filter Sterilized C. aromaticus on the Growth of S. aureus</td>
<td>48</td>
</tr>
</tbody>
</table>
Figure 13: Effect of (A) 2.08 mg/ml C. aromaticus Ethanolic Extract, (B) 5.20 mg/ml Heat Sterilized Ethanolic C. aromaticus Extract and (C) 16.66 mg/ml Filter Sterilized C. aromaticus on the Growth of E. coli

Figure 14: Effect of (A) 4.16 mg/ml C. aromaticus Ethanolic Extract, (B) 10.42 mg/ml Heat Sterilized Ethanolic C. aromaticus Extract and (C) 25.00 mg/ml Filter Sterilized C. aromaticus on the Growth of P. aeruginosa

Figure 15: Effect of (A) 5.20 mg/ml C. aromaticus Ethanolic Extract, (B) 9.38 mg/ml Heat Sterilized Ethanolic C. aromaticus Extract and (C) 20.84 mg/ml Filter Sterilized C. aromaticus on the Growth of K. pneumonia

Figure 16: Effect of (A) 2.08 mg/ml C. aromaticus Ethanolic Extract, (B) 5.20 mg/ml Heat Sterilized Ethanolic C. aromaticus Extract and (C) 18.76 mg/ml Filter Sterilized C. aromaticus on the Growth of P. mirabilis

Figure 17: Wet Granulation Tissue Proliferation of Wound in Monosodium Glutamate Induced Diabetic Mice Treated with C. aromaticus. (A) Non Diabetic Mice without Treatment. (B) Non Diabetic Mice Treated Orally with Dried Extract of C. aromaticus. (C) Diabetic Mice without Treatment. (D) Diabetic Mice Treated Orally with Dried Extract of C. aromaticus.
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Zone of Inhibition (mm) of the Ethanolic Extract of <em>C. aromaticus</em> and Antibiotics Tested against Five Common Diabetic Wound Pathogens</td>
<td>31</td>
</tr>
<tr>
<td>Table 2</td>
<td>Minimum Inhibitory Concentration of Ethanolic Extract of <em>C. aromaticus</em> and Chloramphenicol on Five Common Diabetic Wound Pathogens</td>
<td>32</td>
</tr>
<tr>
<td>Table 3</td>
<td>Minimum Bactericidal Concentration of Ethanolic Extract of <em>C. aromaticus</em> and Chloramphenicol on Five Common Diabetic Wound Pathogens</td>
<td>32</td>
</tr>
<tr>
<td>Table 4</td>
<td>Zone of Inhibition of Ethanolic Extract, Heat Sterilized Ethanolic Extract and Filter Sterilized Ethanolic Extract of <em>C. aromaticus</em></td>
<td>45</td>
</tr>
<tr>
<td>Table 5</td>
<td>Minimum Inhibitory Concentration of Ethanolic Extract, Heat Sterilized Ethanolic Extract and Filter Sterilized Ethanolic Extract of <em>C. aromaticus</em></td>
<td>46</td>
</tr>
<tr>
<td>Table 6</td>
<td>Minimum Bactericidal Concentration of Ethanolic Extract, Heat Sterilized Ethanolic Extract and Filter Sterilized Ethanolic Extract of <em>C. aromaticus</em></td>
<td>46</td>
</tr>
<tr>
<td>Table 7</td>
<td>Wound Area Measurement in Five Different Groups of Mice with Excision Wound Model</td>
<td>61</td>
</tr>
<tr>
<td>Table 8</td>
<td>Epithelialization of Wounds Treated with <em>C. aromaticus</em> in <em>Monosodium Glutamate</em> Induced Diabetic Mice at Day 10</td>
<td>62</td>
</tr>
<tr>
<td>Table 9</td>
<td>Weight of Dry (A) and Wet (B) Granulation Tissue in <em>Monosodium Glutamate</em> Induced Diabetic Mice at Day 10</td>
<td>63</td>
</tr>
<tr>
<td>Appendix</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Appendix A</td>
<td>Comparison of Inhibition Zone between Ethanolic Extract of <em>C. aromaticus</em> with Commercial Antibiotics</td>
<td>93</td>
</tr>
<tr>
<td>Appendix B</td>
<td>Comparison of Inhibition Zone between Unsterilized, Heat Sterilized and Filter Sterilized Ethanolic <em>C. aromaticus</em> Extract</td>
<td>94</td>
</tr>
<tr>
<td>Appendix C</td>
<td>Minimum Inhibitory Concentration of Unsterilized, Heat Sterilized and Filter Sterilized Ethanolic Extract of <em>C. aromaticus</em></td>
<td>95</td>
</tr>
<tr>
<td>Appendix D</td>
<td>Minimum Bactericidal Concentration of Unsterilized, Heat Sterilized and Filter Sterilized Ethanolic Extract of <em>C. aromaticus</em></td>
<td>96</td>
</tr>
<tr>
<td>Appendix E</td>
<td>Log_{10} Reduction of Different Bacteria Treated with Unsterilized, Heat Sterilized and Filter Sterilized Ethanolic <em>C. aromaticus</em> Extract</td>
<td>97</td>
</tr>
<tr>
<td>Appendix F</td>
<td>Percentage of Wound Area Reduction for Five Different Groups of Mice with Different Treatments</td>
<td>98</td>
</tr>
<tr>
<td>Appendix G</td>
<td>Two Fold Serial Dilution of Ethanolic Extract of <em>C. aromaticus</em></td>
<td>99</td>
</tr>
<tr>
<td>Appendix H</td>
<td>List of Publications and Seminar Presentation</td>
<td>100</td>
</tr>
</tbody>
</table>
# ABBREVIATIONS AND SYMBOLS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADA</td>
<td>American Diabetic Association</td>
</tr>
<tr>
<td>ADP</td>
<td>Adenosine Diphosphate</td>
</tr>
<tr>
<td>AGEs</td>
<td>Advanced Glycation End Products</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>AIDS</td>
<td>Acquired Immune Deficiency Syndrome</td>
</tr>
<tr>
<td>Amp C</td>
<td>Ampicillin class C beta lactamase</td>
</tr>
<tr>
<td>ATP</td>
<td>Adenosine Triphosphate</td>
</tr>
<tr>
<td>CA</td>
<td><em>Coleus aromaticus</em></td>
</tr>
<tr>
<td>CFU/ml</td>
<td>Colony forming unit per millilitre</td>
</tr>
<tr>
<td>cm</td>
<td>Centimetre</td>
</tr>
<tr>
<td>DNA</td>
<td>Deoxyribonucleic acid</td>
</tr>
<tr>
<td>ECM</td>
<td>Extracellular Matrix</td>
</tr>
<tr>
<td>ER</td>
<td>Oestrogen Receptor</td>
</tr>
<tr>
<td>EUS</td>
<td>Epizootic Ulcerative Syndrome</td>
</tr>
<tr>
<td>g</td>
<td>Gram</td>
</tr>
<tr>
<td>HCl</td>
<td>Hydrochloride</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive Care Unit</td>
</tr>
<tr>
<td>IF</td>
<td>Interferon</td>
</tr>
<tr>
<td>IL</td>
<td>Interleukin</td>
</tr>
<tr>
<td>L</td>
<td>Litre</td>
</tr>
<tr>
<td>L-amino acid</td>
<td>Amino acid with left handed configuration</td>
</tr>
<tr>
<td>D-amino acid</td>
<td>Amino acid with right handed configuration</td>
</tr>
<tr>
<td>MBC</td>
<td>Minimum Bactericidal Concentration</td>
</tr>
<tr>
<td>MDR</td>
<td>Multi Drug Resistant</td>
</tr>
<tr>
<td>mg</td>
<td>Milligram</td>
</tr>
<tr>
<td>mg/dL</td>
<td>Milligrams per Decilitre</td>
</tr>
</tbody>
</table>
mg/g
Milligram per Gram

mg/100g
Milligram per Hundred Grams

mg/kg
Milligram per Kilogram

mg/kg/day
Milligram per Kilogram per Day

mg/L
Milligram per Litre

mg/ml
Milligram per Millilitre

MIC
Minimum Inhibitory Concentration

ml
Millilitre

mm
Millimetre

mM
Millimolar

mmol/L
Millimole per Litre

MMPs
Matric Metalloproteinases

MRSA
Methicillin Resistant *Staphylococcus aureus*

MSG
Monosodium Glutamate

nm
Nanometre

NSAID
Non-Steroidal Anti Inflammatory Drug

OGTT
Oral Glucose Tolerance Test

RNA
Ribonucleic acid

SD
Standard deviation

TNF
Tumour Necrosis Factor

μg/ml
Microgram per Millilitre

μl/ml
Microliter per Millilitre

μm
Micrometre

UTI
Urinary Tract Infection

v/v
Volume per volume

WHO
World Health Organization

w/v
Weight per volume

w/w
Weight per weight
REFERENCES


