ACKNOWLEDGEMENTS

Glory to Lord Jesus Christ for His love, guidance and blessings which had been given unto the writer to finish this thesis with the title “STUDY OF STABILITY, ANTIOXIDANT ACTIVITY, AND BINDING CAPACITY OF ANTIOXIDANT – COATED – MAGNETITE NANOPARTICLES” as one of the requirements for obtaining the degree of Sarjana Teknologi Pertanian Strata Satu in the Food Technology Department, Faculty of Science and Technology, Universitas Pelita Harapan.

The writer realizes that the thesis could not be completed without all the assistance, guidance, prayers, and supports from many parties involved. Therefore, the writer would like to express gratitude to those who help and support, whether directly or indirectly, including:

1) Mr. Ir. A. Herry Cahyana, M.Sc, Ph.D, as the thesis supervisor, for the guidance and support during the process and completion of thesis report.

2) Mrs. Natania, M.Eng, as the thesis co-supervisor and Head of Food Processing Laboratory, for the guidance and support during the process and completion of thesis report.

3) Mr. W. Donald R. Pokatong, Ph.D. as the Head of Food Technology Department, Faculty of Science and Technology, Universitas Pelita Harapan.

4) Mrs. Dr. Ir. Melanie Cornelia, MT; Ms. Ratna Handayani, MP; Ms. Yuniwaty Halim, M.Sc; and Mrs. Sisi Patricia L. A. Gultom, M.Eng, as Head of Chemistry, Research, Quality Control and Biology Laboratory.

5) Mr. Darius, Mr. Yosafat, Mrs. Meri, Mr. Hendra, Ms. Sharon Angela, and Ms. Isabella Supardi, for the support and guidance in the laboratory during the research.
6) Beloved family including father (Hong Guang Hui), mother (Wen Shu Mei), and brother (Hong Liang Cai) for the endless support during the thesis period and the making of the report.

7) Cathy Purnomo and family for their support and prayer throughout the making of the report.

8) Fellow friends under the same supervision: Shelly Chandra, Ferdy Tirtakusuma, Selvina Koesyamin, Jessica Aprilly, Jessilia Sugita, Yohanes Cahya, Elizabeth Angeline Lusida, Jessica Lesmana, and Vania Budiyanto for supporting one another in completing this thesis.

9) All C class 2012 member, and the entire members of Food Technology 2012 Universitas Pelita Harapan for the help and support.

10) Every person who cannot be mentioned that had contributed to the completion of the thesis, either directly or indirectly.

The writer realizes that this report may be imperfect and that the writer might have done unexpected things during research and thesis completion. Therefore, the writer wants to apologize for any mistakes and unclear statements found in this thesis that the writer is not aware of. The writer would welcome any criticism and suggestions upon this thesis. Furthermore, the writer sincerely hopes that this thesis may be useful for the readers.

Tangerang, 26th July, 2016

Writer
# TABLE OF CONTENTS

**COVER**

**STATEMENT OF THESIS AUTHENTICITY**

**APPROVAL BY THESIS SUPERVISORS**

**APPROVAL BY THESIS EXAMINATION COMMITTEE**

**ABSTRACT** ........................................................................................................ v

**ACKNOWLEDGEMENTS** ................................................................................ vi

**TABLE OF CONTENTS** .................................................................................. viii

**LIST OF TABLES** ........................................................................................ xi

**LIST OF FIGURES** ....................................................................................... xii

**LIST OF APPENDICES** ................................................................................ xiii

**CHAPTER I INTRODUCTION**

1.1 Background ..................................................................................................... 1

1.2 Research Problems ........................................................................................ 2

1.3 Objectives ....................................................................................................... 2

1.3.1 General Objectives .................................................................................... 2

1.3.2 Specific Objectives .................................................................................... 2

**CHAPTER II LITERATURE REVIEW**

2.1 Nanoparticles ................................................................................................. 4

2.1.1 Properties of Nanoparticles ....................................................................... 4

2.2 Magnetite ........................................................................................................ 5

2.3 Antioxidant ....................................................................................................... 6

2.4 Curcumin ......................................................................................................... 7
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>Xanthones ..................................................................................</td>
<td>8</td>
</tr>
<tr>
<td>2.6</td>
<td>Ascorbic Acid ...........................................................................</td>
<td>9</td>
</tr>
<tr>
<td>2.7</td>
<td>Tetraethoxysilane (TEOS) ................................................................</td>
<td>10</td>
</tr>
<tr>
<td>2.8</td>
<td>Synthesis of Magnetite Nanoparticles using Ascorbic Acid .............</td>
<td>11</td>
</tr>
<tr>
<td>2.9</td>
<td>Nanoparticles Synthesis by Co-precipitation Reactions .................</td>
<td>11</td>
</tr>
<tr>
<td>2.10</td>
<td>Attaching Functional Compounds to Nanoparticles ..........................</td>
<td>12</td>
</tr>
</tbody>
</table>

**CHAPTER III RESEARCH METHODOLOGY**

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Materials and Equipments ..................................................................</td>
<td>14</td>
</tr>
<tr>
<td>3.2</td>
<td>Research Procedures ............................................................................</td>
<td>14</td>
</tr>
<tr>
<td>3.2.1</td>
<td>Synthesis of MNPs ............................................................................</td>
<td>14</td>
</tr>
<tr>
<td>3.2.2</td>
<td>Preparation of TEOS-coated-MNPs ...................................................</td>
<td>15</td>
</tr>
<tr>
<td>3.2.3</td>
<td>Preparation of Antioxidant-coated-MNPs .........................................</td>
<td>16</td>
</tr>
<tr>
<td>3.2.4</td>
<td>Preparation of Curcumin Extract from Turmeric ................................</td>
<td>17</td>
</tr>
<tr>
<td>3.2.5</td>
<td>Preparation of Xanthones Extract from Mangosteen Pericarp ..............</td>
<td>18</td>
</tr>
<tr>
<td>3.3</td>
<td>Research Outline ..............................................................................</td>
<td>19</td>
</tr>
<tr>
<td>3.4</td>
<td>Experimental Design .........................................................................</td>
<td>22</td>
</tr>
<tr>
<td>3.5</td>
<td>Analysis Procedure ..........................................................................</td>
<td>22</td>
</tr>
<tr>
<td>3.5.1</td>
<td>DPPH Radical Scavenging assay ......................................................</td>
<td>22</td>
</tr>
<tr>
<td>3.5.2</td>
<td>Binding Capacity Assay ......................................................................</td>
<td>22</td>
</tr>
<tr>
<td>3.5.3</td>
<td>Stability Assay .................................................................................</td>
<td>23</td>
</tr>
<tr>
<td>3.5.4</td>
<td>Statistical Analysis .........................................................................</td>
<td>23</td>
</tr>
<tr>
<td>3.5.5</td>
<td>SEM Analysis .....................................................................................</td>
<td>24</td>
</tr>
<tr>
<td>3.5.6</td>
<td>PSA Analysis .....................................................................................</td>
<td>24</td>
</tr>
</tbody>
</table>

**CHAPTER IV RESULTS AND DISCUSSION**

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Synthesis of MNPs ...........................................................................</td>
<td>25</td>
</tr>
</tbody>
</table>
4.2 Extraction of Antioxidant ................................................................. 27
4.3 Stability of MNPs ................................................................. 34

CHAPTER V CONCLUSIONS AND SUGGESTIONS

5.1 Conclusions ............................................................................. 39
5.2 Suggestions ............................................................................ 39

BIBLIOGRAPHY ............................................................................. 41
APPENDICES ................................................................................. 44
### LIST OF TABLES

Table 3.1 Sample combinations – use of TEOS and type of functional components .........................................................................................................................18

Table 4.1 Antioxidant activities of MNPs .................................................................25

Table 4.2 Curcumin, xanthones and Ascorbic acid physicochemical analysis ....27

Table 4.3 Binding Capacity and Antioxidant activity of curcumin, xanthones and Ascorbic acid ........................................................................................................................33

Table 4.4 Antioxidant activity of curcumin, xanthones and Ascorbic acid .......33

Table 4.5 Summary of stability’s average mean release ......................................................35
LIST OF FIGURES

Figure 2.1. Relationship between total surface area in different particle size..............5
Figure 2.2. Oversimplified magnetite synthesis reaction........................................5
Figure 2.3. Example of macro-scale magnetite.......................................................5
Figure 2.4. Chemical structure of curcumin............................................................8
Figure 2.5. Chemical structures of two most abundant xanthones in mangosteen.........8
Figure 2.6 Chemical structure of ascorbic acid......................................................10
Figure 2.7 Mechanism of attaching functional compounds to nanoparticles............12
Figure 3.1 Flowchart of synthesis of magnetite nanoparticles...............................14
Figure 3.2 Flowchart of preparation of TEOS coated MNPs......................................15
Figure 3.3 Structure of antioxidant-coated-MNPs................................................16
Figure 3.4 Flowchart of extraction of crucumin from turmeric.................................17
Figure 3.5 Flowchart of extraction of xanthones from mangosteen pericarp.............18
Figure 4.1 SEM result for (a) NPs coated without TEOS (b) NPs with TEOS...........25
Figure 4.2 SEM results of Curcumin-coated-MNPs (a) without TEOS (b) with TEOS..28
Figure 4.3 SEM results of Curcumin-coated-MNPs (a) without TEOS (b) with TEOS..29
Figure 4.4 Stability of (a) Curcumin MNPs (b) Xanthones MNPs (c) Asc. Acid MNPs.35
Figure 4.5 Figure 4.5 Visual Comparison of (a) xanthone and (b) curcumin's stability..35
LIST OF APPENDICES

Appendix A. Synthesis of MNPs
Appendix B. Preparation of antioxidant-coated-Nanoparticles
Appendix C. Standard Curve
Appendix D. DPPH Radical Scavenging Assay
Appendix E. Statistical Analysis of Radical Scavenging Assay
Appendix F. Binding Capacity Assay
Appendix G. Statistical Analysis of Binding Capacity
Appendix H. Correlation between IC50 and Bind. Cap. For each functional Compounds
Appendix I. Stability Assay
Appendix J. Statistical Analysis of Stability
Appendix K. Morphology Assay
Appendix L. Size Distribution Assay