

Al-Azhar University-Gaza
Deanship of Postgraduate Studies
Faculty of Pharmacy
Master of Pharmaceutical Studies



Ethnopharmaceutical Botanical Study of Fructus Anisi and Fructus Foeniculi Sold on Herbalists in Northern Gaza and Gaza city

By

Bsc. Maha Mohammed Ibrahim Elkhateeb

Supervisors

Dr. Jehad H. Ahmed
Assistant Professor of
Pharmaceutical botany
Al-Azhar University

Dr. Mai A. Ramadan
Assistant Professor of
Pharmaceutical Chemistry
Al-Azhar University

**A Thesis Submitted in Partial Fulfillment of the Requirements for
the Degree of Master in Pharmaceutical Sciences**

2017

Declaration

I am who signed below and represent the study that have the following address:

Ethnopharmaceutical Botanical Study of Fructus Anise and Fructus Foeniculi Sold on Herbalists in Northern Gaza and Gaza city

declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: Maha Mohammed Ibrahim Elkhateeb

Signature:

Date: 24/5/2017

Dedication

*To my parents, my husband, my family,
my teachers and my friends for their encouragement and patience
with love and respect*

Acknowledgments

I would like to express my sincere special thanks and gratitude to my supervisors, Asst. Prof. Jehad Ahmed and Asst. Prof. Mai Ramadan for their supervision, encouragement, guidance and help throughout this study.

I offer my faithful thanks for Mr. Hatem Essalhey and Miss. Elham Shaheen for their guidance help.

I will never forget the role of the collaborators in the Pharmacy college, Al-Azhar University- Gaza for their encouragement.

I am also indebted for the generous help and facilities supplied by the Al-Azhar University- Gaza, throughout this work.

Abstract

Ethnopharmaceutical Botanical Study of Fructus Anisi and Fructus Foeniculi Sold on Herbalists in Northern Gaza and Gaza city

Introduction: Anise, *Pimpinella anisum* linn. and fennel, *Foeniculum vulgare* Mill., family *Apiaceae (Umbelliferae)* are parts of Palestinian traditional herbal medicine that provide a source of chemical compounds of medicinal interest.

Aim: This study aimed to evaluate efficacy, safety and quality of anise and fennel fruit samples sold in herbal shops in Northern Gaza and Gaza city.

Methodology: For this purpose, macro- and microscopical identification of the fruit samples was done for authinization. Chemical identification was done by phytochemical identifying tests and thin layer chromatography. Essential oils were extracted and quantified. Methanol and aqueous extracts of the samples were prepared and their total phenolic contents were determined by Folin-ciocalteu's assay. Antioxidant properties of the extracts were determined by DPPH radical antioxidant assay. Antimicrobial suscibtability tests for the extracts were evaluated by disc diffusion method against *E. coli* and *S. aureous* bacteria. Descriptive study among population and herbal practitioners was performed to evaluate the state of anise and fennel fruit in Palestinian traditional medicine.

Results: Anise and fennel fruit samples were identified from chemical, macro- and microscopical characters with respect to standards. Methanolic extracts of anise and fennel fruit have a considerable content of total phenolic compounds that range from 280-455 and 245-320 mg pyrogallol equivalents/100gm dry fruit respectively. While aqueous extracts of anise and fennel fruit have phenolic compounds contents range from 160-260 and 150-220 mg pyrogallol equivalents/100gm dry fruit respectively. Essential oil, aqueous and methanolic extracts have shown strong antioxidant properties. Methanolic extracts of anise and fennel fruit have antioxidant activity measured as 256-376 and 202-291 mg vitamin C equivalents/100gm dry fruit respectively. Aqueous extracts of anise and fennel fruit have 76-202 and 73-158 mg vitamin C equivalents/100gm dry fruit respectively. The antioxidant activity had been significantly correlated with total phenolic contents of the extracts (p - value < 0.05). Regarding antimicrobial activity, essential oils of both herbs had shown antibacterial properties against the mentioned bacteria. The descriptive study had shown that people and herbal practitioners were aware about the medicinal application of these fruits, and the correct method for their preparation as a herbal

tea. Besides, it were shown that pesticides and fumigant gases were applicable to herbal medicines inside the herbal shops.

Conclusion: Anise and fennel fruit are widely being used in the Palestinian traditional medicine for various health problems. They are sources essential oils that have antioxidant and antibacterial effects. Besides, they provide a source of phenolic compounds of considerable antioxidant activity that are significantly correlated with their total phenolic contents. The chemical composition, therapeutic activity and safety of herbal medicines depend, partly, on the quality of herbal medicines sold on herbal markets, including storage conditions.

Key words: Herbalists, Anise, Fennel, traditional medicine, antioxidant, antimicrobial, quality.

الملخص

دراسة في الطب الشعبي النباتي لكل من الينسون والشومر المستخدمة في محلات العطارة في مدينة غزة ومنطقة شمال غزة

المقدمة: يعد الينسون و الشومر - من عائلة الخيميات- جزءا من الطب الشعبي الفلسطيني التي توفر مصدراً لمركبات كيميائية ذات أهمية طبية.

أهداف الدراسة: تهدف هذه الدراسة إلى تقييم جودة و مدى فعالية وسلامة هذه الثمار التي تباع في محلات العطارة في مدينة غزة و منطقة شمال غزة.

طرق البحث: لتحقيق هذه الغاية تم جمع العينات وفحص التركيب الخارجي و المجهري لها؛ كما تم تحليلاً كيميائياً باختبارات الكشف الكيميائية وطرق الفصل النوعي للمركبات؛ تم أيضاً استخلاص الزيوت الطيارة وتحديد كميتها وكذلك تحضير المستخلصات المائية و الكحولية للعينات وتحديد كمية المواد الفينولية فيها باستخدام Folin-ciocalteu's assay؛ بالإضافة إلى ذلك تم قياس خاصية مضادات الأكسدة للمستخلصات المذكورة باستخدام DPPH radical antioxidant assay و كذلك تعين مدى فعاليتها كمضاد للبكتيريا تجاه *E. coli* and *S. aureous* bacteria باستخدام disc diffusion method . كما تم عمل دراسة وصفية بين فئة من الناس و العطارين لتقييم استخدام الينسون والشومر في الطب الشعبي الفلسطيني.

النتائج: تم في هذه الدراسة وصف عينات الينسون و الشومر من الناحية الخارجية و المجهري و الكيميائية مقارنة مع مرجع. المستخلصات الكحولية كانت تحتوي على كمية من المواد الفينولية تتراوح في ثمار الينسون و الشومر من 280-455 و 320-425 مجم مكافئ للبيروجاللول لكل 100 من وزن العينة الجاف بالتالي؛ أما المستخلصات المائية فكانت تحوي 160-260 و 150-220 مجم مكافئ للبيروجاللول لكل 100 من وزن العينة الجاف بالتالي. كما تم اظهار أن الزيوت الطيارة والمستخلصات الكحولية والمائية تحمل خصائص مضادة للأكسدة و تم حسابه كمياً في المستخلص الكحولي لثمار الينسون و الشومر بما يعادل 256-376 و 202-291 مجم مكافئ لفيتامين سي لكل 100 جم من وزن العينة الجاف بالتالي؛ كما تم حسابه في المستخلص المائي بما يعادل 76-202 و 73-158 مجم مكافئ لفيتامين سي لكل 100 جم من وزن العينة الجاف بالتالي. وتم اثبات ان الخصائص المضادة للأكسدة للمستخلصات ترتبط احصائياً بكمية المواد الفينولية فيها. بخصوص التأثير المضاد للبكتيريا تم تحقيق أن الزيوت الطيارة لها تأثير مضاد للبكتيريا لكن المستخلصات المائية و الكحولية لم تحقق ذلك. وقد اظهرت الدراسة الوصفية ان هناك وعي بين الناس و العطارين عن الاستخدامات الطيبة للينسون و الشومر و الطريقة الصحيحة لتحضيرهم كشای اعشاب. كما انها بینت ان المبيدات الحشرية تستخدم لحفظ الاعشاب الطيبة بداخل محلات العطارة.

الاستنتاج: نستنتج من هذه الدراسة أن الينسون والشومر واسعة الاستخدام في الطب الشعبي الفلسطيني لعلاج مختلف المشاكل الصحية. و تعتبر هذه الاعشاب مصدرا للزيوت الطيارة التي اظهرت خصائص مضادة للاكسدة ومضادة للبكتيريا. كما ان هذه الاعشاب تعد مصدرا للمواد الفينولية ذات خواص مضادة للأكسدة. وقد اظهرت الدراسة ان الخواص المضادة للاكسدة ترتبط إحصائيا بتركيز المواد الفينولية فيها. كما نستنتج من هذه الدراسة ان التركيب الكيميائي و الفعالية العلاجية و سلامة تعتمد نوعا ما على مدى جودة هذه الأعشاب الي تباع في المحلات وما يؤثر عليها من ظروف التخزين.

كلمات استدلالية: عطارين؛ ينسون؛ شومر؛ الطب الشعبي؛ مضاد للاكسدة؛ مضاد للبكتيريا؛ جودة.

Table of Contents

Declaration	i
Dedication	ii
Acknowledgments	iii
Abstract	iv
الملخص	vi
Table of Contents	viii
List of Tables	xv
List of Figures	xvi
List of Appendices	xix
Abbreviations	xx
Chapter 1: Introduction.....	1
1.1. Traditional medicine	1
1.2. Fructus Anisi and Fructus Foeniculi in Palestinian traditional herbal medicine	2
1.3. Problem statement	3
1.4. Main objective	3
1.5. Specific objectives	3
1.6. Significance	4
Chapter 2: Literature review	5
2.1. Traditional herbal medicine	5
2.1.1. Importance and global utilization	5
2.1.2. Regulatory situation and WHO policies	6
2.1.3. Reasons for herbal medicine regulation	7
2.1.3.1. Efficacy concerns	7
2.1.3.1.1. Adulteration	7
2.1.3.1.2. Variable chemical composition	8
2.1.3.2. Safety concerns.....	9
2.1.3.2.1. Intrinsic toxic constituents	9
2.1.3.2.2. Herb-drug interaction.....	10

2.1.3.2.3. Contamination	10
2.1.3.3. The state of herbal medicine practitioners	11
2.1.3.4. Lack of standard reference and research methodology	12
2.1.4. Standardization and quality control	12
2.1.4.1. Identity (botanical verification)	13
2.1.4.2. Purity	13
2.1.4.3. Content	14
2.1.5. Palestinian traditional herbal medicine.....	14
2.2. Natural products.....	16
2.2.1. Phenolic compounds	16
2.2.2. Essential oils	17
2.2.3. Biological activity	18
2.2.3.1. Antioxidant activity	18
2.2.3.2. Antimicrobial activity	19
2.3. Medicinal plants included in the study	20
2.3.1. <i>Pimpinella anisum</i> Linn. (<i>Apiaceae</i>).....	20
2.3.1.1. Geographical distribution....	20
2.3.1.2. Taxonomy	20
2.3.1.3. Morphological description	20
2.3.1.4. Medicinal part used (Fructus Anisi)	21
2.3.1.5. Morphological description of Fructus Anisi	21
2.3.1.6. Histoanatomical description of Fructus Anisi	22
2.3.1.7. Chemical constituents of Fructus Anisi	24
2.3.1.8. Traditional uses of Fructus Anisi	24
2.3.1.9. Pharmacological activities of Fructus Anisi extracts and essential oil	26
2.3.1.9.1. Antimicrobial activity	26
2.3.1.9.2. Antioxidant activity	27
2.3.1.9.3. Bronchodilatory activity	28
2.3.1.9.4. Expectorant activity	28
2.3.1.9.5. Gastroprotective activity	29
2.3.1.9.6. Hepatoprotective activity	29
2.3.1.9.7. Estrogenic activity	29
2.3.1.9.8. Anticancer activity	29
2.3.1.9.9. Anticonvulsant activity	29
2.3.1.9.10. Antispasmodic activity	30

2.3.1.9.11. Analgesic and anti-inflammatory activity	30
2.3.1.10. Safety issues	30
2.3.1.10.1. Adverse effects and toxicity	30
2.3.1.10.2. Precautions and interactions	31
2.3.1.10.3. Genotoxicity and carcinogenicity	31
2.3.2. <i>Foeniculum vulgare</i> Mill. (<i>Apiaceae</i>)	31
2.3.2.1. Geographical distribution	31
2.3.2.2. Taxonomy	31
2.3.2.3. Morphological description	32
2.3.2.4. Medicinal part used (Fructus Foeniculi)	33
2.3.2.5. Morphological description of Fructus Foeniculi	33
2.3.2.6. Histoanatomical description of Fructus Foeniculi	33
2.3.2.7. Chemical constituents of Fructus Foeniculi	34
2.3.2.8. Traditional uses of Fructus Foeniculi	37
2.3.2.9. Pharmacological activities of Fructus Foeniculi essential oil and extracts	37
2.3.2.9.1. Antimicrobial activity	37
2.3.2.9.2. Antioxidant activity	39
2.3.2.9.3. Bronchodilatory activity	40
2.3.2.9.4. Expectorant activity	40
2.3.2.9.5. Antihyperglycemic activity	41
2.3.2.9.6. Analgesic and anti-inflammatory activities	41
2.3.2.9.7. Hepatoprotective activity	41
2.3.2.9.8. Antidepressent activity	41
2.3.2.9.9. Estrogenic Activity	41
2.3.2.9.10. Spasmolytic activity	42
2.3.2.10. Safety	42
2.3.2.10.1. Adverse effects and toxicity	42
2.3.2.10.2. Precautions and interactions	42
2.3.2.10.3. Genotoxicity and carcinogenecity	43
Chapter 3: Methodology	44
3.1. Study design	44
3.2. Study population	44
3.3. Materials	44
3.3.1. Plant materials	44
3.3.2. Standards	45

3.3.3. Chemicals and solvents	45
3.3.4. Reagents	47
3.4. Instruments	47
3.5. Experimental design.....	48
3.5.1. Foreign matter determination	48
3.5.2. Macro- and microscopical identification	48
3.5.3. Qualitative phytochemical assay	48
3.5.3.1. Identification of alkaloids	48
3.5.3.2. Identification of cardiac heterosides	49
3.5.3.3. Identification of flavonoids	50
3.5.3.4. Identification of tannins	50
3.5.3.5. Identification of anthocyanins	51
3.5.3.6. Identification of saponines	51
3.5.3.7. Identification of anthracene derivatives (Modified Bornträger's test)	51
3.5.3.8. Identification of coumarins	51
3.5.3.9. Identification of cyanogenic compounds (sodium picrate paper test)	52
3.5.4. Preparation of extracts	52
3.5.4.1. Essential oil extracts	52
3.5.4.2. Methanolic extracts	52
3.5.4.3. Aqueous extracts	53
3.5.5. Thin layer chromatography (TLC)	53
3.5.5.1. TLC for essential oil extracts	53
3.5.5.2. TLC for methanol and aqueous extracts	54
3.5.6. Determination of total phenolic compounds' contents	54
3.5.6.1. Preparation of diluted extract sample	55
3.5.6.2. Preparation of the control sample	55
3.5.6.3. Folin-Ciocalteu (F-C) assay	55
3.5.6.4. Preparation of standard calibration curve	55
3.5.7. Determination of antioxidant activity	56
3.5.7.1. Qualitative antioxidant assay	56
3.5.7.2. Quantitative antioxidant assay	56
3.5.7.2.1. Preparation of diluted extract sample	57
3.5.7.2.2. Preparation of the control sample	57
3.5.7.2.3. DPPH radical scavenging activity assay	57
3.5.7.2.4. Preparation of standard calibration curve	57

3.5.8. Antimicrobial susceptibility assay	58
3.5.8.1. Preparation of the extract test samples.....	58
3.5.8.2. Preparation of bacterial inoculum	58
3.5.8.3. Agar disc diffusion method	58
3.6. Descriptive study.....	59
3.6.1. Inclusion criteria	59
3.6.2. Exclusion criteria	59
3.7. Ethical considerations.....	59
3.8. Data analysis	60
3.9. Limitation of the study	60
Chapter 4: Results	61
4.1. Foreign matter determination	61
4.2. Macro- and microscopical identification	61
4.2.1. Fructus Anise	61
4.2.1.1. Macroscopical characters	61
4.2.1.2. Microscopical characters	62
4.2.2. Fructus Foeniculi	66
4.2.2.1. Macroscopical characters	66
4.2.2.2. Microscopical characters	67
4.3. Phytochemical assay	70
4.4. Extracts' contents	76
4.4.1. Essential oil extracts	76
4.4.2. Crude methanol extract contents	76
4.4.3. Crude aqueous extract content	77
4.5. Thin layer chromatography (TLC)	77
4.5.1. TLC for essential oil	77
4.5.1.1. Detection at UV-254 nm.....	77
4.5.1.2. Detection with vanillin-sulfuric acid reagent at day light	78
4.5.2. TLC for methanol and aqueous extracts	79
4.5.2.1. Fructus Anisi	79
4.5.2.2. Fructus Foeniculi.....	80
4.6. Determination of total phenolic contents	81
4.7. Determination of antioxidant activity	82
4.7.1. Qualitative antioxidant assay	82
4.7.2. Quantitative antioxidant assay	84

4.8. Correlation between total phenolic contents and antioxidant activity	86
4.9. Antimicrobial activity.....	87
4.10. Descriptive study	89
4.10.1. Palestinian traditional herbal medicine	89
4.10.1.1. Role of Palestinian traditional herbal medicine in the primary health care	89
4.10.1.2. Role of anise and fennel fruit in Palestinian ethnomedicine	91
4.10.1.3. Procurement sources of anise and fennel fruits.....	95
4.10.1.4. Storage conditions of anise and fennel fruits inside houses.....	96
4.10.1.5. Sources of ethnomedicinal knowledge among population.....	96
4.10.2. Palestinian traditional herbal medicine practitioners	97
4.10.2.1. General claims about the practitioners	97
4.10.2.2. Applications of anise and fennel fruit by the practitioners	98
4.10.2.3. Sources of medicinal herbs in herbal shops	99
4.10.2.4. Preservation of medicinal herbs in herbal shops.....	101
Chapter 5: Discussion	103
5.1. Foreign matter contents	103
5.2. Botanical identification	103
5.3. Chemical identification	103
5.3.1. Phytochemical tests	103
5.3.2. Thin layer chromatography of the essential oils extracts.....	104
5.3.3. Thin layer chromatography of methanol and aqueous extracts	105
5.4. Extracts' contents	105
5.4.1. Essential oil extracts	105
5.4.2. Methanol and aqueous extracts	106
5.5. Total phenolic contents	107
5.6. Biological activity	109
5.6.1. Antioxidant activity	109
5.6.1.1. Antioxidant activity of essential oil extracts	109
5.6.1.2. Antioxidant activity of methanol and aqueous extracts	109
5.6.1.3. Correlation between total phenolics contents and antioxidant activity	110
5.6.2. Antimicrobial activity.....	111
5.6.2.1. Antimicrobial activity of essential oil	111
5.6.2.2. Antimicrobial activity of methanol and aqueous extracts	112
5.7. Descriptive study	113
5.8. Conclusion	118

5.9. Recommendations	119
Appendix A.....	120
Appendix B	123
References.....	126

List of Tables

Table 3.1. Fruit sources and their given symbols.....	45
Table 3.2. Standards and their manufacturing companies.....	45
Table 3.3. Chemical and solvents with their manufacturing companies	46
Table 3.4. Reagents and their preparation methods	47
Table 3.5. Instruments and their manufacturing companies.....	47
Table 4.1. Foreign matter of anise and fennel fruit samples	61
Table 4.2. Results of phytochemical assay of anise and fennel fruit samples.	72
Table 4.3. Results of the chemical identifying tests.	74
Table 4.4. Essential oil contents of anise and fennel fruit samples.	76
Table 4.5. Crude methanol extract content of anise and fennel fruit samples	76
Table 4.6. Crude aqueous extract content of anise and fennel fruit samples.	77
Table 4.7. Total phenolic contents of Fructus Anisi Extracts	81
Table 4.8. Total phenolic contents of Fructus Foeniculi extracts	82
Table 4.9. Vitamin C equivalent antioxidant capacity (VCEAC) of Fructus Anisi extracts	85
Table 4.10. Vitamin C equivalent antioxidant capacity (VCEAC) of Fructus Foeniculi extracts	85
Table 4.11. Total phenolics contents versus Vitamin C equivalent antioxidant capacity of all extracts.....	86
Table 4.12. Medicinal uses and method of preparation of anise and fennel fruits by the practitioners	100

List of Figures

Figure 2.1. Basic chemical structures of phenolic compounds	16
Figure 2.2. <i>Pimpinella anisum</i> Linn.	21
Figure 2.3. General structure of cremocarp	21
Figure 2.4. Fructus Anisi	22
Figure 2.5. Microscopical elements of Fructus Anisi	23
Figure 2.6. Chemical structures of some constituents of Fructus Anisi	25
Figure 2.7. <i>Foeniculum vulgare</i> M.	32
Figure 2.8. Fructus Foeniculi.	33
Figure 2.9. Microscopical elements of Fructus Foeniculum	35
Figure 2.10. Chemical structures of some constituents of Fructus Foeniculi	36
Figure 4.1. Fructus Anise sample AN _{AB}	62
Figure 4.2. Transverse section (T.S.) of Fructus Anisi	64
Figure 4.3. Microscopical elements of Fructus Anisi powder	65
Figure 4.4. Fructus Foeniculi of sample FN _{AB}	66
Figure 4.5. Transverse section (T.S.) of Fructus Foeniculi	68
Figure 4.6. Microscopical elements of Fructus Foeniculi powder	69
Figure 4.7. TLC plate for essential oil of anise and fennel fruit samples without chemical treatment	78
Figure 4.8. TLC plate for essential oil of anise and fennel fruit samples	79
Figure 4.9. TLC plate for methanol and aqueous extracts of anise fruit samples.....	80
Figure 4.10. TLC plate for methanol and aqueous extracts of fennel fruit samples	80
Figure 4.11. Qualitative antioxidant activity of essential oil extracts of Fructus Anisi and Fructus Foeniculi	82
Figure 4.12. Qualitative antioxidant activity of methanol and aqueous extracts of Fructus Anisi.	83
Figure 4.13. Qualitative antioxidant activity of methanol and aqueous extracts of Fructus Foeniculi.	83

Figure 4.14. Comparative DPPH assay for methanolic and aqueous extracts of <i>Fructus Anisi</i>	83
Figure 4.15. Comparative DPPH assay for methanolic and aqueous extracts of <i>Fructus Foeniculi</i>	84
Figure 4.16. Standard calibration curve of vitamin C in quantitative DPPH antioxidant assay	84
Figure 4.17. Disc paper antibacterial susceptibility test for certain methanol extracts of anise and fennel fruit samples	87
Figure 4.18. Disc paper antibacterial susceptibility test for essential oils of anise fruit samples	88
Figure 4.19. Disc paper antibacterial susceptibility test for essential oils of fennel fruit samples	88
Figure 4.20. Popularity of Palestinian traditional herbal medicine	89
Figure 4.21. Popular uses of Palestinian traditional herbal medicine	90
Figure 4.22. Popular medicinal herbs in Palestinian traditional medicine	90
Figure 4.23. Position of Palestinian traditional herbal medicine among population	91
Figure 4.24. Popularity of anise and fennel fruits in Palestinian ethnomedicine	91
Figure 4.25. Popular uses of <i>Fructus Anisi</i> in Palestinian ethnomedicine	92
Figure 4.26. Popular uses of <i>Fructus Foeniculi</i> in Palestinian ethnomedicine	92
Figure 4.27. Preparation methods of anise and fennel herbal medicine	93
Figure 4.28. Use of anise and fennel fruits during pregnancy and/or lactation	93
Figure 4.29. Common uses of anise and fennel herbal medicine during pregnancy and/or lactation	94
Figure 4.30. Use of anise and fennel fruits for children	94
Figure 4.31. Common uses of anise and fennel herbal medicine in children	95
Figure 4.32. Incidence of side effects upon usage of anise and fennel fruits herbs in ethnomedicine	95

Figure 4.33. Procurement sources of anise and fennel fruits	96
Figure 4.34. Storage conditions of anise and fennel fruits inside houses	96
Figure 4.35. Sources of ethnomedicinal knowledge of anise and fennel fruits	97
Figure 4.36. Experience years of Palestinian traditional medicine practitioners	97
Figure 4.37. Sources of ethnomedicinal knowledge among practitioners	98
Figure 4.38. Sources of medicinal herbs in herbal shops	99
Figure 4.39. Storage containers of medicinal herbs inside herbal shops	101
Figure 4.40. Storage period of medicinal herbs in herbal shops.	101
Figure 4.41. Methods of removal of medicinal herbs that last for more than one year in herbal shops	102
Figure 4.42. Methods for insects' control in herbal shops	102

List of Appendices

Appendix A. Semi-structured questionnaire for population..... 120

Appendix B. Semi-structured questionnaire for Palestinian herbal medicine practitioners..... 123

Abbreviations

Abbreviation	Full word
ALP	Alkaline Phosphatase
ALT	Alanine Aminotransferase
APX	Ascorbate Peroxidase
ASE	Accelerated Solvent Extraction
AST	Aspartate Aminotransferase
AUC	Area Under Kinetic Curve
BHA	Butylated Hydroxyanisole
BHT	Butylated Hydroxytoluene
bw	Body Weight
CAT	Catalase
CBA	Crocin Bleaching Assay
CLSI	Clinical & Laboratory Standards Institute
CPM	Chinese Proprietary Medicines
CUPRAC	Cupric Ion Reducing Antioxidant Capacity
DDT	Dichlorodiphenyltrichloroethane
DNA	Deoxyribonucleic Acid
DPPH	2,2-Diphenyl-1-Picrylhydrazyl
DSHEA	Dietary Supplement Health And Education Act
EMEA	European Medicines Agency
EU	European Union
EVCAA	Equivalent Vitamin C Antioxidant Activity
EVEAA	Equivalent Vitamin E Antioxidant Activity
FC	Folin-Ciocalteu
FCR	Folin-Ciocalteu reagent
FD	Folin-Denis Method
FDA	Food And Drug Administration
FEO	Foeniculum Vulgare (Fennel) Essential Oil
FIC	Ferrous Ion-Chelating
FRAP	Ferric Ion Reducing Antioxidant Power
FRS	Free Radical Scavengers
GAE	Gallic Acid Equivalents
GC	Gas Chromatography
GR	Glutathione Reductase
GRAS	Generally Recognized As Safe
HAT	Hydrogen Atom Transfer
HIV	Human immunodeficiency virus
HMPC	Committee On Herbal Medicinal Products
HPLC	High Performance Liquid Chromatography
HSA	Health Science Authority
IR	Infrared
ISO	The International Organisation For Standardization
LC	Liquid Column Chromatography
LDL	Low Density Lipoprotein
MBC	Mean Bactericidal Concentration
MIC	Mean Inhibitory Concentration

MS	Mass Spectrometry
ORAC	Oxygen Radical Absorbance Capacity
PAs	Pyrrolizidine Alkaloids
PDR	Physician's Desk Reference
PFE	Pressurized Fluid Extraction
PMF	Proton Motive Force
POH	Phenolic Compounds
POX	Peroxidase
PPO	Polyphenol Oxidase
RSD	Relative Standard Deviation
SET	Single Electron Transfer
SFE	Supercritical Fluid Extraction
SOD	Superoxide Dismutase
S-R	Singleton And Rossi
STDEV.P	Calculated Standard Deviation
TBARS	Thiobarbituric Acid Reactive Species Assay
TEAC	Trolox Equivalent Antioxidant Capacity
TLC	Thin Layer Chromatography
TNF	Tumor Necrosis Factor
TRAP	Total Radical-Trapping Antioxidant Parameter
USA	United States Of America
UV	Ultraviolet
UV/VIS	Ultraviolet/Visible Spectroscopy
VCEAC	Vitamin C Equivalent Antioxidant Capacity
WHO	World Health Organization
YES	Yeast Estrogen Screen